BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2015 HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

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

Total marks – 100

Section I Pages 2–28

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 21–31
- Allow about 1 hour and 40 minutes for this part

Section II Pages 29–43

25 marks

- Attempt ONE question from Questions 32–36
- 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 What is the name of the theory which describes evolution as patterns of rapid first appearances or extinctions followed by periods of little or no change?

(A) Gradualism

(B) Convergence

(C) Adaptive radiation

(D) Punctuated equilibrium

2 What are alternative forms of genes called?

(A) Alleles

(B) Autosomes

(C) Chromatids

(D) Chromosomes

3 Which adaptation would decrease water loss from a plant in a region with low rainfall?

(A) Broad leaves

(B) Surface roots

(C) Sunken stomates

(D) Loosely packed epidermal cells

4 Which of the following does NOT play a role in maintaining the health of an organism?

(A) Mitosis

(B) Cell death

(C) Gene expression

(D) Sexual reproduction

5 The diagram shows a model for enzyme action.



Which letter indicates the substrate in this diagram?

(A) *W*

(B) *X*

(C) *Y*

(D) *Z*

6 An extremely high concentration of carbon dioxide is undesirable in active muscle tissue because it will

(A) increase the pH.

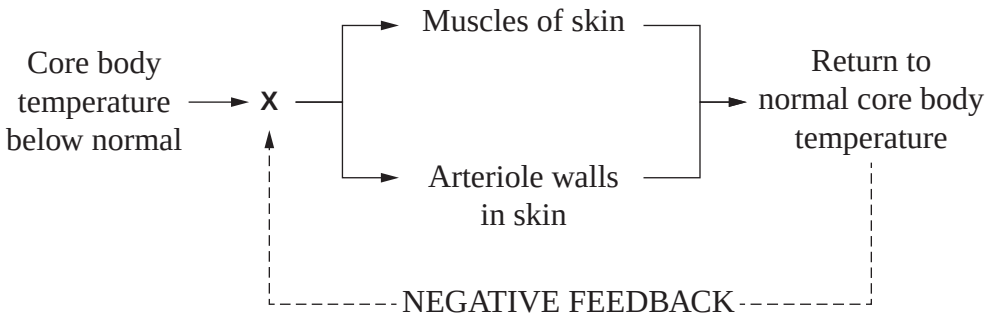
(B) cause enzymes to denature.

(C) increase cellular reaction rates.

(D) cause haemoglobin to release oxygen.

Refer to the following information to answer Questions 7 and 8.

The diagram shows a homeostatic mechanism in a mammal.



7 What does **X** represent in the diagram?

(A) The heart

(B) The brain

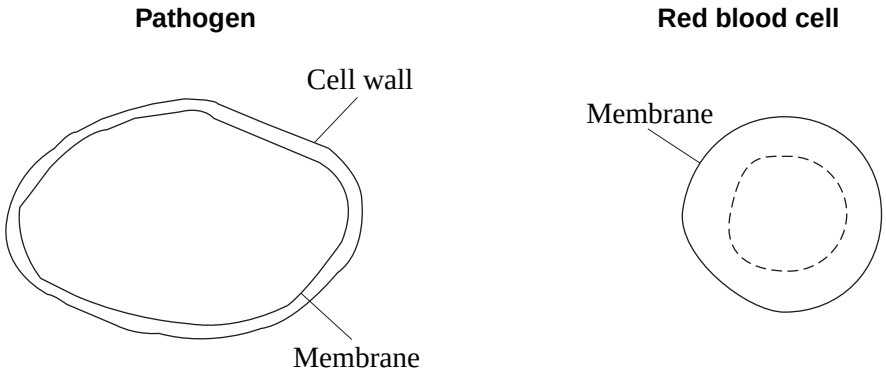
(C) A thermoreceptor in the skin

(D) A pressure receptor in a blood vessel

8 Which of the following describes what happens to the muscles and the arteriole walls in the skin when the core body temperature is below normal?

	Muscles of skin	*Arteriole walls in skin*
(A)	Relax to lower epidermal hairs	Expand
(B)	Contract to raise epidermal hairs	Contract
(C)	Relax to raise epidermal hairs	Expand
(D)	Contract to lower epidermal hairs	Contract

9 A pathogen and a red blood cell are drawn to the same scale, with some features indicated.



What type of pathogen is this?

(A) A virus

(B) A prion

(C) A fungus

(D) A bacterium

10 ATP is an organic molecule common to the metabolism of every species on Earth.

Which of the following statements explains why this fact is considered evidence for evolution?

(A) All species have evolved to be suited to the environment of Earth.

(B) ATP molecules were transferred between organisms early in the history of life.

(C) The gene for ATP developed in the earliest organisms and has been retained by subsequent species.

(D) All species on Earth developed the same gene for ATP as a consequence of convergent evolution.

11 Environment can affect phenotype by altering the sequence of bases in DNA.

Which of the following is an example of this?

(A) High protein diets making children taller than their parents

(B) Stress causing the expression of one set of genes instead of another

(C) Language and music lessons improving intelligence in young children

(D) Nuclear fallout from atomic bombs increasing birth defects in populations

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

> The larvae of fruit flies damage fruit in Western Australia. To control the problem, growers are advised to spray fruit trees with pesticides. Any already damaged fruit is boiled and disposed of as chicken food or landfill. Another control measure is the release of genetically engineered infertile flies of this species.

12 Which reason best explains why the corresponding control measure reduces this problem?

	Control measure	*Reason*
(A)	Release of infertile flies	Infertile flies do not eat the fruit
(B)	Release of infertile flies	The number of flies in the next generation is decreased
(C)	Boiling fruit and feeding to chickens	Chickens are unaffected by the damaged fruit
(D)	Boiling fruit and feeding to chickens	The amount of waste for landfill is reduced

13 The following measures could be used to prevent the spread of this fruit fly across Australia.

1. Australia-wide release of infertile fruit flies
2. Aerial spraying of orchards throughout the country
3. Spot spraying of newly affected orchards in Western Australia
4. Stopping the transport of fruit from Western Australia to other states

To prevent the spread of this fruit fly across Australia, which combination of measures would be most practical to use?

(A) 1 and 2

(B) 1 and 4

(C) 2 and 3

(D) 3 and 4

14 The table shows the base triplets in mRNA for amino acids.

From the table, the amino acid Serine (Ser) can be coded for by the base triplet UCG.

Base triplets found in messenger RNA

First base	Second base U	Second base C	Second base A	Second base G	Third base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Phe	Ser	Stop	Stop	A
	Phe	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

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Which base triplet could code for the amino acid Tyrosine (Tyr)?

(A) CCU

(B) CAU

(C) UAA

(D) UAC

15 In a certain plant species, individual plants have either yellow, red or orange flowers.

Two plants, each with a different flower colour, were crossed in a breeding experiment like those carried out by Mendel. The F2 results were: 6 red, 11 orange and 5 yellow flowered plants.

What were the genotypes of the original parent plants?

(A) RY and RY

(B) RR and rr

(C) RR and YY

(D) Rr and RY

16 Why might epidemiology be considered more essential for the study of non-infectious diseases than for the study of infectious diseases?

(A) The causes of infectious diseases have already been determined.

(B) Only non-infectious diseases are affected by patterns of behaviour.

(C) Epidemiology cannot be used to find the causes of infectious diseases.

(D) Koch's postulates are not useful in finding the causes of non-infectious diseases.

17 The diagram shows an interaction between cells of the immune system.

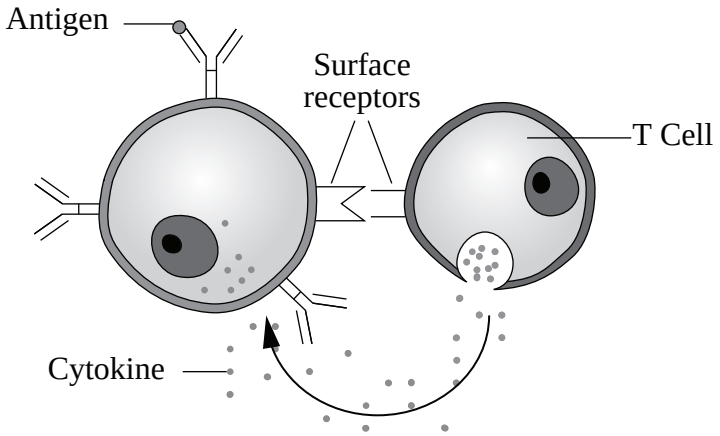


Illustration from Anatomy & Physiology, Connexions Website by OpenStax College. http://cnx.org/content/col11496/1.6/, Jun 19, 2013.

What specific process is shown in the diagram?

(A) B cell encountering an antigen

(B) Activation of a macrophage by a helper T cell

(C) Stimulation of a B cell to become a plasma cell

(D) Cytotoxic T cell destroying a virus-infected cell

18 Students conducted a large first-hand investigation into enzyme activity.

The aim in the report is shown.

Aim: To determine the optimum pH of four different enzymes.

How many independent variables were in this first-hand investigation?

(A) 1

(B) 2

(C) 4

(D) 5

Refer to the following information to answer Questions 19 and 20.

> The intestinal tract of a human foetus is sterile.
>
> After birth, microflora from the mother are transferred to the baby's mouth through close contact. After a year, the microflora of the baby is similar to the mother's, with the baby's immune system ignoring these microbes.
>
> Also during the first year of life, breast milk from the mother provides antibodies to the baby for any disease the mother has already experienced. When breastfeeding ceases, these antibody levels in the baby start to fall.
>
> After the first year, any new species of invading bacteria is treated as a pathogen by the baby's immune system.

19 A medical consequence for six-month-old babies that have only been bottle-fed with formula milk and not breastfed is that

(A) they will not develop microflora.

(B) their immune system will be damaged.

(C) their consumption of milk cannot be quantified.

(D) they will be at increased risk of infectious disease.

20 Strict hygiene practices are followed in the care of newborns, whereas hygiene practices in the care of older babies are less emphasised.

Which of the following is the best reason for this difference?

(A) Vaccinations render personal hygiene unnecessary for older babies.

(B) Procaryotic cells are not identified as antigens in early development.

(C) Antibiotic treatments kill bacterial populations in the digestive system.

(D) Early exposure to pathogens helps to build a strong immune system.

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Biology

Centre Number

Student Number

Section I (continued)

Part B – 55 marks
Attempt Questions 21–31
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 27 and 28. 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.

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Question 21 (2 marks)

Explain ONE control measure for malaria. **2**

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Question 22 (2 marks)

Explain why insects excrete uric acid as their principal nitrogenous waste. **2**

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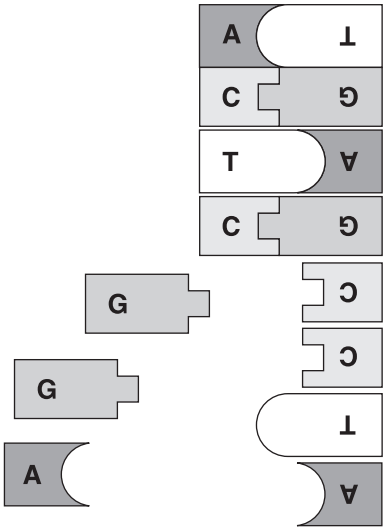
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Question 23 (3 marks)

The diagram shows a model involving DNA.



(a) What process is being modelled? **1**

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(b) Identify TWO structural features of the DNA molecule which are NOT shown in this model. **2**

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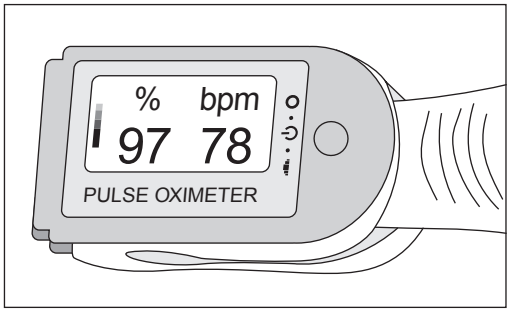
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Question 24 (7 marks)

Data can be provided by a pulse oximeter pegged to a person's finger, as shown in the diagram.



(a) What is the oxygen saturation for this person? **1**

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(b) Outline TWO limitations of using only the information provided in the diagram to determine the 'health' of a person. **2**

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(c) Explain TWO advantages in using a pulse oximeter to measure oxygen saturation compared to using another named technology in a specific setting. **4**

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Question 25 (5 marks)

A group of students wanted to test whether water purifying tablets were effective in making creek water free from bacteria.

They conducted an experiment using a water sample collected from the creek and found that the tablets were effective.

(a) Describe a means of addressing ONE identified hazard relevant to this investigation. **2**

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(b) Illustrate the results of this experiment in diagrammatic form. **3**

Use labels to clearly identify the data collected.

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Question 26 (5 marks)

Sugar is transported in vascular tissues in plants and animals. **5**

Contrast the structure and workings of ONE named plant tissue and ONE named animal tissue used to transport sugar.

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Question 27 (5 marks)

(a) Outline TWO differences between whole blood and plasma. **2**

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(b) The steps below show the preparation and use of blood products in the treatment of Ebola Virus Disease. This disease is characterised by significant blood loss. **3**

World Health Organisation Protocol

1. A patient recovers from Ebola Virus Disease.
2. The same patient is disease-free for 28 days.
3. Blood is taken from the patient and screened for transmissible diseases.
4. Plasma is separated from the whole blood.
5. Plasma is transfused into another person with early signs of Ebola Virus Disease.

Use of convalescent whole blood or plasma collected from patients recovered from Ebola virus disease
http://www.who.int/csr/resources/publications/ebola/convalescent-treatment/en/

Explain why this protocol produces an effective treatment for Ebola Virus Disease.

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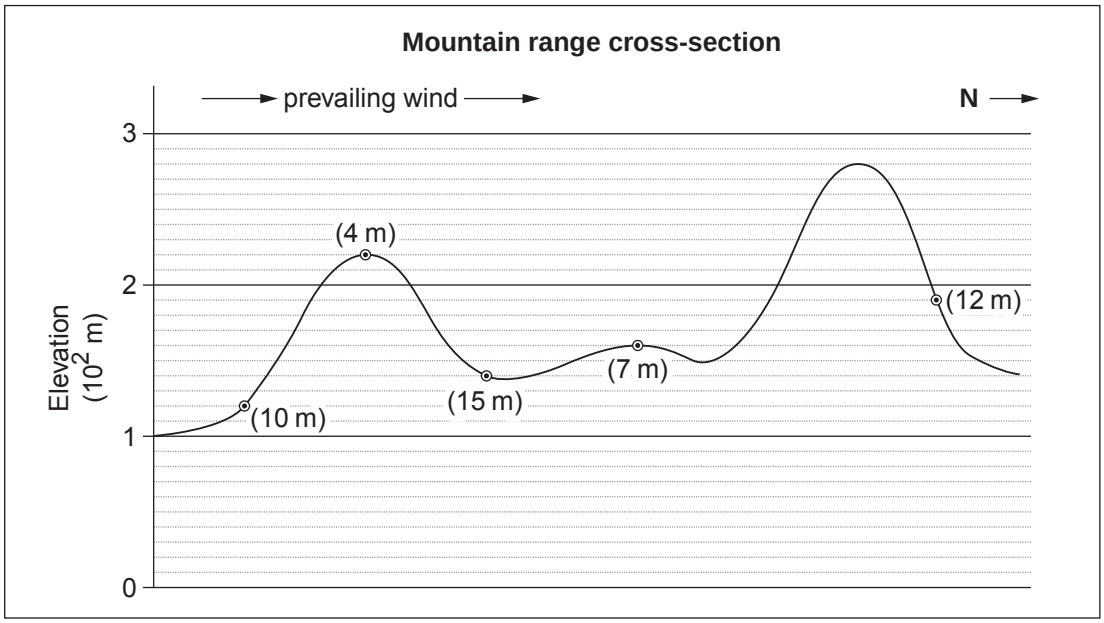
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Question 28 (5 marks)

A group of students hypothesised that the height of plants decreases with increased elevation.

The students planted ten plant cuttings from the same plant at each of five locations. The locations were at varying elevations in the same mountain range. All the cuttings were provided with the same volume of water on planting, and no fertiliser was applied. The students returned after the same growth period and measured the height of the plants.

The cross-section shown indicates the average height of the plants in metres after the growth period at each location in the mountain range.



(a) Evaluate the validity of the experiment. **3**

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Question 28 continues on page 21

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Question 28 (continued)

(b) Complete both columns of the table to best present the data for the analysis of any trend. **2**

End of Question 28

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Question 29 (6 marks)

'The application of modern reproductive techniques in plant and animal breeding limits genetic diversity.' **6**

Discuss this statement.

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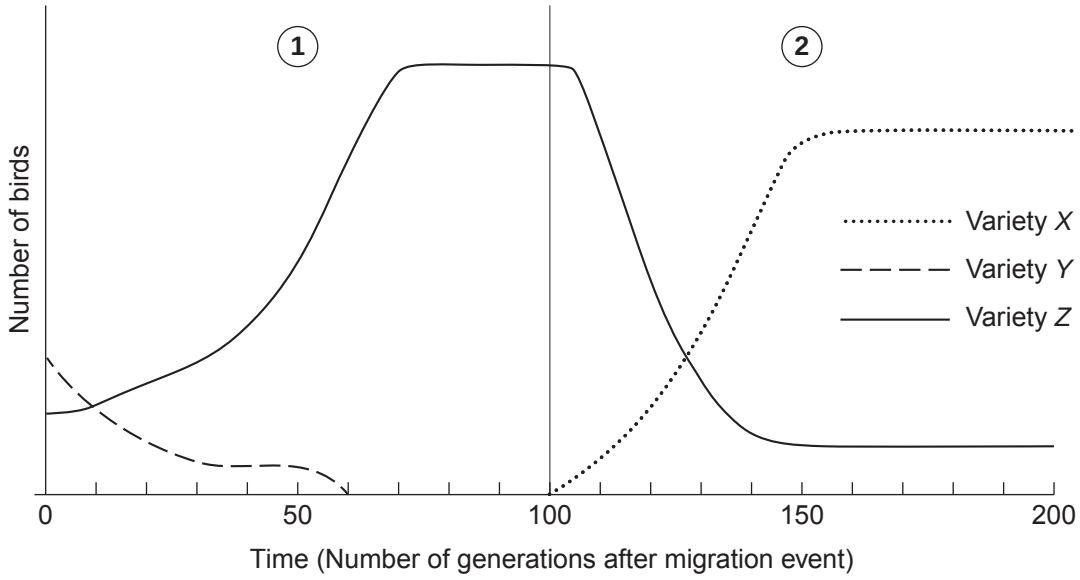
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Question 30 (7 marks)

The graph shows the history of the relative numbers of three varieties of bird (*X*, *Y* and *Z*) within a bird species, on a remote island in the Pacific Ocean.

The bird species arrived on the island in a migration event. Before migration, the bird species was not present on the island.

The graph record of bird numbers on the island is divided into two sections (**1** and **2**). Over the time data were recorded, the environment of the island did not change.



(a) What bird varieties originally migrated to the island? **1**

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Question 30 continues on page 25

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Question 30 (continued)

(b) Using the Darwin/Wallace theory of evolution, and making reference(s) to the data in the graph, explain the changes to the population of each variety of bird in

(i) section (1) of the graph. **2**

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(ii) section (2) of the graph. **4**

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Question 31 (8 marks)

'Renal dialysis and kidney transplants are very different treatments for the same medical condition. Each treatment was developed from a new application of biological knowledge.' **8**

Justify these statements.

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Biology

Section II

25 marks
Attempt ONE question from Questions 32–36
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.

Pages

Question 32 Communication 30–31

Question 33 Biotechnology 33–35

Question 34 Genetics: The Code Broken? 37–39

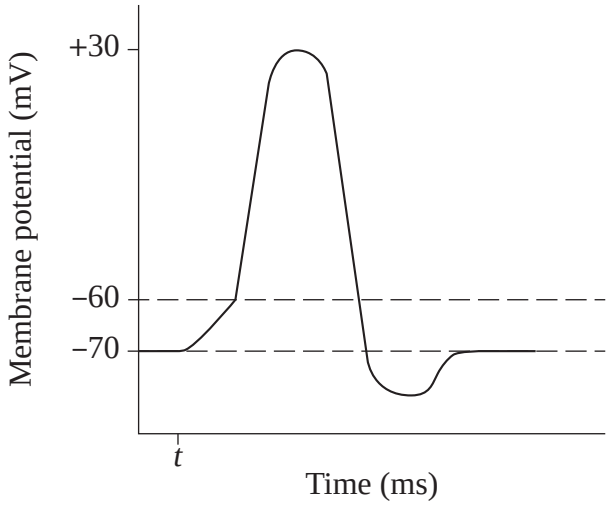
Question 35 The Human Story 40–41

Question 36 Biochemistry 42–43

Question 32 — 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 diagram shows changes in membrane potential in a neurone after a stimulus is applied at time *t*.



Adapted from Art Connection graph: Figure 3. http://cnx.org/contents/72cfcf6f-e196-4e0b-9bcf-45f4853993e4@5/How-Neurons-Communicate

(i) What is the resting membrane potential of this neurone? **2**

(ii) With reference to this diagram, explain why some stimuli would not generate an action potential in a neurone. **2**

(b) Different species of animals can see the same environment differently. **4**

Explain this in terms of the wavelengths of the electromagnetic spectrum that animals can detect. Use specific examples in your answer.

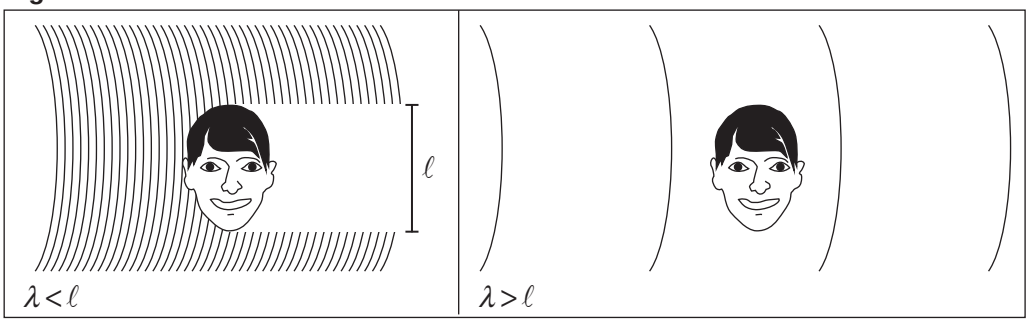
(c) Account for the diversity of senses in humans, in terms of receptors and corresponding regions of the brain. Support your answer with TWO examples. **4**

Question 32 continues on page 31

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.

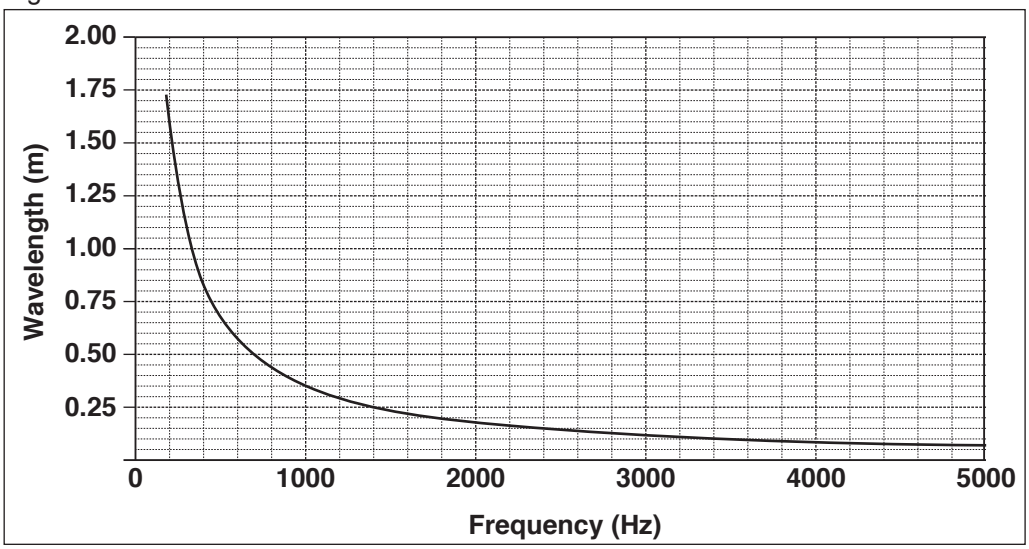
(d) A sound shadow is produced when the wavelength (λ) of a sound is shorter than the length of the human head (ℓ). When a sound of wavelength longer than the head is used, no sound shadow occurs. See Figure 1.

Figure 1



©Thomas Haslwanter

Figure 2



(i) Predict a difference in the loudness of the sound in each ear if the sound has a wavelength shorter than the length of the head. Justify your answer. **2**

(ii) A person's head is 25 cm long. Using Figures 1 and 2, and showing all the steps, determine the frequency range of sound for which a sound shadow occurs for this person. **4**

(e) 'Science is used to solve problems for the benefit of society.' **7**

Justify this statement with reference to the scientific knowledge used to solve ONE problem in hearing and ONE problem in visual accommodation.

End of Question 32

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Question 33 — 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) The fermentation reaction shown occurs as yeast biomass increases.

$$\text{Glucose} \longrightarrow X + Y$$

(i) Identify the products *X* and *Y*. **2**

(ii) Describe how, after the 18th century, the fermentation of glucose was modified to increase the yield of yeast biomass. **2**

(b) DNA can be extracted in a school laboratory. **4**

Describe separately the method used to get the DNA out of the cells, and the method used to isolate the DNA from other cell components in this setting.

(c) Explain why the domestication of species for agriculture is described as a biotechnology. In your answer, refer to ONE specific domesticated organism. **4**

Question 33 continues on page 34

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) (i) Why is lactic acid fermentation used in the transformation of milk into cheese? **2**

(ii) Several groups of students in a class investigated the optimum conditions for the transformation of milk into cheese using a common bacterial starter culture. **4**

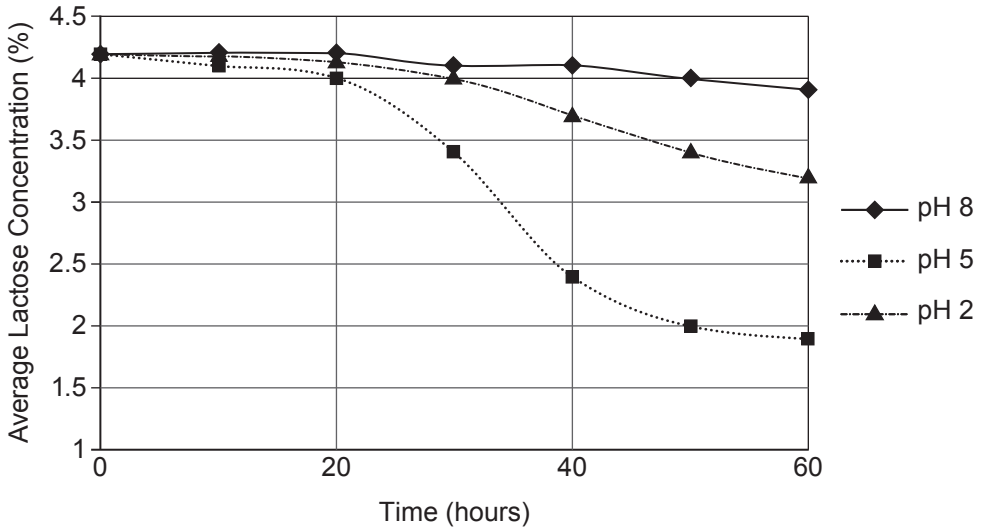
Each group conducted experiment 1 and the class obtained average values of their results. The class then designed experiment 2 and each group conducted the experiment, again obtaining average values of their results. The average values for each experiment are shown below.

Experiment 1 – The effect of temperature on lactic acid production in milk at pH 5

Time after bacteria added (hours)	*Average lactic acid concentration in substrate* (%)		
	Fermentation temperature 2°C	Fermentation temperature 25°C	Fermentation temperature 35°C
0	0.1	0.1	0.1
10	0.1	0.2	0.2
20	0.1	0.3	0.2
30	0.2	0.8	0.4
40	0.3	1.8	0.7
50	0.4	2.2	1.0
60	0.6	2.3	1.3

Question 33 continues on page 35

Experiment 2 – The effect of pH on lactose conversion in milk at 25°C



The students concluded that the results were contradictory and that they could not define the optimum conditions for their cheese production.

Evaluate the students' conclusion with reference to their data from both experiments.

(e) 'Science is used to solve problems for the benefit of society.' **7**

Justify this statement with reference to the scientific knowledge behind DNA technology, using ONE example from medicine and ONE from forensics.

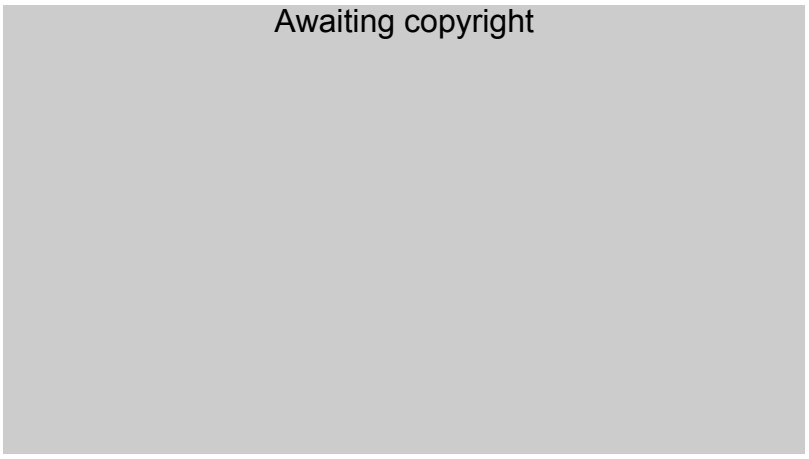
End of Question 33

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Question 34 — 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) The diagram shows two cells taken from the same organism.



(i) What type of cell is Cell B? **1**

(ii) Explain the potential effects on this species of a disadvantageous mutation in each of these cell types. **3**

(b) Describe how the current models of the structure of tRNA and mRNA have helped us understand the production of a sequence of amino acids. **4**

(c) Describe how the action of genes can explain features of embryonic development. **4**

Question 34 continues on page 38

Question 34 (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) A biology class searched the internet for published results of cross-breeding experiments on the same three traits controlled by genes known to be linked.

They found two breeding experiments on the same species of flowering plant, involving the genes for stamen length, flower colour and fruit colour.

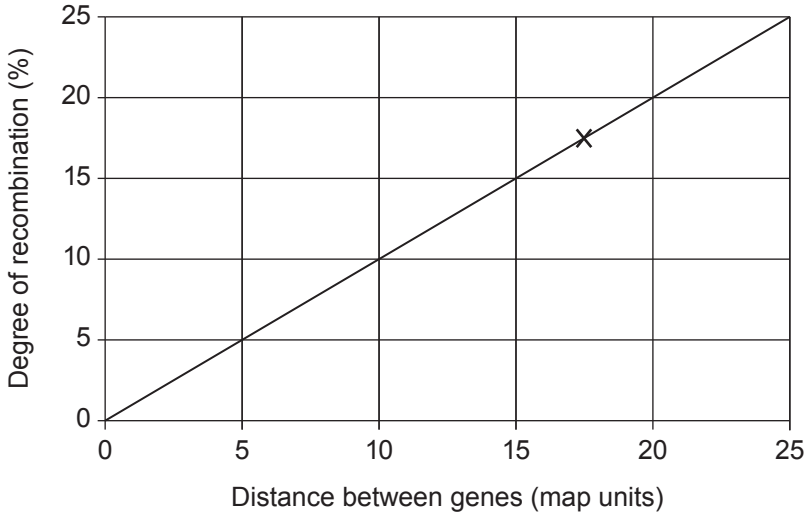
Each experiment investigated two of the three genes. The experimental results were presented in different formats.

Experiment 1: AaEe × aaee

Raw data: Phenotypic ratios in offspring
– 27 long stamen, red flowers
– 3 long stamen, yellow flowers
– 3 short stamen, red flowers
– 27 short stamen, yellow flowers

Experiment 2: BbEe × bbee

After data analysis: Result indicated on a reference graph.



Question 34 continues on page 39

The class concluded that the distance between Gene A and Gene E is less than the distance between Gene B and Gene E.

(i) Show, with working, that Gene A is 10 map units from Gene E. **2**

(ii) Evaluate the conclusions drawn by the class. **2**

(iii) What further data would need to be collected to draw a quantitative map of the chromosome showing the relative positions of all these genes? Justify your answer. **2**

(e) 'Science is used to solve problems for the benefit of society.' **7**

Justify this statement with reference to the scientific knowledge behind DNA technology, using ONE example from medicine and ONE from forensics.

End of Question 34

Question 35 — 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) The diagram shows two primates. **2**



Figure 1

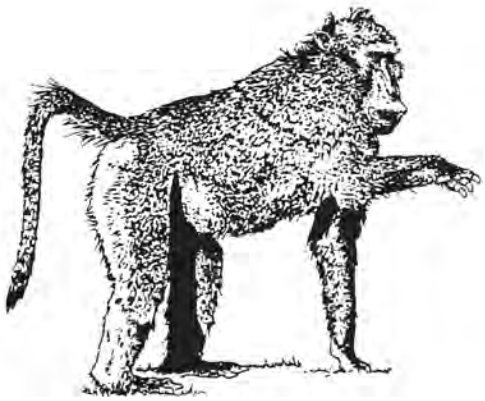


Figure 2

BIOZONE, Human Evolution OHT Masters Set No. 8, 1998, BIOZONE International. Reproduced with permission

Provide the word that describes the tail for the classification of each primate.

(ii) Spider monkeys and baboons are members of the same order. Use the hierarchical classification system to explain whether they would necessarily be in the same phylum and the same genus. **2**

(b) Explain ONE piece of evidence for, and ONE piece of evidence against, the theory of regional continuity. **4**

(c) Account for identified differences in the cultural development of *Australopithecines* and *Homo neanderthalensis* in relation to their cranial capacities. **4**

Question 35 continues on page 41

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) (i) Distinguish between relative dating and absolute dating of fossils. **2**

(ii) Students found three fossils (**A**, **B** and **C**) at an archaeological site. **4**

The depth of each fossil below the surface was recorded and the strata of rocks at the site were mapped.

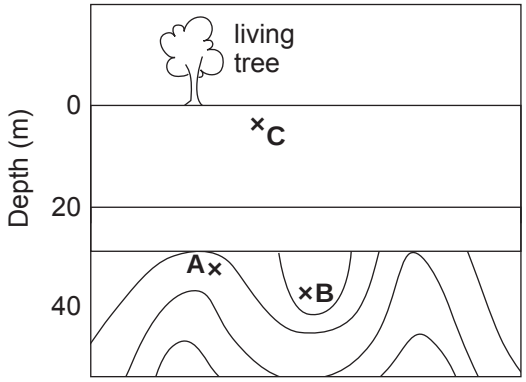


Figure 1

The fossils were analysed in the laboratory for ratios of C^{14} to C^{12}, and the results were presented on a C^{14} half-life curve.

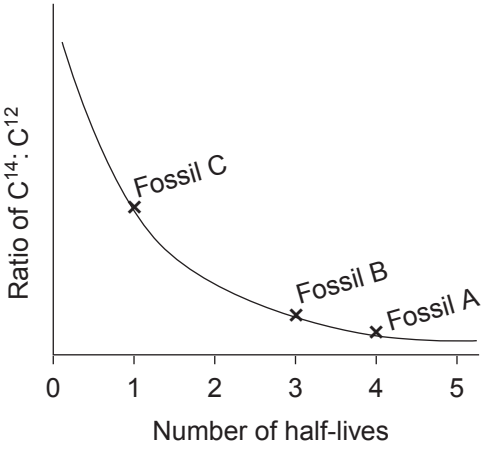


Figure 2

The students concluded that their data were conflicting and they could not determine the relative ages of the fossils.

Evaluate the students' conclusion with reference to the data presented.

(e) 'Science has been used to solve problems in the investigation of evolutionary relationships between humans and other primates, and so has provided information of interest to society.' **7**

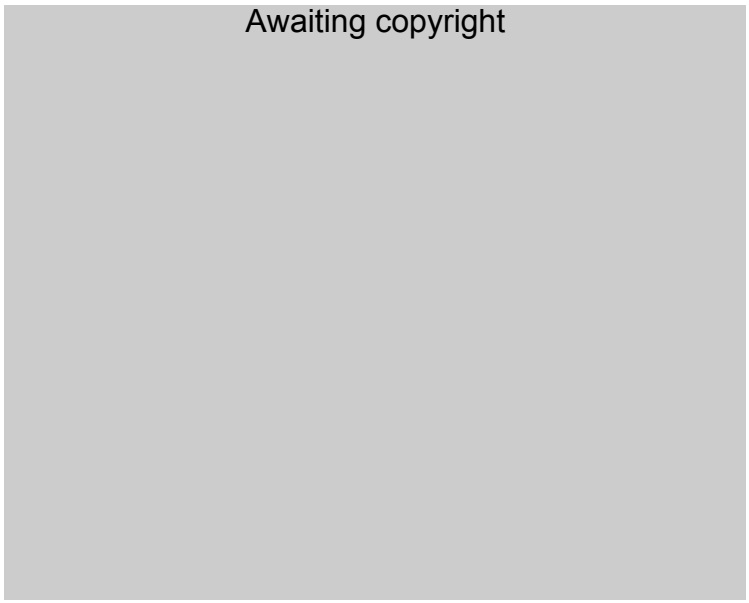
Justify this statement in terms of the scientific knowledge behind DNA–DNA hybridisation AND karyotype analysis.

End of Question 35

Question 36 — 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.

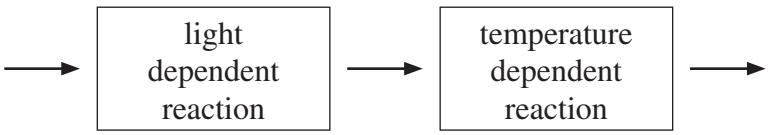
(a) (i) The diagram shows a model of a photosynthetic unit. **1**



What is an appropriate label for the components **X**?

(ii) Explain why having photosystem I and photosystem II acting together increases the efficiency of photosynthesis. **3**

(b) From their experiments, Blackman and Mathgel hypothesised that photosynthesis was a two-step process as follows: **4**



Explain how their results led them to hypothesise that photosynthesis begins with a light dependent reaction.

(c) Explain the location of the light and dark reactions within the chloroplast, with reference to a specific feature of the organelle at each location. **4**

Question 36 continues on page 43

Question 36 (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) (i) Outline how pigments can be extracted from leaves. **2**

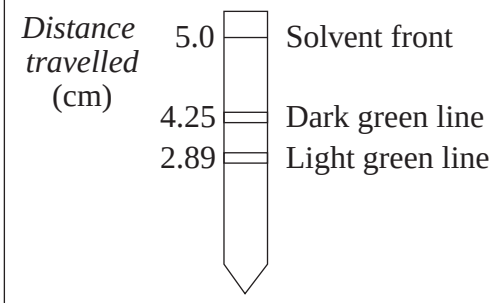
(ii) Students investigated the pigments in the leaves of a newly-discovered plant, and compared their results to results from experiments on known pigments from a familiar plant. All experimental results are shown. **4**

Results of chromatography with the same solvent

Familiar plant

Pigment	*Distance travelled by pigment* (cm)	*Distance travelled by solvent* (cm)
Chlorophyll b	6.2	10.7
Chlorophyll a	9.1	10.7

New plant



The students concluded that the new plant has a unique pigment system.

Evaluate the students' conclusion with reference to the data presented.

(e) 'Science has been used to solve problems in the investigation of photosynthesis, and so has provided information of benefit to society.' **7**

Justify this statement with reference to the scientific knowledge behind radioactive tracers for the study of photosynthesis.

End of paper

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