International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Biology

Higher and standard level

Specimen papers

For first examinations in 2016

CONTENTS

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BIOLOGY
HIGHER LEVEL
PAPER 1

SPECIMEN PAPER

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The maximum mark for this examination paper is *[40 marks]*.

1. What structures are found in eukaryotes but not in prokaryotes?

A. Naked DNA and mitochondrion

B. Golgi apparatus and 70S ribosomes

C. 70S ribosomes and nuclear membrane

D. Mitochondrion and nuclear membrane

2. Membrane proteins of mice cells were marked with green and membrane proteins of human cells were marked with red. The cells were fused together. What would be seen after two hours?

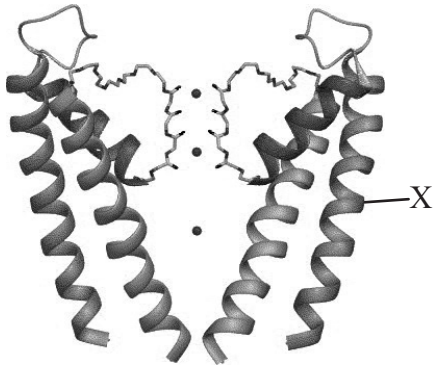
A. Red and green markers fully mixed

B. All red markers and no green markers

C. Half of the new cell with green markers and the other half with red

D. Red markers on the inside of the membrane and green markers on the outside

Question 3 and question 4 refer to the following diagram. It shows a potassium channel in an axon membrane. The three dots in the channel represent potassium ions.



[Source: adapted from SY Noskov and B Roux, (2006), *Biophysical Chemistry*, **124** (3), pages 279–291]

3. What is the function of this potassium channel?

A. Facilitated diffusion of potassium ions into the axon

B. Passage of potassium ions by active transport out of the axon

C. Facilitated diffusion of potassium ions out of the axon

D. Passage of potassium ions by active transport into the axon

4. What structure is labelled X?

A. DNA

B. Beta pleated sheet

C. Alpha helix

D. Prosthetic group

5. In the experiments performed by Meselson and Stahl, *E. coli* were grown for many generations in ^{15}N then for one generation in ^{14}N. What results for the DNA of the last generation showed that replication was semi-conservative?

A. Both strands containing only ^{15}N

B. Both strands containing only ^{14}N

C. One strand containing only ^{15}N and one stand containing only ^{14}N

D. Both strands containing a mixture of ^{15}N and ^{14}N in equal amounts

6. In 1828, Friedrich Wöhler artificially produced urea (organic compound) by an internal rearrangement of the atoms of ammonium cyanate (inorganic compound). What important principle did this experiment show?

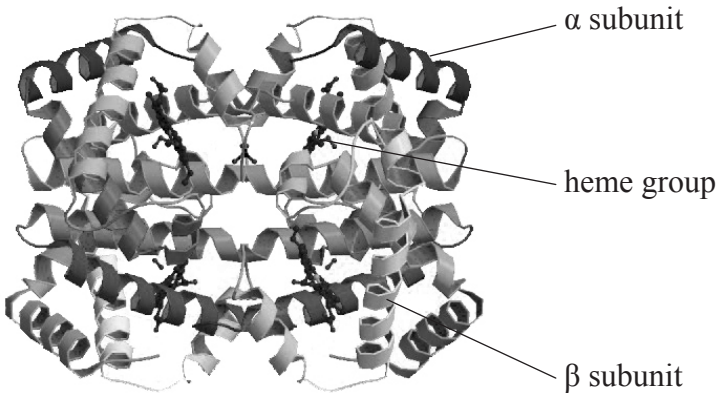
A. Organic compounds can be synthesized without the need of a vital force.

B. Organic compounds can only be formed from pre-existing inorganic compounds.

C. Inorganic compounds are essential for living organisms.

D. Organic compounds are more simple substances than inorganic compounds.

7. The diagram shows the molecular structure of human hemoglobin as found in Protein Data Bank.



[Source: www.rcsb.org/pdb]

What characteristic of hemoglobin allows it to be considered a protein with quaternary structure?

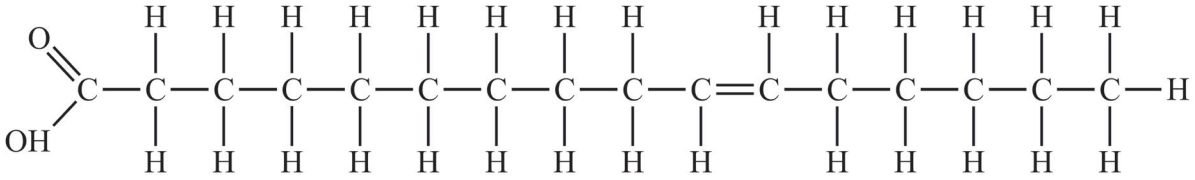
A. It contains many beta sheets.

B. It consists of polypeptide subunits and heme groups.

C. It allows bonding to oxygen atoms.

D. It contains histidine (His) residues.

8. What type of fatty acid is shown in this diagram?



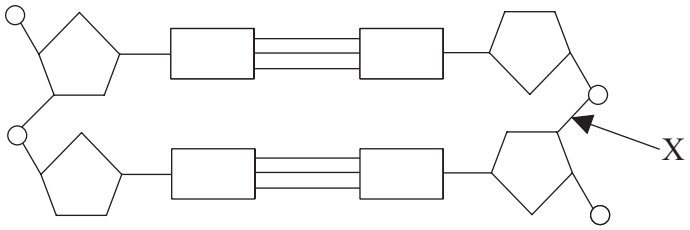
A. Saturated cis

B. Saturated trans

C. Unsaturated cis

D. Unsaturated trans

9. The diagram shows part of a DNA molecule.



What type of bond is labelled X?

A. Covalent bond

B. Hydrogen bond

C. Peptide bond

D. Semi-conservative bond

10. The following alignment represents part of the sequence of a gene in two species, the mouse (*Mus musculus*) and woolly monkey (*Lagothrix lagotricha*).

Mouse MGDVEKGKKIFVMKCAQCHTVEKGGKHKTGPNLHGLFGRKTGQAAGFSYTDANKNK

Woolly monkey MGDVEKGKRIFIMKCSQCHTVEKGGKHKTGXNLHGLFGRKTGQASGYTYTEANKNK

What term is used for different forms of a gene such as these?

A. Loci

B. Alleles

C. Homologues

D. Heterologues

11. Rice has 24 chromosomes in diploid cells while humans have 46. What is a valid conclusion from these data?

A. Plants always have fewer chromosomes than animals.

B. More chromosomes means the species evolved more.

C. The number of chromosomes is a unique characteristic of species.

D. The number of chromosomes present in an organism is random.

12. The electron micrograph shows the chromosomes in one stage of meiosis in rice. Image I shows the whole cell with a boxed region. Image II shows a magnified view of the boxed region.

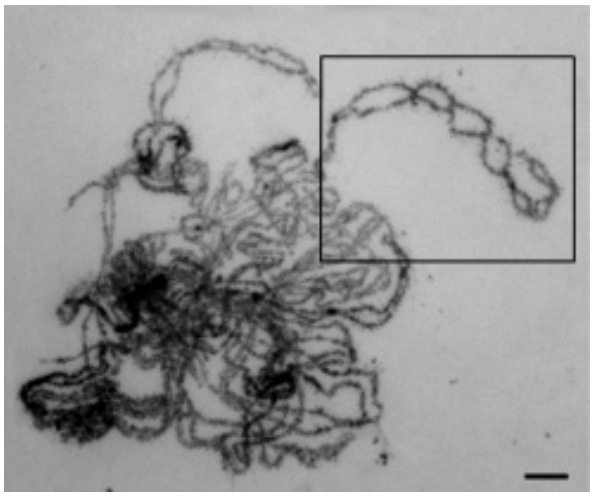


Image I

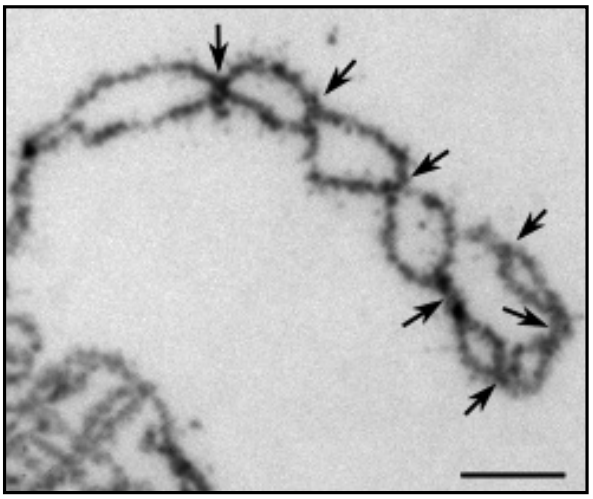


Image II

[Source: adapted from M Wang, *et al*., (2010), Plant Cell, **22** (2), pages 417–430]

What do the arrows indicate?

A. Condensation

B. Chiasmata

C. Centrioles

D. Centromeres

13. Huntington's disease is a neurological disorder caused by the repetition of the amino acid glutamine in the protein Huntingtin. The higher the number of repetitions of glutamine, the earlier the onset of the disease. What type of disease is it?

A. It is an inherited disease.

B. It is a nutritional disease.

C. It is a sexually transmitted disease.

D. It is a sex-linked disease.

14. The table shows the genetic code.

	U	**C**	**A**	**G**	
U	Phe	Ser	Tyr	Cys	**U**
	Phe	Ser	Tyr	Cys	**C**
	Leu	Ser	STOP	STOP	**A**
	Leu	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**

Which triplet coding for methionine represents the start codon?

A. AUG

B. UAC

C. UGA

D. ACU

15. What is a mesocosm?

A. A lake where experiments are performed in uncontrolled conditions

B. A small area where parts of the natural environment are kept under controlled conditions

C. An experimental area in a laboratory

D. An ocean

16. Which group of organisms converts carbon into a form that is available to primary consumers?

A. Decomposers

B. Saprotrophs

C. Detritivores

D. Producers

17. What is a consequence of a global temperature rise on arctic ecosystems?

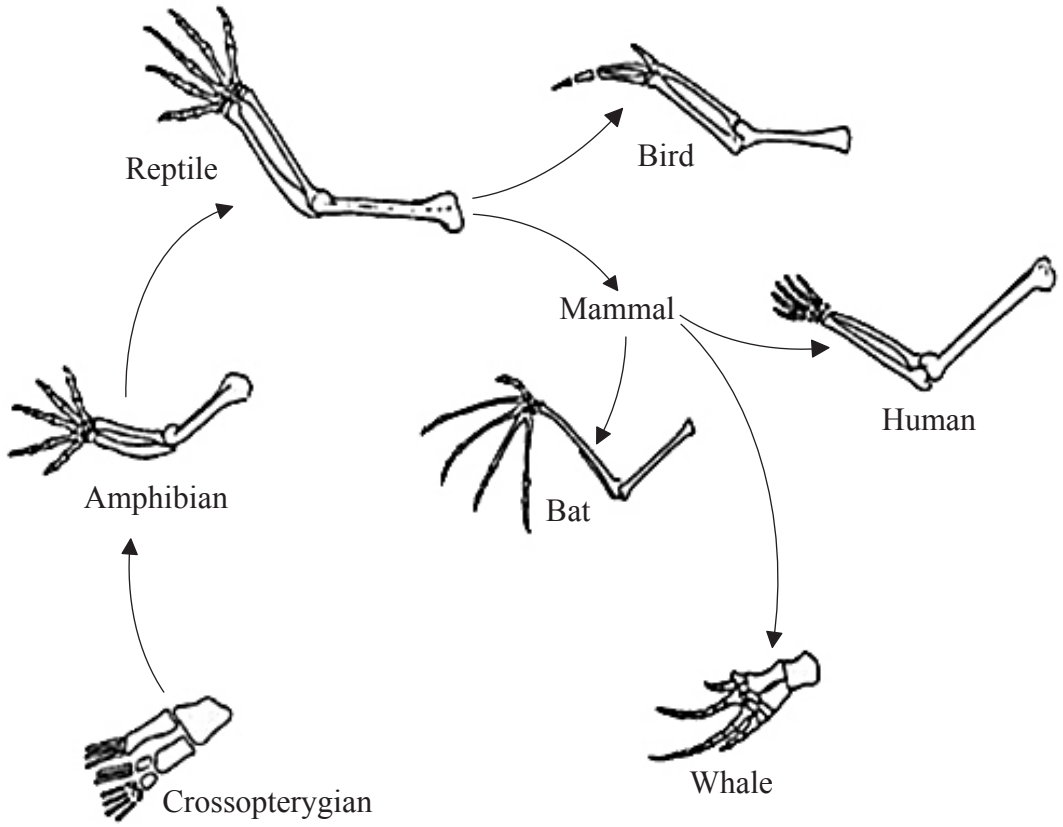
A. Decrease in CO_2 released from decomposing detritus

B. Increase in the greenhouse effect

C. Decrease in ocean level

D. Increase in pest species

18. The limbs of many vertebrates have a similar structure (the pentadactyl limb). In the diagram, all of the organisms have humerus, radius and ulna bones.



[Source: adapted from http://hscbiology.wordpress.com]

What hypothesis is currently accepted to account for the similarity in the limbs?

A. Organisms pass on characteristics that they acquire during their lifetime.

B. The pentadactyl limb is an ideal design for a broad range of purposes.

C. All of the organisms have descended from a common ancestor.

D. Convergent evolution has resulted in each organism finding a similar solution to a mechanical problem.

19. What are the three domains of living organisms?

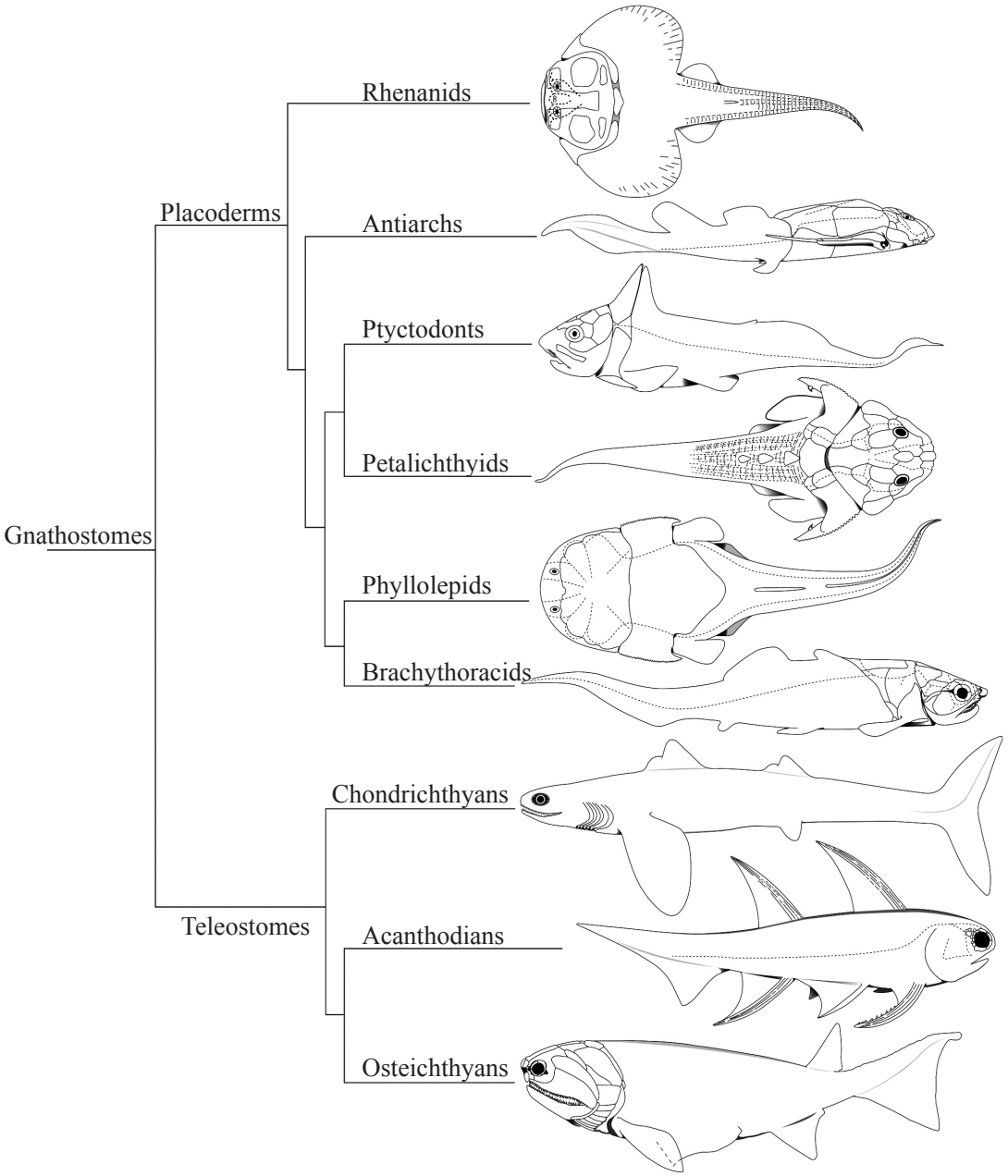
A. Classes, orders and families

B. Bacteria, eukaryotes and viruses

C. Archaea, eubacteria and eukaryotes

D. Decomposers, producers and consumers

20. The cladogram shows the phylogenic relationships in jawed vertebrates.



[Source: adapted from R K Carr and G L Jackson, (2008), *Guide to the Geology and Paleontology of the Cleveland Member of the Ohio Shale*, Ohio Geological Survey Guidebook 22, Chapter 5]

What can be deduced about Brachythoracids from this cladogram?

A. They evolved from Placoderms.

B. They gave rise to Gnathostomes.

C. They evolved at the same time as Ptyctodonts.

D. They differ from Phylollepids by only one mutation.

21. What is a similarity between arteries and capillaries?

A. They both have elastic tissue.

B. They both have smooth muscle cells.

C. Neither has collagen fibres in their walls.

D. Neither has valves.

22. What effect does HIV have on the immune system?

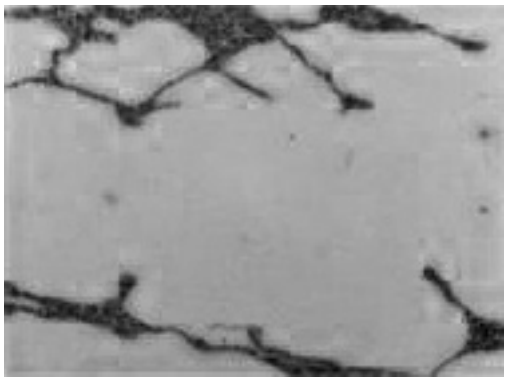
A. It prevents leucocytes from fighting bacteria by phagocytosis.

B. It causes excessive production of leucocytes in bone marrow.

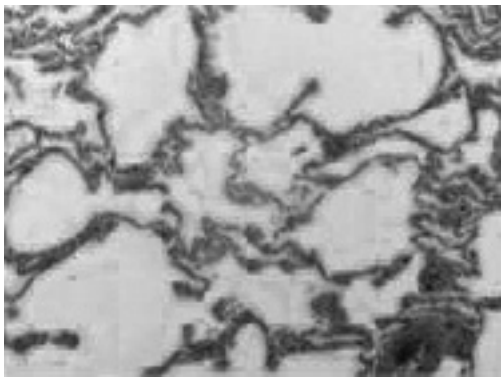
C. It destroys antibodies produced by leucocytes.

D. It reduces antibody production by lowering the number of leucocytes.

23. Emphysema is a long-term, progressive disease that causes shortness of breath. The electron micrographs show the alveoli of a patient with emphysema and the alveoli of a normal person.



Emphysema (magnification ×200)



Normal lung (magnification ×200)

[Source: with permission of *Nature Communications*, 21 May (2013).]

What can be observed in the alveoli of a person suffering from emphysema?

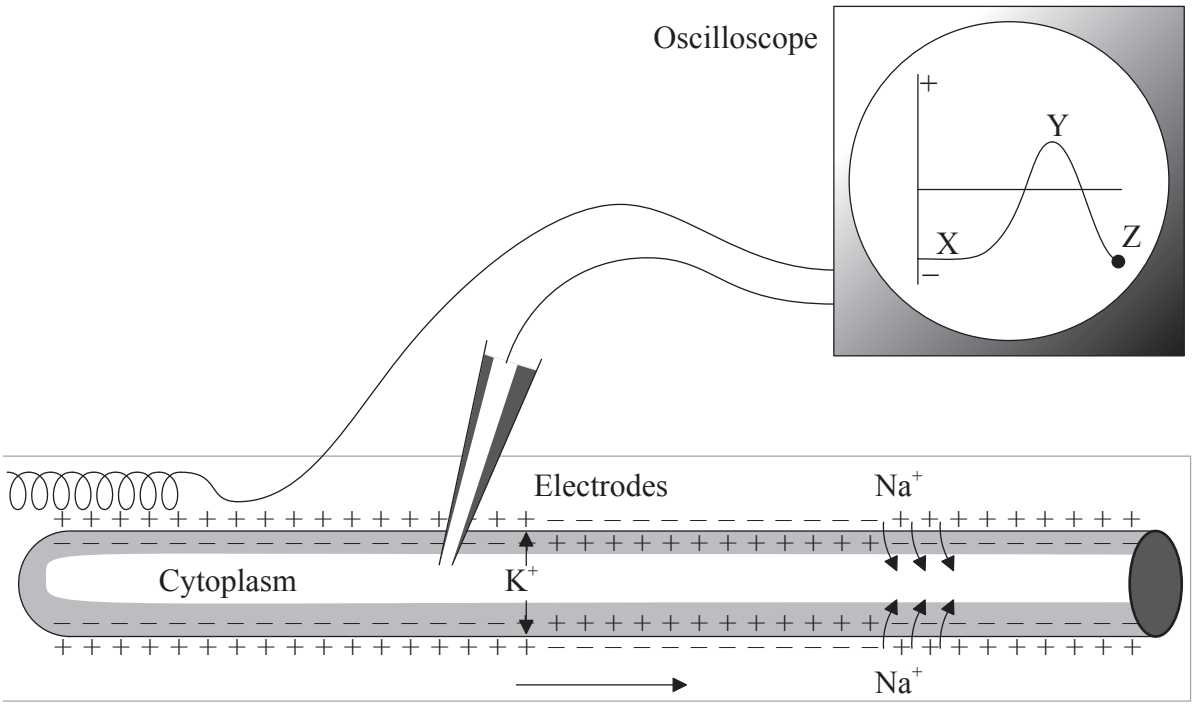
A. Large surface area, large air spaces and many capillaries

B. Small surface area, large air spaces and few capillaries

C. Small surface area, small air spaces and few capillaries

D. Large surface area, small air spaces and many capillaries

24. The diagram shows the results obtained with an oscilloscope attached to a neuron.



[Source: adapted from www.topbiomedical.com]

Why is the change in the oscilloscope occurring between X and Y?

A. Hyperpolarization

B. Hypopolarization

C. Repolarization

D. Depolarization

25. Which response takes place when blood glucose levels are low?

A. Glucagon is released from the α cells of the pancreatic islets.

B. Glucagon is released from the β cells of the pancreatic islets.

C. Insulin is released from the α cells of the pancreatic islets.

D. Insulin is released from the β cells of the pancreatic islets.

26. In the Hershey and Chase experiment what observation led to the conclusion that DNA was the genetic material?

A. Phages containing radioactive phosphorus were unable to infect the bacteria.

B. Phages containing radioactive sulfur were unable to infect the bacteria.

C. Radioactive phosphorus was found in the pellet.

D. Radioactive sulfur was found in the pellet.

27. Some regions of DNA do not code for proteins. What is coded for by some of these regions?

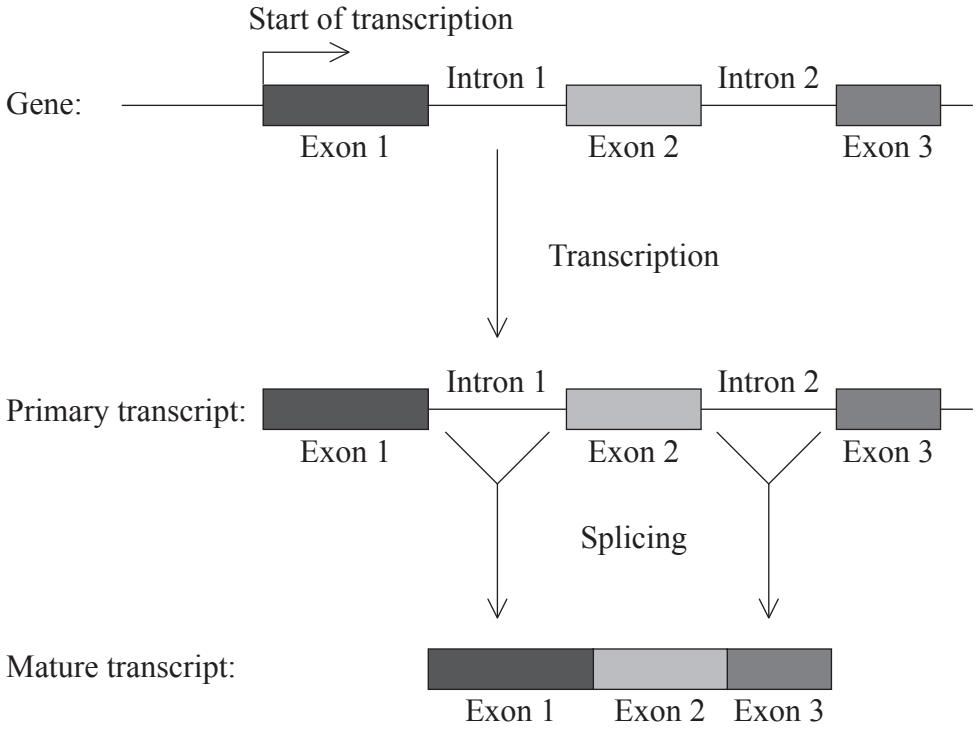
A. tRNA

B. mRNA

C. cDNA

D. Enzymes

28. The diagram shows the post-transcription changes occurring in RNA.



[Source: adapted from http://faculty.uca.edu]

Where in the cell does the splicing process occur in eukaryotes?

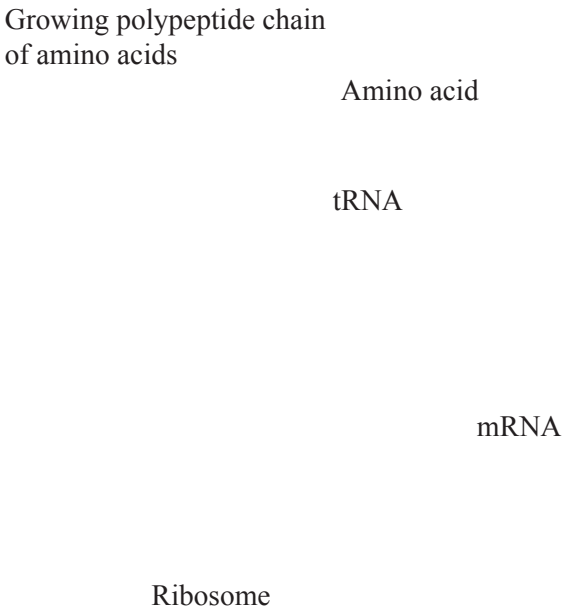
A. Nucleus

B. Ribosomes

C. Cytoplasm

D. Golgi apparatus

29. The diagram shows the translation of an mRNA molecule.



[Courtesy: National Human Genome Research Institute]

A tRNA molecule with anticodon CAG carries the amino acid valine. Which codon of mRNA will the tRNA join?

A. CTG

B. CAG

C. GTC

D. GUC

30. How does a competitive inhibitor interact with an enzyme?

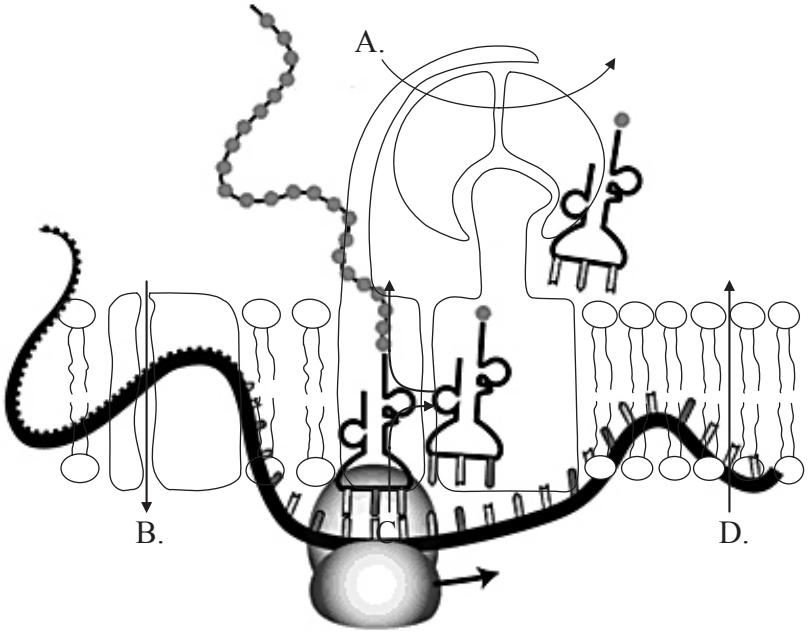
A. It binds to the active site, denaturing the enzyme.

B. It binds to the active site, preventing substrate binding.

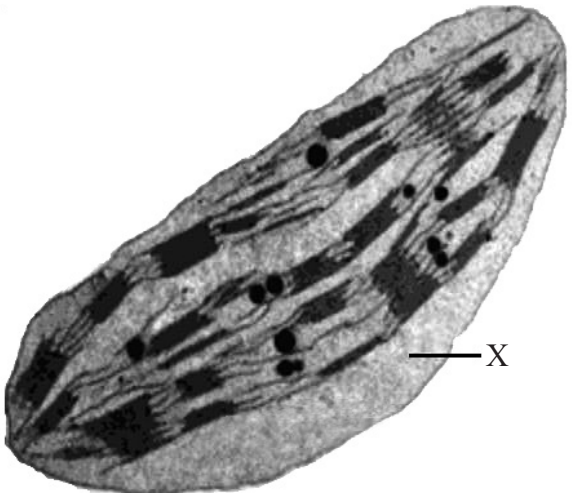
C. It binds to the allosteric site, causing competition with the substrate.

D. It binds to an allosteric site, causing conformational change of the enzyme.

31. The diagram represents components of the cristae in mitochondria. Which arrow indicates how protons (H^+) move to generate ATP directly?



32. The image shows an electron micrograph of a chloroplast.



[Source: www.uic.edu]

What is a function of X?

A. Carbon fixation

B. Production of ATP

C. Storage of glucose

D. Absorption of light

33. How does water travel up the xylem vessel on a hot, sunny day?

A. Mass flow under tension with cohesion between water molecules

B. Diffusion from higher to lower water concentration

C. Osmosis from roots to leaves

D. Active transport with energy provided by the Sun

34. In growing shoots, auxin is transported from the apex down the shoot. Proton pumps store energy in the form of a proton gradient and membrane potential, and then tap this energy source to allow the movement of auxin. What method of transport is this?

A. Diffusion

B. Active transport

C. Facilitated diffusion

D. Osmosis

35. Which chemicals are required for the germination of seeds to occur?

I. Water

II. Oxygen

III. Carbon dioxide

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

36. In a species with a diploid number of 16, what will the number of chromosomes be in a daughter cell after division by mitosis or meiosis?

	Mitosis	Meiosis
A.	16	16
B.	16	8
C.	8	16
D.	8	8

37. What causes genetic variation in gametes during meiosis?

A. Crossing over in prophase I and random orientation of homologous chromosomes in metaphase I

B. Crossing over in metaphase I and random orientation of homologous chromosomes in metaphase II

C. Linkage of genes in prophase I and crossing over in metaphase I

D. Linkage of genes in metaphase I and random orientation of homologous chromosomes in metaphase II

38. The Rh^+ antigen is found on the surface of red blood cells in people who are rhesus positive. A rhesus negative woman gives birth to a rhesus positive baby. What is a possible explanation for subsequent pregnancies triggering an immune response?

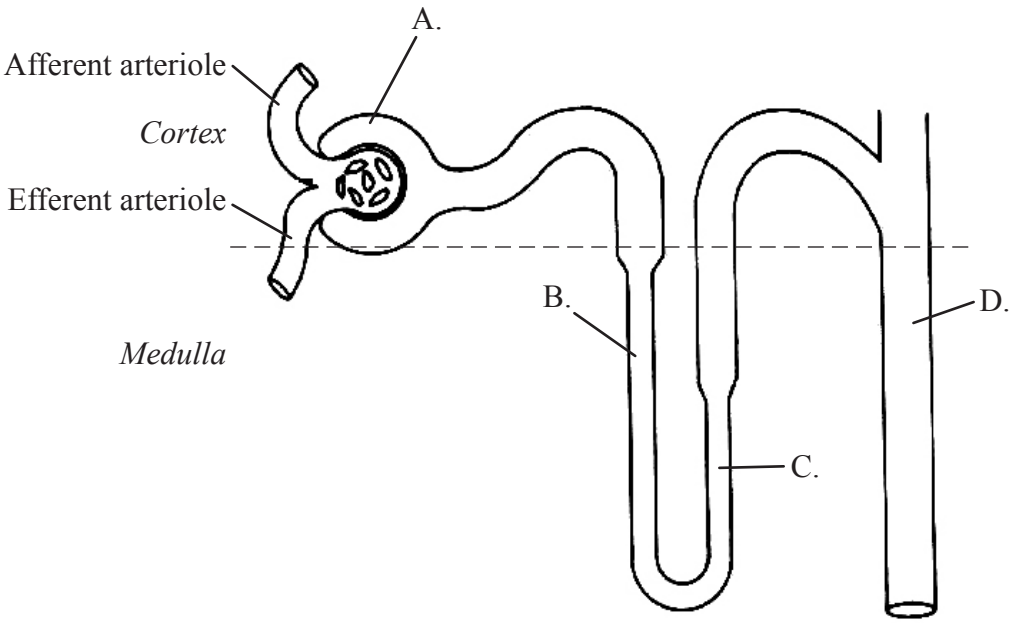
A. Exposure to the Rh^+ antigen in the first pregnancy triggered the development of specific phagocytes that could attack the blood of a future Rh^+ baby.

B. Exposure to the Rh^+ antigen in the first pregnancy triggered the development of antibodies that could attack the blood of a future Rh^+ baby.

C. The mother's immune system has been weakened by pregnancy.

D. Antibodies against the Rh^+ factor from the fetus pass to the mother across the placenta.

39. The diagram shows a nephron in a kidney. Which labelled part is permeable to sodium and not to water?



[Source: www.medcyclopaedia.com]

40. Which is the correct sequence of stages in fertilization?

A. cortical reaction → penetration of the egg membrane → acrosome reaction

B. cortical reaction → acrosome reaction → penetration of the egg membrane

C. acrosome reaction → cortical reaction → penetration of the egg membrane

D. acrosome reaction → penetration of the egg membrane → cortical reaction

SPEC/4/BIOLO/HPM/ENG/TZ0/XX/M

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MARKSCHEME

SPECIMEN PAPER

BIOLOGY

Higher Level

Paper 1

2 pages

1.	D	16.	D	31.	C	46.	–
2.	A	17.	D	32.	A	47.	–
3.	C	18.	C	33.	A	48.	–
4.	C	19.	C	34.	B	49.	–
5.	C	20.	A	35.	A	50.	–
6.	A	21.	D	36.	B	51.	–
7.	B	22.	D	37.	A	52.	–
8.	D	23.	B	38.	B	53.	–
9.	A	24.	D	39.	C	54.	–
10.	B	25.	A	40.	D	55.	–
11.	C	26.	C	41.	–	56.	–
12.	B	27.	A	42.	–	57.	–
13.	A	28.	A	43.	–	58.	–
14.	A	29.	D	44.	–	59.	–
15.	B	30.	B	45.	–	60.	–

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BIOLOGY
HIGHER LEVEL
PAPER 2

Candidate session number

SPECIMEN PAPER

Examination code

2 hours 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[72 marks]*.

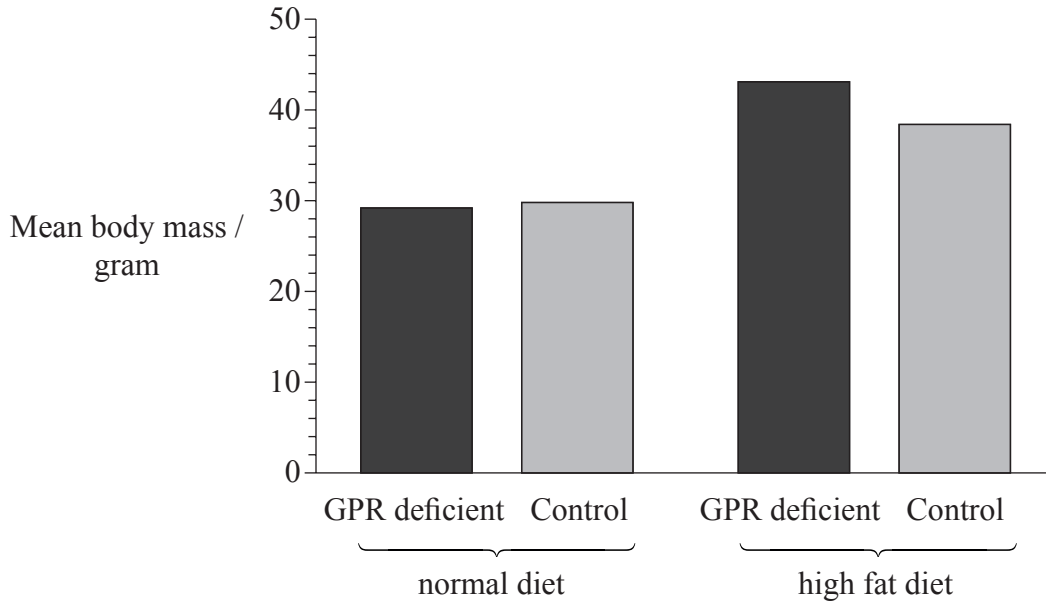
20 pages

SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. GPR120 is a trans-membrane protein that functions as a receptor for long-chain unsaturated fatty acids. When fatty acids outside the cell bind to the receptor, the receptor changes shape and as a result a signal is passed to the interior of the cell. This causes an increase in the intracellular calcium concentration (Ca^{2+}), which has a wide range of effects on cell activity.

A strain of mice was developed that did not produce GPR120 protein. Groups of these GPR120 deficient mice were fed from the age of 5 weeks until they were 16 weeks old either on a high fat diet containing 60 % fat or on a normal diet containing 13 % fat. Control groups of mice that did produce GPR120 protein were fed on the same diets. The bar chart shows the mean body mass of each group when the mice were 16 weeks old.



[Source: adapted from A Ichimur, *et al.*, (2012), *Nature*, **483**, pages 350–354, Reprinted by permission from Macmillan Publishers Ltd]

(This question continues on the following page)

(Question 1 continued)

(a) Compare and contrast the body mass of GPR120 deficient mice and the control mice on a normal diet and a high fat diet. *[3]*

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(Question 1 continued)

The gene for GPR120 protein is located on Chromosome 10. The alleles for GPR120 protein from 312 extremely obese adults and children were base sequenced. Six alleles were discovered that differed by one base from the wild-type allele. They are likely to have been produced by a base substitution mutation. Two of the mutations cause a change in the amino acid sequence of the GPR120 protein (missense mutation) but the other four do not (synonymous mutation). The table gives details of the six mutant alleles.

Mutant allele	**Nucleotide change**	**Chromosome 10 position**	**Type of mutation**
R67C	C → T	95 316 666	Missense
R270H	G → A	95 337 031	Missense
V38V	G → A	95 316 581	Synonymous
S192S	G → A	95 325 846	Synonymous
V243V	C → T	95 328 938	Synonymous
S264S	G → A	95 337 014	Synonymous

[Source: adapted from A Ichimur, *et al.*, (2012), *Nature*, **483**, pages 350–354, Reprinted by permission from Macmillan Publishers Ltd]

(b) Explain how only some of the base substitution mutations cause a change in the amino acid sequence of the gene for GPR120. *[2]*

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(c) Using the positions on chromosome 10, identify which **two** mutations were closest together in the gene for GPR120. *[1]*

1. . . . . .

2. . . . . .

(This question continues on the following page)

(Question 1 continued)

The frequency of the two alleles that caused a change in amino acid sequence was measured in 6942 unrelated obese humans and 7654 controls. The results are shown in the table.

Allele	Allele frequency / %	
	obese humans	controls
R67C	5.5	4.3
R270H	2.4	1.3

[Source: adapted from A Ichimur, *et al.*, (2012), *Nature*, **483**, pages 350–354, Reprinted by permission from Macmillan Publishers Ltd]

(d) Outline the reasons for using large numbers of obese humans and controls in this research. *[2]*

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(e) The association of one of the alleles with obesity was statistically significant. Deduce, with a reason, which allele this was. *[1]*

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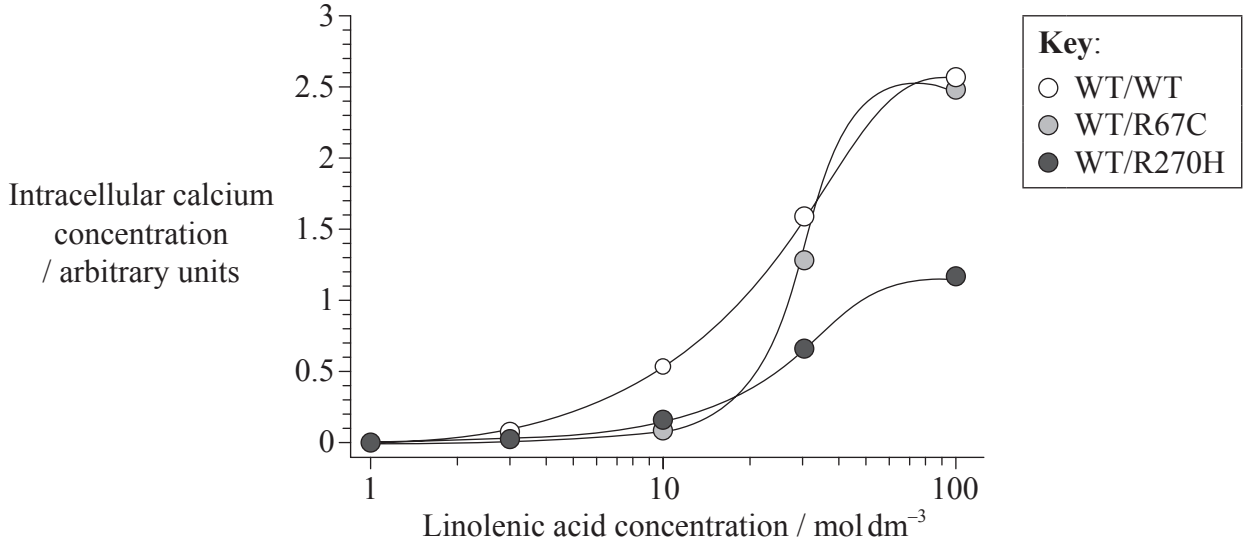
(This question continues on the following page)

(Question 1 continued)

A clone of human cells that contained the wild type allele for GPR120 was genetically modified by inserting either another wild-type allele (WT) or one of two mutant alleles (R67C and R270H). The intracellular concentration of calcium was measured in these cells at varying levels of linolenic acid. Linolenic acid is a long-chain unsaturated fatty acid. The graph shows the results. The scale on the *x*-axis is logarithmic.



(f) Suggest advantages of genetically modifying a clone of human cells for use in this experiment rather than using cells from obese people naturally containing the mutant alleles. *[2]*

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(Question 1 continued)

(g) Outline the effect of linolenic acid concentration on intracellular calcium concentration in the WT/WT cells. *[2]*

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(h) Compare and contrast the effect of the two mutant alleles on intracellular calcium concentration. *[2]*

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Biologists have often debated whether characteristics in humans are due to genes, the environment, or a combination of both.

(i) Discuss the evidence provided by the data for the relative role of genes and diet in causing obesity. *[3]*

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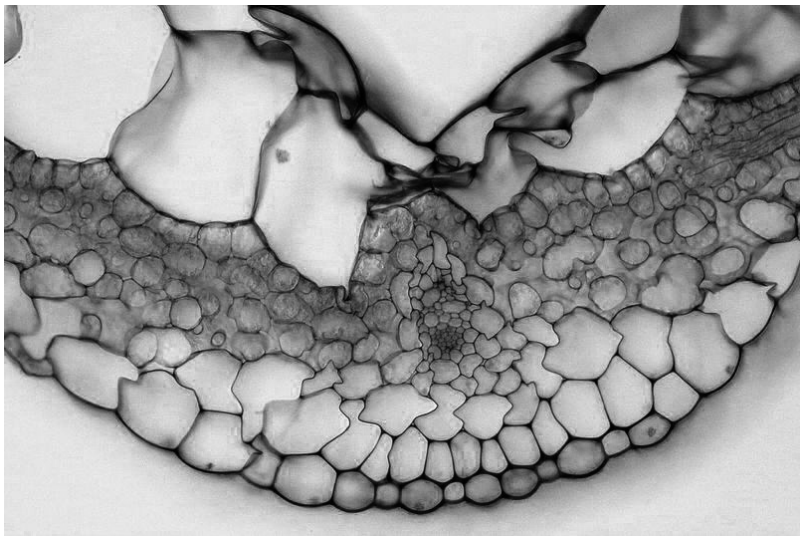
2. The micrograph below shows a thin vertical section through a *Tradescantia* leaf.



[Source: adapted from http://upload.wikimedia.org/wikipedia/commons/thumb/5/5b/Tradescantia%2C_leaf%2C_Etzold_green_1.JPG/800px-Tradescantia%2C_leaf%2C_Etzold_green_1.JPG]

(a) State **two** general features of the structure of complex organisms that are visible in the micrograph. *[2]*

1. . . . . .

2. . . . . .

The leaf tissue contains the enzyme Rubisco and NADP.

(b) Outline the function of Rubisco. *[2]*

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(This question continues on the following page)

(Question 2 continued)

(c) Explain precisely where NADP is located in the leaf and how it is used. *[4]*

Location:

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Function:

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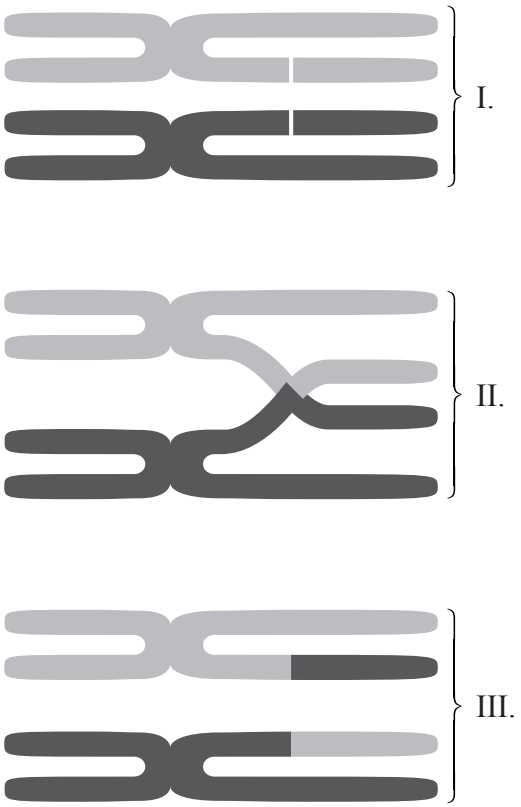
3. The diagrams show two chromosomes at three stages in meiosis.



(a) The two chromosomes in these diagrams are homologous. State **one** similarity and **one** difference between homologous chromosomes. *[2]*

Similarity:

. . . . . .

. . . . . .

Difference:

. . . . . .

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(This question continues on the following page)

(Question 3 continued)

(b) State, with a reason, whether the cell that contained these chromosomes would have been haploid **or** diploid. *[1]*

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. . . . . .

(c) Explain how genetic variation is promoted by the process shown in the diagrams. *[3]*

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(d) State the type of life-cycle that includes meiosis and the reason for it being needed in this type of life-cycle. *[2]*

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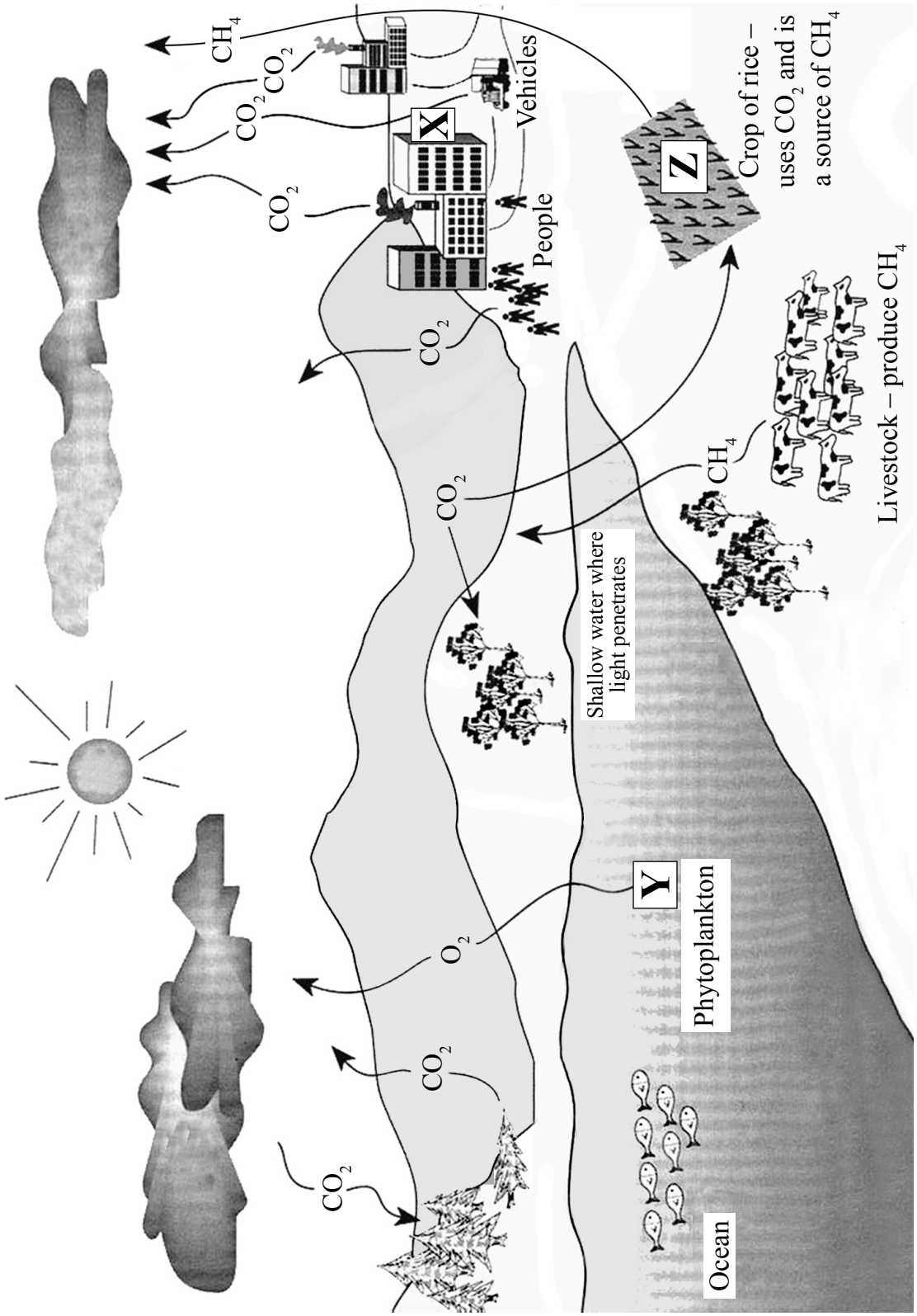
4. The diagram shows the carbon cycle.



[Source: adapted from www-das.uwyo.edu/~geerts/cwx/notes/chap01/carbon_cycle.jpeg]

(This question continues on the following page)

(Question 4 continued)

(a) State the processes occurring at X and Y. *[2]*

X: . . . . . .

Y: . . . . . .

(b) Predict the conditions that would increase the release of methane shown at Z. *[2]*

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(c) Outline the impact of the gases shown in the diagram on the greenhouse effect. *[2]*

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SECTION B

*Answer **two** questions. Up to [1] additional mark is available for the quality of your answers for each question.*

5. Water has properties that make it essential to all living organisms.

(a) Explain how the properties of water, that are essential to living things, arise from the dipolar nature of water. *[8]*

(b) Describe the adaptations of plants in deserts for water conservation. *[4]*

(c) Outline the use of models to investigate the transport of water in xylem. *[3]*

6. From an early stage in human development, blood flow is needed for transport and exchange of materials.

(a) Explain the exchange of materials between the mother and the fetus in the uterus. *[8]*

(b) Outline how William Harvey changed the understanding of blood flow around the human body. *[4]*

(c) Describe how, in microscope images, blood vessels can be identified as arteries, capillaries and veins. *[3]*

7. The species is the basis for naming and classifying organisms.

(a) Explain how new species can emerge by

- directional selection
- disruptive selection
- polyploidy. *[8]*

(b) Outline the advantages to scientists of the binomial system for naming species. *[4]*

(c) Describe the use of dichotomous keys for the identification of specimens. *[3]*

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MARKSCHEME

SPECIMEN PAPER 2016

BIOLOGY

Higher Level

Paper 2

17 pages

Subject Details: Biology HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A and **TWO** out of **THREE** questions in Section B. Maximum total = **[72 marks]**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (/). Either wording can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***" on the line between the alternatives. Either answer can be accepted.

7. Words in angled brackets ‹ › in the "Answers" column are not necessary to gain the mark.

8. Words that are <u>underlined</u> are essential for the mark.

9. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

10. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded.
When marking, indicate this by adding **ECF** (error carried forward) on the script. "ECF acceptable" will be displayed in the "Notes" column.

13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

Section B

Extended response questions - quality mark

- Extended response questions for HLP2 each carry a mark total of ***[16]***. Of these marks, ***[15]*** are awarded for content and ***[1]*** for the quality of the answer.
- ***[1]*** quality mark is to be awarded when:
  - the candidate's answers are clear enough to be understood without re-reading
  - the candidate has answered the question succinctly with little or no repetition or irrelevant material.
- It is important to judge this on the overall answer, taking into account the answers to all parts of the question. Although, the part with the largest number of marks is likely to provide the most evidence.
- Candidates that score very highly on the content marks need not necessarily automatically gain ***[1]*** mark for quality (and *vice versa*).

SECTION A

Question			Marking point	Answers	Notes	Total
1.	a		*a*	no difference on normal diet ‹between control and GPR120 deficient› ✓		3
			b	both higher on a high fat diet than a normal diet ✓		
			c	GPR120 deficient higher than control on a high fat diet ✓		
	b		*a*	base substitution changes a codon ✓		2
			b	amino acids are coded for by different codons ✓		
			c	several codons can code for the same amino acid ✓		
	c			*1.* 95 337 031 ✓ ***AND*** *2.* 95 337 014 ✓	*Both needed*	1
	d		*a*	increase reliability ✓		2
			b	identify anomalous results ✓		
			c	some allele frequencies are very low ✓		
			d	because there is much genetic variation among obese people ***OR*** different causes of obesity ✓		
			e	to allow statistical testing of results ✓		
	e			R27OH because of larger percentage difference between obese and control ✓		1

(Question 1 continued)

Question			Marking point	Answers	Notes	Total
	f		***a***	control variables ✓		**2 max**
			b	cells from obese people will have lots of differences ✓		
			c	only difference will be the genes that have been introduced ✓		
			d	repeatable experiment with the culture of the clone ✓		
	g		***a***	intracellular calcium concentration increases as linolenic acid concentration increases ✓	*Do not accept answers stating that there is a slow initial increase*.	**2**
			b	increases become smaller ‹given the logarithmic *x*-axis› ✓		
	h		***a***	both mutant alleles reduce calcium concentration by the same amount at low linolenic acid concentrations ✓		**2**
			b	still lower with high linolenic acid with R270H but as high as WT with R67C ✓		

(Question 1 continued)

Question			Marking point	Answers	Notes	Total
	i				*Do not accept answers that are unrelated to the data eg: overeating, sedentary lifestyle.*	**3 max**
			a	*Arguments for both factors having an effect:* ‹all› mice on a high fat diet had higher body mass than on a normal diet ✓		
			b	mass of GPR deficient mice was higher than control mice on the high fat diet ✓		
			c	high fat diet will give high blood concentrations of linolenic acid ✓		
			d	responses in WT humans are mediated via an increase in intracellular Ca^{2+} ✓		
			e	less Ca^{2+} release with mutant alleles so less response ✓		
			f	*Argument for diet having more effect:* more of mass increase on the high fat diet was due to diet than to the genetic difference ✓		
			g	*Argument for genes not being the only factor:* there are differences in allele frequency between obese and non-obese groups ✓		
			h	but some non-obese people have the same alleles as obese people ✓		

Question			Marking point	Answers	Notes	Total
2.	**a**		***a***	*1.* multicellular ***OR*** made of cells ✓		**2**
			b	*2.* cell specialization ***OR*** differentiation ***OR*** presence of tissues ✓		
	b		***a***	fixes CO_2 ***OR*** carboxylation ✓		**2 max**
			b	production of glycerate 3-phosphate ✓		
			c	RuBP is a substrate ✓		
	c		***a***	*location*: stroma ***OR*** chloroplast ✓		**4**
			b	‹palisade› mesophyll ✓		
			c	*function*: hydrogen acceptor ***OR*** accepts electrons ✓		
			d	transfers hydrogen/electrons to Calvin cycle ***OR*** reduces glycerate 3-phosphate ✓		

Question			Marking point	Answers	Notes	Total
3.	**a**		***a***	*similarity*: same length ***OR*** same centromere position ***OR*** same sequence of genes ✓		**2**
			b	*difference*: different alleles ‹of some genes› ✓		
	b			diploid because a pair of homologous chromosomes are present ✓		**1**
	c		***a***	mutual exchange of DNA/alleles/genes ✓		**3 max**
			b	between sister chromatids ✓		
			c	splits up combinations of linked genes/alleles ✓		
			d	new combinations of alleles produced ✓		
			e	independent assortment of genes on a chromosome ✓		
			f	recombination ✓		
	d		***a***	sexual reproduction ✓		**2**
			b	producing gametes without doubling the ‹chromosome› number in the ‹zygote› ***OR*** conserving chromosome number ✓		

Question			Marking point	Answers	Notes	Total
4.	**a**		***a***	*X*: combustion ✓		**2**
			b	*Y*: photosynthesis ✓		
	b		***a***	anaerobic ✓		**2 max**
			b	warm ✓		
			c	presence of the methanogenic bacteria ✓		
			d	waterlogged ✓		
	c		***a***	CO_2 is the main greenhouse gas ✓		**2**
			b	methane contributes to the greenhouse effect ✓		

SECTION B

Clarity of communication*: *[1]

The candidate's answers are clear enough to be understood without re-reading. The candidate has answered the question succinctly with little or no repetition or irrelevant material.

Question			Marking point	Answers	Notes	Total
5.	**a**		***a***	oxygen in water ‹slightly› negatively charged and hydrogens ‹slightly› positive ✓		**8 max**
			b	hydrogen bonding due to the dipolar nature ✓		
			c	water molecules are cohesive due to hydrogen bonding ✓		
			d	cohesion useful in xylem transport ***OR*** other application ✓		
			e	hydrogen bonds with other structures, giving adhesive properties ✓		
			f	adhesion of water to cellulose in cell walls ***OR*** other application ✓		
			g	high boiling point due to cohesion/hydrogen bonding ✓		
			h	water is liquid rather than a gas over the global temperature range ***OR*** other application ✓		
			i	high latent heat of vaporisation as energy needed to break hydrogen bonds ✓		

(Question 5a continued)

Question			Marking point	Answers	Notes	Total
			j	use of sweat for cooling the body ***OR*** other application ✓		
			k	high specific heat capacity as hydrogen bonds must be broken to warm water up ✓		
			l	water is a thermally stable habitat ***OR*** other application ✓		

	b		***a***	thick waxy cuticle to reduce cuticular transpiration ✓		**4 max**
			b	few/small stomata ✓		
			c	stomata that open at night when it is cooler ✓		
			d	leaf surface area small/reduced ***OR*** leaves replaced with spines ✓		
			e	water storage tissue in leaves/stems/roots ✓		
			f	deep/extensive roots ✓		

(Question 5 continued)

Question			Marking point	Answers	Notes	Total
	c		***a***	models allow one factor/aspect to be studied independently ✓		**3 max**
			b	‹glass› capillary tubes to model adhesion between water and xylem vessel walls ✓		
			c	porous pot to model flow in a xylem vessel due to transpiration from the leaf ✓		
			d	blotting paper ***OR*** porous pot ***OR*** other suitable material to model capillary attraction/adhesion ✓		

*(Plus up to **[1]** for quality)*

Question			Marking point	Answers	Notes	Total
6.	**a**		***a***	exchange occurs in the placenta ✓		**8 max**
			b	large placental surface area due to placental villi ✓		
			c	microvilli on the surface of the villi increase the surface area ✓		
			d	fetal blood flows through capillaries in villi/placenta ✓		
			e	capillaries/fetal blood very close to the surface of the placenta/to mother's blood ✓		
			f	maternal blood flows in inter-villous spaces ***OR*** in spaces around the villi ✓		
			g	membranes/cells separating the fetal and maternal blood are selectively permeable ✓		
			h	water movement by osmosis ✓		
			i	oxygen from mother to fetus by diffusion ✓		
			j	carbon dioxide/urea/waste products from fetus to mother by diffusion ✓		
			k	glucose/amino acids/digested foods from mother to fetus by facilitated diffusion ✓		
			l	antibodies from mother to fetus by endocytosis ✓		

	b		***a***	discovered the circulation of blood ✓		**4 max**
			b	showed that valves in the veins/heart ensure one-way flow of blood ✓		
			c	showed that blood was not consumed by the body ✓		
			d	predicted the existence of capillaries ✓		
			e	showed that the theories of Galen were false ✓		

(Question 6 continued)

Question			Marking point	Answers	Notes	Total
	c		***a***	arteries have thick walls relative to the diameter of the lumen ***OR*** have large amounts of muscle/elastic fibres ✓		**3**
			b	veins have thin walls relative to the diameter of the lumen ***OR*** have valves ✓		
			c	capillaries have a thin wall containing only one layer of cells ***OR*** are about 10 micrometres wide ✓		

*(Plus up to **[1]** for quality)*

Question			Marking point	Answers	Notes	Total
7.	a			*directional selection:*		8 max
			a	natural selection favours one end of the range of variation ✓		
			b	progressive change in a population in that direction ✓		
			c	species changes sufficiently over time to be regarded as a different species ‹in the fossil record› ✓		
			d	isolated population subjected to directional selection while other parts of the species are not ✓		
			e	isolated population eventually different enough not to interbreed/to be regarded as new species ✓		
				disruptive selection:		
			f	extreme types selected for/intermediate types selected against ✓		
			g	extreme types are adapted to different niches ✓		
			h	reproductive barriers become established between extreme types ✓		
				polyploidy:		
			i	having three or more sets of chromosomes ✓		
			j	sometimes occurs due to an error in mitosis/meiosis/cytokinesis/ gametogenesis ✓		
			k	many new species formed as tetraploids ✓		
			l	triploids are infertile/sterile so tetraploids and diploids do not produce fertile offspring together ✓		

(Question 7 continued)

Question			Marking point	Answers	Notes	Total
	b		***a***	international system ✓		**4 max**
			b	names/naming system agreed at congresses ✓		
			c	all scientists use the same names for species ✓		
			d	misunderstandings due to language differences are avoided ✓		
			e	double names are easy to use/remember ✓		
			f	first name is the genus name and shows which other species are closely related ✓		

	c		***a***	consist of pairs of choices ✓		**3 max**
			b	each choice in a pair leads to another pair of choices or gives the identification ✓		
			c	necessary to have a good specimen for identification ✓		
			d	key should only use clear/reliable characteristics ✓		
			e	example of a simple key to illustrate the answer ✓		

*(Plus up to **[1]** for quality)*

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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

SPECIMEN PAPER

Examination code

1 hour 15 minutes

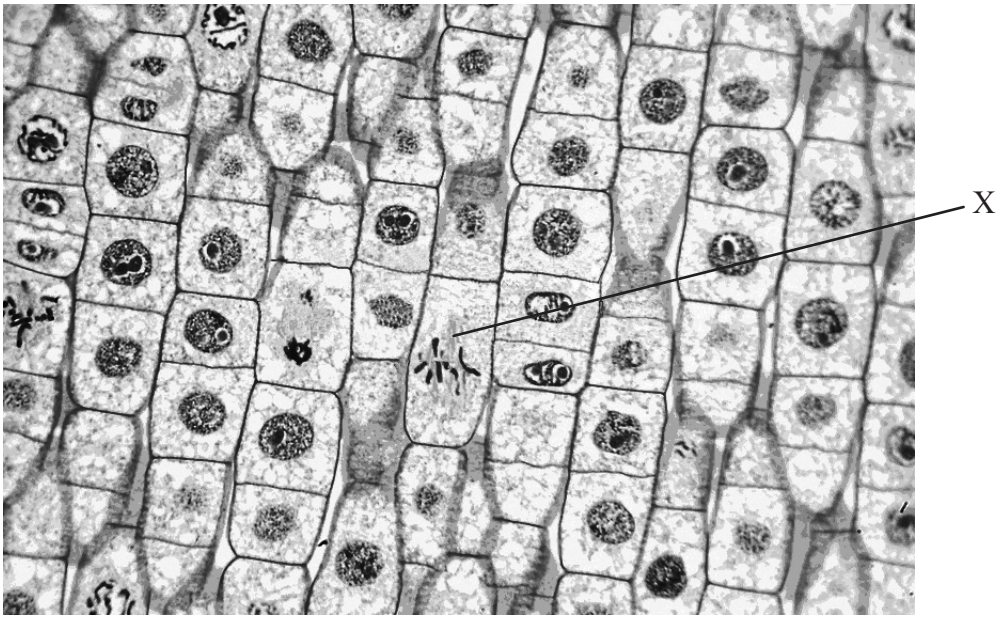
INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all of the questions from one of the options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[45 marks]*.

Option	Questions
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	15 – 19
Option D — Human physiology	20 – 25

SECTION A

1. The figure is a photomicrograph of cells from an onion root tip.



[Source: adapted from http://fphoto.photoshelter.com/image/I0000AUwvOv1erSI]

(a) Identify the phase of mitosis represented by cell X. *[1]*

. . . . . .

(b) Outline **two** distinctive features of cells undergoing mitosis in the micrograph. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(c) Explain how a mitotic index can be calculated from the image. *[2]*

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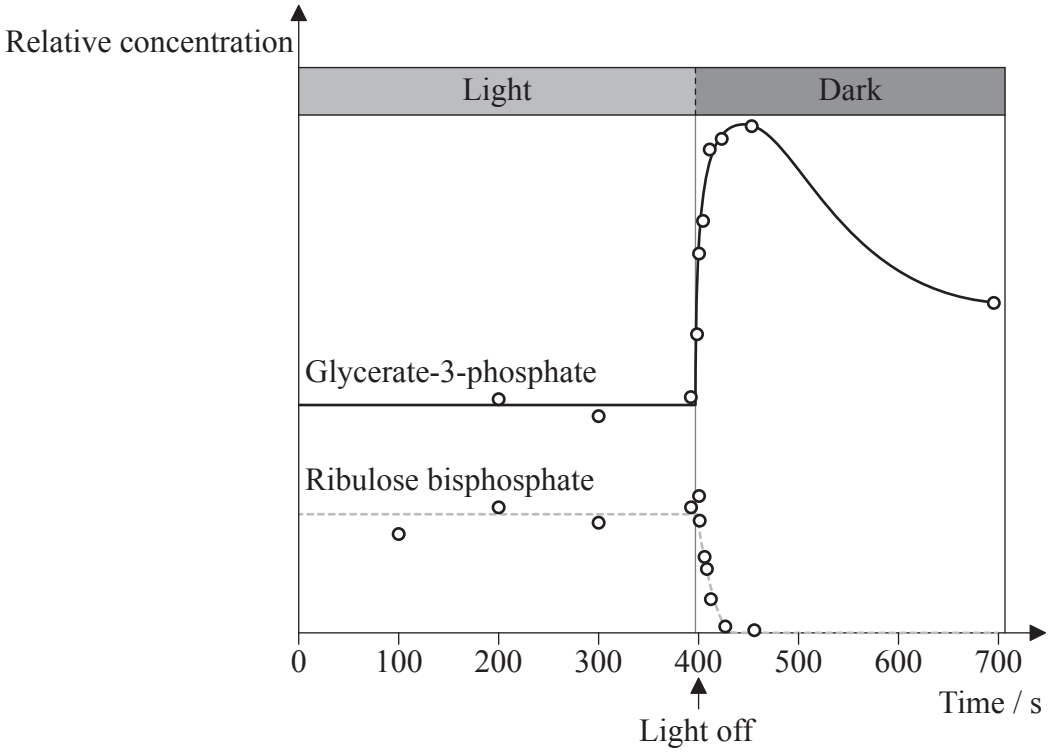
2. Concentrations of ribulose bisphosphate and glycerate-3-phosphate were monitored in a culture of cells of the alga, *Scenedesmus*. The algae were kept in bright light and then in the dark.



[Source: adapted from the course companion]

(a) Explain the change that took place in the 50 seconds after the start of darkness to the concentration of glycerate-3-phosphate. *[2]*

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(This question continues on the following page)

(Question 2 continued)

(b) Predict the effect on the concentration of ribulose bisphosphate, of turning the bright light back on after the period of darkness. *[3]*

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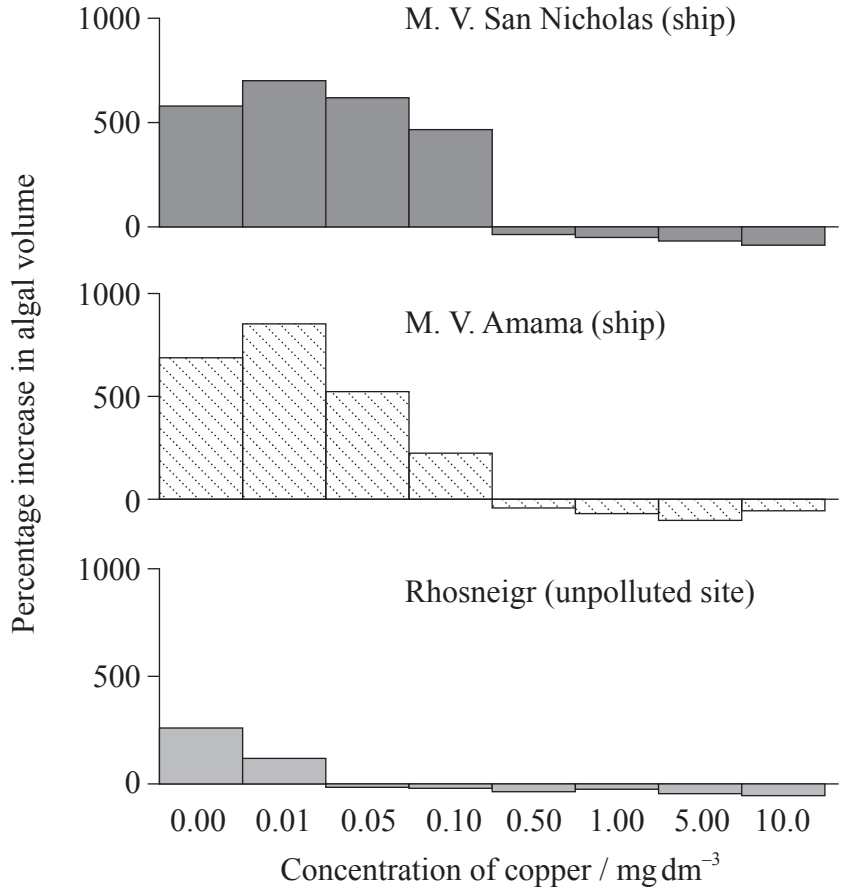
3. Samples of the alga, *Ectocarpus siliculosus*, were taken from three sites. Two samples came from the underside of ships that had been painted with a copper-containing paint. The other sample came from a nearby unpolluted environment at Rhosneigr, north Wales (UK).

The samples of algae were cultured at different copper concentrations and the changes in the number of algae were monitored. The results are shown in the bar charts. Positive values indicate an increase in numbers of algae and negative values indicate a decrease.



[Source: adapted from Russell and Morris (1970)]

(a) Outline the evidence from the graph for greater copper tolerance in the samples of algae taken from the ships than in the samples taken from the unpolluted environment. *[2]*

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(This question continues on the following page)

(Question 3 continued)

(b) Explain how copper tolerance could develop in the algae in environments polluted with copper. *[3]*

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SECTION B

Option A — Neurobiology and behaviour

4. Drug addiction is characterized by compulsive and at times uncontrollable drug craving, seeking and use.

A study was undertaken to compare ten drugs, using a scale from 0 to 3 for intensity of response, psychological addiction and physical addiction, to create a overall mean score for addiction.

Drug	Intensity of effect	Psychological addiction	Physical addiction	Overall mean
Heroin	3.0	3.0	3.0	3.00
Cocaine	3.0	2.8	1.3	2.37
Alcohol	2.3	1.9	1.6	1.93
Tobacco	2.3	2.6	1.8	2.23
Barbiturates	2.0	2.2	1.8	2.01
Benzodiazepines	1.7	2.1	1.8	1.83
Amphetamine	2.0	1.9	1.1	1.67
LSD	2.2	1.1	0.3	1.23
Cannabis	1.9	1.7	0.8	1.51
Ecstasy	1.5	1.2	0.7	1.13

[Source: adapted from D Nutt, *et al.*, (2007), *The Lancet*, **369**, pages 1047–1053]

(a) Using the table, identify which drug causes the lowest physical addiction. *[1]*

. . . . . .

(Option A continues on the following page)

(Option A, question 4 continued)

(b) (i) State **one** example of a drug that is a stimulant and **one** example that is a sedative. *[2]*

Stimulant: . . . . . .

Sedative: . . . . . .

(ii) Outline the effects of MDMA (ecstasy) on synaptic transmission. *[2]*

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(c) Novocaine is an example of a drug used as anesthetic. Describe the effects of local anesthetics on the nervous system. *[2]*

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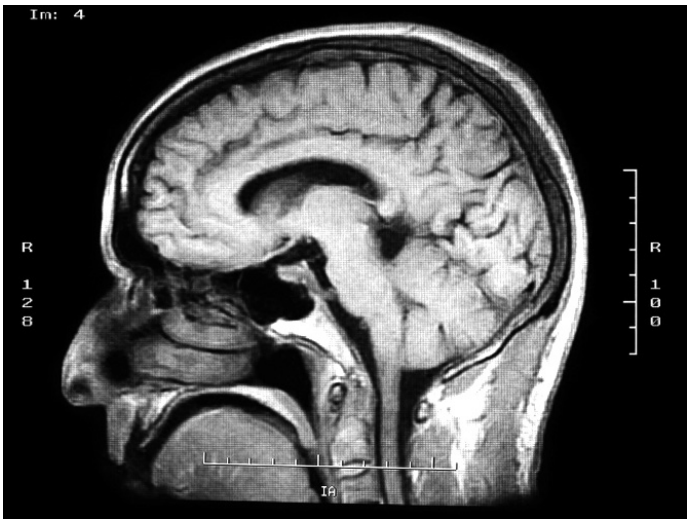
(Option A continues on the following page)

(Option A continued)

5. Brain death is a clinical diagnosis based on the absence of neurological function, with a known irreversible cause of coma.



[Source: www.npr.org/blogs/health/2012/10/16/162997951/teenage-brains-are-malleable-and-vulnerable-researchers-say, courtesy of iStock]

(a) Explain a **named** method to assess brain damage. *[2]*

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(b) Distinguish between a reflex arc and other responses by the nervous system. *[1]*

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(Option A continues on the following page)

(Option A, question 5 continued)

(c) Describe the events that occur in the nervous system when something very hot is touched. *[3]*

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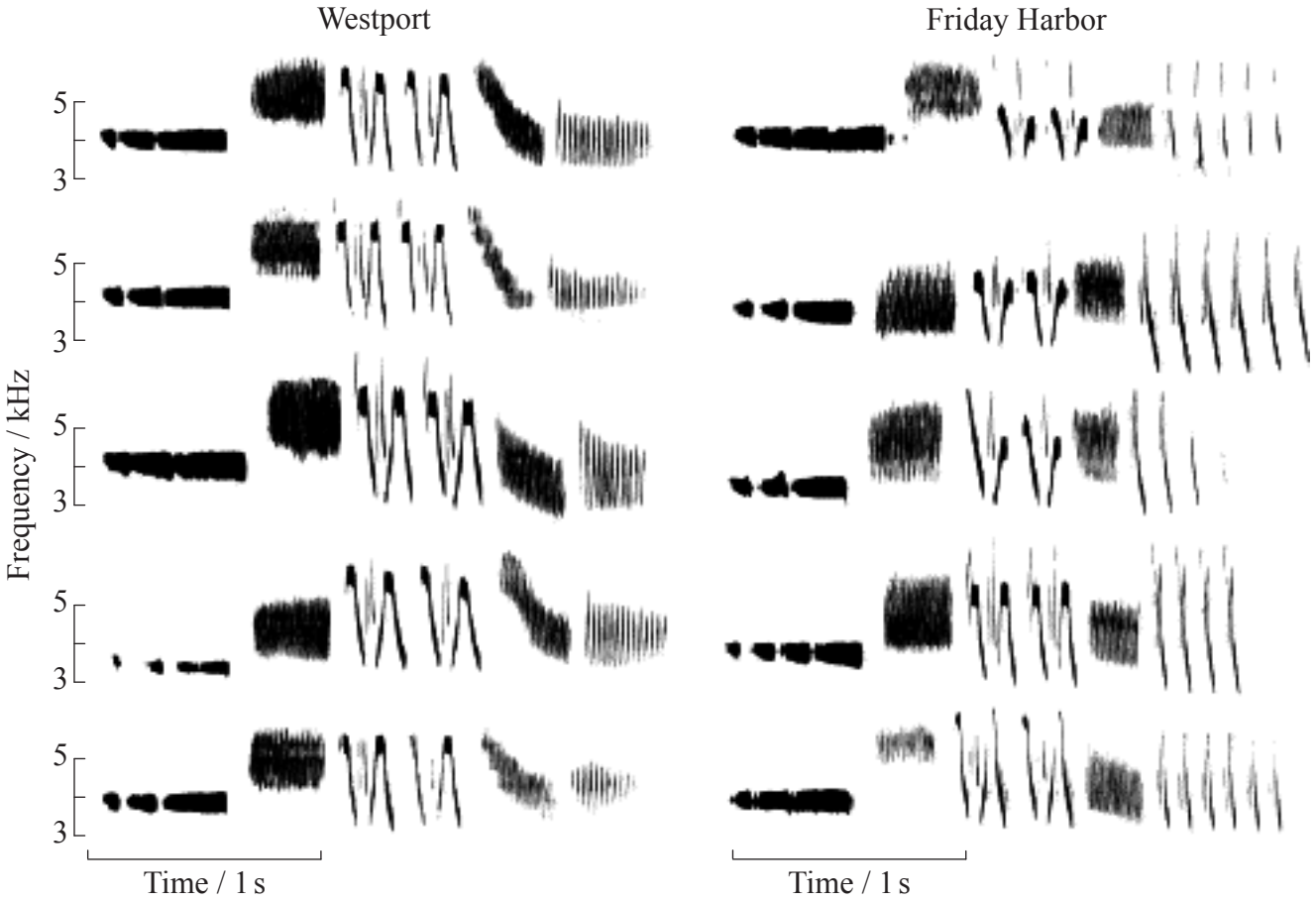
(Option A continues on the following page)

(Option A continued)

6. The sounds that birds produce can be categorized into two distinct classes: calls and songs. A song tends to be a long and complex vocalization produced during a breeding season. Songs are organized into several phrases (or motifs) which consist of a series of syllables.

The sonogram shows the birdsong of ten different male, white-crowned sparrows. Five are from Westport and five are from Friday Harbor in the Pacific Northwest coast of North America.



[Source: adapted from DA Nelson and JA Soha, (2004), *Animal Behaviour*, **68** (2), pages 395–405]

(a) Identify **one** similarity in all of the birdsongs. *[1]*

. . . . . .

(Option A continues on the following page)

(Option A, question 6 continued)

(b) Identify **one** difference between the birdsongs at Westport and Friday Harbor. *[1]*

. . . . . .

(c) Discuss the role of inheritance and learning in the development of birdsong in birds. *[3]*

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(d) Outline Pavlov's experiments into conditioning in dogs. *[3]*

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(Option A continues on the following page)

(Option A continued)

7. Explain altruistic behaviour using blood sharing in vampire bats as an example. *[3]*

[Source: http://animals.nationalgeographic.com/staticfiles/NGS/Shared/StaticFiles/animals/images/1024/vampire-bat.jpg]

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(Option A continues on the following page)

(Option A continued)

8. Explain how sound is received, transmitted and processed in humans. *[6]*

End of Option A

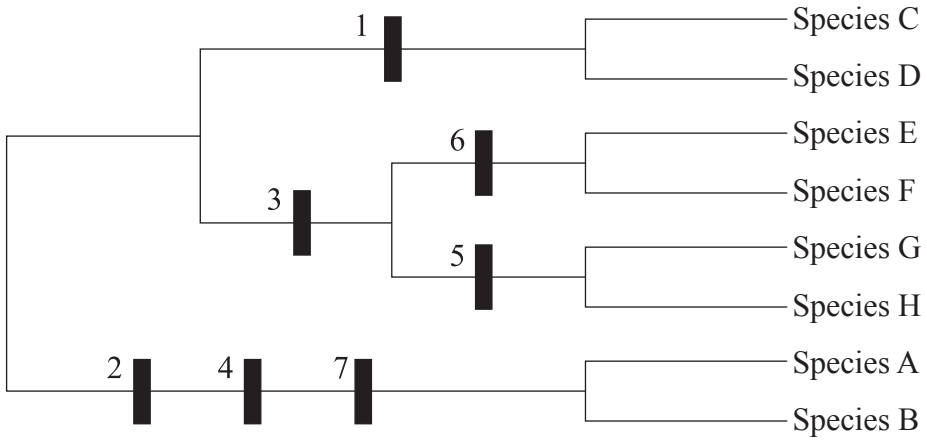
Option B — Biotechnology and bioinformatics

9. (a) State **one** difference between the p arm and the q arm of chromosome 21. *[1]*

. . . . . .

(b) The diagram shows the nucleotide alignment of an area in the DNA of eight related species and its corresponding cladogram. Numbers 1 to 7 indicate a nucleotide which has mutated.

	1	2	3	4	5	6	7
Species A	A C C A G C **C** T G T G C A T C G A T G **A** C G A C T A A G T G A T A C C A T A A **A** G A C T
Species B	A C C A G C **C** T G T G C A T C G A T G **A** C G A C T A A G T G A T A C C A T A A **A** G A C T
Species C	A C **G** A G C A T G T G C A T C G A T G C C G A C T A A G T G A T A C C A T A A T G A C T
Species D	A C **G** A G C A T G T G C A T C G A T G C C G A C T A A G T G A T A C C A T A A T G A C T
Species E	A C C A G C A T G T G **T** A T C G A T G C C G A C T A A G T G A T A C C A **A** A A T G A C T
Species F	A C C A G C A T G T G **T** A T C G A T G C C G A C T A A G T G A T A C C A **A** A A T G A C T
Species G	A C C A G C A T G T G **T** A T C G A T G C C G A C T A A G T G **C** T A C C A T A A T G A C T
Species H	A C C A G C A T G T G **T** A T C G A T G C C G A C T A A G T G **C** T A C C A T A A T G A C T



[Source: adapted from www.life.illinois.edu]

(Option B continues on the following page)

(Option B, question 9 continued)

(i) Outline the nature of mutation 6. *[2]*

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(ii) Identify a mutation which according to the cladogram, is common to species G and E. *[1]*

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(c) If scientists have determined the amino acid sequence of a novel protein, explain how they could find whether a similar protein is found in other organisms. *[2]*

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(Option B continues on the following page)

(Option B continued)

10. (a) Explain how nutrient levels affect the production of penicillin in a fermenter. *[3]*

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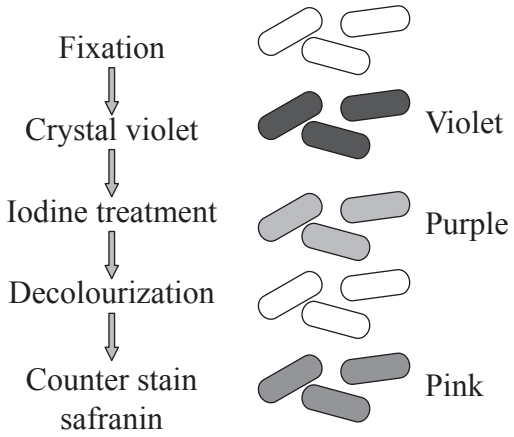
(b) The diagram represents the outcome of a Gram staining procedure.



[Source: adapted from http://pathmicro.med.sc.edu/fox/gram-st.jpg]

(i) Outline what must be done during the fixation stage. *[2]*

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(Option B continues on the following page)

(Option B, question 10 continued)

(ii) Deduce, with a reason, what type of bacterium is represented in the diagram. *[2]*

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11. (a) In order to produce a transgenic organism, other types of sequences need to be inserted into the host genome in addition to the target gene. List **two** examples of other types of sequences that have to be inserted. *[2]*

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(b) The company BASF produces a genetically modified potato called Amflora. Outline the purpose of modifying the potato. *[2]*

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(Option B continues on the following page)

(Option B continued)

12. Explain the use of biofilms in trickle filter beds for sewage treatment. *[3]*

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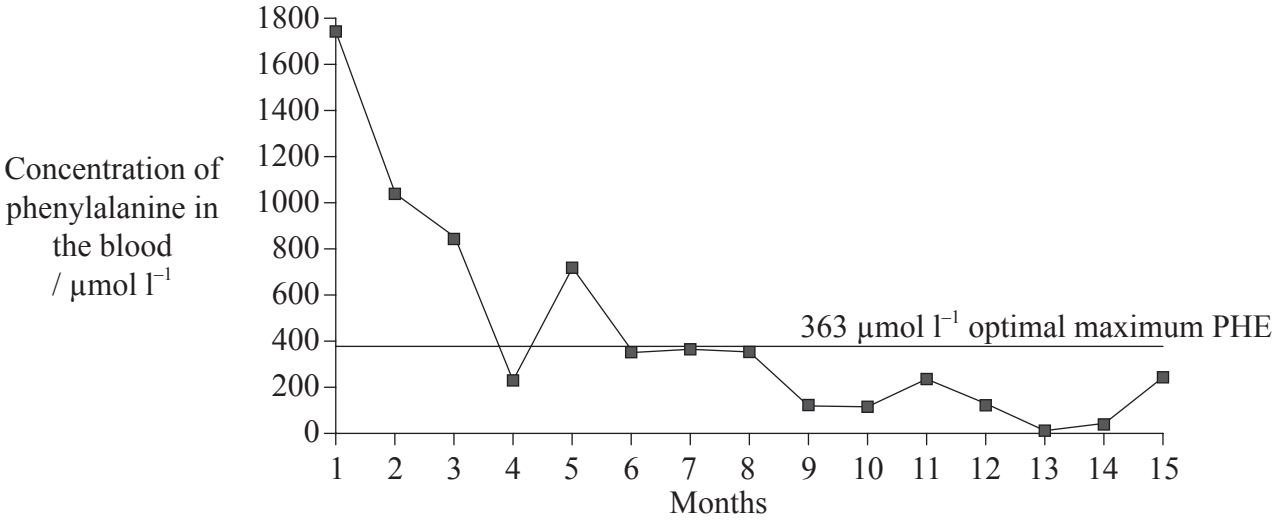
(Option B continues on the following page)

(Option B continued)

13. Phenylketonuria (PKU) is a recessive genetic disease in which the affected individual lacks functional phenylalanine hydroxylase. As a consequence, affected individuals cannot convert dietary phenylalanine (an amino acid) to the amino acid tyrosine and phenylalanine (PHE) builds up in the blood. The graph shows the levels of phenylalanine in the blood of a newborn baby with PKU until the age of 15 months. The baby was fed a modified diet to control blood phenylalanine. The target maximum blood PHE is 363 μmol l^{-1}.



[Source: www.pahdb.mcgill.ca/?Topic=Information&Section=Clinical&Page=1]

(a) Determine the number of months that the baby's blood phenylalanine level was above the optimal maximum PHE. *[1]*

. . . . . .

(b) Suggest how the baby's diet might have been modified. *[1]*

. . . . . .

. . . . . .

(Option B continues on the following page)

(Option B continued)

(c) If a parent is a carrier for PKU, it is likely that their DNA possesses genetic markers. List **two** methods that can be used to detect the presence of these markers. *[2]*

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(Option B continues on the following page)

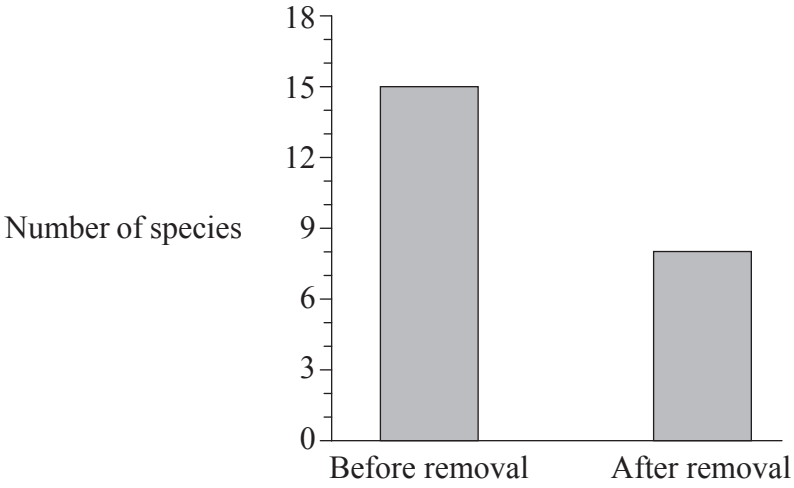
(Option B continued)

14. Outline the ELISA test for screening for HIV infection. *[6]*

End of Option B

Option C — Ecology and conservation

15. In a study examining the ecological role of keystone species, the sea star, *Pisaster*, was removed from a study area. The sea star is a top carnivore. After an extended period of time, researchers returned to analyse changes in the species diversity in the study area. The bar chart shows the species diversity before and after the removal from the habitat.



[Source: adapted from R T Paine, (1966), *The American Naturalist*, **100** (910), pages 65–75]

(a) State the effect of removing the sea star. *[1]*

. . . . . .

(b) (i) Define keystone species. *[1]*

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(Option C continues on the following page)

(Option C, question 15 continued)

(ii) Suggest reasons for the change in species diversity after removal of the sea star. *[3]*

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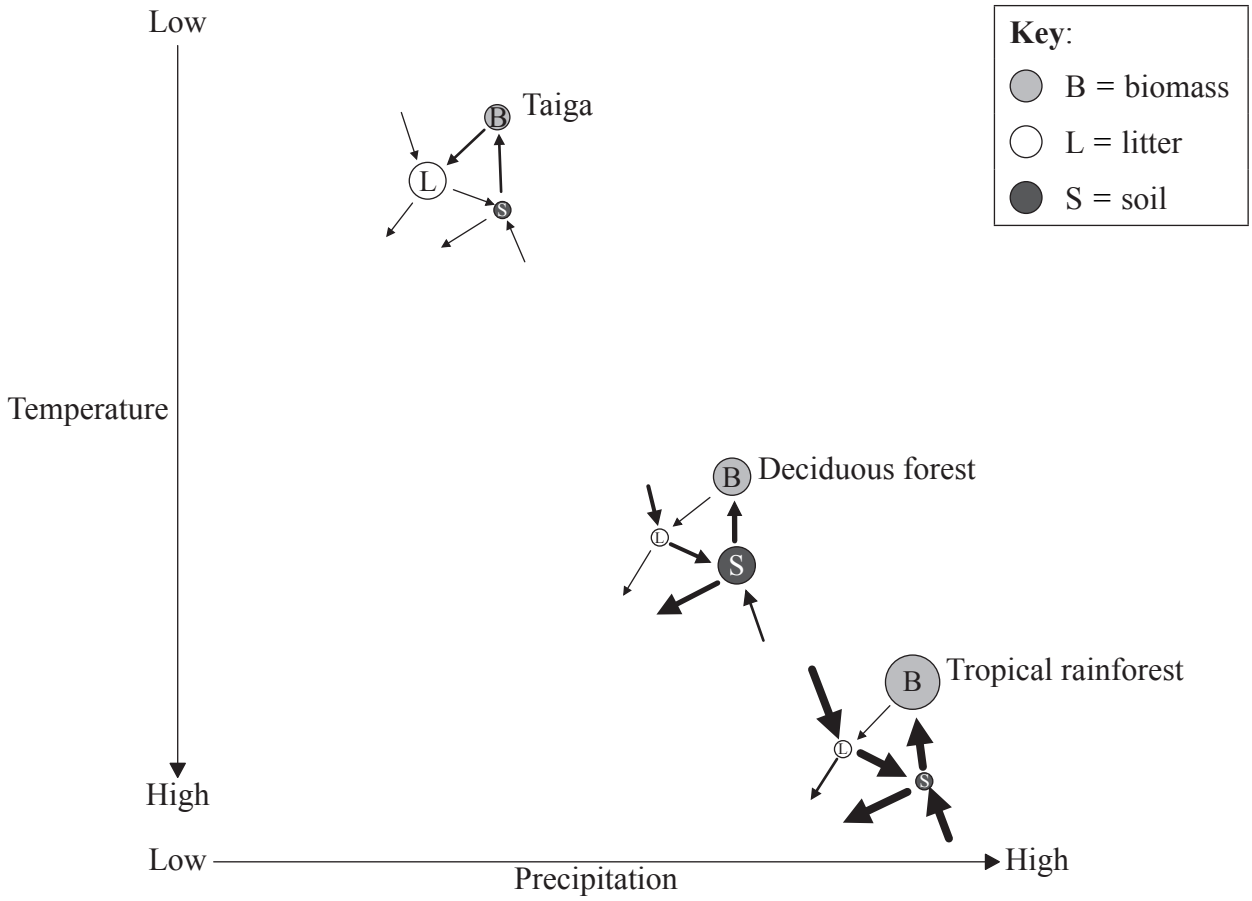
(Option C continues on the following page)

(Option C continued)

16. The model depicted represents the effect of temperature and precipitation on the flow of nutrients within different types of ecosystems. The thickness of the arrow represents the rate of nutrient flow.



[Source: adapted from www.slideshare.net/ecumene/ecosystems-3-nutrient-cycle-presentation]

(a) Identify **one** ecosystem where the litter represents the highest level of nutrient store. *[1]*

. . . . . .

(Option C continues on the following page)

(Option C, question 16 continued)

(b) Deduce what process is indicated by the arrow connecting the litter to the soil. *[1]*

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(c) State the relationship between the level of precipitation and the relative amount of nutrients stored in biomass. *[1]*

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(d) High levels of rainfall can lead to water-logging of soils. Outline the impact of water-logging on the nitrogen cycle. *[2]*

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(e) Deduce, with a reason, whether the models assume the ecosystems to be open **or** closed. *[2]*

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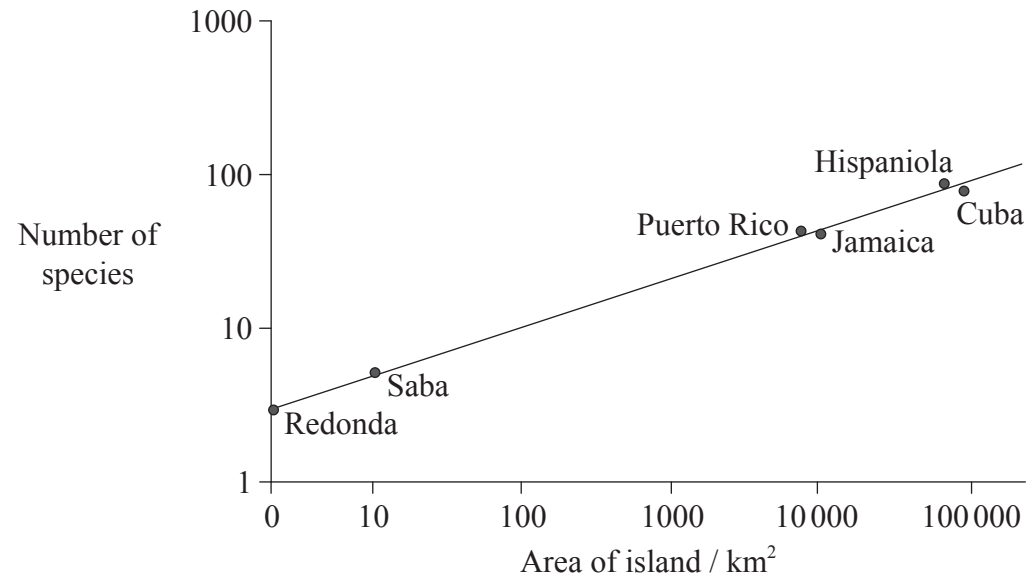
(Option C continues on the following page)

(Option C continued)

17. The graph shows the relationship between island area and reptilian diversity in the West Indies.



[Source: adapted from http://web2.uwindsor.ca/courses/biology/macisaac/55-437/lecture9.htm]

(a) Outline the relationship between island area and the number of reptile species. *[1]*

. . . . . .

. . . . . .

(b) Montserrat has an area of 100 km^2. Predict the number of species of reptile that can be found there. *[1]*

. . . . . .

(Option C continues on the following page)

(Option C, question 17 continued)

(c) Explain how an alien species can become invasive. *[2]*

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(d) List the **two** types of data needed to calculate the value of a biotic index for a local stream. *[2]*

1. . . . . .

2. . . . . .

(Option C continues on the following page)

(Option C continued)

18. (a) With reference to **one** example of each, distinguish between a top down limiting factor and a bottom up limiting factor. *[3]*

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(b) Discuss the trade-off between the control of the malarial parasite and DDT pollution. *[3]*

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(Option C continues on the following page)

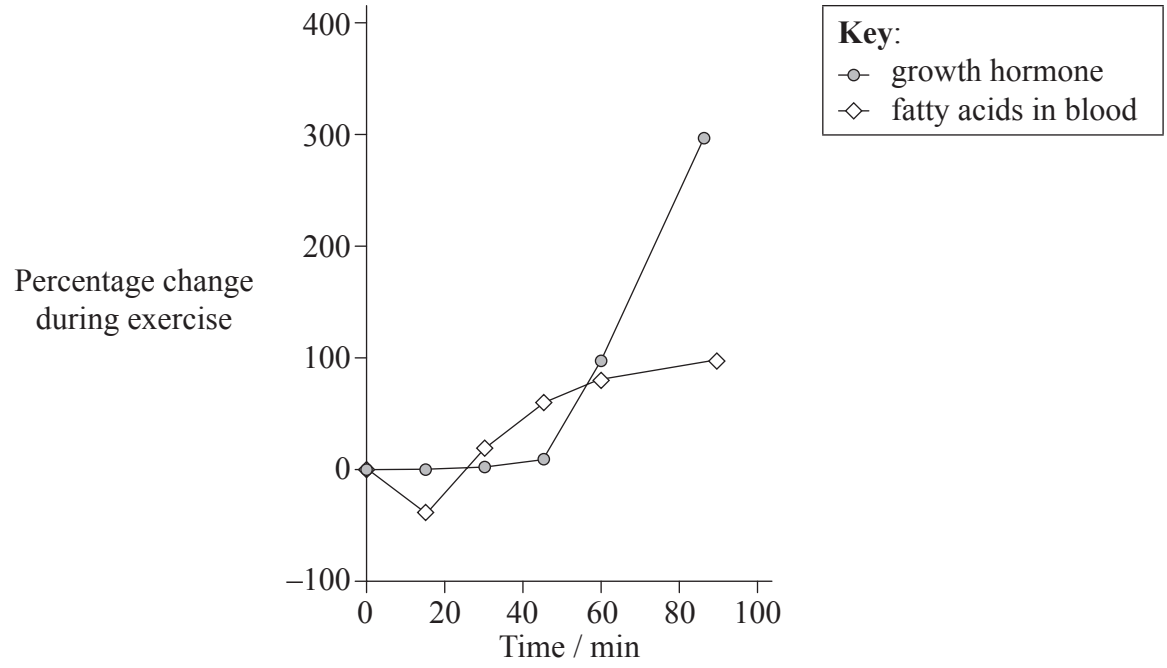
(Option C continued)

19. Evaluate the methods used to estimate the size of commercial fish stocks. *[6]*

End of Option C

Option D — Human physiology

20. The graph shows the responses in levels of growth hormone and free fatty acids to relatively intense exercise combining aerobic and anaerobic components.



[Source: adapted, by permission, from J.H. Wilmore and D.L. Costill, (2004), *Physiology of Sport and Exercise*, 3rd ed., (Champaign, IL: Human Kinetics), page 178]

(a) Identify the level of growth hormone after one hour of exercise. *[1]*

. . . . . .
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(Option D continues on the following page)

(Option D, question 20 continued)

(b) (i) State **one** reason that motivates some athletes to take growth hormones. *[1]*

. . . . . .

(ii) State **one** risk associated with the use of growth hormones in sports. *[1]*

. . . . . .

(c) Suggest **one** possible use of fatty acids during exercise. *[1]*

. . . . . .
. . . . . .

(d) Testosterone is a steroid hormone. Outline the mechanism by which steroid hormones affect target cells. *[2]*

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. . . . . .
. . . . . .
. . . . . .

(Option D continues on the following page)

(Option D continued)

21. (a) The liver produces cholesterol. State **two** other functions of the liver. *[2]*

1. . . . . .
. . . . . .

2. . . . . .
. . . . . .

(b) Compare and contrast cholesterol produced by the liver and dietary cholesterol. *[2]*

. . . . . .
. . . . . .
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(Option D continues on the following page)

(Option D, question 21 continued)

(c) The CAT scan shows a patient who has a blocked bile duct.

[Source: adapted from http://upload.wikimedia.org/wikipedia/commons/4/4c/Obstructivebiliarydilation.png]

The blockage of the bile duct causes a build-up of bilirubin in the blood.

(i) State **one** consequence of a build-up of bilirubin in the blood. *[1]*

. . . . . .

(ii) State **one** other possible cause for the build-up of bilirubin in the blood. *[1]*

. . . . . .

(Option D continues on the following page)

(Option D continued)

22. The X-ray shows the legs of a young boy who suffers from rickets.

[Source: www.millathomeopathy.com/images/disease-cd-rickets.jpg]

(a) State the symptom of rickets evident in the X-ray. *[1]*

. . . . . .

(b) State the main cause of rickets. *[1]*

. . . . . .

(c) Identify **one** vitamin and **one** hormone that are based on a steroid ring. *[2]*

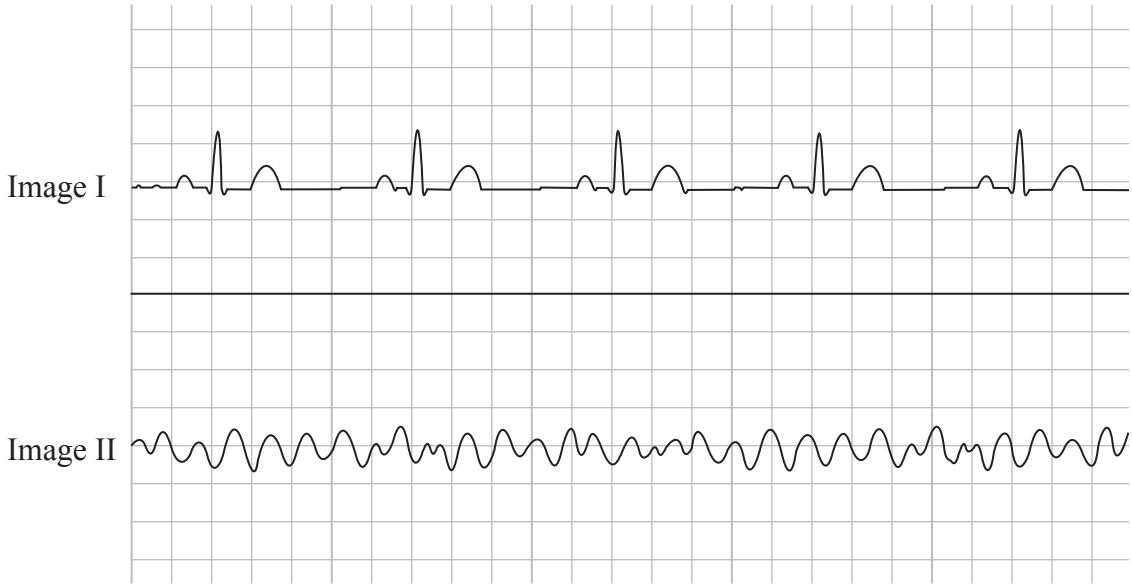
Vitamin: . . . . . .

Hormone: . . . . . .

(Option D continues on the following page)

(Option D continued)

23. Image I represents a normal heart rhythm and image II represents an abnormal heart rhythm.



[Source: adapted from www.homeheart.co.uk/ecg_example.jpg]

(a) State the name given to the abnormal rhythm pattern. *[1]*

. . . . . .

(b) State a **named** technique used to restore the normal heart rhythm. *[1]*

. . . . . .

(c) Annotate image I to indicate **one** phase where the atrium is contracting and **one** phase where the ventricle is contracting. *[2]*

(Option D continues on the following page)

(Option D, question 23 continued)

(d) State **one** unique characteristic of cardiac muscle cells. *[1]*

. . . . . .
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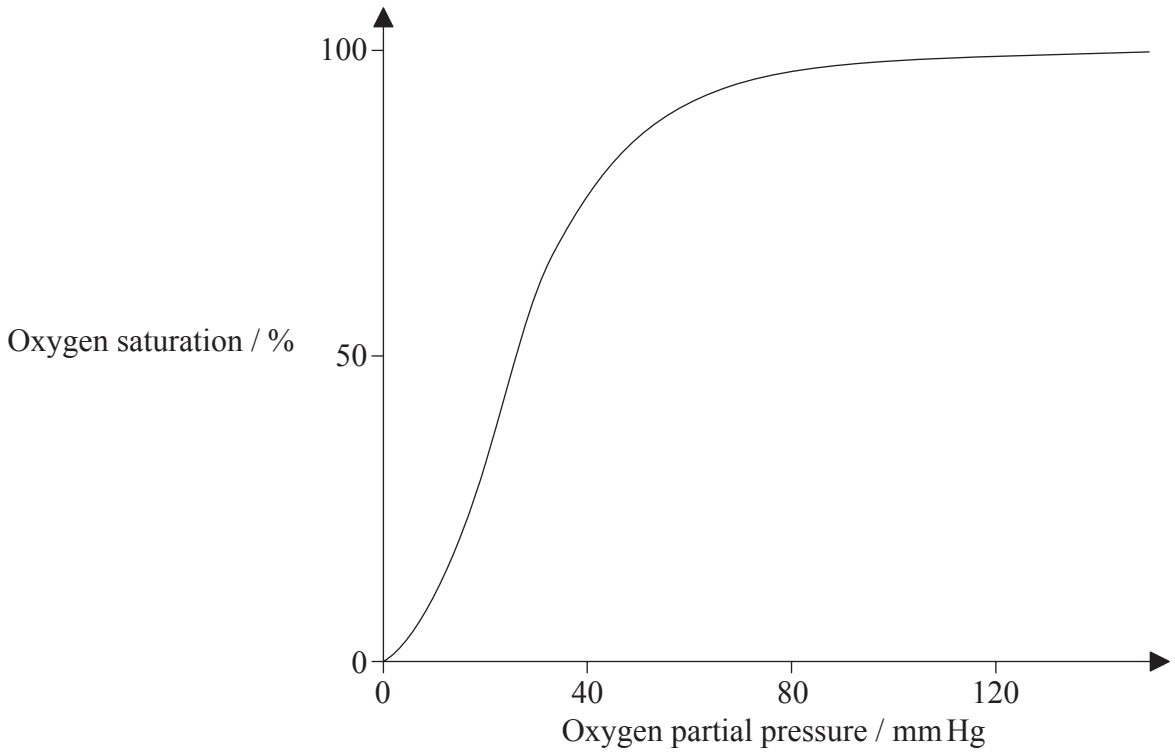
(Option D continues on the following page)

(Option D continued)

24. Gas exchange between maternal blood and fetal blood occurs in the placenta. The graph shows the dissociation curve of oxygen from the mother.



(a) State which mineral ion is found in hemoglobin. *[1]*

. . . . . .

(b) On the graph, draw the dissociation curve for fetal hemoglobin. *[2]*

(Option D continues on the following page)

(Option D continued)

25. Explain the mechanisms carried out in the blood to control the changes of pH during the transport of gases. *[6]*

End of Option D

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MARKSCHEME

SPECIMEN PAPER 2016

BIOLOGY

Higher Level

Paper 3

23 pages

Subject Details: Biology HL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A and **ONE** out of **FOUR** questions in Section B. Maximum total = **[72 marks]**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (/). Either wording can be accepted.

6. An alternative answer is indicated in the "***OR***" on the line between the alternatives. Either answer can be accepted.

7. Words in angled brackets ‹ › in the "Answers" column are not necessary to gain the mark.

8. Words that are underlined are essential for the mark.

9. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

10. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded.
When marking, indicate this by adding **ECF** (error carried forward) on the script. "ECF acceptable" will be displayed in the "Notes" column.

13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

SECTION A

Question			Marking point	Answers	Notes	Total
1.	**a**			metaphase ✓		**1**
	b		***a***	chromosomes are condensed ***OR*** uneven distribution of chromatin ***OR*** discrete chromosomes ✓		**2 max**
			b	cell plate ***OR*** two similarly sized smaller adjacent cells ✓		
			c	no nuclear membrane ***OR*** nucleus not clearly visible ✓		
			d	‹condensed› chromosomes lined up in the centre ✓		
	c		***a***	count the total number of cells visible ✓		**2 max**
			b	count the number of cells undergoing mitosis ✓		
			c	$\text{mitotic index} = \frac{\text{number of cells undergoing mitosis}}{\text{number of cells visable}}$ ✓		

Question			Marking point	Answers	Notes	Total
2.	**a**		***a***	light dependent reactions including reduction of NADP ceases ✓		**2**
			b	glycerate – 3–phosphate can no longer be converted to triose phosphate so levels rise ✓		
	b		***a***	concentration would rise ✓		**3 max**
			b	reduced NADP produced in the light ✓		
			c	glycerate –3–phosphate converted to triose phosphate ✓		
			d	triose phosphate converted to ribulose bisphosphate ✓		
3.	**a**		***a***	both boat samples grow in copper concentrations up to 0.1 mg dm^{-3} ‹whereas unpolluted site algae do not› ✓		**2**
			b	growth of both boat samples higher than unpolluted site at all copper concentrations ✓		
	b		***a***	variation in tolerance ***OR*** some algae more copper tolerant than others ✓		**3 max**
			b	copper kills algae that lack tolerance ✓		
			c	tolerant individuals reproduce and pass advantageous alleles onto offspring ✓		
			d	frequency of advantageous alleles rises in population ✓		

SECTION B

Option A — Neurobiology and behaviour

Question			Marking point	Answers	Notes	Total
4.	**a**			LSD ✓		**1**
	b	**i**	***a***	nicotine ***OR*** cocaine ***OR*** amphetamines ✓	*Accept one stimulant.*	**2**
			b	benzodiazepines ***OR*** alcohol ***OR*** THC ✓	*Accept one sedative.*	
	b	**ii**	***a***	blocks re-uptake of serotonin by neuron ✓		**2**
			b	serotonin levels rise in synapse and continue to stimulate post synaptic neuron ✓		
	c		***a***	block nerve transmission to pain centers ✓		**2 max**
			b	cause numbness/lack of sensation ***OR*** block feeling of pain ✓		
			c	in one part of the body ***OR*** without causing unconsciousness ✓		

Question			Marking point	Answers	Notes	Total
5.	**a**		***a***	light shone into eyes to test pupil reflex ✓		**2 max**
			b	pupils will constrict in patient without brain death ***OR*** no response by pupils in brain dead patient ✓		
			c	both eyes need to be tested ✓		
	b			a reflex arc produces an automatic/involuntary response to a stimulus whereas other responses require input from the brain ✓		**1**
	c		***a***	impulse travels along sensory neuron to CNS ✓		**3 max**
			b	transferred to motor neuron ‹via relay neuron› in spinal cord ✓		
			c	motor neuron stimulates effector muscle to pull away from stimulus ✓		
			d	stimulus transmitted afterwards to brain ***OR*** reaction is very rapid as does not wait for message to get to brain ✓		

Question			Marking point	Answers	Notes	Total
6.	a		*a*	they all start with a lower frequency ‹sound› ✓		1 max
			b	all ‹of the songs› have a five part pattern ✓		
	b		*a*	the birdsongs at Friday Harbor have a greater range in frequency at the end ✓		1 max
			b	fourth phase shows a fall in frequency at Westport but not at Friday Harbor ✓		
	c		*a*	birdsong is a mix of both innate and learned behaviour ✓		3 max
			b	there is a basic species song pattern ✓		
			c	birds developing in isolation will display species song pattern ✓		
			d	young birds learn their parents' song ✓		
			e	normal song has a greater range of frequencies than innate song ✓		
	d		*a*	dogs give unconditional response ‹salivate› to unconditional stimulus ‹food› ✓		3
			b	‹Pavlov› rang the bell before food was given so dogs associated the two ✓		
			c	‹after a few days› dogs gave conditioned response ‹salivated› to the conditional stimulus ‹bell› ✓		

Question			Marking point	Answers	Notes	Total
7.			***a***	instinctive behaviour that is detrimental to the individual but benefits others ✓		**3 max**
			b	occurs in stable social groups of vampire bats ✓		
			c	bats will starve if deprived of food for more than 48 hours ✓		
			d	older females will feed younger, unrelated bats ✓		
			e	vampire bats display reciprocal altruism ✓		

8.			***a***	eardrum vibrates when sound waves reach it ✓		**6 max**
			b	ossicles/earbones vibrate and pass sound to oval window ✓		
			c	ossicles amplify the sound and oval window is smaller than eardrum so adds to amplification ✓		
			d	sound waves transmitted to fluid-filled cochlea via round window ✓		
			e	hair cells in cochlea rest on membrane and have hair bundles on surface ✓		
			f	different hair bundles resonate with different frequencies of sound, so these can be distinguished ✓		
			g	hair bundles vibrate when hit by waves and pass message to auditory nerve ✓		
			h	auditory nerve pushes impulse to auditory cortex ✓		
			i	connections between regions of the brain allow perception of speech, music and other noises ✓		

Option B — Biotechnology and bioinformatics

Question			Marking point	Answers	Notes	Total
9.	**a**		***a***	the p arm is shorter ✓		**1 max**
			b	the p arm has fewer protein coding sequences/genes ✓		
	b	**i**	***a***	‹it is most likely to be a› change from T to A ✓		**2**
			b	base substitution ✓		
	b	**ii**		‹mutation› 3 ✓		**1**
	c		***a***	search a database ***OR*** upload the sequence to a database ✓		**2 max**
			b	conduct a BLASTp search ✓		
			c	review results to find high percentage similarity ✓		
10.	**a**		***a***	*P. notatum*/*Penicillium* produces penicillin ✓		**3 max**
			b	nutrients given to encourage fungal growth ✓		
			c	some metabolites are produced under stress conditions ✓		
			d	as nutrients run out penicillin is produced ✓		

(Question 10 continued)

Question			Marking point	Answers	Notes	Total
	b	**i**	***a***	heat over flame ✓		**2**
			b	to make bacteria adhere/fix to slide ✓		

	b	**ii**	***a***	Gram-negative ✓		**2**
			b	because it decolorizes/stains pink ✓		

11.	**a**		***a***	promoter/regulatory sequences ✓		**2**
			b	marker genes ***OR*** antibiotic resistance genes ✓		

	b		***a***	to block production of amylose ✓		**2**
			b	‹amylose› reduces quality of starch for technical applications/polymer formation/paper production ✓		

Question			Marking point	Answers	Notes	Total
12.	**a**		***a***	biofilm attaches ‹millions of› bacteria to the solid surfaces in the filter bed ✓		**3 max**
			b	prevents bacteria from being washed away ✓		
			c	large numbers of bacteria to break down organic matter ✓		
			d	biolfilm is thin so oxygen diffuses in ✓		
			e	as biofilm increases in thickness, layer closest to bed becomes anaerobic ✓		
13.	**a**			four <months> ✓		**1**
	b			lower protein/phenylalanine in the diet ✓		**1**
	c		***a***	DNA microarrays ✓		**2**
			b	PCR and electrophoresis ***OR*** DNA profiling ✓	*Both needed*	

Question			Marking point	Answers	Notes	Total
14.			***a***	HIV antigens bound/adsorbed to surface ✓		**6 max**
			b	human serum applied and rinsed to remove all except anti-HIV antibodies ✓		
			c	anti-HIV antibodies remain bound to plate ✓		
			d	anti – human antibodies applied with enzyme attached ✓		
			e	bind to human/anti-HIV antibodies remaining on plate ✓		
			f	quantity of enzyme on plate is proportional to quantity of anti-HIV antibody present ✓		
			g	substrate to the enzyme applied which fluoresces when broken down ✓		
			h	degree of fluorescence indicates quantity of anti-HIV antibodies present ✓		
			i	degree of fluorescence converted to a number indicating positive/negative result for HIV positive status ✓		

Option C — Ecology and conservation

Question			Marking point	Answers	Notes	Total
15.	**a**			species diversity is reduced ✓		**1**
	b	**i**		a species with a large/disproportionate impact on the community structure ✓		**1**
	b	**ii**	***a***	removal causes disruption of the ecological structure ✓		**3 max**
			b	sea star controls numbers of other predators in the ecosystem ✓		
			c	on removal some organisms are over-predated ✓		
			d	lack of food resources ✓		
			e	migration of individuals out of study area ✓		
16.	**a**			Taiga ✓		**1**
	b			decomposition ✓		**1**
	c			higher level of precipitation, greater amount of nutrients stored as biomass ✓		**1**
	d		***a***	‹water-logging› reduces available oxygen/creates anaerobic conditions ✓		**2 max**
			b	anaerobic bacteria convert nitrate to gaseous nitrogen ✓	*eg: Pseudomonas denitrificans*	
			c	soil becomes depleted of nitrate, reducing plant growth ✓		

(Question 16 continued)

Question			Marking point	Answers	Notes	Total
	e		***a***	open because there is input and output ***OR*** open because nutrients enter and leave ✓		**2**
			b	flow of energy as well as nutrients and organisms in and out ✓		

17.	**a**			as island area increases the number of <u>species</u> of reptiles increases ✓	*Species is necessary for the mark to be awarded.*	**1**

	b			10 ✓		**1**

	c		***a***	competitive exclusion ***OR*** native species in the same niche out-competed ✓		**2 max**
			b	rapid/efficient reproduction ✓		
			c	lack of local predators ✓		
			d	causes reduction in local biodiversity ✓		

	d		***a***	the frequency/numbers of each organism/species ‹in the sample› ✓		**2**
			b	pollution tolerance rating ‹of each organism› ✓		

Question			Marking point	Answers	Notes	Total
18.	**a**		***a***	example of top down limiting factor ✓	*eg: predator/top consumer*	**3**
			b	example of bottom up limiting factor ✓	*eg: producer/nutrient availability*	
			c	top down limiting factors affect population size by predation/death whereas bottom up limiting factors affect population size by limiting/lack of nutrients ✓		
	b		***a***	DDT kills mosquitoes but also kills other insects indiscriminately ✓		**3 max**
			b	need to stop life cycle of malarial parasites by destroying the vector ‹*Anopheles*› ✓		
			c	residual spraying in houses is improvement over use as crop pesticide ✓		
			d	DDT is biomagnified up the food chain ✓		
			e	has a disproportionate effect on top carnivore/consumer/predator ✓		
			f	birds of prey have thin egg shells ✓		

Question			Marking point	Answers	Notes	Total
19.			***a***	random sampling inaccurate due to movement of fish ✓		**6 max**
			b	age distribution calculation allows observation of spawning rates ✓		
			c	size/age structure of commercial catches used ✓		
			d	dependant on accurate reporting by fishermen ✓		
			e	capture–mark–release–recapture ✓		
			f	useful in lakes, not in sea due to migration patterns ✓		
			g	echo location ✓		
			h	only useful in shoals close to water surface ✓		
			i	does not give data on age/size/species of fish ✓		
			j	inaccuracies allow for disagreement between industry and conservationists ✓		

Option D — Human physiology

Question			Marking point	Answers	Notes	Total
20.	**a**			100 % ‹greater than initial level› ✓	.	**1**
	b	**i**		build more muscle ✓		**1**
	b	**ii**		thyroid damage ***OR*** elevated cholesterol ***OR*** liver damage ✓		**1**
	c			source of energy ***OR*** used when glycogen stores are running out ✓		**1**
	d		***a***	fat soluble so can pass through plasma membrane ✓		**2 max**
			b	bind to receptors in the cytoplasm to form receptor-hormone complex ✓		
			c	initiate transcription of specific genes ✓		

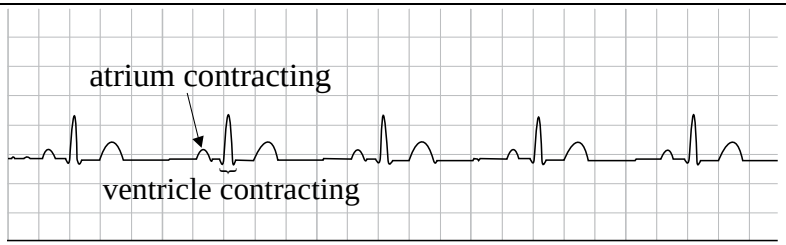
Question			Marking point	Answers	Notes	Total
21.	**a**		***a***	detoxifies blood ✓		**2 max**
			b	breaks down erythrocytes ✓		
			c	excess cholesterol is converted to bile salts ✓		
	b		***a***	liver decreases synthesis of cholesterol when dietary cholesterol rises ✓		**2 max**
			b	dietary cholesterol inhibits enzyme catalyzing liver cholesterol synthesis ✓		
			c	cholesterol from both sources used in body to waterproof skin/synthesize vitamin D/synthesize steroid hormones ✓		
	c	**i**		jaundice ✓		**1**
	c	**ii**	***a***	any cause of increase rate of hemolysis ✓		**1 max**
			b	malaria ✓		
			c	genetic ✓		
			d	defects in bilirubin metabolism ✓		
			e	cirrhosis ✓		
22.	**a**		***a***	bowed legs ***OR*** soft bones ✓		**1 max**
			b	lack of mineralization ✓		
	b			lack of vitamin D/calcium ✓		**1**

(Question 22 continued)

Question			Marking point	Answers	Notes	Total
	c		***a***	*vitamin*: vitamin D ✓		**2**
			b	*hormone*: testosterone/androgen/estrogen/progesterone ✓		

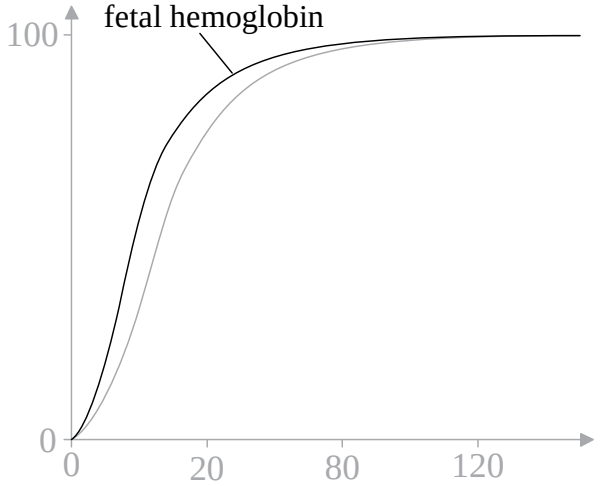
23.	**a**			arrhythmia ***OR*** ventricular fibrillation ✓		**1**

	b			defibrillation ✓		**1**

	c			image I 		
			a	atrium contracting correctly marked on image ✓		**2**
			b	ventricle contracting correctly marked on image ✓		

	d			myogenic contractions ***OR*** branched ✓		**1**

Question			Marking point	Answers	Notes	Total
24.	**a**			iron ✓		**1**

	b					
			a	correct position to left of adult hemoglobin ✓		**2**
			b	shape similar to adult hemoglobin ✓		

Question			Marking point	Answers	Notes	Total
25.			***a***	CO_2 combines in RBCs with H_2O to produce carbonic acid/ H_2CO_3 ✓		**6 max**
			b	catalysed by carbonic anhydrase ✓		
			c	‹carbonic acid› dissociates to form hydrogencarbonate ions and hydrogen ions/ $HCO_3^- + H^+$ ✓		
			d	dissociation of carbonic acid is a reversible reaction so can act as a buffer ✓		
			e	$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$ ✓		
			f	hydrogencarbonate ions move out of RBCs by facilitated diffusion ✓		
			g	the carrier protein moves a chloride ion/ Cl^- into RBC ✓		
			h	chloride shift keeps charge balance across membrane stable ✓		
			i	in low pH, tendency to dissociate will be low and equation will shift to left/less hydrogencarbonate plus hydrogen ions formed ✓		
			j	in high pH, tendency to dissociate will be high and equation will shift to right/more hydrogencarbonate plus hydrogen ions formed ✓		
			k	hemoglobin can act as a buffer combining with hydrogen ions to produce hemoglobinic acid ✓		

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BIOLOGY
STANDARD LEVEL
PAPER 1

SPECIMEN PAPER

45 minutes

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The maximum mark for this examination paper is *[30 marks]*.

1. Why is stem cell research considered unethical by some groups?

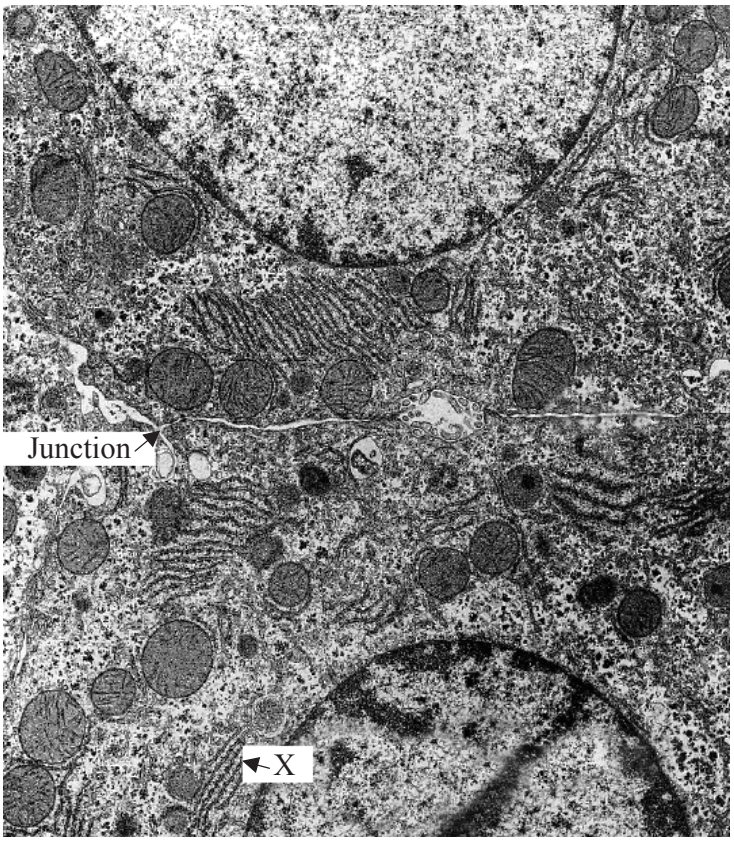
A. Stem cells are living organisms.

B. New organisms could be produced from stem cells.

C. Use of stem cells could involve the culture of pluripotent cells.

D. Use of embryonic cells involves the death of early-stage embryos.

2. The electron micrograph shows part of two adjacent liver cells.



[Source: adapted from www.relfe.com/Images/ratlivercells.gif]

What is happening at the structure labelled X?

A. Synthesis of proteins

B. Transport of proteins to the nucleus

C. Modification of proteins prior to export

D. Secretion of proteins through the plasma membrane

3. What is the approximate thickness of the plasma membrane of a cell?

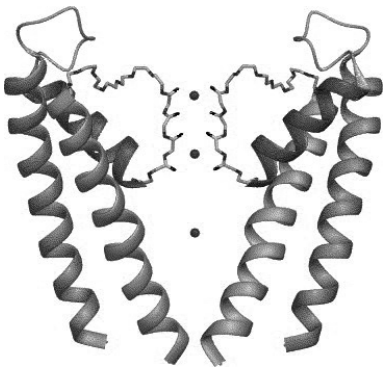
A. 10 µm

B. 50 µm

C. 10 nm

D. 50 nm

4. The diagram shows a potassium channel in an axon membrane. The three dots in the channel represent potassium ions.



[Source: adapted from S Y Noskov and B Roux, (2006), *Biophysical Chemistry*, **124** (3), pages 279–291]

What is the function of this potassium channel?

A. Facilitated diffusion of potassium ions into the axon

B. Passage of potassium ions by active transport out of the axon

C. Facilitated diffusion of potassium ions out of the axon

D. Passage of potassium ions by active transport into the axon

5. In the experiments performed by Meselson and Stahl, *E. coli* were grown for many generations in ^{15}N then for one generation in ^{14}N. What results for the DNA of the last generation showed that replication was semi-conservative?

A. Both strands containing only ^{15}N

B. Both strands containing only ^{14}N

C. One strand containing only ^{15}N and one stand containing only ^{14}N

D. Both strands containing a mixture of ^{15}N and ^{14}N in equal amounts

6. Cyclins were discovered by Timothy R Hunt in 1982 while studying sea urchins. What is a function of cyclins?

A. Circulation of seawater for gas exchange

B. Rotation of tentacles

C. Control of the cell cycle

D. Recycling of nutrients

7. In 1828, Friedrich Wöhler artificially produced urea (organic compound) by an internal rearrangement of the atoms of ammonium cyanate (inorganic compound). What important principle did this experiment show?

A. Organic compounds can be synthesized without the need of a vital force.

B. Organic compounds can only be formed from pre-existing inorganic compounds.

C. Inorganic compounds are essential for living organisms.

D. Organic compounds are more simple substances than inorganic compounds.

8. What promotes genetic variation in meiosis?

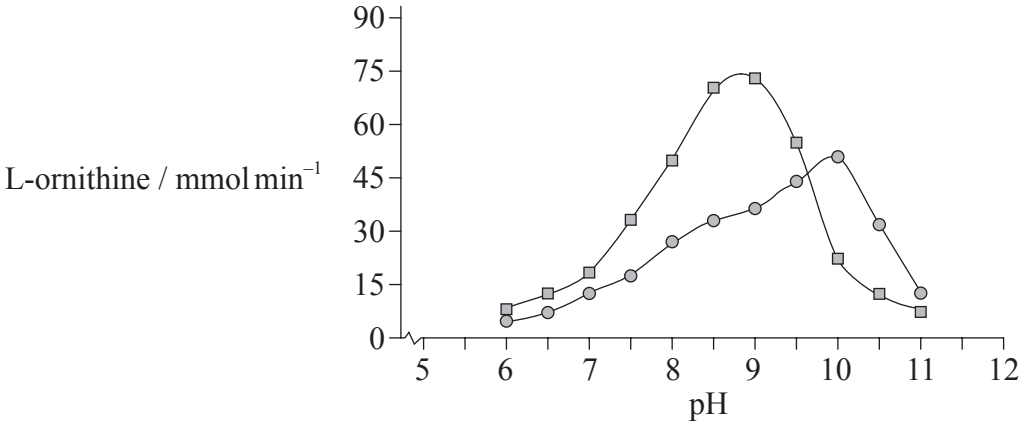
A. Cytokinesis

B. Replication of DNA

C. Condensation of chromosomes

D. Crossing over in homologous chromosomes

9. Arginase catalyses the hydrolysis of L-arginine to form L-ornithine and urea. Arginase was purified from cowpea cotyledons (◎) and buffalo liver (▣) and its activity was measured at different pH values.



[Source: adapted from S Dabir, *et al*., (2005), *International Journal of Biological Sciences*, **1** (3), pages 114–122]

What can be concluded from these results?

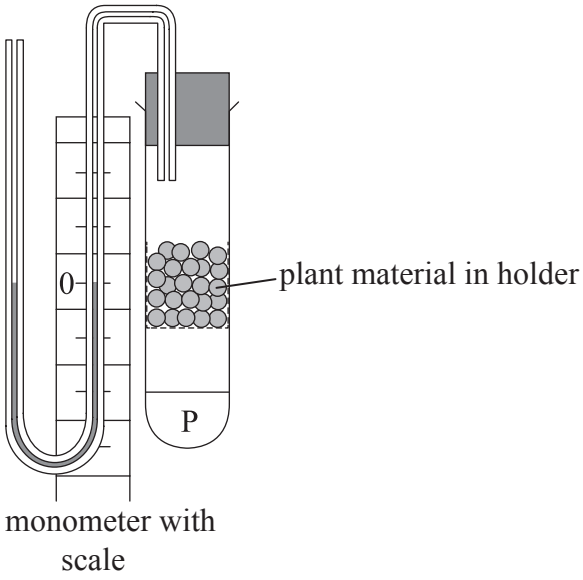
A. The optimum pH for buffalo liver arginase is 10.

B. Cowpea arginase works better in alkaline conditions.

C. Cowpea arginase works at a wider range of pH than buffalo liver arginase.

D. At a more acid pH the cowpea arginase works better than buffalo liver arginase.

10. The diagram shows seeds in a respirometer. What is substance P?



[Source: adapted from K Sands, (1998), *Problems in plant physiology*]

A. An acid used to absorb O_2 produced by seeds.

B. An acid used to release O_2 for use by seeds.

C. An alkali used to absorb CO_2 produced by seeds.

D. An alkali used to release CO_2 for use by seeds.

11. What is the energy absorbed by chlorophyll used directly for in plants?

I. To produce ATP

II. To split water

III. To fix CO_2

A. I only

B. III only

C. I and II only

D. II and III only

12. Which statement is part of the cell theory?

A. All cells have a cell wall.

B. Every cell shows emergent properties.

C. All cells come from pre-existing cells.

D. Every cell carries out all the functions of life.

13. The following alignment represents part of the sequence of a gene in two species, the mouse (*Mus musculus*) and woolly monkey (*Lagothrix lagotricha*).

Mouse MGDVEKGKKIFVMKCAQCHTVEKGGKHKTGPNLHGLFGRKTGQAAGFSYTDANKNK

Woolly monkey MGDVEKGKRIFIMKCSQCHTVEKGGKHKTGXNLHGLFGRKTGQASGYTYTEANKNK

What term is used for different forms of a gene such as these?

A. Loci

B. Alleles

C. Homologues

D. Heterologues

14. The rate of mutation in genes is fairly constant over time. What can be deduced from differences in amino acid sequences between particular proteins in different species?

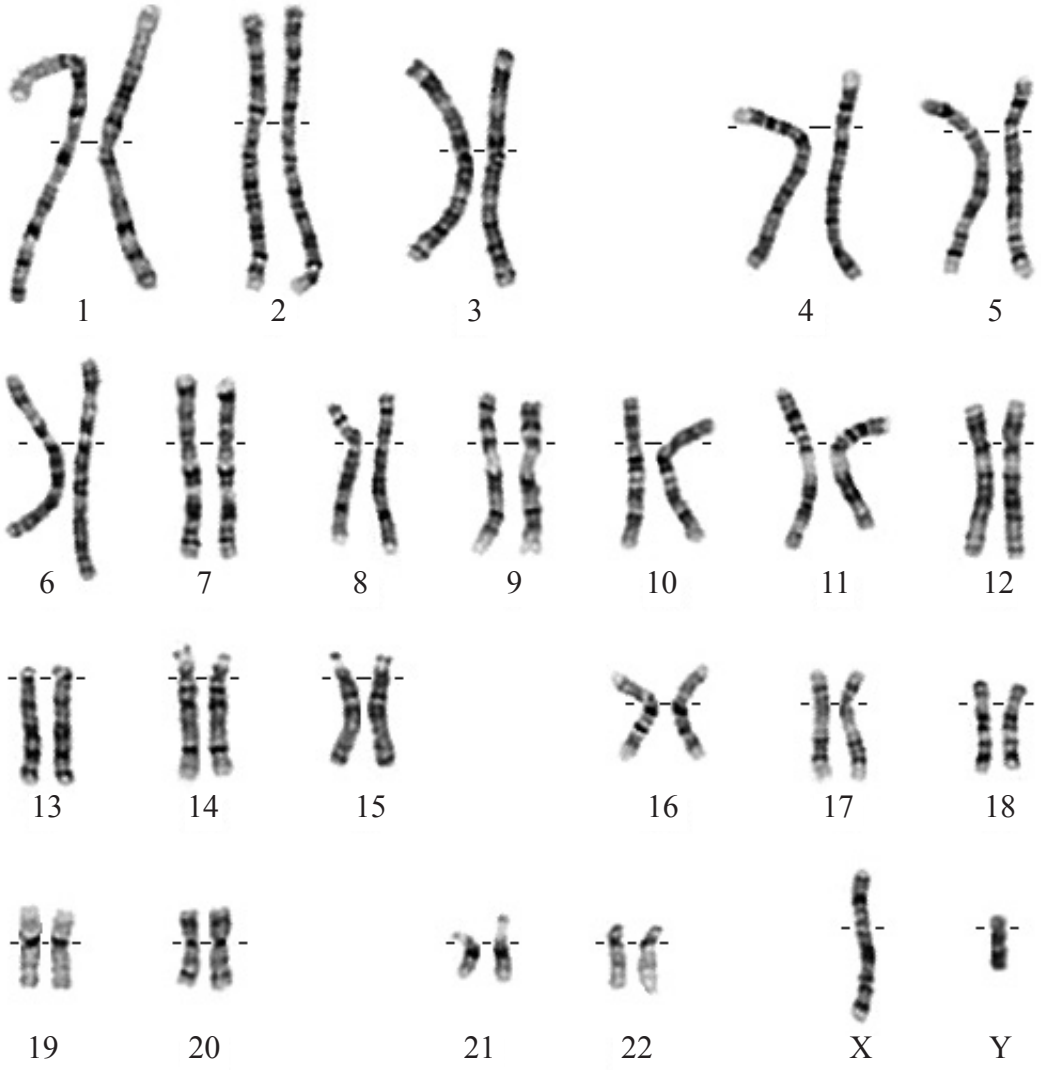
A. How long ago they shared a common ancestor.

B. Which acquired characteristics have been inherited.

C. How different they will be in the future.

D. Which species is most similar to an ancestral form.

15. What is shown by this karyogram?



[Source: www.ucl.ac.uk]

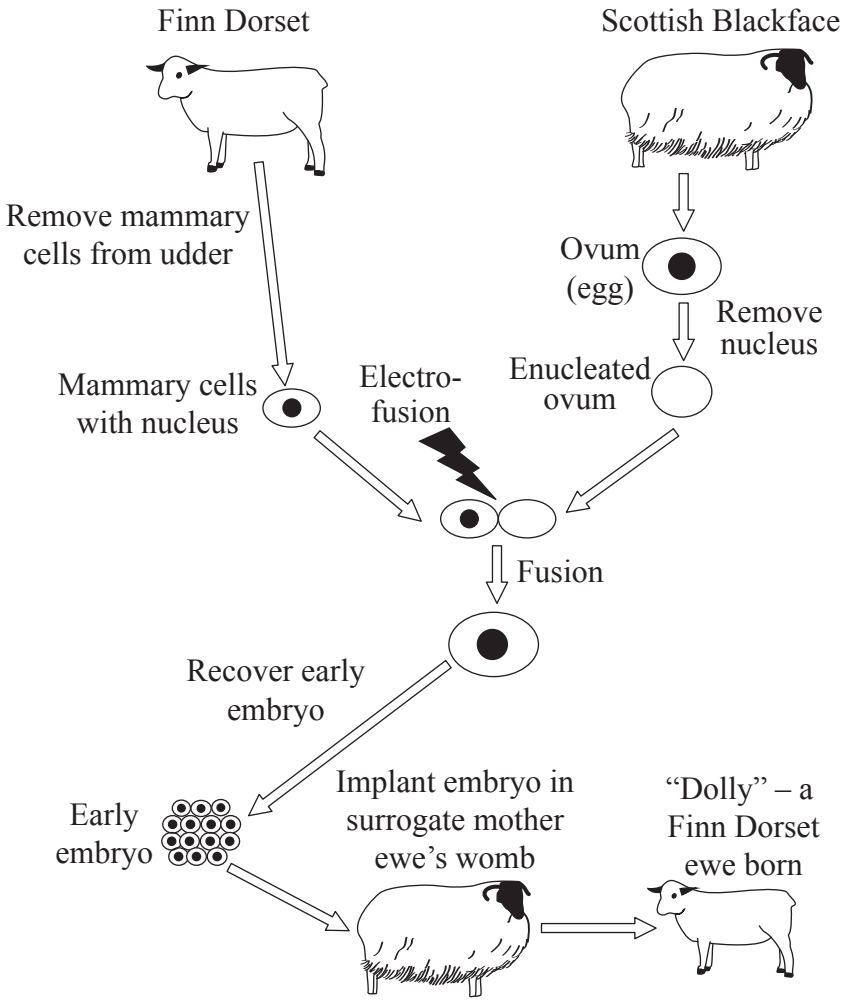
A. The person is male.

B. The person has Down Syndrome.

C. The person has suffered non-disjunction.

D. The person has suffered mutation in chromosome 1.

16. The diagram shows the cloning of the first sheep by Wilmut and Campbell in Scotland in 1997.



[Source: adapted from www.coldmeadow.com]

What is Dolly's DNA composition?

A. The nuclear DNA is from the Finn Dorset and the mitochondrial DNA is from the Scottish Blackface.

B. Half of the DNA is from the Finn Dorset and half is from the Scottish Blackface.

C. All of the DNA is from the Scottish Blackface.

D. All of the DNA is from the Finn Dorset.

17. What is a mesocosm?

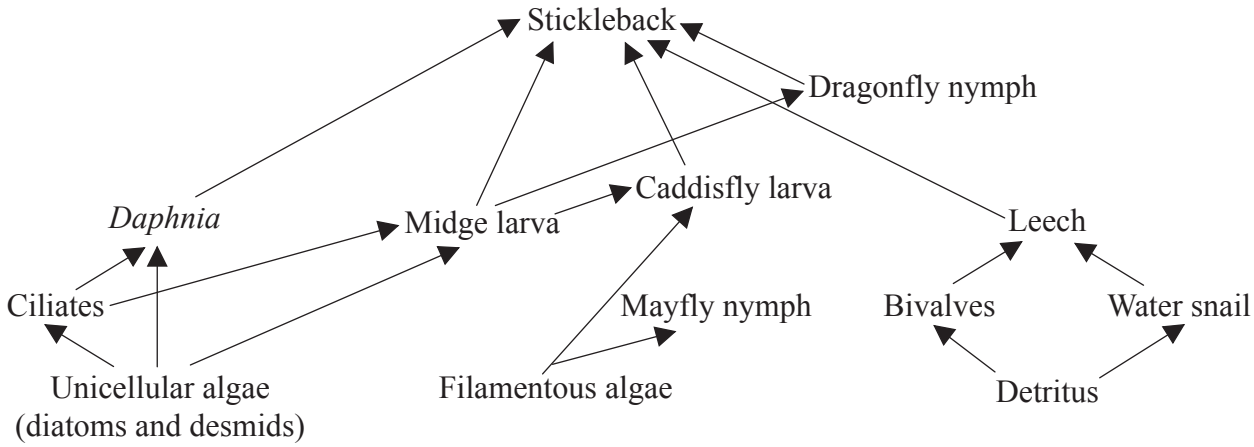
A. A lake where experiments are performed in uncontrolled conditions

B. A small area where parts of the natural environment are kept under controlled conditions

C. An experimental area in a laboratory

D. An ocean

18. The diagram is part of a food web for a freshwater habitat.



Which represents a correct food chain from this web?

A. stickleback → midge larva → unicellular algae

B. ciliates → *Daphnia* → stickleback → dragonfly nymph

C. diatom → midge larva → caddisfly larva → stickleback

D. detritus → bivalves → water snail → leech

19. What is recycled in an ecosystem?

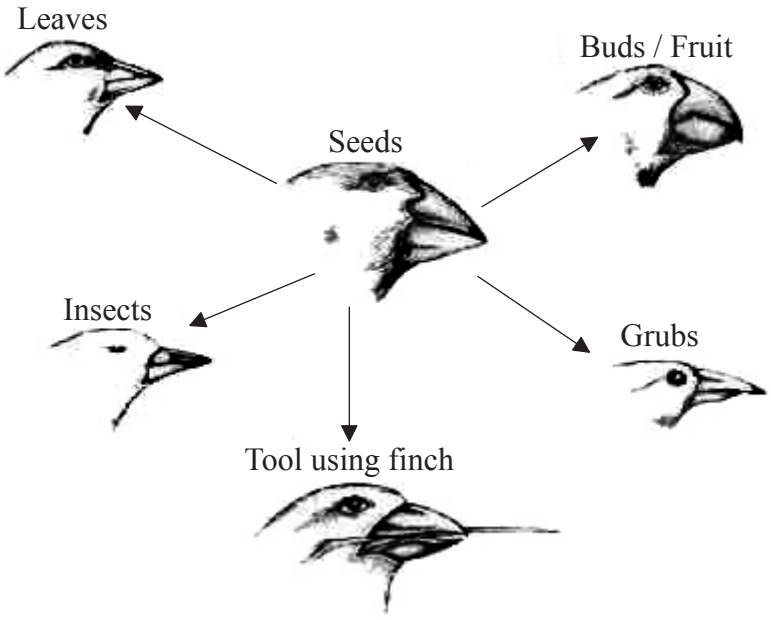
A. Nitrogen, carbon and energy are all recycled.

B. Nitrogen and carbon are all recycled but not energy.

C. Nitrogen is recycled but not carbon or energy.

D. Nitrogen, carbon and energy are not recycled.

20. The diagram shows the beaks of finches on the Galapagos Islands.



[Source: adapted from www.hras.org]

Which process of evolution has occurred in the finches?

A. Convergent evolution of the beaks

B. Natural selection for the strongest beaks

C. Selection pressure caused by the exploitation of different food sources

D. Mutation of the beaks to adapt in different environments

21. What are the three domains of living organisms?

A. Classes, orders and families

B. Bacteria, eukaryotes and viruses

C. Archaea, eubacteria and eukaryotes

D. Decomposers, producers and consumers

22. What characteristic is only found in mammals and **not** other chordates?

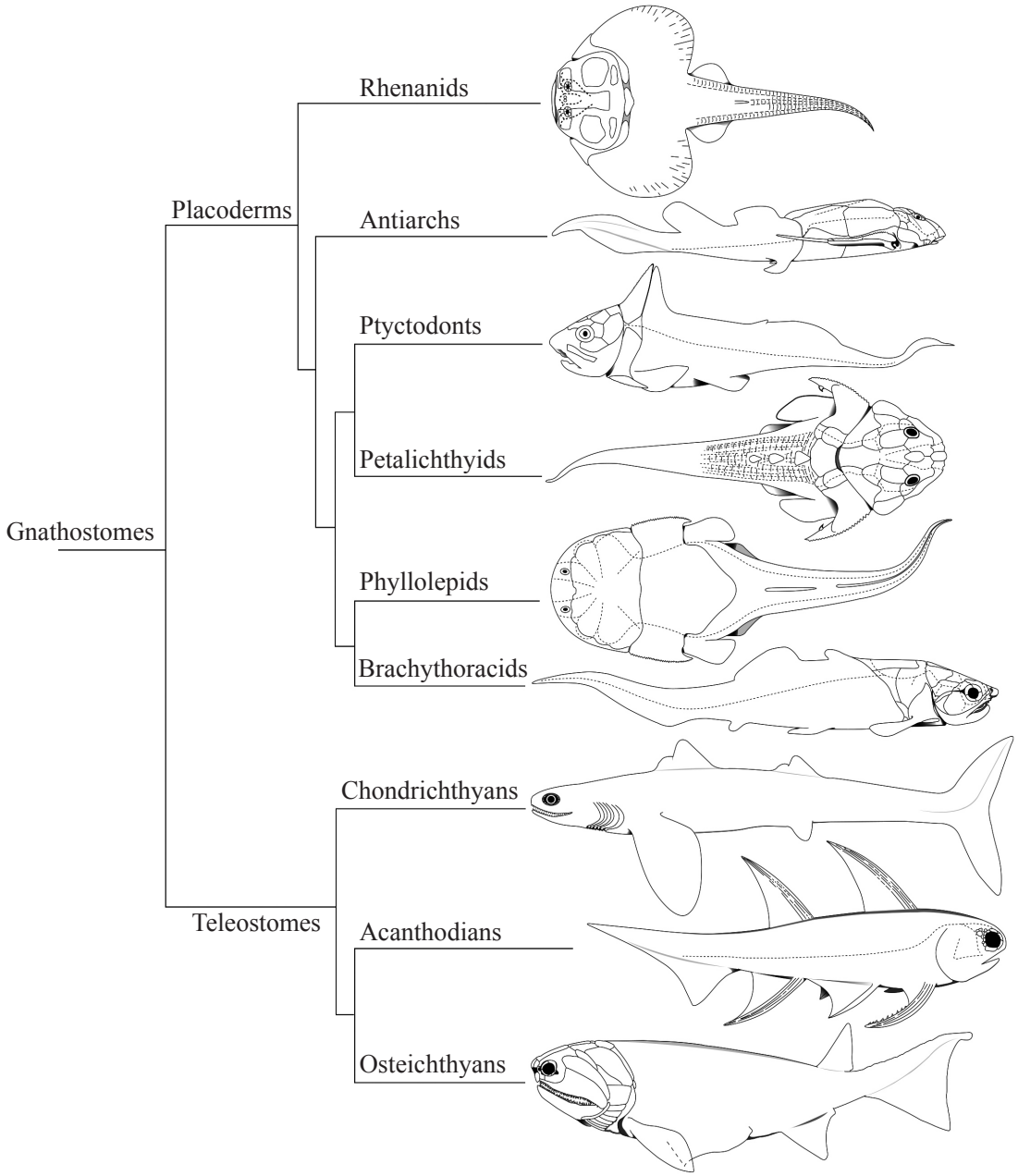
A. Regulation of body temperature

B. Teeth

C. Pentadactyl limb

D. Hair

23. The cladogram shows the phylogenic relationships in jawed vertebrates.



[Source: adapted from R K Carr and G L Jackson, (2008), *Guide to the Geology and Paleontology of the Cleveland Member of the Ohio Shale*, Ohio Geological Survey Guidebook 22, Chapter 5]

What can be deduced about Brachythoracids from this cladogram?

A. They evolved from Placoderms.

B. They gave rise to Gnathostomes.

C. They evolved at the same time as Ptyctodonts.

D. They differ from Phylollepids by only one mutation.

24. What is a characteristic of intestinal villi?

A. They contain few capillaries.

B. They increase the surface area of the small intestine.

C. They have a smooth surface.

D. They are projections from the plasma membranes of the intestinal cells.

25. What is a role of the coronary arteries?

A. To transport blood from the lungs to the heart.

B. To remove deoxygenated blood from the heart muscle.

C. To supply the heart muscle with glucose.

D. To remove cholesterol from the heart muscle.

26. Which statement is a feature of antibodies?

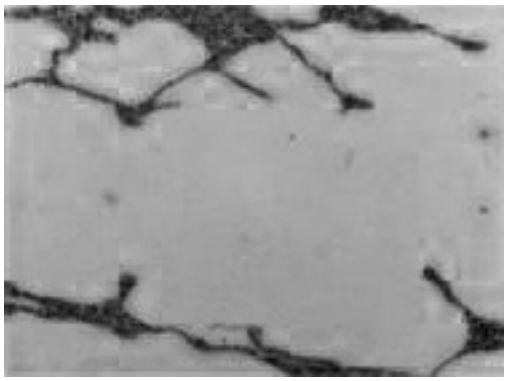
A. Antibodies are pathogenic foreign substances.

B. Antibodies are produced by the bone marrow.

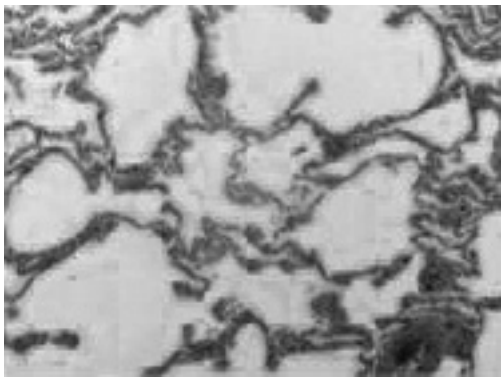
C. Antibodies are composed of polypeptides.

D. Antibodies kill bacteria but not viruses.

27. Emphysema is a long-term, progressive disease that causes shortness of breath. The electron micrographs show the alveoli of a patient with emphysema and the alveoli of a normal person.



Emphysema (magnification × 200)



Normal lung (magnification × 200)

[Source: adapted from www.health-pic.com]

What can be observed in the alveoli of a person suffering from emphysema?

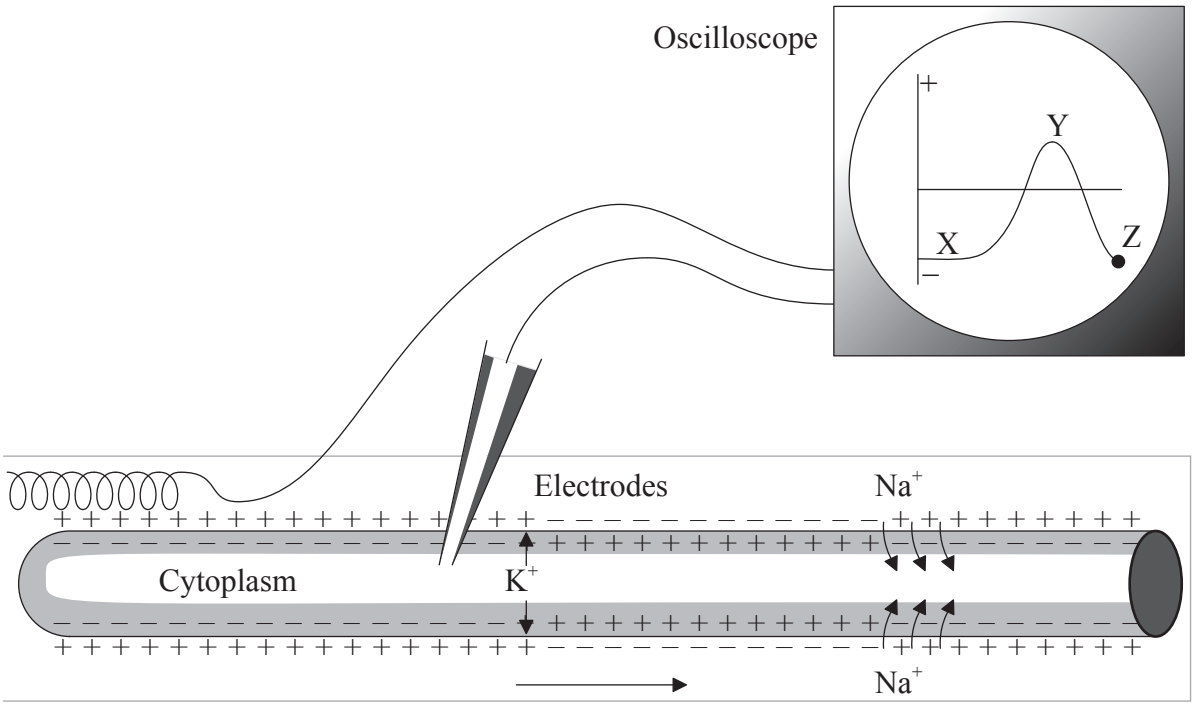
A. Large surface area, large air spaces and many capillaries

B. Small surface area, large air spaces and few capillaries

C. Small surface area, small air spaces and few capillaries

D. Large surface area, small air spaces and many capillaries

28. The diagram shows the results obtained with an oscilloscope attached to a neuron.



[Source: adapted from www.topbiomedical.com/2007/08/action-potential.html]

Why is the change in the oscilloscope occurring between X and Y?

A. Hyperpolarization

B. Hypopolarization

C. Repolarization

D. Depolarization

29. Which hormone triggers ovulation?

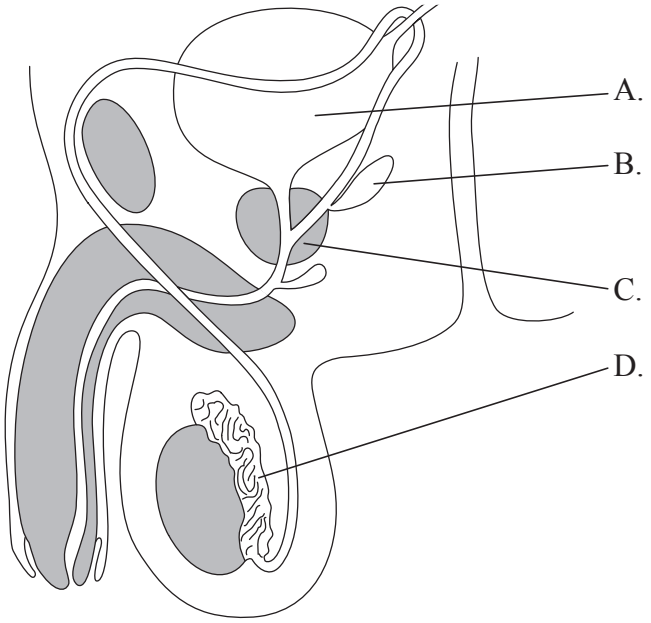
A. FSH

B. Testosterone

C. Progesterone

D. LH

30. The diagram shows a section through the male reproductive system. Where are sperm stored?



SPEC/4/BIOLO/SPM/ENG/TZ0/XX/M

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MARKSCHEME

SPECIMEN PAPER

BIOLOGY

Standard Level

Paper 1

2 pages

1.	D	16.	A	31.	–	46.	–
2.	A	17.	B	32.	–	47.	–
3.	C	18.	C	33.	–	48.	–
4.	C	19.	B	34.	–	49.	–
5.	C	20.	C	35.	–	50.	–
6.	C	21.	C	36.	–	51.	–
7.	A	22.	D	37.	–	52.	–
8.	D	23.	A	38.	–	53.	–
9.	B	24.	B	39.	–	54.	–
10.	C	25.	C	40.	–	55.	–
11.	C	26.	C	41.	–	56.	–
12.	C	27.	B	42.	–	57.	–
13.	B	28.	D	43.	–	58.	–
14.	A	29.	D	44.	–	59.	–
15.	A	30.	D	45.	–	60.	–

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BIOLOGY
STANDARD LEVEL
PAPER 2

Candidate session number

SPECIMEN PAPER

Examination code

1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[50 marks]*.

20 pages

SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

1. Large areas in northern Indiana (USA) are used for the cultivation of corn (*Zea mays*). Headwater streams are water bodies that drain the land and merge to form larger rivers.

Ecologists asked questions after the introduction of genetically modified *Bt* corn varieties:

- does organic debris from fields of genetically modified corn enter headwater streams?
- are there any effects on stream life?

To try to answer these questions, a group of researchers took measurements from twelve headwater streams in Indiana and carried out laboratory experiments. Corn crops were growing on both sides of each of the streams.

After the corn was harvested, traps were used to measure the amount of corn leaves, cobs and pollen entering the streams. The results are shown in the table.

Stream	Leaf and cob inputs / $g\,m^{-2}\,y^{-1}$	Pollen inputs / $g\,m^{-2}\,y^{-1}$
1A	0.1	0.03
1B	1.3	0.73
1C	0.7	0.09
1D	3.4	0.39
1E	1.5	0.59
1F	8.2	0.16
2A	3.0	1.05
2B	0.0	0.27
2C	0.2	0.37
2D	0.3	0.24
2E	0.6	0.31
2F	0.9	0.38

[Source: adapted from Rosi-Marshall, *et al.*, (2007), *Proceedings of the National Academy of Sciences*, **104**, pages 16204–16208.

(This question continues on the following page)

(Question 1 continued)

(a) Identify the stream with the highest total input of organic debris from corn crops. *[1]*

. . . . . .

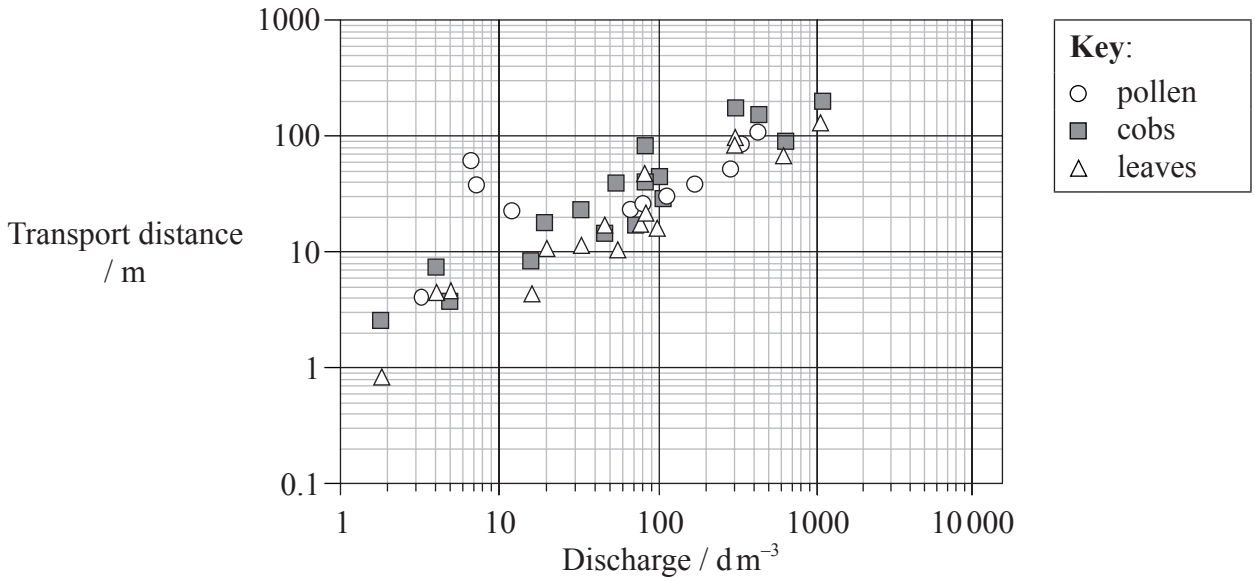
(b) Determine, with a reason, whether the data in the table supports the hypothesis that the inputs of leaves and cobs to streams is always greater than the input of pollen. *[1]*

. . . . . .
. . . . . .

(This question continues on the following page)

(Question 1 continued)

Leaves, cobs and pollen were stained with a pigment and then released into the streams to find the average transport distance. The volume of water flowing in the streams (discharge) was also measured. The results are shown in the graph.



[Source: adapted from Rosi-Marshall, *et al.*, (2007), *Proceedings of the National Academy of Sciences*, **104**, pages 16204–16208. Copyright (2007) National Academy of Sciences, U.S.A.]

(c) Estimate the maximum transport distance for cobs. *[1]*

. . . . . .

(d) State the relationship between discharge rates and transport distance for debris from the corn crop. *[1]*

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(This question continues on the following page)

(Question 1 continued)

(e) Distinguish between the transport distance of cobs and leaves. *[2]*

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(This question continues on the following page)

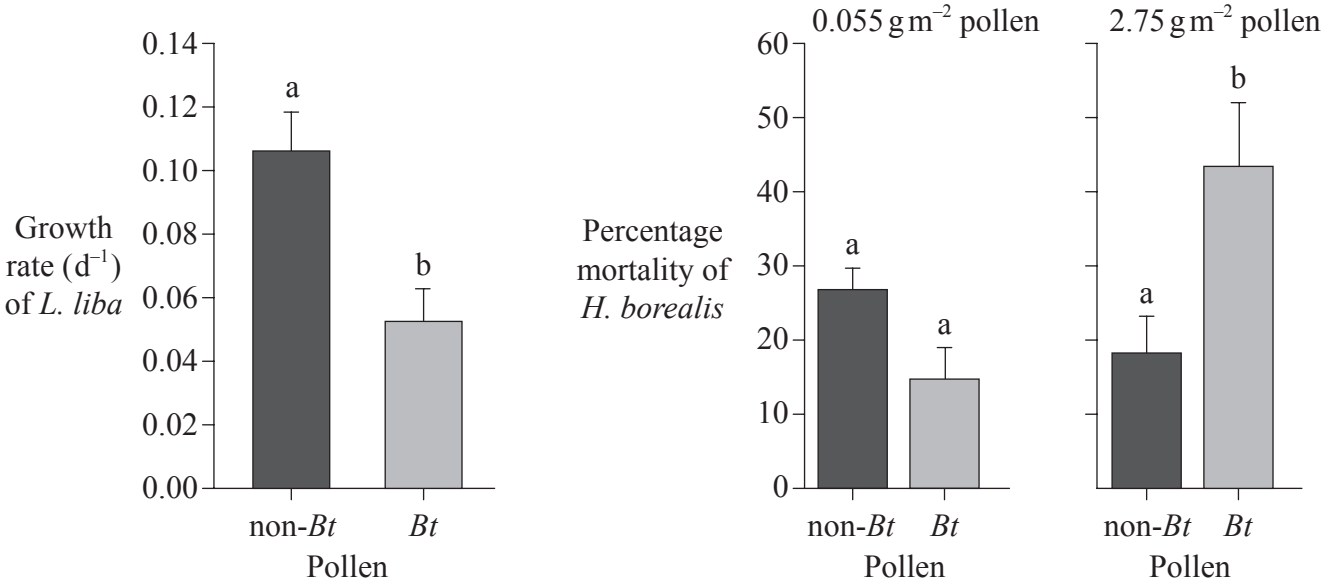
(Question 1 continued)

Larvae of caddis flies were observed in parts of the headwater streams where organic debris from corn crops had accumulated. Laboratory experiments were performed to try to find out if these larvae could be affected by consuming debris from *Bt* corn.

Lepidostoma liba is a caddis fly that feeds by shredding dead plant matter. The growth rate of *L. liba* was measured when it was fed on leaves from *Bt* corn and non-*Bt* corn. *Helicopsyche borealis* is a caddis fly that feeds by scraping algae surfaces. The mortality rate of *H. borealis* was measured when it fed on biofilms of algae containing *Bt* pollen or non-*Bt* pollen.

Two concentrations of pollen were tested. One concentration ($0.055\,g\,m^{-2}$) was based on the maximum observed daily pollen input rate to streams. The other concentration was 50 times higher ($2.75\,g\,m^{-2}$).

The results are shown in the bar charts. Statistically significant differences between non-*Bt* pollen and *Bt* pollen in each bar chart are indicated by different letters on error bars.



[Source: adapted from Rosi-Marshall, *et al.*, (2007), *Proceedings of the National Academy of Sciences*, **104**, pages 16204–16208. Copyright (2007) National Academy of Sciences, U.S.A.]

(This question continues on the following page)

(Question 1 continued)

(f) Using the data in the bar charts, evaluate the effects of the *Bt* pollen on caddis flies. *[3]*

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The research described in this question was strongly criticized soon after it was published by some other biologists and by the company that produced *Bt* varieties of crop plants. In particular there were objections to a statement in the research paper that "Widespread planting of *Bt* crops has unexpected ecosystem-scale consequences".

(g) Discuss whether this statement in the research paper was justified, based on the methods used in the research and the data obtained. *[3]*

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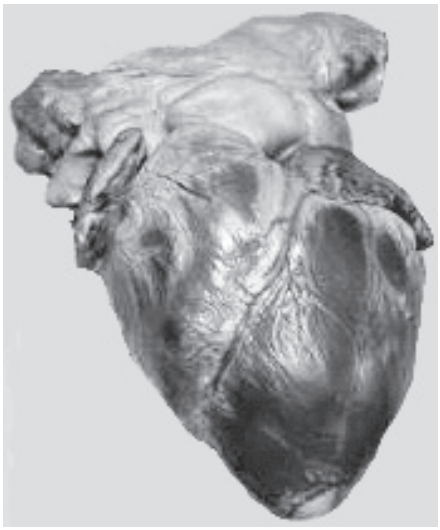
2. The photograph shows a heart, viewed from the ventral side.



(a) Label the photograph to show the position of

- the right ventricle
- the left atrium
- a coronary blood vessel. *[3]*

(b) Outline **two** ways the body uses to increase the heart rate. *[2]*

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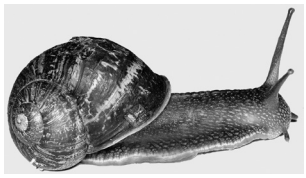
Please **do not** write on this page.

Answers written on this page
will not be marked.

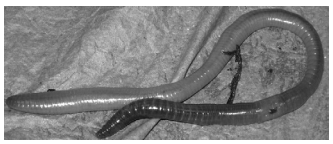
3. The photographs show different organisms (not to scale).

Hadronyche modesta

Cardisoma armatum



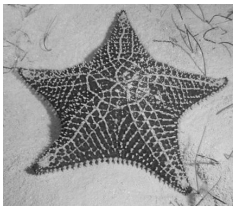
Helix aspersa



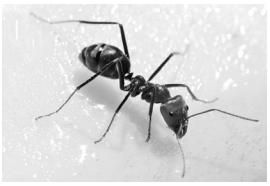
Lumbricus terrestris

Pteridium aquilinum

Zalophus wollebaeki



Oreaster reticulatus



Iridomyrmex purpureus

Helianthus annuus

(a) Deduce all of the organisms that belong to each of the following phyla. *[3]*

Filicinophyta:

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Arthropoda:

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Mollusca:

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(This question continues on the following page)

(Question 3 continued)

(b) Explain how scientists avoid confusion over the names of living organisms. *[3]*

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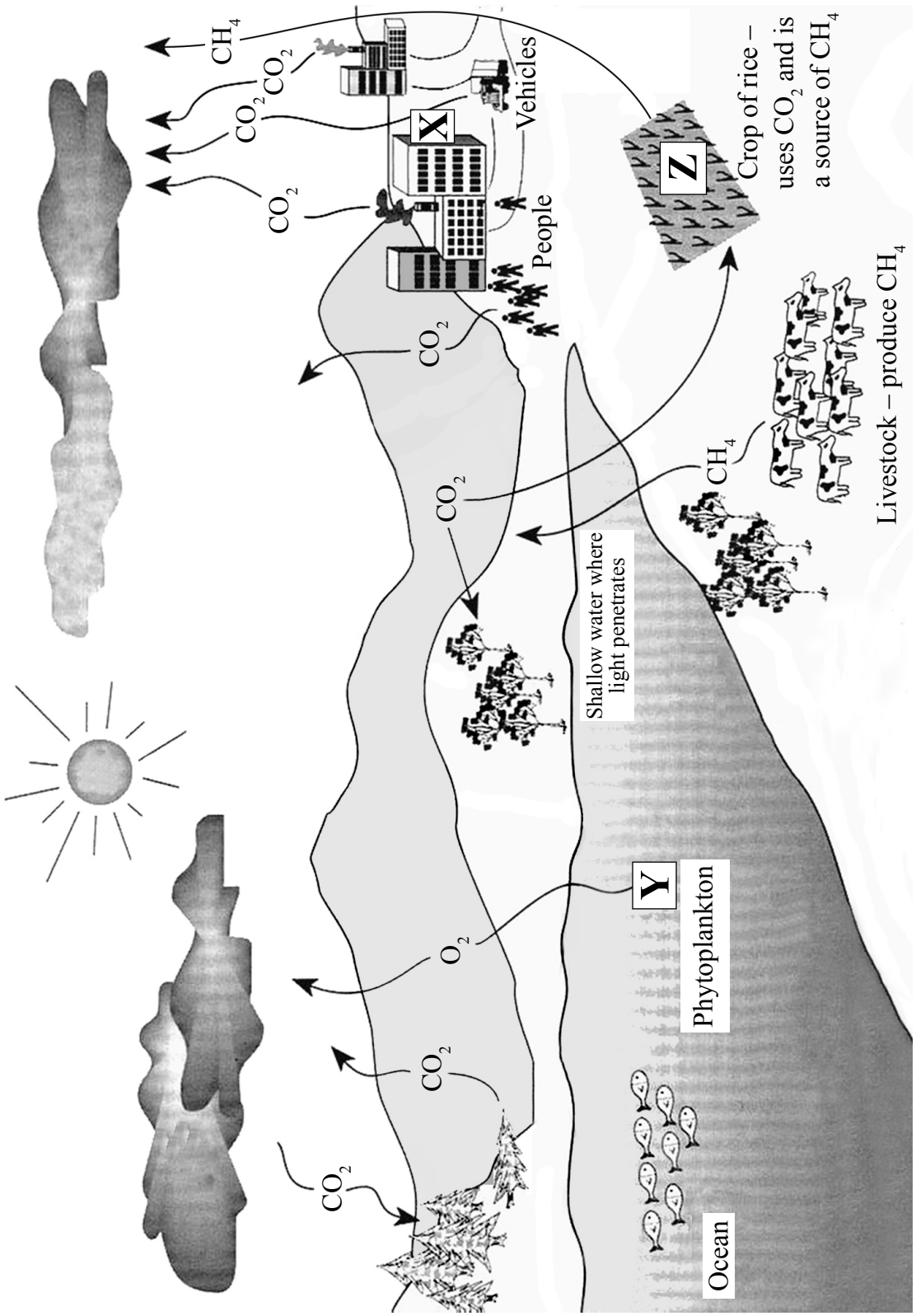
4. The diagram shows the carbon cycle.



[Source: adapted from www-das.uwyo.edu/~geerts/cwx/notes/chap01/carbon_cycle.jpeg]

(This question continues on the following page)

(Question 4 continued)

(a) State the processes occurring at X and Y. *[2]*

X: . . . . . .

Y: . . . . . .

(b) Predict the conditions that would increase the release of methane shown at Z. *[2]*

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(c) Outline the impact of the gases shown in the diagram on the greenhouse effect. *[2]*

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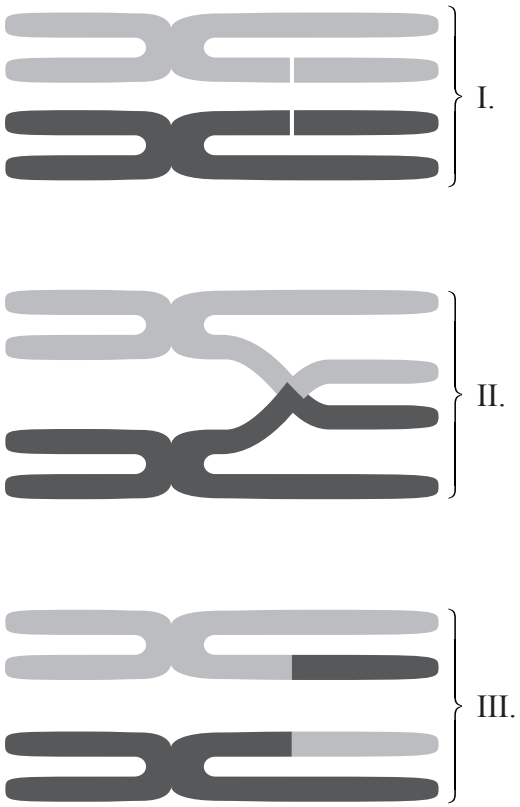
5. The diagrams show two chromosomes at three stages in meiosis.



(a) The diagrams show a process that promotes genetic variation. Describe this process. *[3]*

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(This question continues on the following page)

(Question 5 continued)

(b) State the type of life-cycle that includes meiosis and the reason for it being needed in this type of life-cycle. *[2]*

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SECTION B

*Answer **one** question. Up to [1] additional mark is available for the quality of your answer.*

6. Antibiotics can be used to treat bacterial infections in human tissues because of differences in cell structure between prokaryotes and eukaryotes.

(a) Distinguish between the structure of prokaryotes and eukaryotes. *[8]*

(b) Evaluate the drug tests that Florey and Chain carried out on penicillin. *[3]*

(c) Explain the reasons for the ineffectiveness of antibiotics in the treatment of viral diseases. *[4]*

7. Humans need a supply of energy for processes such as active transport in cells.

(a) Explain how humans release energy from digested foods to make it available for processes in cells. *[7]*

(b) Describe **one** example that occurs in axons for each of the following

- active transport
- and facilitated diffusion. *[5]*

(c) Outline how biologists can ensure that research into energy release involving animals is ethically acceptable. *[3]*

SPEC/4/BIOLO/SP2/ENG/TZ0/XX/M

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MARKSCHEME

SPECIMEN PAPER 2016

BIOLOGY

Standard Level

Paper 2

13 pages

Subject Details: Biology SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A and **ONE** out of **TWO** questions in Section B. Maximum total = **[50 marks]**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (/). Either wording can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***" on the line between the alternatives. Either answer can be accepted.

7. Words in angled brackets ‹ › in the "Answers" column are not necessary to gain the mark.

8. Words that are <u>underlined</u> are essential for the mark.

9. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

10. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded.
When marking, indicate this by adding **ECF** (error carried forward) on the script. "ECF acceptable" will be displayed in the "Notes" column.

13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

Section B

Extended response questions - quality of construction

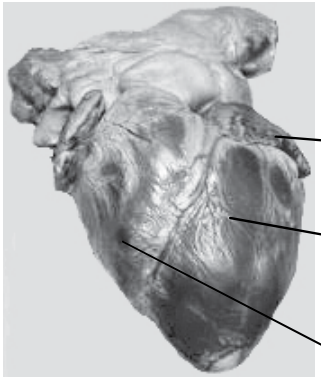
- Extended response questions for SLP2 carry a mark total of ***[16]***. Of these marks, ***[15]*** are awarded for content and ***[1]*** for the quality of the answer.
- ***[1]*** quality mark is to be awarded when:
  - the candidate's answers are clear enough to be understood without re-reading
  - the candidate has answered the question succinctly with little or no repetition or irrelevant material.
- It is important to judge this on the overall answer, taking into account the answers to all parts of the question. Although, the part with the largest number of marks is likely to provide the most evidence.
- Candidates that score very highly on the content marks need not necessarily automatically gain ***[1]*** mark for quality (and *vice versa*).

SECTION A

Question			Marking point	Answers	Notes	Total
1.	**a**			1F ✓		**1**
	b			does not support it because pollen input higher in 2B/2C ✓		**1**
	c			200 m ✓	*Accept answer in the range of 150 m to 250 m, wide range allowed because of logarithmic scale.*	**1**
	d			positive correlation ***OR*** the higher the discharge rate the further the transport distance ✓		**1**
	e		***a***	cobs transported further ✓		**2 max**
			b	for a given discharge rate ✓		
			c	minimum/maximum distance lower for leaves ‹than cobs› ✓	*Accept converse.*	
	f		***a***	the growth rate was lower with *Bt* pollen ‹than non-*Bt*› ✓		**3**
			b	no significant difference in mortality at 0.055 g m^{-2} pollen ✓		
			c	‹significantly› higher mortality with *Bt* than non-*Bt* pollen at 2.75 g m^{-2} pollen ✓		

(Question 1 continued)

Question			Marking point	Answers	Notes	Total
	g		***a***	*Bt* pollen reduced growth rate ‹in *L. liba*› ✓		**3 max**
			b	*Bt* pollen/cobs/leaves are transported in streams ✓		
			c	*Bt* pollen did not increase mortality at the maximum observed daily pollen input rate ✓		
			d	harmful consequences of *Bt* crops not shown in natural ecosystems ✓		
			e	harmful consequences only shown in lab experiments ✓		
			f	ecosystems much more complex than lab systems ✓		

Question			Marking point	Answers	Notes	Total
2.	**a**			 left atrium coronary blood vessel right ventricle		**3**
			a	ventricle to left of main coronary vessel labelled as right ventricle ✓		
			b	left atrium ‹mid-upper right› clearly labelled ✓		
			c	main coronary vessel or one of its branches labelled ✓		
	b		***a***	impulses from the medulla carried by a nerve ✓		**2**
			b	epinephrine ✓		

Question			Marking point	Answers	Notes	Total
3.	**a**		***a***	*Filicinophyta*: *Pteridium aquilinum* only ✓		**3**
			b	*Arthropoda*: *Hadronyche modesta, Cardisoma armatum* and *Iridomyrmex purpureus* only ✓		
			c	*Mollusca*: *Helix aspersa* only ✓		
	b		***a***	use binomials ✓		**3 max**
			b	international system of names ✓		
			c	agreed at congresses ✓		
			d	local names not used as too variable ✓		
4.	**a**		***a***	*X*: combustion ✓		**2**
			b	*Y*: photosynthesis ✓		
	b		***a***	anaerobic ✓		**2 max**
			b	warm ✓		
			c	presence of the methanogenic bacteria ✓		
			d	waterlogged ✓		
	c		***a***	CO_2 is the main greenhouse gas ✓		**2**
			b	methane contributes to the greenhouse effect ✓		

Question			Marking point	Answers	Notes	Total
5	a		*a*	crossing over ✓		3
			b	mutual exchange between ‹non-sister› chromatids ✓		
			c	breakage and rejoining of DNA molecules ✓		
	b		*a*	sexual life-cycle ✓		2
			b	producing gametes without doubling the ‹chromosome› number in the ‹zygote› ***OR*** conserving chromosome number ✓		

SECTION B

Clarity of communication*: *[1]

The candidate's answers are clear enough to be understood without re-reading. The candidate has answered the question succinctly with little or no repetition or irrelevant material.

Question			Marking point	Answers	Notes	Total
6.	**a**		***a***	simpler cell structure in prokaryotes ✓		**8 max**
			b	no compartmentalizing in prokaryotes ✓		
			c	DNA associated with histones in eukaryotes ✓		
			d	naked DNA in ‹most› prokaryotes ✓		
			e	nucleus in eukaryotes but not prokaryotes ✓		
			f	nucleoid in prokaryotes ✓		
			g	mitochondria in eukaryotes but not in prokaryotes ✓		
			h	ribosomes are smaller in prokaryotes ✓		
			i	70S versus 80S ribosomes ✓		
			j	chloroplasts/Golgi/ER/lysosomes in eukaryotes but not in prokaryotes ✓		
			k	cell wall in prokaryotes but only in some eukaryotes ✓		
			l	loop of DNA in prokaryotes ✓		
			m	linear chromosomes in eukaryotes ✓		

(Question 6 continued)

Question			Marking point	Answers	Notes	Total
	b		***a***	tested penicillin on mice before testing on humans ✓		**3 max**
			b	only one test before risking use in humans ✓		
			c	results of the test were very clear ✓		
			d	first humans given penicillin were close to death ✓		
			e	initial samples of penicillin were very impure ✓		
			f	could have been toxic substances in the samples ✓		

	c		***a***	antibiotics are effective against bacterial diseases because they block metabolic pathways ✓		**4 max**
			b	no/very little viral metabolism ✓		
			c	few/no viral enzymes ✓		
			d	virus uses host cell metabolism/processes ✓		
			e	any chemical that stops the virus from reproducing would also harm the host cells ✓		

*(Plus up to **[1]** for quality)*

Question			Marking point	Answers	Notes	Total
7.	a		***a***	‹cell› respiration ✓		**7 max**
			b	controlled release of energy ✓		
			c	energy released from organic compounds/foods ✓		
			d	carbohydrates/glucose/fats/lipids provide energy ✓		
			e	blood carries foods/organic compounds to cells ✓		
			f	aerobic respiration involves use of oxygen ✓		
			g	anaerobic respiration involves production of lactate/lactic acid ✓		
			h	energy from respiration is in the form of ATP ✓		
			i	more ATP ‹per glucose› from aerobic than anaerobic respiration ✓		
			j	carbon dioxide produced by aerobic respiration ✓		
			k	aerobic respiration involves the mitochondrion ✓		
			l	ATP in the cell moves/diffuses through the cytoplasm to the pumps for active transport ✓		
	b		***a***	sodium-potassium pump ✓		**5 max**
			b	sodium pumped out and potassium pumped in ✓		
			c	energy supplied to pump as ATP ✓		
			d	potassium channel for facilitated diffusion ***OR*** K^+ channel allows potassium to diffuse out ✓		
			e	pore through channel protein allows only K^+ ions to pass through ✓		

(Question 7 continued)

Question			Marking point	Answers	Notes	Total
	c		***a***	only use animals if other methods are impossible ✓		**3 max**
			b	only use animals if the research is important enough to justify it ✓		
			c	avoid any procedures that cause suffering to animals ✓		
			d	do not use animals taken from the wild ✓		
			e	use anesthetics/painkillers to prevent suffering ✓		

*(Plus up to **[1]** for quality)*

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BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate session number

SPECIMEN PAPER

Examination code

1 hour

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all of the questions from one of the options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[35 marks]*.

Option	Questions
Option A — Neurobiology and behaviour	4 – 7
Option B — Biotechnology and bioinformatics	8 – 11
Option C — Ecology and conservation	12 – 15
Option D — Human physiology	16 – 18

Please **do not** write on this page.

Answers written on this page
will not be marked.

SECTION A

1. Photosynthesis rates were determined in young kerosene trees (*Copaifera langsdorffii*) under sunny or shaded conditions and in dry or rainy conditions.

	Dry conditions		**Rainy conditions**	
	Sun	**Shade**	**Sun**	**Shade**
Light intensity / mol photons m^{-2} day^{-1}	51.0	5.5	58.7	2.8
Net photosynthesis / mol CO_2 m^{-2} day^{-1}	101.6	36.1	285.4	62.4

[Source: adapted from C C Ronquin, *et al.*, (2009), *Brazilian Journal of Plant Physiology*, **21** (3), pages 197–208]

(a) Using the table, identify the conditions that result in the highest rate of photosynthesis. *[1]*

. . . . . .

(b) Suggest which factor is limiting photosynthesis in young kerosene trees that were in rainy conditions in the sun. *[1]*

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(c) Describe a method for measuring the rate of photosynthesis in aquatic plants. *[3]*

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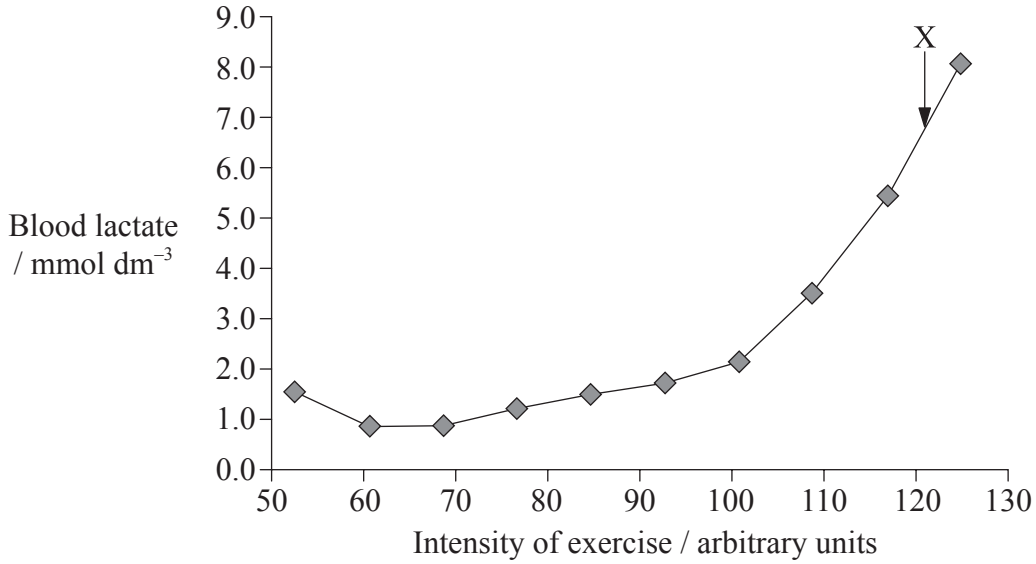
2. A study was undertaken to observe physiological responses to different levels of exercise. The graph shows the relationship between intensity of exercise and the concentration of lactate in blood.



[Source: R Ramsbottom, *et al*., (1989), *British Journal of Sports Medicine*, **23** (3), pages 171–176]

(a) Outline the relationship between exercise intensity and levels of lactate in the blood. *[2]*

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(b) Identify the type of cellular respiration carried out by the muscle cells at X. *[1]*

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(This question continues on the following page)

(Question 2 continued)

(c) Explain how lactate production is used to maximize the power of muscle contraction. *[3]*

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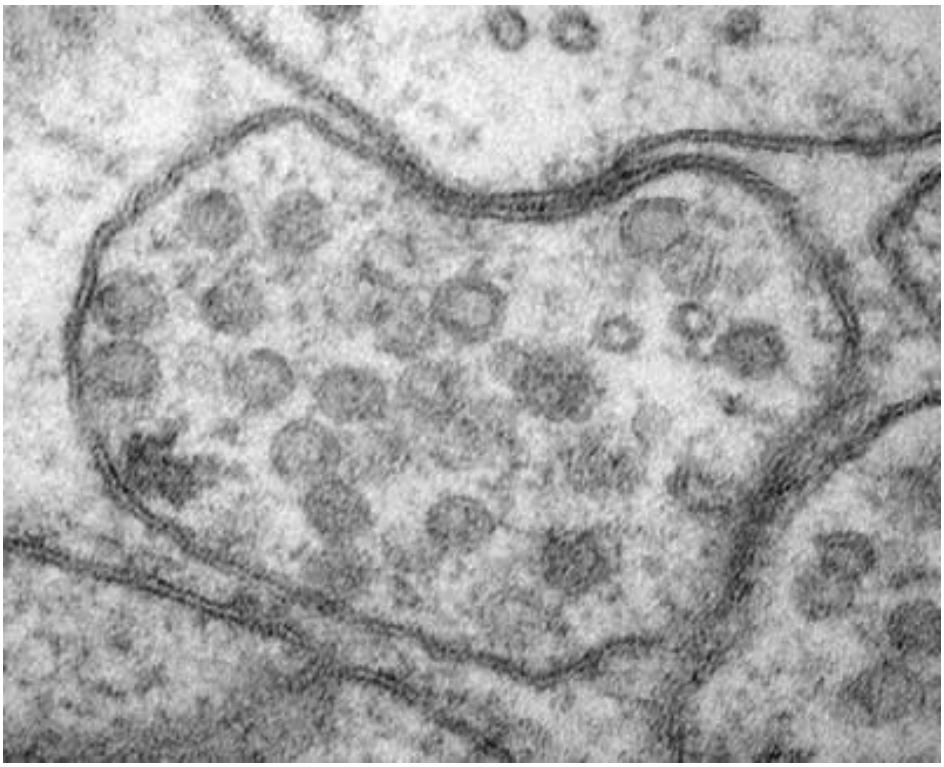
3. The electron micrograph shows a section through a neuron (nerve cell).



[Source: adapted from www.research.utah.edu/advanced-microscopy/_images/content/education/electron-micro/junction.jpg]

(a) Calculate the magnification of the electron micrograph. *[2]*

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(This question continues on the following page)

(Question 3 continued)

(b) Suggest how images of this type led to Davson–Danielli model of membrane structure. *[2]*

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SECTION B

Option A — Neurobiology and behaviour

4. A study was undertaken to evaluate the effectiveness of cochlear implants and hearing aids at improving the understanding of 100 abstract words such as "hope" and "trust" in pre-school children. The study involved ten deaf children with cochlear implantation, ten deaf children with hearing aids and ten children with normal hearing (control). The table shows the level of understanding of the 100 words expressed as a percentage. The initial understanding of abstract words by the deaf children was minimal.

Group	Percentage of words understood
Control	77.9
Cochlear implant	26.8
Hearing aid	20.3

[Source: adapted from S Ostojić, *et al*., (2011), *Vojnosanit Pregl*, **68**, pages 349–352]

(a) Compare and contrast the understanding of the abstract words in the three groups. *[2]*

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(b) Describe the type of hearing problems that are treated by cochlear implants. *[2]*

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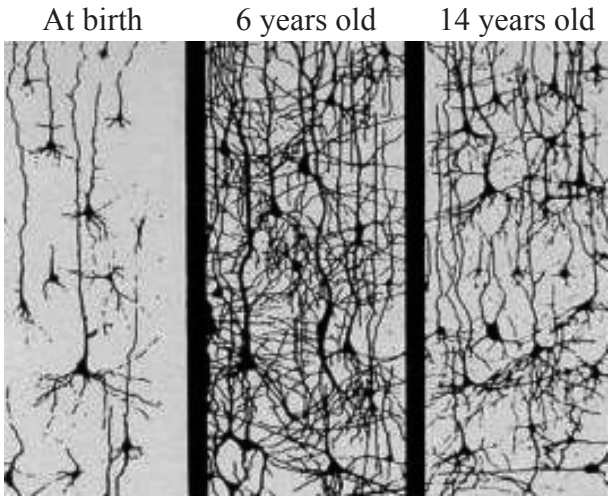
(Option A continues on the following page)

(Option A continued)

5. The images show neurons in the cerebral hemispheres at three stages of human development.



(a) Distinguish between the neural density at 6 years old and 14 years old. *[1]*

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(b) Outline the concept of neuroplasticity. *[3]*

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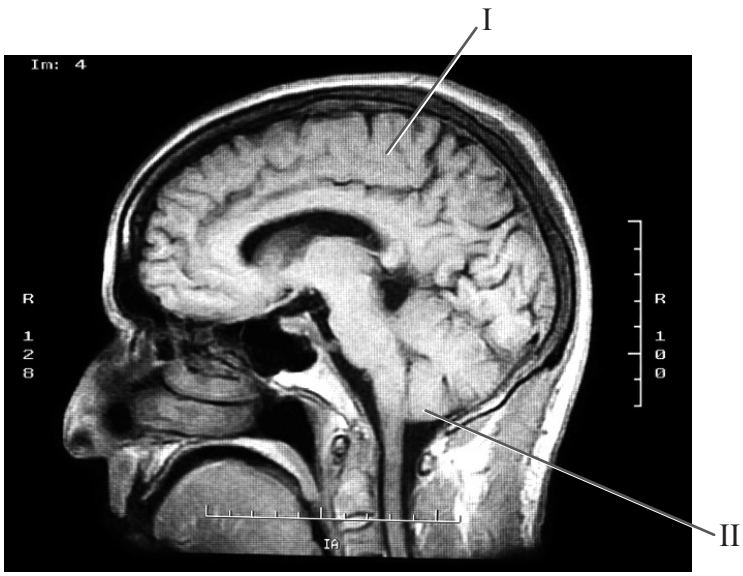
(Option A continues on the following page)

(Option A continued)

6. The image is of the human brain.



[Source: www.npr.org/blogs/health/2012/10/16/162997951/teenage-brains-are-malleable-and-vulnerable-researchers-say]

(a) Identify the parts labelled I and II. *[2]*

I. . . . . .

II. . . . . .

(b) Brain death is a clinical diagnosis based on the absence of neurological function, with a known irreversible cause of coma. Explain a **named** method to assess brain damage. *[2]*

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(Option A continues on the following page)

(Option A, question 6 continued)

(c) Photoreceptors detect light. List **two** other receptors and the stimulus that each detects. *[2]*

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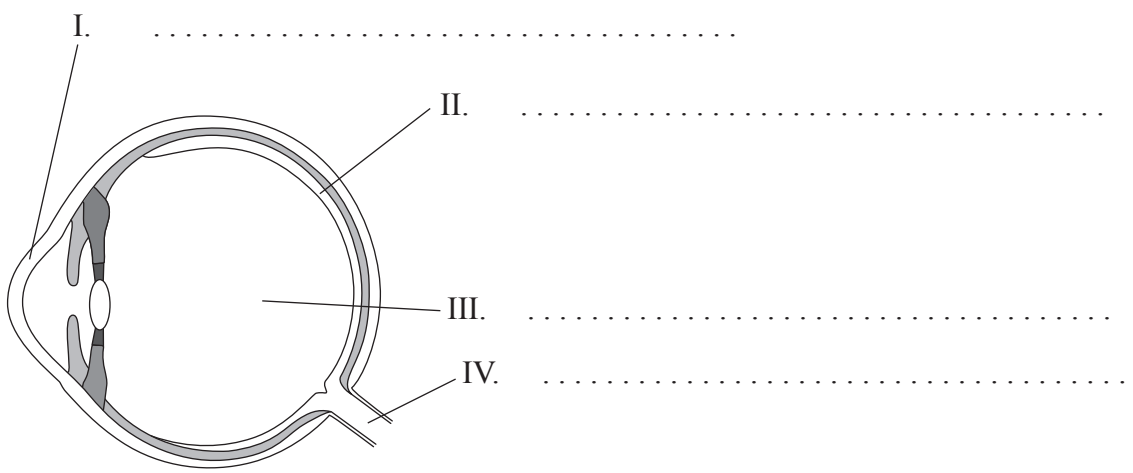
(Option A continues on the following page)

(Option A continued)

7. (a) Label the diagram of the human eye. *[2]*



(b) Compare and contrast the functions of the rod and cone cells in the human retina. *[4]*

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End of Option A

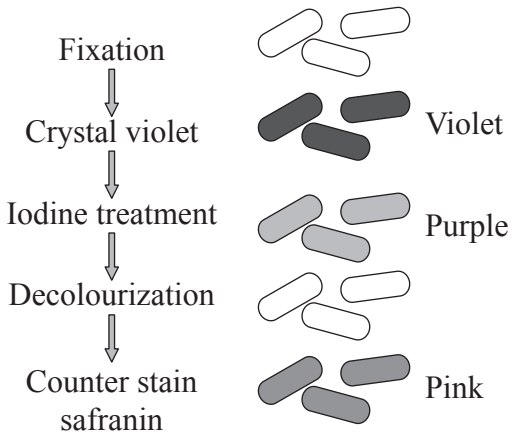
Please **do not** write on this page.

Answers written on this page
will not be marked.

Option B — Biotechnology and bioinformatics

8. (a) Explain how nutrient levels affect the production of penicillin in a fermenter. *[3]*

(b) The diagram represents the outcome of a Gram staining procedure.



[Source: adapted from http://pathmicro.med.sc.edu/fox/gram-st.jpg]

(i) Outline what must be done during the fixation stage. *[2]*

(Option B continues on the following page)

(Option B, question 8 continued)

(ii) Deduce, with a reason, what type of bacterium is represented in the diagram. *[2]*

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(Option B continues on the following page)

(Option B continued)

9. (a) In order to produce a transgenic organism, other types of sequences need to be inserted into the host genome in addition to the target gene. List **two** examples of other types of sequences that have to be inserted. *[2]*

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(b) The company BASF produces a genetically modified potato called Amflora. Outline the purpose of modifying the potato. *[2]*

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10. A researcher wishes to determine whether the DNA sequence shown could encode a protein.

GCTTCTCAAACGAGAAGTTATGGTGGCAGCAAGTCGTTTGGCTCTTCTGGTGATAGACGAGGCTCCTCATCTTCTGGTACAGAGAA

Outline the process of identifying an open reading frame. *[3]*

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(Option B continues on the following page)

(Option B continued)

11. (a) Explain the use of biofilms in trickle filter beds for sewage treatment. *[3]*

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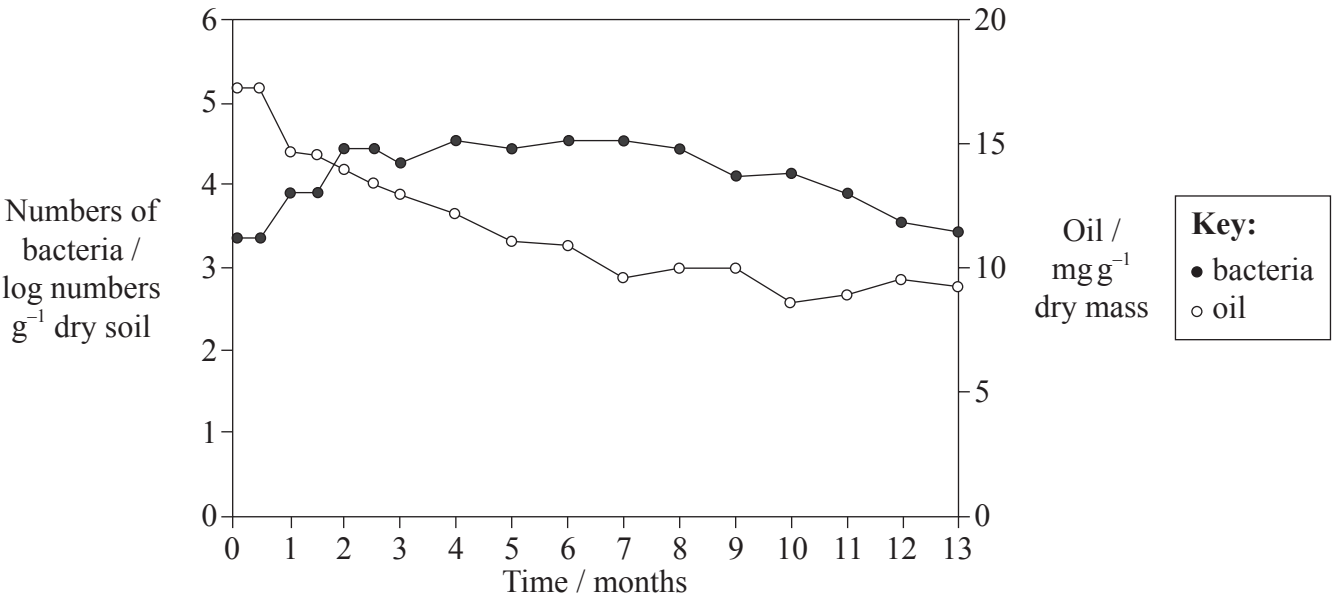
The amount of oil found in a sample of contaminated soil is shown in the graph along with the population levels of an aerobic oil degrading bacterium.



[Source: adapted from www.sciencedirect.com/science/article/pii/S0964830502001026]

(b) (i) Outline the relationship between bacterial population and soil oil content. *[2]*

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(Option B continues on the following page)

(Option B, question 11 continued)

(b) (ii) Suggest why the numbers of bacteria begin to fall towards the end of the study period. *[1]*

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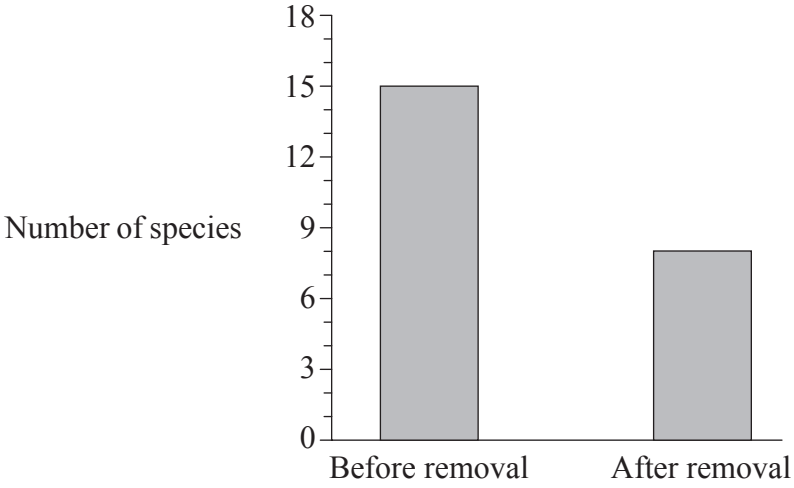
End of Option B

Please **do not** write on this page.

Answers written on this page
will not be marked.

Option C — Ecology and conservation

12. In a study examining the ecological role of keystone species, the sea star, *Pisaster*, was removed from a study area. The sea star is a top carnivore. After an extended period of time, researchers returned to analyse changes in the species diversity in the area. The bar chart shows the species diversity before and after the removal from the habitat.



[Source: adapted from R T Paine, (1966), *The American Naturalist*, **100** (910), pages 65–75]

(a) State the effect of removing the sea star. *[1]*

. . . . . .

(b) (i) Define keystone species. *[1]*

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(Option C continues on the following page)

(Option C, question 12 continued)

(ii) Suggest reasons for the change in species diversity after removal of the sea star. *[3]*

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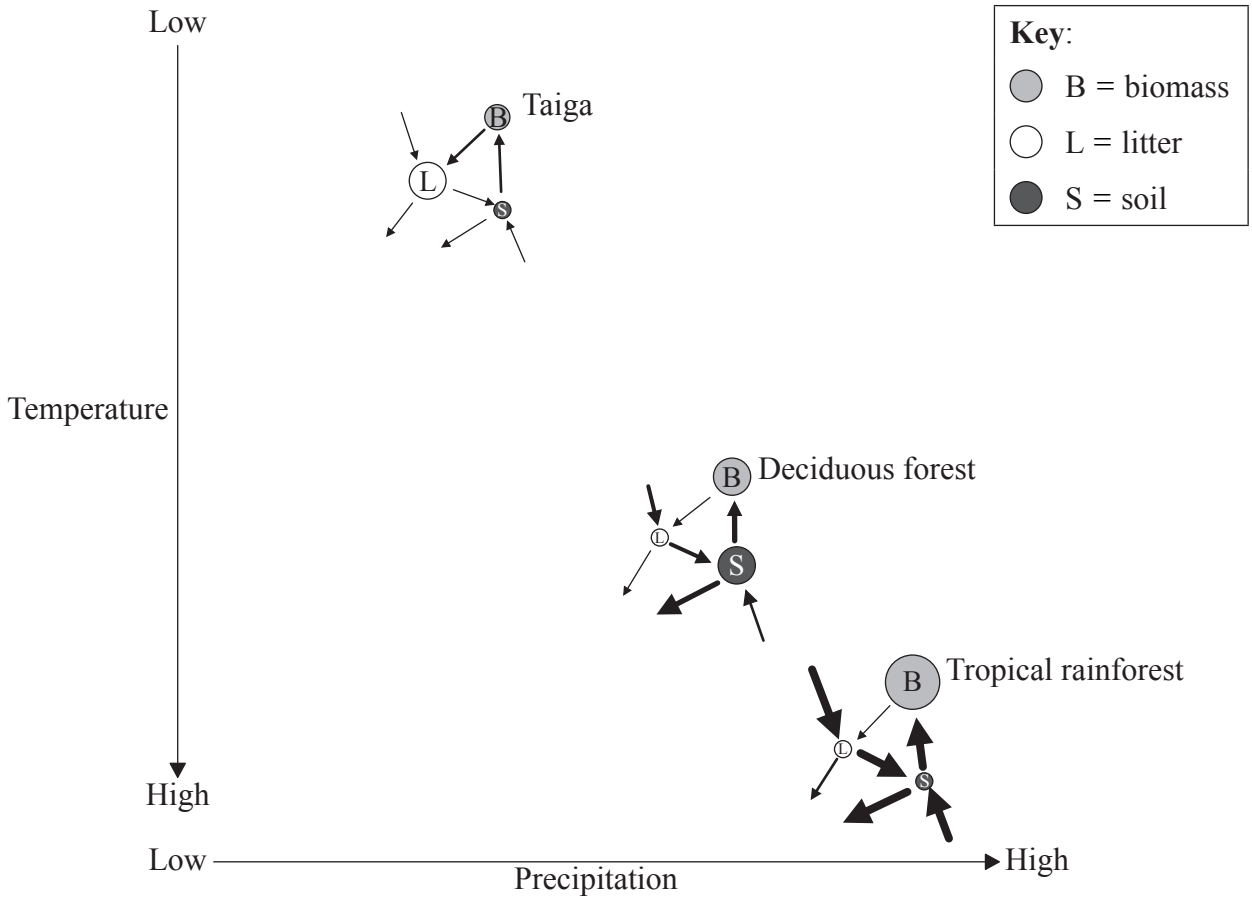
(Option C continues on the following page)

(Option C continued)

13. The model depicted represents the effect of temperature and precipitation on the flow of nutrients within different types of ecosystems. The thickness of the arrow represents the rate of nutrient flow.



[Source: adapted from www.slideshare.net/ecumene/ecosystems-3-nutrient-cycle-presentation]

(a) Identify **one** ecosystem where the litter represents the highest level of nutrient store. *[1]*

. . . . . .

(Option C continues on the following page)

(Option C, question 13 continued)

(b) Deduce what process is indicated by the arrow connecting the litter to the soil. *[1]*

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(c) State the relationship between the level of precipitation and the relative amount of nutrients stored in biomass. *[1]*

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(d) Deduce, with a reason, whether the models assume the ecosystems to be open **or** closed. *[2]*

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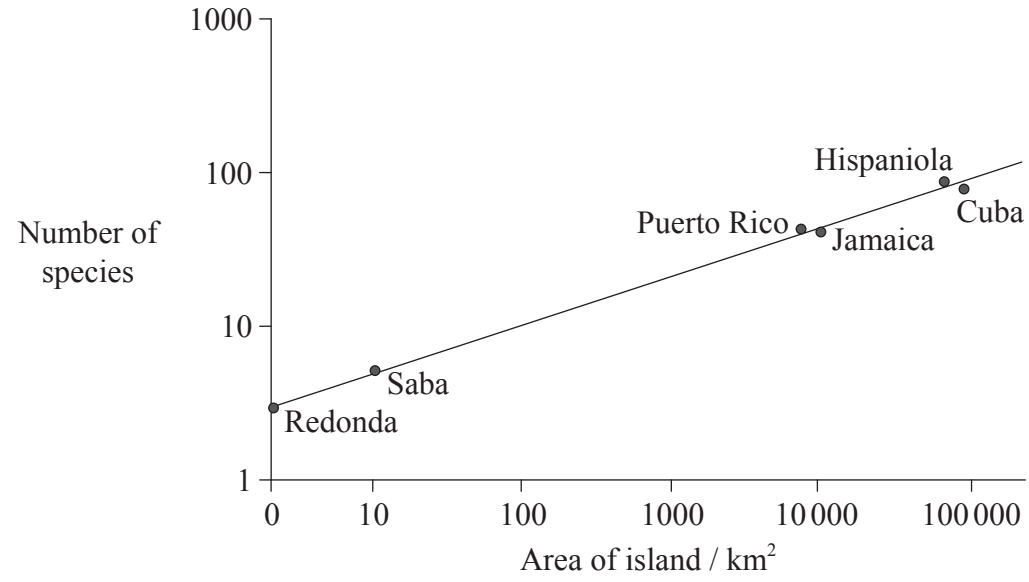
(Option C continues on the following page)

(Option C continued)

14. The graph shows the relationship between island area and reptilian diversity in the West Indies.



[Source: adapted from http://web2.uwindsor.ca/courses/biology/macisaac/55-437/lecture9.htm]

(a) Outline the relationship between island area and the number of reptile species. *[1]*

. . . . . .

. . . . . .

(b) Montserrat has an area of 100 km^2. Predict the number of species of reptile that can be found there. *[1]*

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(Option C continues on the following page)

(Option C, question 14 continued)

(c) Explain how an alien species can become invasive. *[2]*

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(Option C continues on the following page)

(Option C, question 14 continued)

The pollution tolerance rating of some representative stream macroinvertebrates are shown in the table. The higher the value, the more tolerant the individual.

Organism	Pollution tolerance rating	Number found at site
Stonefly	1.5	5
Caddis fly	3.5	1
Mayfly	3.0	4
Scud	4.0	35
Midges	6.0	25

(d) Explain, with reference to this data, how a biotic index is used. *[2]*

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(e) Discuss whether this data is drawn from a polluted stream **or** a relatively pollution free stream. *[2]*

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15. Outline **one** argument in favour of the use of DDT. *[2]*

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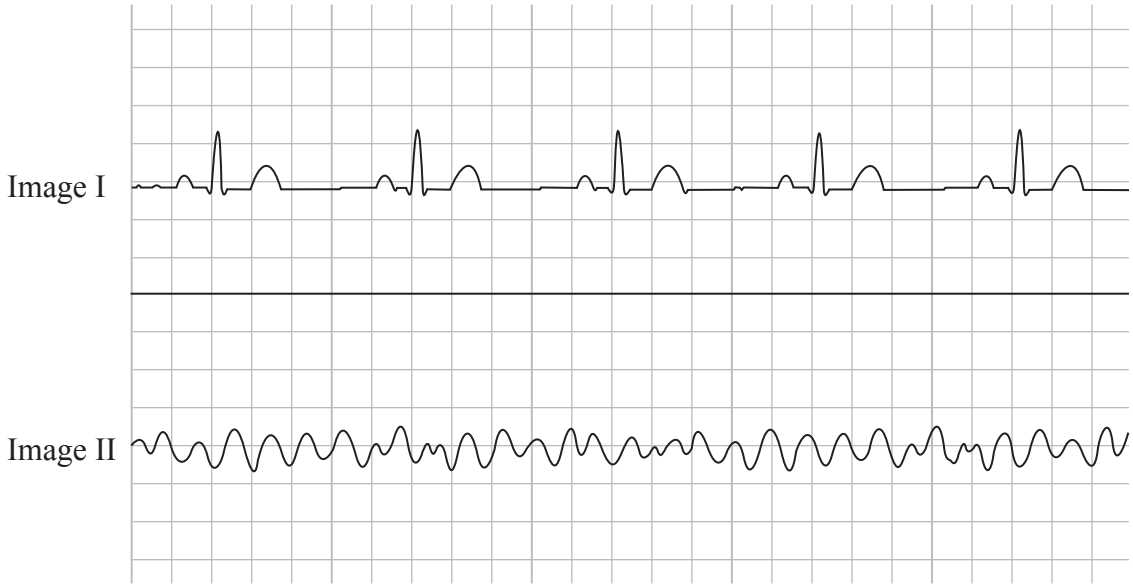
End of Option C

Option D — Human physiology

16. Image I represents a normal heart rhythm and image II represents an abnormal heart rhythm.



[Source: adapted from www.homeheart.co.uk/ecg_example.jpg]

(a) State the name given to the abnormal rhythm pattern. *[1]*

. . . . . .

(b) State a **named** technique used to restore the normal heart rhythm. *[1]*

. . . . . .

(c) Annotate image I to indicate **one** phase where the atrium is contracting and **one** phase where the ventricle is contracting. *[2]*

(Option D continues on the following page)

(Option D, question 16 continued)

(d) State **one** unique characteristic of cardiac muscle cells. *[1]*

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(e) Outline **one** consequence of hypertension on the heart. *[2]*

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(Option D continues on the following page)

(Option D continued)

17. The picture shows a newborn child being tested for phenylketonuria (PKU).

[Source: www.mun.ca/biology/scarr/MGA2-03-02.jpg]

(a) Describe the main cause of PKU. *[2]*

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(b) Suggest why an early detection of this disease is important. *[1]*

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(c) Suggest a possible treatment for a PKU patient. *[1]*

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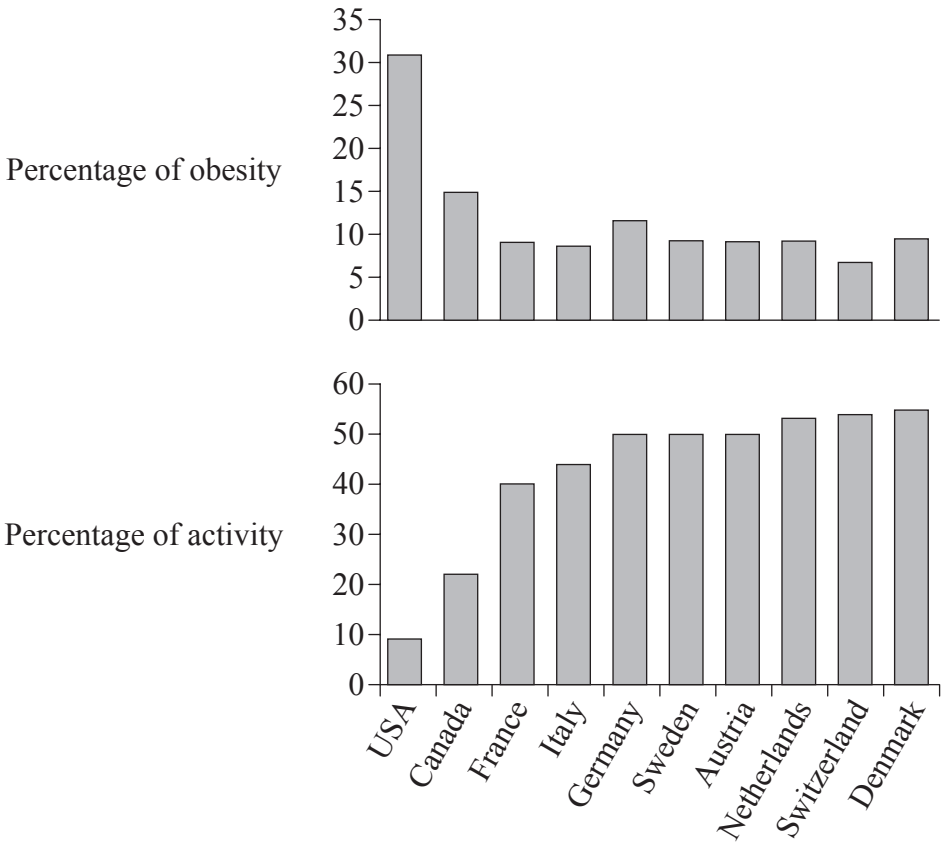
(Option D continues on the following page)

(Option D continued)

18. The bar charts show the percentage of obesity and activity in the populations of different countries.



[Source: adapted from http://noimpactman.typepad.com/blog/2007/10/healthier-plane.html]

(a) Outline, using the bar charts, the relationship between activity and obesity. *[1]*

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(Option D continues on the following page)

(Option D, question 18 continued)

(b) State **two** essential nutrients in the human diet that the body cannot synthesize. *[2]*

1. . . . . .

2. . . . . .

(c) Discuss the implications of sun exposure for human health. *[2]*

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(d) Outline the mechanisms involved in the control of secretion of gastric juices. *[4]*

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End of Option D

SPEC/4/BIOLO/SP3/ENG/TZ0/XX/M

International Baccalaureate®
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MARKSCHEME

SPECIMEN PAPER 2016

BIOLOGY

Standard Level

Paper 3

17 pages

Subject Details: Biology SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A and **ONE** out of **FOUR** questions in Section B. Maximum total = **[35 marks]**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (/). Either wording can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***" on the line between the alternatives. Either answer can be accepted.

7. Words in angled brackets ‹ › in the "Answers" column are not necessary to gain the mark.

8. Words that are <u>underlined</u> are essential for the mark.

9. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

10. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

12. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded.
When marking, indicate this by adding **ECF** (error carried forward) on the script. "ECF acceptable" will be displayed in the "Notes" column.

13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

SECTION A

Question			Marking point	Answers	Notes	Total
1.	**a**			sunny and rainy conditions ✓		**1**
	b			temperature ***OR*** carbon dioxide ✓		**1**
	c		***a***	bubbles indicate that aquatic plant is photosynthesizing ✓		**3 max**
			b	measure oxygen production over a fixed period of time ***OR*** measure rate of oxygen production ✓		
			c	collect bubbles of oxygen ‹from water plant› ✓		
			d	measure volume of bubbles ✓		
			e	use of oxygen sensor probe ✓		

Question			Marking point	Answers	Notes	Total
2.	**a**		***a***	no change ‹in blood lactate› until after 100 ‹units› ✓		**2**
			b	‹blood lactate› increases significantly after 110 ‹units› ✓		
	b			anaerobic ✓		**1**
	c		***a***	ATP needed for muscle contractions ✓		**3max**
			b	‹anaerobic respiration› very rapid ATP production ✓		
			c	not limited to rate of oxygen supply ✓		
			d	lactate neutralizes acidosis ✓		
3.	**a**		***a***	$0.1\,\mu m \equiv 40\,mm$ ✓	*Allow other relevant calculation.*	**2**
			b	$\times 40\,000$ magnification ✓	*Allow ECF.*	
	b		***a***	‹Davson–Danielli model› is the protein ‹lipid› sandwich ✓		**2 max**
			b	it appears as tramlines/two black lines ✓		
			c	proteins stained black and phospholipids unstained ✓		

SECTION B

Option A — Neurobiology and behaviour

Question			Marking point	Answers	Notes	Total
4.	**a**		***a***	both groups of deaf children have a lower understanding than the control group ✓		**2**
			b	higher understanding in the cochlear implant group than in the hearing aid group ✓		
	b		***a***	auditory nerve must be undamaged ✓		**2 max**
			b	‹suitable for› sensory deafness rather than conductively deaf ***OR*** ‹suitable for› defective cochlear hair cells ✓		
			c	‹suitable for› children with worse than mild and moderate hearing ✓		

Question			Marking point	Answers	Notes	Total
5.	**a**			greater neural density at 6 years ✓	*Allow vice versa.*	**1**

	b		***a***	death of neurons that are not used ✓		**3 max**
			b	pruning of synapses that are not used ✓		
			c	strengthening/establishment of new synapses ***OR*** additional neural pathways activated ✓		
			d	nervous system able to change with experience ***OR*** synaptic transmission enhanced by repeated practice ✓		
			e	reassignment of functions to different parts of the brain after injury ✓		

6.	**a**		***a***	I. cerebrum ***OR*** cerebral hemisphere ✓		**2**
			b	II. cerebellum ✓		

	b		***a***	light shone into eyes to test pupil reflex ✓		**2 max**
			b	pupils will constrict in patients without brain death ***OR*** no response by pupils in brain dead patient ✓		
			c	both eyes need to be tested ✓		

	c		***a***	mechanoreceptors detect pressure ✓		**2 max**
			b	chemoreceptors detect dissolved chemicals and changes of pH ✓		
			c	thermoreceptors detect changes in temperature ✓		

Question			Marking point	Answers	Notes	Total
7.	**a**			I. cornea II. retina III. vitreous humour IV. optic nerve ✓	*Award **[1]** for any two correct labels*	**2**

	b					**4 max**

	rod cells	cone cells
a	groups of rod cells share same sensory neuron	cone cells have individual sensory neurons ✓
b	wide field of vision as rod cells widely dispersed through retina	acute vision as cone cells concentrated around fovea ✓
c	function better in dim light as more sensitive	require bright light as less sensitive ✓
d	monochrome vision as all wavelengths of light absorbed	colour vision as either red, blue or green light absorbed ✓
e	both are types of photoreceptor cells located in the retina ✓	
f	both result in the transmission of impulses to the brain via the optic nerve ✓	

Option B — Biotechnology and bioinformatics

Question			Marking point	Answers	Notes	Total
8.	**a**		***a***	*P. notatum*/*Penicillium* produces penicillin ✓		**3 max**
			b	nutrients given to encourage fungal growth ✓		
			c	some metabolites are produced under stress conditions ✓		
			d	as nutrients run out penicillin is produced ✓		
	b	**i**	***a***	heat over flame ✓		**2**
			b	to make bacteria adhere/fix to slide ✓		
	b	**ii**	***a***	Gram-negative ✓		**2**
			b	because it decolorises/stains pink ✓		
9.	**a**		***a***	promoter/regulatory sequences ✓		**2**
			b	marker genes ***OR*** antibiotic resistant genes ✓		

(Question 9 continued)

Question			Marking point	Answers	Notes	Total
	b		***a***	to block production of amylose ✓		**2**
			b	‹amylose› reduces quality of starch for technical applications/polymer formation/paper production ✓		

10.			***a***	an ORF begins with a start codon and ends with one of three stop codons ✓		**3 max**
			b	stop codons occur approximately once in every 20 codons ✓		
			c	if an extended sequence lacks stop codons then it is an ORF candidate ✓		
			d	situation in eukaryotes is more complicated as introns can occur within an ORF ✓		
			e	requires conducting analysis starting at first base, then the second, then the third ✓		

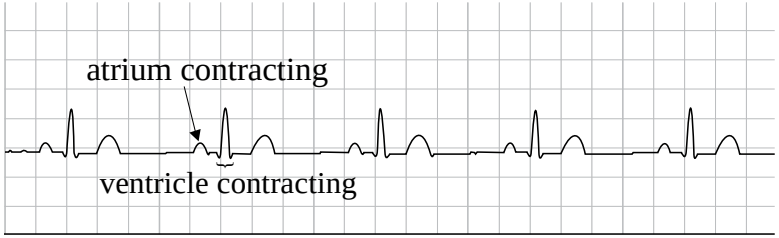
Question			Marking point	Answers	Notes	Total
11.	**a**		***a***	biofilm attaches ‹millions of› bacteria to the solid surfaces in the filter bed ✓		**3 max**
			b	prevents bacteria from being washed away ✓		
				large numbers of bacteria to break down organic matter ✓		
				biolfilm is thin so oxygen diffuses in ✓		
			c	as biofilm increases in thickness, layer closest to bed becomes anaerobic ✓		
	b	**i**	***a***	inverse relationship ✓		**2**
			b	bacterial population falls at the end as oil content stabilizes ✓		
	b	**ii**		lack of ‹other› nutrients/K/P ***OR*** development of unfavourable conditions ✓		**1**

Option C — Ecology and conservation

Question			Marking point	Answers	Notes	Total
12.	**a**			species diversity is reduced ✓		**1**
	b	**i**		a species with a large/disproportionate impact on the community structure ✓		**1**
	b	**ii**	***a***	removal causes disruption of the ecological structure ✓		**3 max**
			b	sea star controls numbers of other predators in the ecosystem ✓		
			c	on removal some organisms are over-predated ✓		
			d	lack of food resources ✓		
			e	migration of individuals out of study area ✓		
13.	**a**			Taiga ✓		**1**
	b			decomposition ✓		**1**
	c			higher level of precipitation, greater amount of nutrients stored as biomass ✓		**1**
	d		***a***	open because there is input and output ***OR*** open because nutrients enter and leave ✓		**2**
			b	flow of energy as well as nutrients and organisms in and out ✓		

Question			Marking point	Answers	Notes	Total
14.	**a**			as island area increases the number of <u>species</u> of reptiles increases ✓	*Species is necessary for the mark to be awarded.*	**1**
	b			10 ✓		**1**
	c		***a***	competitive exclusion ***OR*** native species in the same niche out-competed ✓		**2 max**
			b	rapid/efficient reproduction ✓		
			c	lack of local predators ✓		
			d	causes reduction in local biodiversity ✓		
	d		***a***	uses presence of indicator species and their relative numbers ✓		**2**
			b	in this index, pollution tolerance is multiplied by the number found at the site ✓		
	e		***a***	high numbers of pollution tolerant species such as scud and midges ✓		**2**
			b	low numbers of pollution intolerant species such as stonefly/caddisfly/mayfly ✓		
15.			***a***	DDT is an insecticide ✓		**2**
			b	used to control insect parasites/malaria/dengue fever carrying mosquitoes ✓		

Option D — Human physiology

Question			Marking point	Answers	Notes	Total
16.	**a**			arrhythmia ***OR*** ventricular fibrillation ✓		**1**
	b			defibrillation ✓		**1**
	c			image I 		
			a	atrium contracting correctly marked on image ✓		**2**
			b	ventricle contracting correctly marked on image ✓		
	d			myogenic contractions ***OR*** branched ✓		**1**

(Question 16 continued)

Question			Marking point	Answers	Notes	Total
	e		***a***	increase resistance to blood flow ***OR*** coronary thrombosis ✓		**2 max**
			b	causes increased work by heart ***OR*** may cause heart failure/heart attack ✓		
			c	imbalance of input and output of blood by heart ✓		
			d	may cause systolic and diastolic dysfunction ✓		

17.	**a**		***a***	mutation in gene coding for tyrosine hydroxylase ✓		**2**
			b	phenylalanine in diet cannot be converted to tyrosine so levels rise ✓		
	b			high levels of phenylalanine cause neurological damage ✓		**1**
	c			diet low in phenylalanine ✓		**1**

Question			Marking point	Answers	Notes	Total
18.	**a**			the greater the activity the lesser the obesity ✓		**1**
	b		***a***	minerals ✓		**2 max**
			b	essential amino acids ✓		
			c	essential fatty acids ✓		
			d	vitamin B12 ***OR*** vitamin C ✓		
	c		***a***	needed for production of vitamin D ✓		**2**
			b	exposure to UV rays increases chances of cancer ✓		
	d		***a***	both nervous and hormonal control ✓		**4 max**
			b	gland cells in stomach secrete by reflex action to sight/smell of food ✓		
			c	greater rate of secretion when food reaches stomach due to mechano and chemoreceptors in stomach ✓		
			d	messages sent to gland cells by brain in response to this stimulation ✓		
			e	gland cells stimulated to produce gastrin ✓		
			f	gastrin stimulates gland cells to increase secretion of hydrochloric acid ✓		