BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2014 HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams using pencil
- Board-approved calculators may be used

Total marks – 100

Section I Pages 2–22

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks

- Attempt Questions 21–30
- Allow about 1 hour and 40 minutes for this part

Section II Pages 25–37

25 marks

- Attempt ONE question from Questions 31–35
- Allow about 45 minutes for this section

Section I
75 marks

Part A – 20 marks
Attempt Questions 1–20
Allow about 35 minutes for this part

Use the multiple-choice answer sheet for Questions 1–20.

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1 Exposure to radiation such as X-rays may change the sequence of bases in DNA.

What is this called?

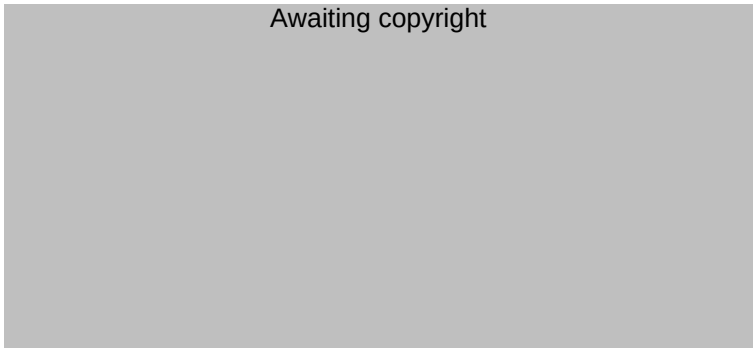
(A) Mutation

(B) Translation

(C) Replication

(D) Transcription

2 The diagram models the movement of particles in a particular process.



What process is being modelled?

(A) Osmosis

(B) Filtration

(C) Diffusion

(D) Active transport

3 Which of the following is a plant adaptation that minimises water loss?

(A) Small leaves

(B) Large flowers

(C) Large fleshy fruit

(D) Deep root systems

4 Which of the following correctly identifies the nitrogenous wastes of mammals, marine fish and insects?

	Mammals	*Marine fish*	*Insects*
(A)	Uric acid	Urea	Ammonia
(B)	Uric acid	Ammonia	Urea
(C)	Urea	Uric acid	Ammonia
(D)	Urea	Ammonia	Uric acid

5 In which of the following cases would bacteria be described as pathogens?

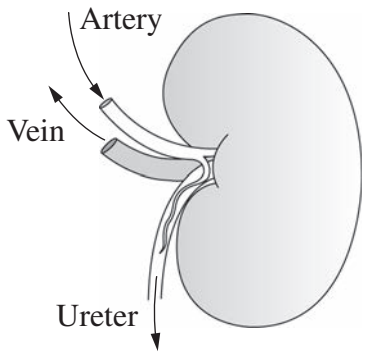
(A) Bacteria reducing lung function in mammals

(B) Bacteria in the human gut assisting digestion

(C) Bacteria producing insulin as a result of genetic engineering

(D) Bacteria in the mouth preventing growth of harmful bacteria

6 A body organ is shown.



One function of this organ is to

(A) store the products of digestion.

(B) regulate salt levels in body fluids.

(C) remove carbon dioxide from the blood.

(D) release ADH when water levels in the blood are high.

7 Which of the following is essential in any model of natural selection?

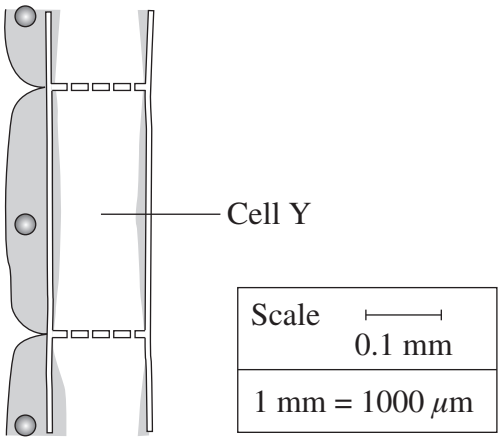
(A) High reproductive rates

(B) Random selection of prey

(C) A population of predators

(D) Differences in the population

Refer to the diagram of plant tissue shown to answer Questions 8 and 9.



8 What is the most suitable title for this diagram?

(A) A section of xylem tissue

(B) A section of phloem tissue

(C) A transverse section of phloem tissue

(D) A longitudinal section of xylem and phloem tissue

9 What is the width of Cell Y?

(A) 3 mm

(B) 13 mm

(C) 130 μm

(D) 180 μm

10 Why do co-dominant alleles NOT produce simple Mendelian ratios?

(A) Both alleles are expressed in the phenotype.

(B) Neither allele is expressed in the phenotype.

(C) The recessive allele is only expressed in the homozygous genotype.

(D) The expression of the dominant allele is affected by the recessive allele.

11 What is a likely adverse impact of the evolution of bacteria on the management of infectious disease?

(A) Viruses become resistant to antibiotics.

(B) Some treatments lose their effectiveness.

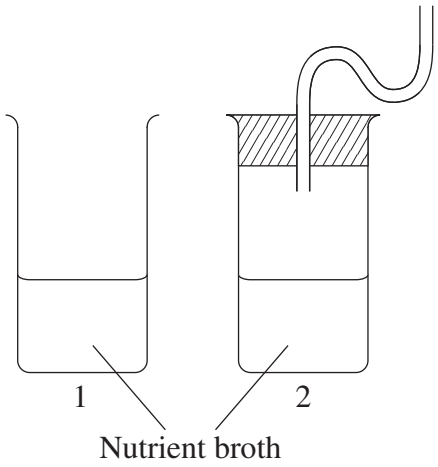
(C) Inherited diseases become more common.

(D) Quarantine of infected individuals no longer works.

Refer to the following information to answer Questions 12 and 13.

A student conducted a first-hand investigation using nutrient broth, beakers and an S-shaped delivery tube in an attempt to model Pasteur's experiment.

The equipment and data collected are shown.



Test tube	*Observation of nutrient broth* Day 1	*Observation of nutrient broth* Day 14
1	Clear	Cloudy
2	Clear	Cloudy

12 The data collected by the student are

(A) quantitative because data were collected for fourteen days.

(B) qualitative because the appearance of the broth is described.

(C) qualitative because this is a model of a past scientific experiment.

(D) quantitative because the results were recorded for two different beakers.

13 The student's results were different from Pasteur's results.

Which of the following provides the best explanation for the difference?

(A) The nutrient broth was different from Pasteur's.

(B) The nutrient broth always goes cloudy as it ages.

(C) The nutrient broth was not boiled thoroughly on Day 1.

(D) The nutrient broths were both exposed to oxygen from the outside air.

14 The current theory to explain the movement of materials within the phloem of a living plant involves the following steps:

1. Osmosis
2. Active transport of sugars into non-photosynthetic cells
3. Active transport of sugars from photosynthetic cells
4. Flow of sugar solution up and down

Which of the following is the correct order of these steps?

(A) 3, 4, 1, 2

(B) 2, 4, 1, 3

(C) 1, 3, 2, 4

(D) 3, 1, 4, 2

15 Goltz Syndrome is a condition in humans that adversely affects the skin. It is inherited as a dominant gene carried on the X chromosome.

A man with Goltz Syndrome and a woman who does NOT have the trait have two children, a boy and a girl.

Which of the following is correct about the inheritance of Goltz Syndrome in these children?

(A) Both children have the syndrome.

(B) The girl has the syndrome and the boy does not.

(C) The girl has the syndrome and the boy is a carrier.

(D) The girl has a 50% chance of having the syndrome and the boy has a 0% chance.

16 What is the best explanation for the successful development of transgenic species?

(A) Artificial pollination works across the plant kingdom.

(B) Nuclear transplantation from cell to cell is easily achieved.

(C) DNA in the biosphere is composed of the same chemical components.

(D) Genes from different animals within the one species are easily combined.

17 When B cells are activated they divide to form a large number of antibody-secreting cells.

How is this best explained?

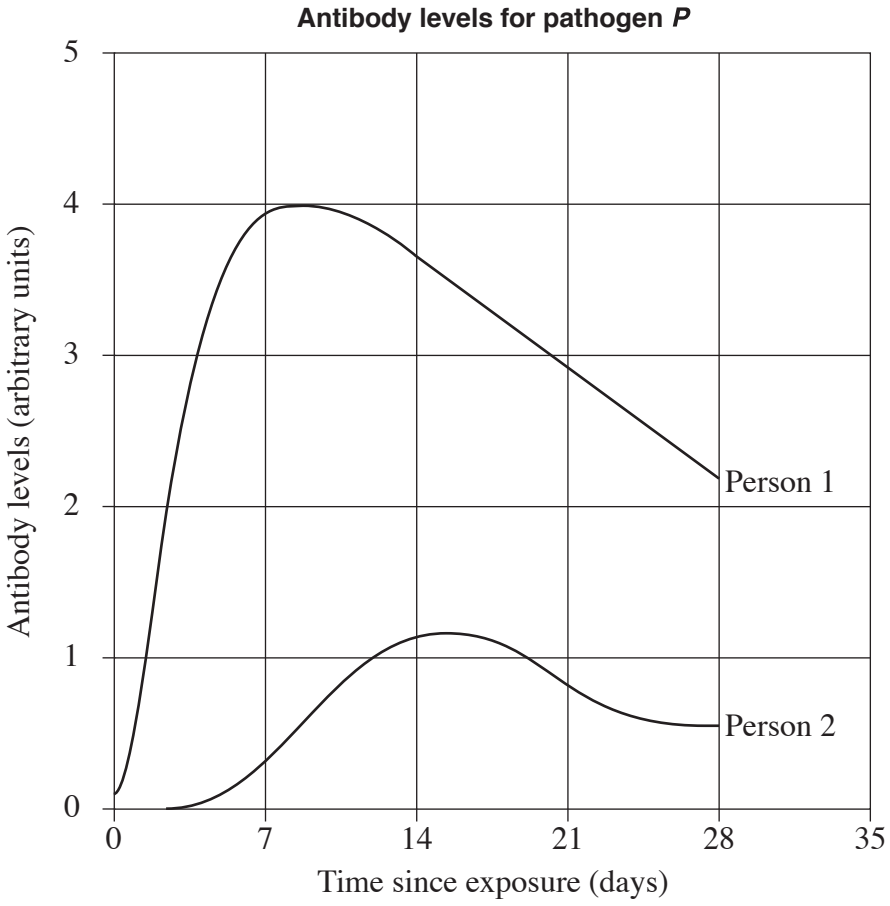
(A) Mitosis and gene expression produce cytotoxic cells.

(B) Mitosis and differentiation produce B cells that repair tissues.

(C) Mitosis and cell specialisation produce cells that maintain health.

(D) Mitosis and differentiation produce cells for growth and development.

18 Two people were exposed to pathogen *P* on the same day. The graph shows the blood antibody levels for that pathogen over the following 28 days for each person.



Which of the following best explains these results?

(A) Person 1 had not been previously exposed to pathogen *P* but had a recent organ transplant.

(B) Person 1 had been previously exposed to pathogen *P*.

(C) Person 2 had already been vaccinated against pathogen *P*.

(D) Person 2 had recent contact with a person infected with a similar pathogen.

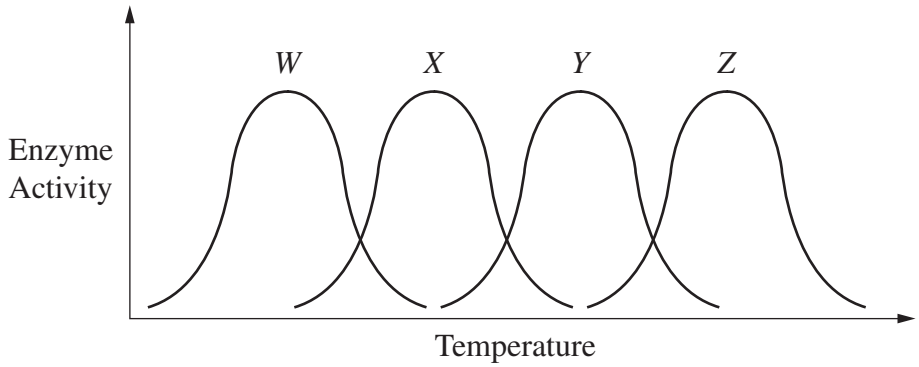
Refer to the information to answer Questions 19 and 20.

A case study of a fish species

A fish species can survive in environments with a wide range of temperature variation as long as the temperature change is gradual. The fish die if the temperature change is rapid because some metabolic reactions cannot take place.

Scientists have discovered that all the fish in this species have genes to produce four different enzymes (*W*, *X*, *Y* and *Z*) that catalyse the same reaction at different temperatures.

The graph shows the effect of increasing temperature on enzyme activity.



19 What is the best explanation for the fish surviving gradual temperature change but not a rapid temperature change?

(A) It takes time for each gene to be expressed.

(B) Enzyme activity is decreased at low temperatures.

(C) The fish produce different enzymes at different temperatures.

(D) Some enzymes will not denature if the temperature change is gradual.

20 What does this case study demonstrate?

(A) The specificity of substrates to enzymes

(B) The effect of the environment on phenotype

(C) The narrow temperature limitations for individual species

(D) The maintenance of a constant body temperature for metabolic efficiency

Biology

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–30
Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

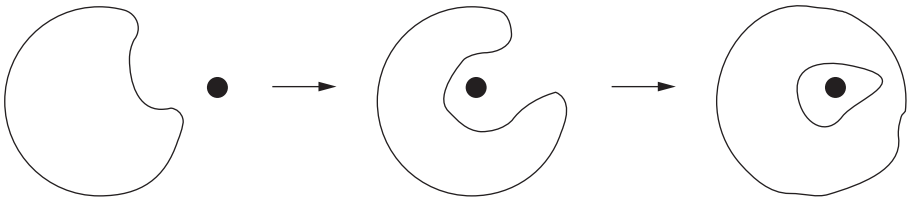
Extra writing space is provided on pages 21 and 22. If you use this space, clearly indicate which question you are answering.

Write your Centre Number and Student Number at the top of this page.

Please turn over

Question 21 (3 marks)

(a) The diagram shows a process that is a part of the immune response. **1**



What is the name of the process?

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(b) Outline how inflammation contributes to the immune response. **2**

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Question 22 (6 marks)

(a) Explain how TWO specific personal hygiene practices reduce the risk of infection. **4**

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(b) Drinking water contaminated with dissolved lead (a heavy metal) can cause a serious disease. **2**

Classify this disease as either infectious or non-infectious. Justify your answer.

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Question 23 (5 marks)

Fungicides are chemicals that are used to treat fungal diseases such as rust in plants. Rust symptoms include orange-brown patches on the underside of leaves.

A new brand of fungicide claims to successfully treat rust disease in plants.

You designed an experiment to test this claim. Other students also performed your experiment and gave you their results.

(a) Write a valid procedure for your experiment. **4**

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(b) How would you assess the reliability of your experimental design? **1**

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Question 24 (4 marks)

(a) Use labelled diagrams to distinguish between the structure of an artery and that of a capillary. **2**

(b) Relate one structure of a capillary to its function. **2**

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Question 25 (6 marks)

(a) Name a development in the history of our understanding of malaria and identify a prevention strategy that resulted from that development. **2**

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(b) Scientists are currently developing a vaccine for malaria. **4**

Outline how a vaccine against malaria would prevent the occurrence and spread of the disease in a population.

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Question 26 (5 marks)

Explain how Darwin/Wallace's theory of evolution by natural selection and isolation accounts for convergent evolution. Use an example to support your answer. **5**

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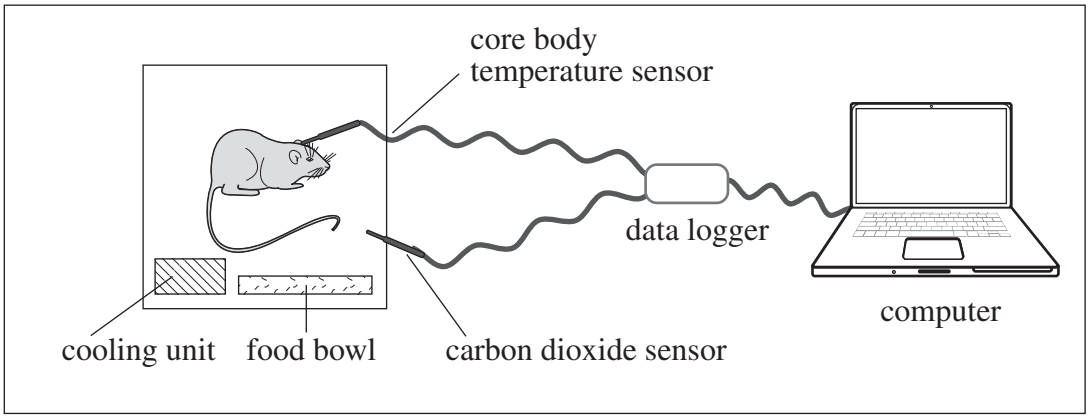
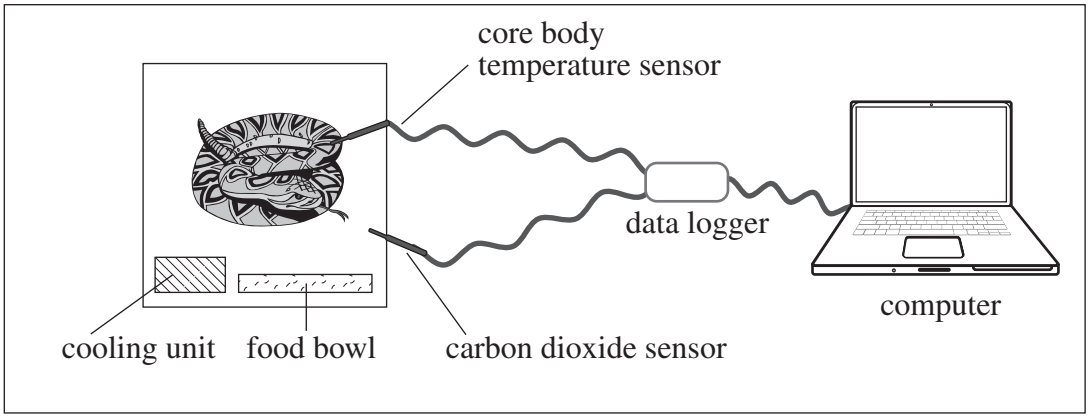
Question 27 (7 marks)

A student set up an experiment as shown.

Set-up 1: Rat



Set-up 2: Snake



The animals were each placed in 1 m^3 incubators which had glass front doors. The incubators were set at 25°C and the temperature was gradually decreased to 10°C. The initial core temperature of the rat was 37°C and that of the snake was 25°C. The experiment ran for two hours.

(a) The carbon dioxide concentrations rose in each of the incubators. **1**

Explain why.

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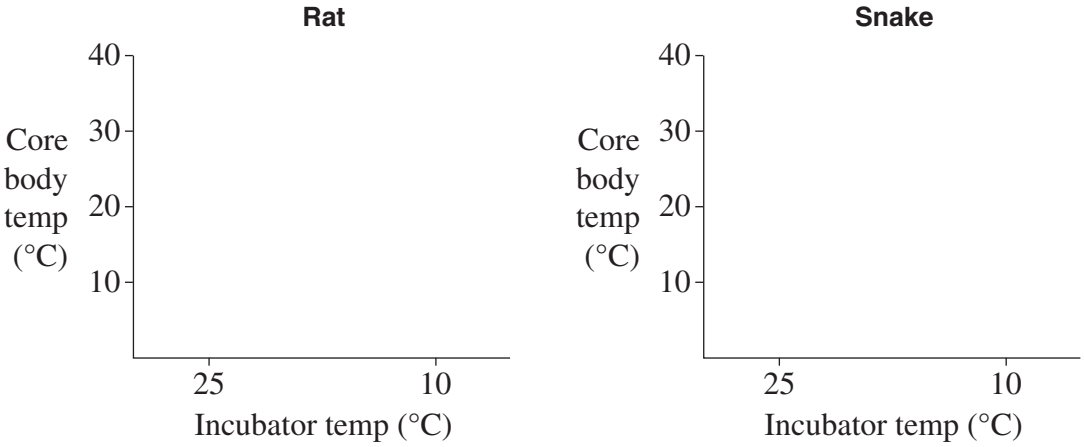
Question 27 continues on page 17

Question 27 (continued)

(b) Sketch line graphs on the axes below to predict body temperature data that would be collected in each set-up. **3**



(c) Complete the table to explain TWO predicted observations, other than body temperature, that could be made of Set-up 1: Rat during the experiment. **3**

Predicted observation	*Explanation*

End of Question 27

Question 28 (6 marks)

Rennin is an enzyme found in the stomach of young mammals. Rennin curdles the milk drunk by the mammal and allows the milk solids to stay longer in the stomach to be further digested.

Students conducted an investigation into rennin activity. They bubbled different volumes of carbon dioxide gas into milk samples. Each sample was 50 mL and was kept at a constant temperature. The students then added rennin to each milk sample and recorded the time taken for the milk to curdle.

Volume of CO_2 (number of bubbles)	*Time taken for rennin to curdle milk samples* (seconds)				
	Trial 1	*Trial 2*	*Trial 3*	*Trial 4*	*Average*
100	253	257	250	260	255
150	238	232	241	229	235
200	216	214	219	211	215
250	208	202	212	198	205
300	210	200	199	311	203

(a) Account for the students' calculated average time for 300 bubbles of CO_2. **2**

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(b) Explain the results of this experiment. **4**

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Question 29 (5 marks)

Scientists have tried to achieve a viable embryo by fusing two ova (eggs) from the same female. **5**

Explain whether the offspring produced using this process would be a clone of the female whose two ova were used. Use your knowledge of gamete formation and sexual reproduction to support your answer.

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Question 30 (8 marks)

Our knowledge of biology is increased by scientists exploring and testing ideas using available technologies. The explanations of scientists are then verified or modified by the work of later scientists using newer technologies. **8**

Justify this statement using the work of THREE named scientists who have contributed to the development of ideas on inheritance.

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Section I Part B extra writing space

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Biology

Section II

25 marks
Attempt ONE question from Questions 31–35
Allow about 45 minutes for this section

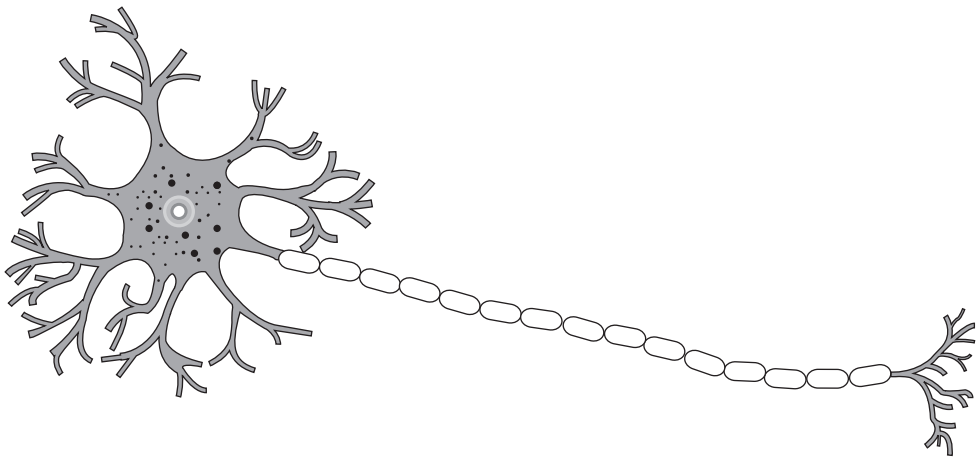
Answer parts (a)–(e) of ONE question in the Section II Writing Booklet. Extra writing booklets are available.

Question 31 — Communication (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) The biological structure shown is part of one of the systems in the body.

(i) Name the biological structure. **1**



(ii) Outline the steps involved in this system's response to a stimulus. **3**

(b) Construct a flow chart to show the energy pathway of sound waves from the outer ear to the auditory nerve. On your flow chart indicate the locations and types of energy transformation that occur. **4**

(c) Explain how the differences between photoreceptor cells in the eye contribute to human vision. **4**

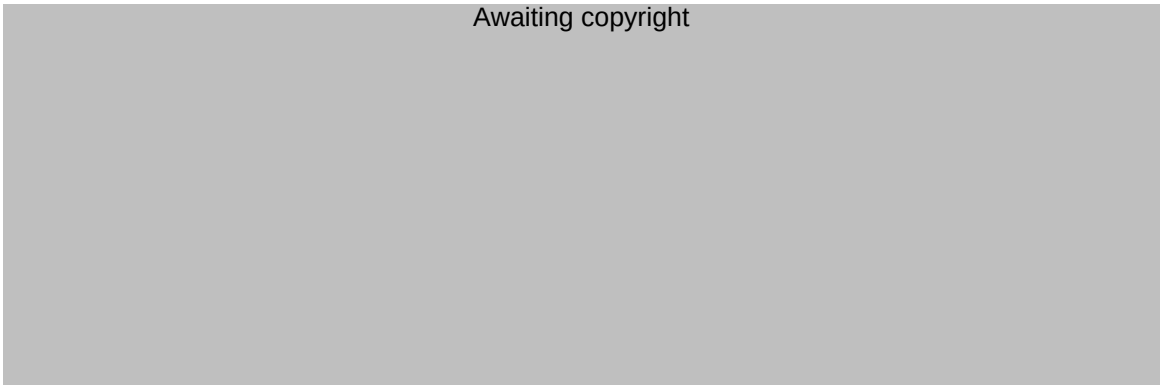
Question 31 continues on page 27

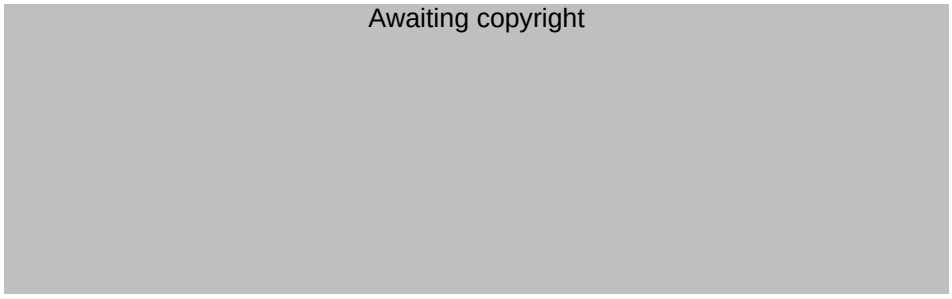
Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) The diagram shows the visual fields of three animals. The visual field is the proportion of the 360° view of the environment which can be seen by the animal when looking straight ahead.

Visual fields can be mapped according to which eye provides the vision in each part of the visual field.

The diagram also shows how the position of the eyes on the skull affects the visual field map.





(i) Use the data to describe the relationship between the position of the eyes in the head and the visual fields of the animal. **2**

(ii) Explain the effects of the loss of one eye on a monkey's vision and its chance of survival. **4**

(e) **7**

Sound is a versatile form of communication. It relies on the successful transfer of signals between individuals of the same species, as well as of different species, for a purpose.

Justify this statement with reference to specific animals other than humans.

End of Question 31

Question 32 — Biotechnology (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Name the process for the synthesis of a polypeptide chain from a messenger–RNA base sequence. **1**

(ii) Outline the steps in the formation of a functional enzyme from polypeptide chains. **3**

(b) Construct a flow chart to summarise the process of the polymerase chain reaction to amplify DNA. **4**

(c) Compare a traditional biotechnology to a biotransformational biotechnology in terms of ONE similarity and ONE difference. **4**

Question 32 continues on page 29

Question 32 (continued)

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Bacteria can be used to produce human blood protein that functions at pH 7.4. Two bacterial species are described in the table.

Species	pH growth conditions			Efficiency of plasmid uptake
	Minimum pH	Optimum pH	Maximum pH	
Sulfolobus acidocaldarius	1.0	2.5	5.0	Low
Thiobacillus novellus	5.7	7.0	9.0	High

(i) Which of these species would a modern scientist choose in order to make a new bacterial species capable of producing a human blood protein? Give reasons for your choice with reference to these data. **2**

(ii) These two species of bacteria were mixed. Describe how a biotechnologist in the 1940s would have isolated them from each other using an experimental procedure based on these data and standard techniques. **4**

(e) The text summarises an ethical framework for decision-making related to the use of biotechnologies. **7**

> *Utilitarian Ethics*
> An ethical activity is one that provides the greatest balance of good over harm for society and the environment.
>
> *The Precautionary Principle*
> If there is doubt about the harm that may be caused by an activity, the proposers of the activity must prove the harm is not significant for society and the environment.

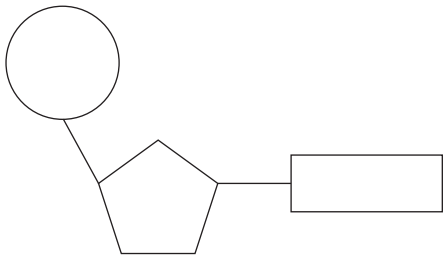
Evaluate the ethics of the use of ONE specific biotechnology in relation to this framework.

End of Question 32

Question 33 — Genetics: The Code Broken? (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Name the segment of DNA shown in the diagram. **1**



(ii) Outline the ability of DNA to repair itself. **3**

(b) Construct a flow chart to summarise the process of 'gene cloning' in a named example. **4**

(c) Assess the use of blood groups and highly variable genes for paternity testing. **4**

Question 33 continues on page 31

Question 33 (continued)

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) The data compare a segment of the eye control gene in mice to the equivalent gene segment in a range of different species. The expression of these genes is necessary for eye development to begin.

Mouse
eye control gene:
GTATCCAACGGTTGTGTGAGTAAAATTCTGGGCAGGTATTACGAGACTGGCTCCATCAGA

Species 1
Genetic similarity to mouse: 76.66%
Protein similarity to mouse: 100%
eye control gene:
GTATCAAATGGATGTGTGAGCAAAATTCTCGGGAGGTATTATGAAACAGGAAGCATACGA

Species 2
Genetic similarity to mouse: 85%
Protein similarity to mouse: 100%
eye control gene:
GTGTCCAACGGTTGTGTCAGTAAAATCCTGGGCAGATACTATGAAACAGGATCCATCAGA

Species 3
Genetic similarity to mouse: 78.33%
Protein similarity to mouse: 100%
eye control gene:
GTCTCCAACGGCTGCGTTAGCAAGATTCTCGGACGGTACTATGAGACGGGCTCCATAAGA

Species 4
Genetic similarity to mouse: 71.66%
Protein similarity to mouse: 100%
eye control gene:
GTGTCTAATGGTTGTGTTAGTAAAATACTTTGCCGATATTATGGAACAGGTTCTATTAAA

Acknowledgement: Reproduced by permission of the University of California, Museum of Paleontology
Homologous genes - http://evolution.berkeley.edu/evolibrary/article/1_0_0/eyes_10

Note: grey highlighted bases are the same as those in the mouse gene.

(i) With reference to the data in the table, explain why it is possible for different gene sequences to produce the same protein. **2**

(ii) Discuss ONE strength and ONE limitation of using the data shown to determine the evolutionary relationships between these species. **4**

Question 33 continues on page 32

Question 33 (continued)

(e) The text below summarises some recent scientific experiments. **7**

> Scientists, studying the development of human female embryos, recently discovered a gene called XIST. This gene silences one of the two X chromosomes so that they do not over-function in normal human females.
>
> The scientists were then able to insert the XIST gene into human cells grown in tissue culture to successfully silence other chromosomes.
>
> Scientists are now attempting to insert the XIST gene into the extra chromosome of mice that have trisomy.

With reference to genetics and gene technologies, explain these experiments and their implications.

End of Question 33

Question 34 — The Human Story (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) State a feature that is used to classify humans as *Homo*. **1**

(ii) Outline the difficulties of interpreting data from fossils. **3**

(b) Construct a key to identify old world monkeys, apes, new world monkeys and prosimians using observable characteristics. **4**

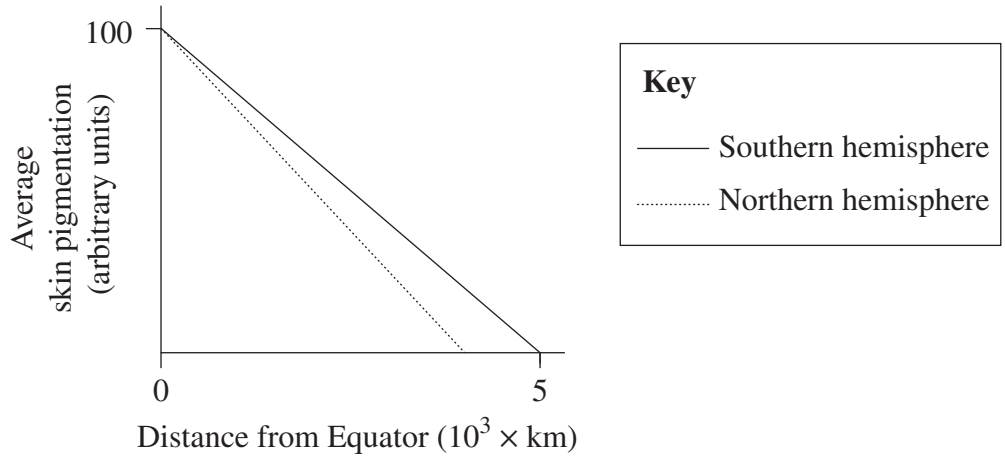
(c) Demonstrate how applications of the Human Genome Project could affect future trends in human biological evolution. **4**

Question 34 continues on page 34

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) (i) The graph shows the relationship between the average skin pigmentation of humans and the distance they live from the equator. **2**

Identify the TWO general trends shown in the graph.



(ii) Explain the evolutionary significance of a named example of polymorphism (other than skin colour) in humans. **4**

(e) This text summarises new ideas on recently discovered fossil hominins called Denisovans. **7**

> Denisovans were identified from a number of separate intact fossil bones discovered in a cave in western Russia. One of these fossils was dated to 41 000 years ago. Very recently another cave site, this time in Spain, revealed even older intact Denisovan fossil bones.
>
> These fossils have been analysed to reveal a story of migration of Denisovans out of Africa 600 000 years ago. They were a large and genetically diverse group of hominins.
>
> Denisovans interbred with Neanderthals and *Homo sapiens*. A group of Denisovan males even migrated to Papua New Guinea and interbred with *Homo sapiens* there.

Using this information, analyse how scientists use technologies and the results they generate, to deduce ideas on hominin history which could modify existing theories.

End of Question 34

Question 35 — Biochemistry (25 marks)

Answer parts (a), (b) and (c) of the question on pages 2–4 of the Section II Writing Booklet. Start each part of the question on a new page.

(a) (i) Name a scientist from the 17th or 18th century who contributed to the development of ideas on plant growth. **1**

(ii) Outline how the findings from a 17th or 18th century experiment informed a conclusion about plant growth. **3**

(b) Construct a flow chart to summarise the procedure used to produce named photosynthetic plant cell fractions. **4**

(c) Explain how the design of Calvin's experiments involving paper chromatography led to his development of an understanding of the light-independent reactions of photosynthesis. **4**

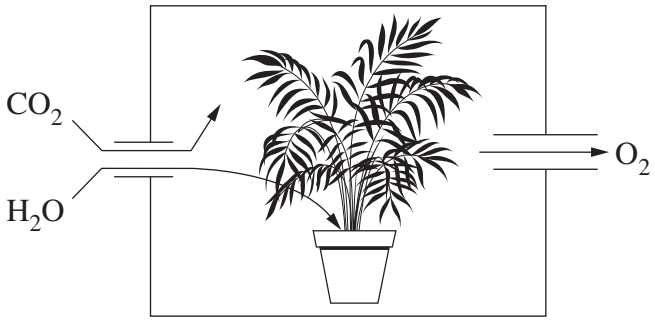
Question 35 continues on page 36

Question 35 (continued)

Answer parts (d) and (e) of the question on pages 6–8 of the Section II Writing Booklet. Start each part of the question on a new page.

(d) Data were collected from two experiments on photosynthesising plants. Each experiment used a different tracer containing oxygen–18.

Each plant was placed in a container into which water and carbon dioxide were supplied. The oxygen released by the plant was collected.



The data collected are shown in the table.

Experiment	Ratio of ^{18}O to ^{16}O		
	Reactants		*Product*
	CO_2	H_2O	O_2
1	0.003	0.900	0.857
2	0.850	0.003	0.003

(i) Write the chemical formula for each of the tracers used in Experiment 1 and Experiment 2. In your answer, clearly specify the tracer used in each of the experiments. **2**

(ii) Explain the results for Experiment 1 and Experiment 2, making specific reference to the data. **4**

Question 35 continues on page 37

Question 35 (continued)

(e) This text summarises new scientific research into the development of micro-algae for high efficiency photosynthesis in the making of high energy raw materials for human use. **7**

> Micro-algal cells very efficiently capture light energy but do not perform the downstream electron transfer and carbon fixation as efficiently. These chemical bottlenecks can cause wastage of captured light energy as heat. Also, in large liquid cultures, micro-algae on the surface of the culture deny light energy to algae located deeper in the liquid.
>
> Scientists have successfully modified the expression of chlorophyll-b genes in algal cells. They have grown new algae with less active chlorophyll-b molecules, identified by quantitative observation of oxygen production. These new micro-algae can more uniformly and efficiently photosynthesise in large liquid cultures.

Explain the main ideas presented in this text and include implications for society and the environment.

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