International Baccalaureate®
Baccalauréat International
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Biology

Higher and Standard level

Specimen papers 1A, 1B and 2

For first examinations in 2025

CONTENTS

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 1A

Specimen Paper

2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- The maximum mark for paper 1A is **[40 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

0000 – 6001

1. What allows the movement of water under tension in the xylem?

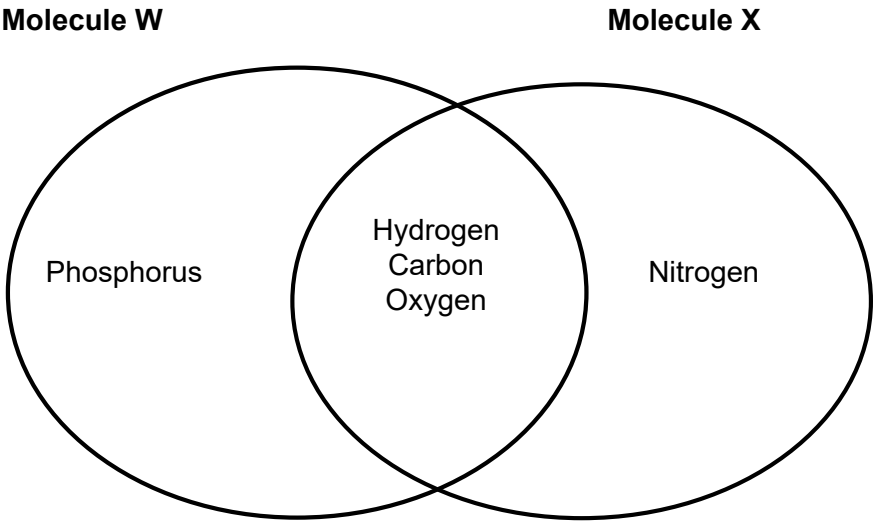
A. Adhesion of water molecules to dissolved mineral salts

B. Cohesion of water molecules due to hydrogen bonding

C. Adhesion between water molecules due to uneven sharing of charges

D. Cohesion between water molecules and other polar substances

2. The diagram shows the elements present in two organic molecules, W and X.
Which molecules could W and X be?



	Molecule W	Molecule X
A.	monosaccharide	amino acid
B.	nucleic acid	triglyceride
C.	phospholipid	protein
D.	triglyceride	fatty acid

3. Which property of DNA explains how genetic information can be replicated accurately?

A. Complementary base pairing

B. The double helical shape

C. 5’ – 3’ bonding in the sugar-phosphate backbone

D. The ability of DNA to bind to histones

4. Which molecules are produced during the hydrolysis of a triglyceride molecule?

A. Water and glycerol

B. Fatty acids and glycerol

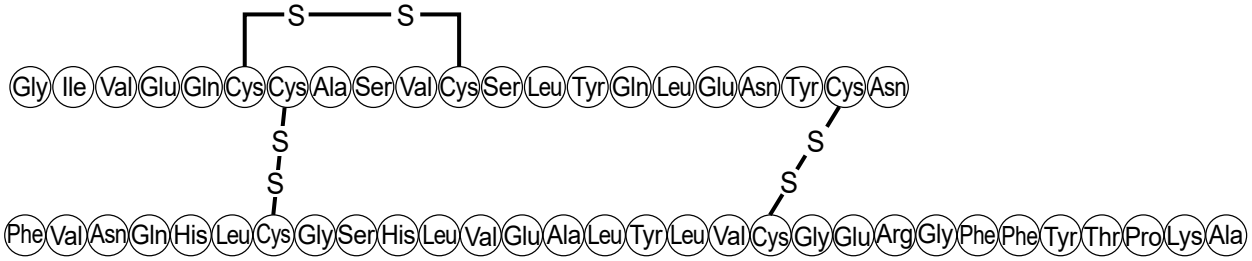
C. Water and fatty acids

D. Water and lipids

5. The structure of monomers affects the structure and function of the polymers they form. Which row describes the structural features of polysaccharides made from alpha-glucose and beta-glucose?

	Monomer	**Polymer**	**Shape of polymer**
A.	alpha-glucose beta-glucose	starch cellulose	unbranched, straight branched, helical
B.	alpha-glucose beta-glucose	starch cellulose	branched, helical unbranched, straight
C.	alpha-glucose beta-glucose	cellulose starch	branched, helical unbranched, straight
D.	alpha-glucose beta-glucose	cellulose starch	unbranched, straight branched, helical

6. The diagram shows the structure of insulin.



From the diagram, what can be concluded about the structure of insulin?

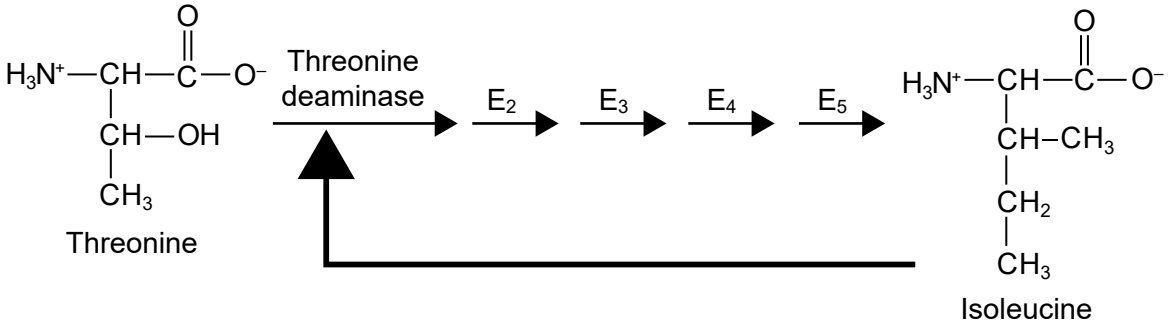
A. It is composed of two polypeptide chains stabilized by disulfide bonds.

B. It is a simple protein composed of one continuous polypeptide chain.

C. It is a fibrous protein.

D. Its molecules do not display quaternary structure.

7. The diagram represents the metabolic pathway that converts threonine to isoleucine.



What is a feature of this pathway?

A. The pathway is regulated by positive feedback.

B. Isoleucine is a competitive inhibitor.

C. Isoleucine is a substrate for threonine deaminase.

D. Isoleucine is an allosteric inhibitor.

8. What is a common feature of enzymes?

A. They all react with substrates.

B. They all decrease the rate of reaction.

C. They are all secreted from cells in vesicles.

D. They all bind to the active site of their substrate.

9. What is a reason that Taq polymerase is a suitable enzyme for use in the polymerase chain reaction (PCR)?

A. It can work at a wide range of pH.

B. It works at higher temperatures than most enzymes.

C. It can separate two strands of DNA.

D. It allows DNA to be replicated without the use of primers.

10. Which are examples of non-coding DNA?

A. Dominant and recessive alleles

B. Promoters and telomeres

C. Oncogenes and tumour suppressor genes

D. Introns and exons

11. The table shows the mRNA codons for three amino acids.

Valine	Threonine	Proline
GUU	ACU	CCU
GCC	ACC	CCC
GCA	ACA	CGA
GCG	ACG	CCG

Which substitution mutation of a base triplet on a DNA strand will lead to the same polypeptide being formed at translation?

A. TGA to TCA

B. CGT to CTA

C. CAA to CGA

D. GCT to GGA

12. Which is a feature of phloem sieve tube cells?

A. Numerous chloroplasts

B. No nucleus

C. Lignified walls

D. No cytoplasm

13. How does the Miller-Urey experiment contribute to an explanation of the origin of life?

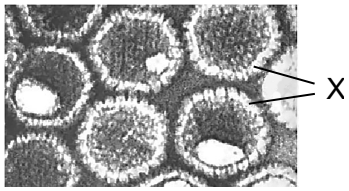
A. It shows how phospholipids form protocells in specific laboratory conditions.

B. It explains how organic molecules arise from inorganic ones under certain environmental conditions.

C. It explains the synthesis of RNA, recreating deep sea vent conditions in the laboratory.

D. It shows how the last universal common ancestor (LUCA) evolved from vesicles.

14. The image shows a group of enveloped viral particles.



What is the most likely composition of the structure labelled X?

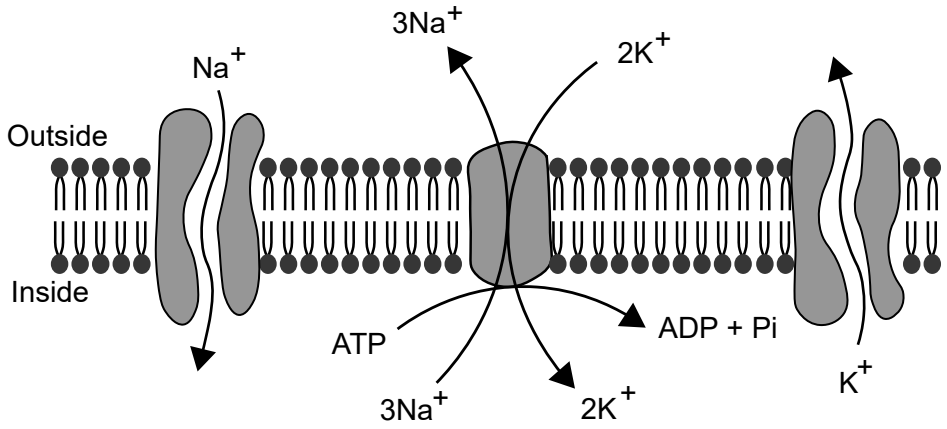
A. Membrane derived from the host cell

B. Viral DNA

C. Viral cell walls

D. Viral enzymes

15. The diagram shows the movement of ions that can occur across the membrane of a neuron.



From the diagram, what can be deduced about the movement of sodium ions?

A. They are actively pumped out and some re-enter by facilitated diffusion.

B. They are actively pumped out and some re-enter by simple diffusion.

C. They diffuse out of the cell along with potassium ions.

D. There is a net movement of sodium ions into the cell.

16. In multicellular animals, embryonic stem cells have the ability to differentiate into a range of cells with different functions. What is the term used to describe cells with this property?

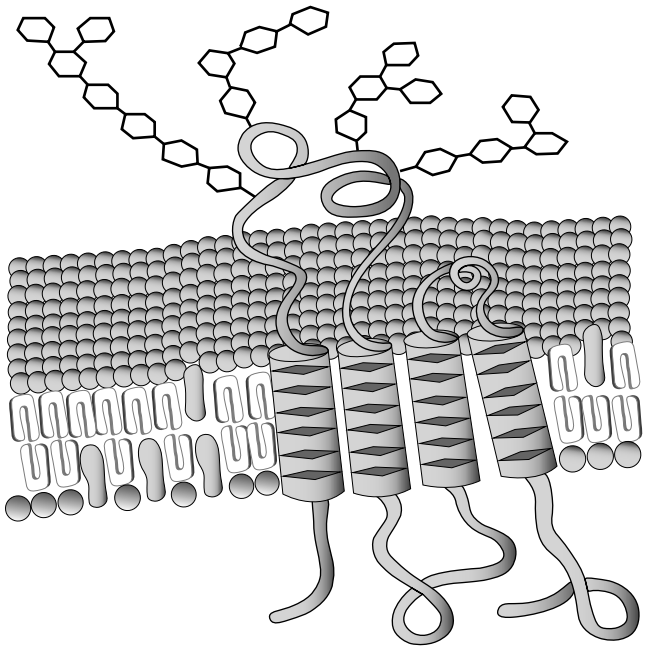
A. Pluripotent

B. Multipotent

C. Totipotent

D. Specialized

17. The image shows a glycoprotein embedded in the phospholipid bilayer of a cell membrane.



Which feature of this glycoprotein can be deduced from the image?

A. It is a peripheral protein that allows attachment to neighbouring cells.

B. It is a channel protein that provides hydrophilic channels for carbohydrate transport.

C. It is an integral protein that may be involved in cell recognition.

D. It is a transport protein that increases the permeability of the membrane to glucose.

18. What activates a tyrosine kinase pathway in a cell following binding to a receptor?

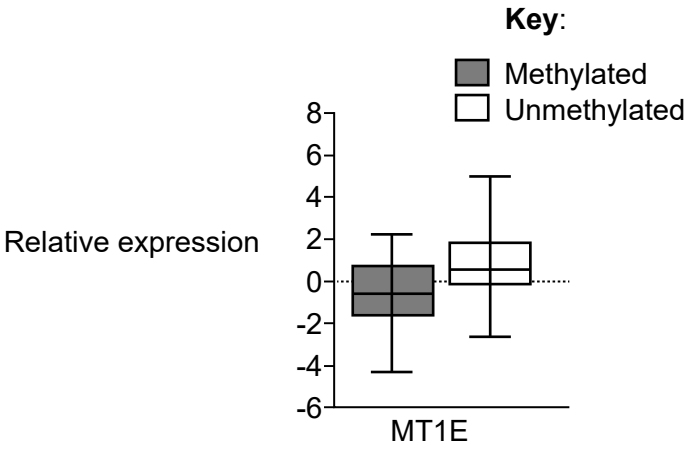
A. Odorant molecules

B. Epinephrine

C. Taste molecules

D. Insulin

19. The graph shows the effect of methylation on the expression of MT1E, a gene involved in the control of prostate cancer development. Patients with a reduced expression of this gene are more likely to develop prostate cancer.



What are effects of MT1E methylation?

A. It reduces transcription of MT1E, increasing the risk of prostate cancer.

B. It increases translation of MT1E, reducing the risk of prostate cancer.

C. It reduces replication of MT1E, reducing the risk of prostate cancer.

D. It increases the chances of mutation in proto-oncogenes, increasing the risk of prostate cancer.

20. What is a function of histones?

A. Supercoiling of DNA during binary fission in prokaryotes

B. Synthesis of proteins

C. Formation of microtubules during mitosis

D. Condensation of DNA

21. What is the cause of positive phototropism?

A. Increased concentration of auxin on the side of the stem closest to the light

B. Degradation of auxin on the side of the stem closest to the light

C. Increased concentration of auxin on the side of the stem furthest from the light

D. Degradation of auxin on the side of the stem furthest from the light

22. Which role does positive feedback play in fruit ripening?

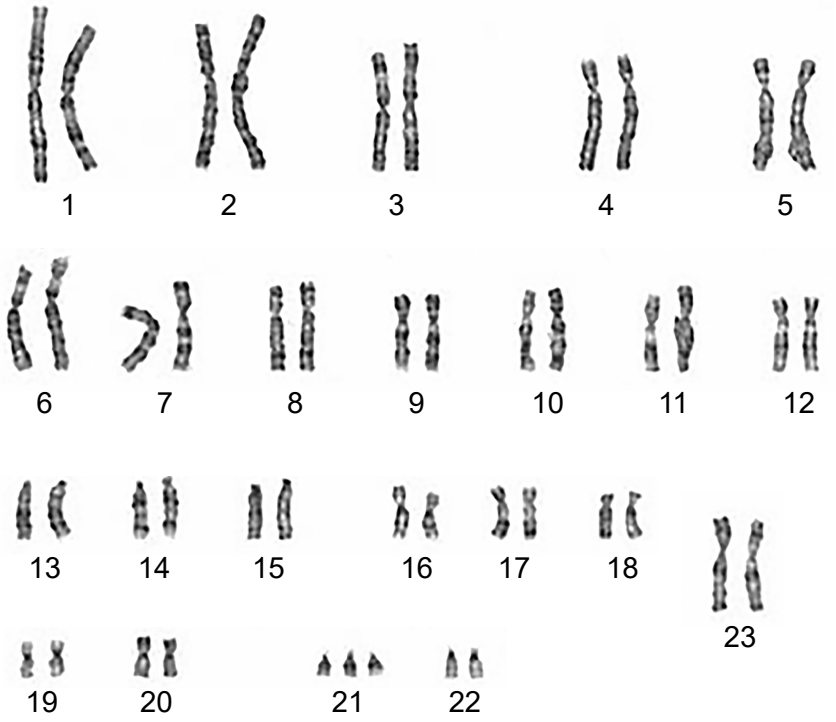
A. The production of ethylene leads to fruit ripening, which stops the production of ethylene.

B. The production of ethylene leads to fruit ripening, which causes more ethylene production.

C. The production of RuBP leads to fruit ripening, which stops the production of RuBP.

D. The production of RuBP leads to fruit ripening, which causes more RuBP production.

23. The karyogram shows a chromosome abnormality in a human female.



What could cause the abnormality to arise?

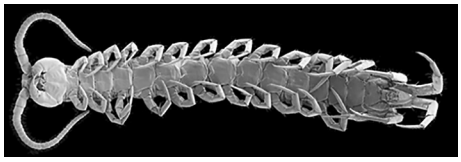
A. Failure of homologous chromosomes to separate during gamete formation

B. Chromosome 21 replicating after fertilization

C. A gene mutation of the mother's chromosomes during cell division

D. Polyploidy occurring during anaphase I of meiosis in both parents

24. The image shows an organism from the phylum Arthropoda.

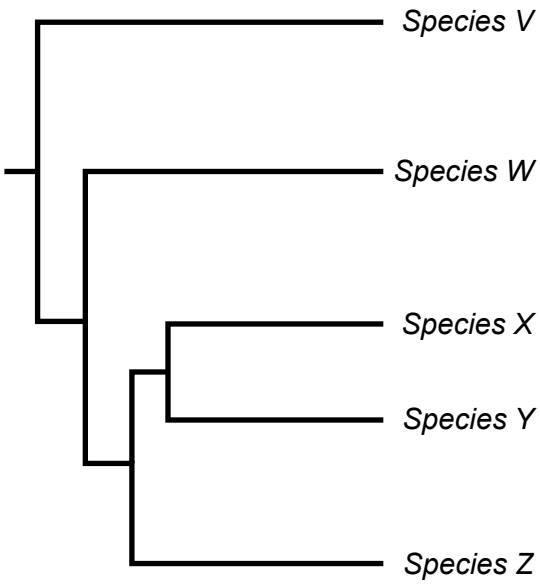


A dichotomous key was used to classify this arthropod. To which group does it belong?

Dichotomous key:

1. antennae pointing forwards . . . . . go to 2
   antennae pointing sideways . . . . . go to 3
2. branched antennae . . . . . A.
   unbranched antennae . . . . . B.
3. one pair of legs in each body segment . . . . . C.
   two pairs of legs in each body segment . . . . . D.

25. Scientists studied differences in the base sequences of a gene found in five animal species in order to determine their evolutionary relationships. A cladogram was constructed based on these differences.



What can be deduced from the cladogram?

A. There are only three clades shown.

B. Morphological differences between V and Z increase with time.

C. There is only one difference between the amino acid sequences of X and Y.

D. Y and Z have a more recent common ancestor than W and X.

26. What is always a consequence of the evaporation of water from mesophyll cells in leaves of a healthy plant?

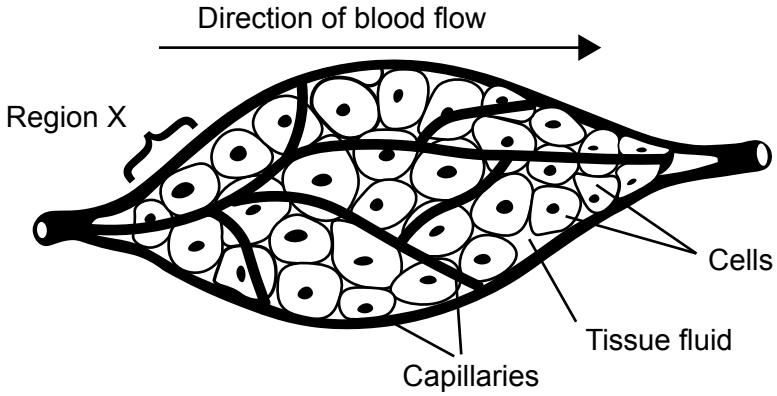
A. Plasmolysis occurs in mesophyll cells.

B. Photosynthesis stops.

C. Stomata close to reduce transpiration.

D. Water moves up the stem in the xylem.

27. The diagram shows where the exchange of substances between blood and tissue fluid occurs in a capillary bed.



What explains the movement of solutes between blood and tissue fluid at region X?

A. Blood plasma has a higher concentration of solutes than tissue fluid.

B. Tissue fluid has a more negative water potential than blood plasma.

C. Hydrostatic pressure is higher in blood than in tissue fluid.

D. The permeability of capillary walls is highest at region X.

28. How is involuntary peristalsis in the intestine directly controlled in humans?

A. By the endocrine system

B. By the central nervous system (CNS)

C. By the sympathetic nervous system

D. By the enteric nervous system (ENS)

29. Which cell is a component of the innate immune system?

A. T lymphocyte

B. Phagocyte

C. B lymphocyte

D. B memory cell

30. How would the body respond to a rise above normal body temperature?

	Type of feedback	Response
A.	positive	increased secretion from sweat glands
B.	positive	spread limbs to increase surface area
C.	negative	vasodilation of skin blood vessels
D.	negative	shivering

31. Female grasshoppers have XX sex chromosomes and males have XO, signifying a single X chromosome. An X chromosome will be present in only half of the male gametes. A recessive mutation is induced by radiation in the X chromosome of a male. In which generation will the effect of this radiation appear?

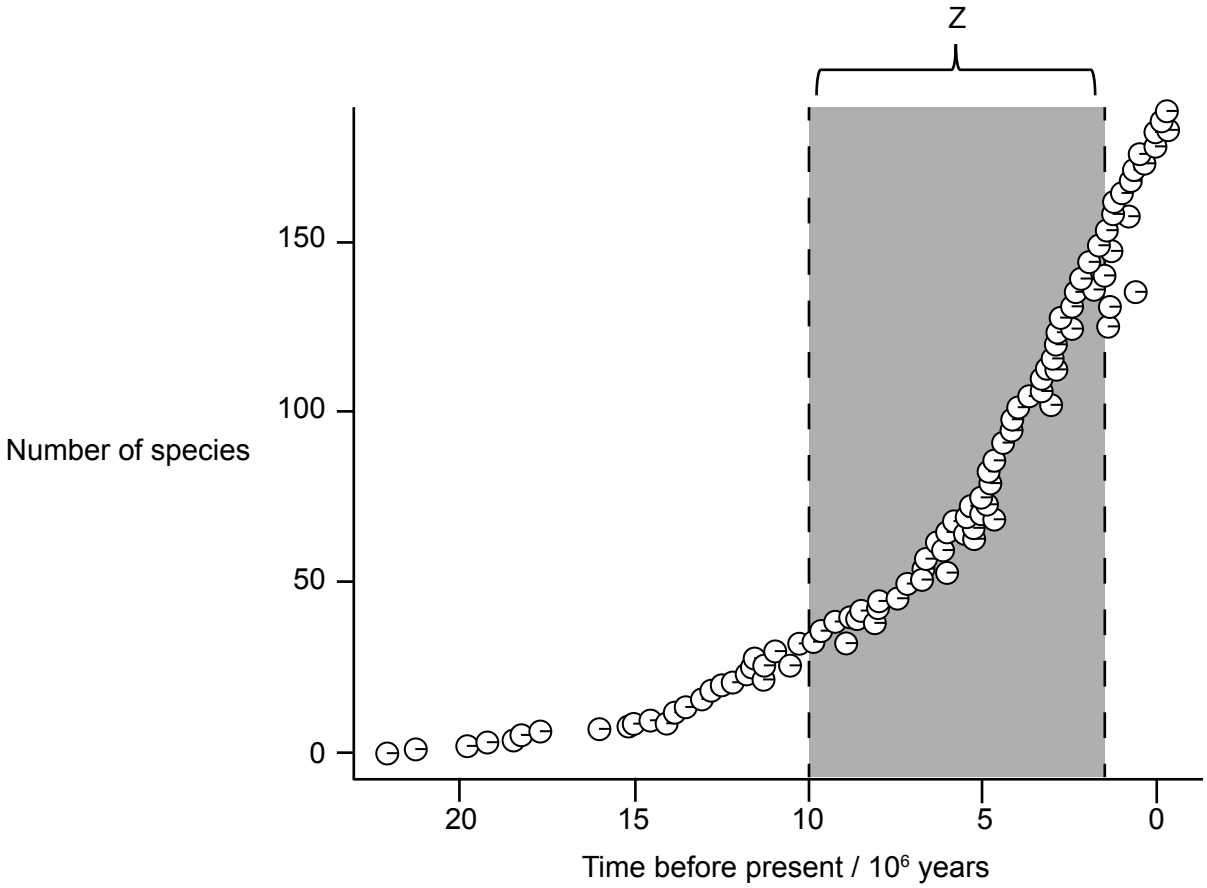
A. F1 females

B. F1 males

C. F2 females

D. F2 males

32. The number of hummingbird species in South America has increased continuously as shown in the graph.



What could be a reason for the increase in the number of hummingbird species during the period labelled Z?

A. Food and shelter are plentiful and there is little intraspecific competition.

B. Closely related species can coexist indefinitely in the same niche.

C. A wide range of unoccupied potential niches exists, leading to adaptive radiation.

D. There are few limiting factors on the population size of hummingbirds.

33. Polyploidy has been a cause of rapid speciation in some plant genera, such as *Helianthus*. Which observation is evidence that speciation has occurred?

A. A polyploid plant reproduces asexually.

B. A polyploid plant produces male and female gametes.

C. Fertile offspring are produced when a polyploid plant crosses with a diploid plant.

D. Fertilization can occur between polyploid individuals.

34. *Yersinia pestis* is a bacterium that caused an outbreak of bubonic plague in the 14th century. It normally produces ATP in the presence of oxygen but can still produce ATP if oxygen is absent. Which term describes this characteristic?

A. Facultative respiration

B. Facultative anaerobe

C. Obligate anaerobe

D. Obligate aerobe

35. What are common features of holozoic nutrition and saprotrophic nutrition?

	Mostly fungi and bacteria	**Secretion of enzymes to digest food**	**Ingestion of food particles**
A.	✓	✓	✗
B.	✓	✗	✓
C.	✗	✓	✗
D.	✗	✗	✗

36. The preferred temperature ranges for three species of trout that are found together in freshwater lakes in North America are shown.

Lake trout
(*Salvelinus namaycush*)
6–13 °C

Rainbow trout
(*Oncorhynchus mykiss*)
12–18 °C

Brown trout
(*Salmo trutta*)
11–23 °C

What can be deduced from this information?

I. The niches for all three species overlap.
II. Brown trout have the most specialized niche.
III. Lake trout can avoid competition by living in colder water.

A. I only

B. II only

C. I and III only

D. I, II and III

37. Which is a density-independent limiting factor for a kangaroo?

A. A forest fire

B. Predation

C. Climate change

D. Eutrophication

38. Black walnut (*Juglans nigra*) secretes the chemical juglone into the soil surrounding its roots. Juglone inhibits cell respiration in other species of plants. What does this example illustrate?

A. Mutualism

B. Intraspecific competition

C. Allelopathy

D. Parasitism

39. What assumption is made when using the Hardy-Weinberg equation for calculating changes in allele frequencies in a population?

A. The population size is large.

B. Natural selection is taking place.

C. Mutations are occurring in the population.

D. There is variation among the phenotypes of the population.

40. Domestic dogs (*Canis familiaris*) have evolved from grey wolves (*Canis lupus*). Evidence suggests that the domestication of dogs first occurred around 30 000 years ago. Which best describes the evolution giving rise to the domestic dog?

A. The wolf produced offspring in large numbers which underwent natural selection.

B. Variations in the wolf population that resembled modern dogs favoured wolf survival.

C. Wolves showing favourable traits were selected for breeding.

D. Dogs were better suited to changes in the natural environment than wolves.

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References:

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

Markscheme

Specimen paper

Biology

Higher level

Paper 1A

2 pages

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

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 1B

Specimen Paper

Candidate session number

2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for paper 1B is **[35 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.

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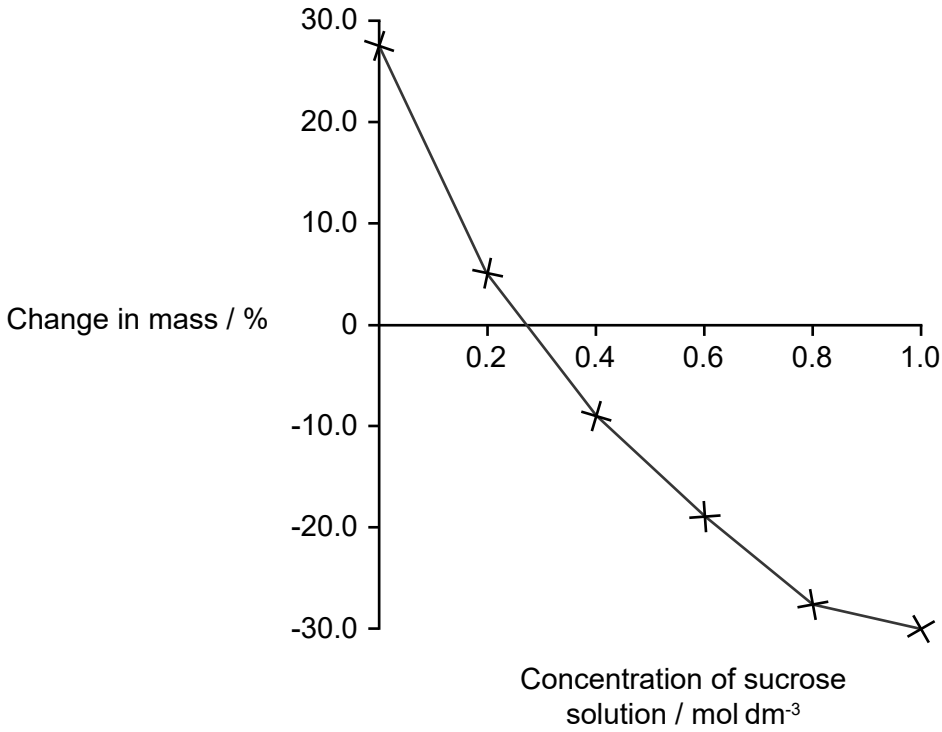
Answer **all** questions. Answers must be written within the answer boxes provided.

1. Beetroot (*Beta vulgaris*) tissue was cut into pieces of similar size and shape. The masses of the individual pieces were measured. Three pieces of beetroot were placed in each of six sucrose solutions of different concentrations.

After three hours, the pieces of beetroot were removed from the solutions, surface dried and their masses recorded. The mean percentage change in mass of the beetroot in each solution was calculated and displayed in the graph.



Concentration of sucrose solution / mol dm^{-3}	Change in mass / %
0.0	28.0
0.2	5.0
0.4	–9.0
0.6	–19.0
0.8	–28.0
1.0	–30.0

(This question continues on the following page)

(Question 1 continued)

(a) (i) State the independent variable in this experiment. [1]

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(ii) Outline the reason that beetroot pieces of similar size and shape are needed in order to obtain reliable results. [2]

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(b) Suggest a reason for expressing the changes in mass as percentages. [1]

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(c) Explain the effect of the 0.0 mol dm^{-3} sucrose solution on the water potential of the beetroot pieces. [3]

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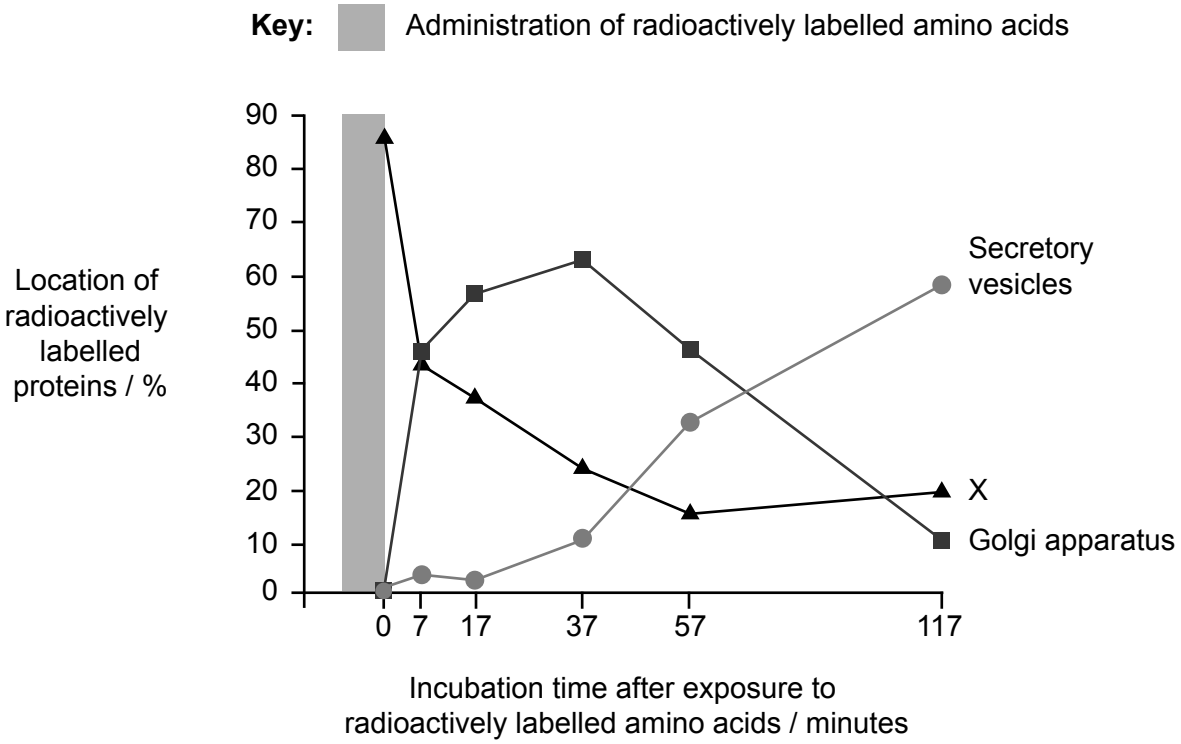
2. In an experiment investigating the secretion of proteins by gland cells, researchers supplied radioactively labelled amino acids to a sample of pancreas cells that secrete digestive enzymes.

The graph shows the relative abundance of radioactively labelled proteins in three different organelles during the period after the cells were exposed to the radioactively labelled amino acids.



(a) Suggest a reason for using amino acids that were radioactively labelled. [1]

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(b) (i) X is a membrane-bound organelle. Identify X. [1]

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(This question continues on the following page)

(Question 2 continued)

(ii) Explain the role of ribosomes located on X. [2]

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(iii) Outline the evidence provided by the data that molecules containing radioactively labelled amino acids move from X to the Golgi apparatus. [1]

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(c) Gland cells that secrete large volumes of fluid typically have many aquaporins in their plasma membranes. Suggest a reason for this. [1]

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(d) After synthesis, globular proteins assume their final tertiary structure. Explain the relationship between the sequence of amino acids and the tertiary structure of globular proteins. [4]

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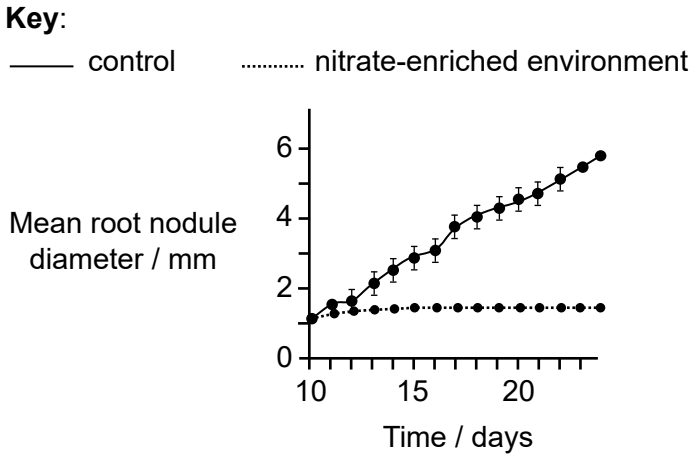
3. *Rhizobium* is a genus of bacteria that live in the roots of flowering plants in the family Fabaceae. The plants form nodules surrounding a population of *Rhizobium*. The bacteria fix nitrogen from the air into nitrogen compounds, especially ammonium, which are made available to the host plant.

The graph shows changes in the diameter of root nodules for plants grown in a nitrate-enriched environment and a control group grown in a nitrate-free environment.



(a) Outline the concept of mutualism with respect to this example. [2]

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(This question continues on the following page)

(Question 3 continued)

(b) Distinguish between the cells in *Rhizobium* and Fabaceae. [2]

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(c) Suggest a reason that mutualistic relationships often involve species from distantly related groups of organisms. [1]

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(d) Analyse the results of the experiment. [3]

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4. Before the structure of DNA was known, researchers analysed the ratios of the DNA bases found in cells of different species. The tetranucleotide hypothesis, formulated in 1910, proposed that DNA was made up of equal amounts of adenine, guanine, cytosine and thymine.

This hypothesis was revised following the publication of Chargaff's paper in 1951, from which data is shown in the table.

	Ratios				
Source	**A:G**	**T:C**	**A:T**	**G:C**	**purines:pyrimidines**
Ox	1.29	1.43	1.04	1.00	1.10
Human	1.56	1.75	1.00	1.00	1.00
Chicken	1.45	1.29	1.06	0.91	0.99
Salmon	1.43	1.43	1.02	1.02	1.02
Wheat	1.22	1.18	1.00	0.97	0.99
Yeast	1.67	1.92	1.03	1.20	1.00

(a) State **one** example of a purine. [1]

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(b) Explain how these results falsify the tetranucleotide hypothesis. [2]

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(c) Using these data, evaluate the hypothesis that the ratio of purines to pyrimidines in DNA in all organisms is 1.00. [1]

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(This question continues on the following page)

(Question 4 continued)

(d) Discuss how these results are consistent with the existence of a last universal common ancestor (LUCA). [2]

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(e) Discuss the evidence of the relationship between genome size and the complexity of organisms. [4]

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Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

2. Jamieson, J.D. and Palade, G.E., 1967. Intracellular transport of secretory proteins in the pancreatic exocrine cell. *Journal of Cell Biology*, 34, pp.597–615.

3. **image**
Ninjatacoshell, 2009. *Medicago italica root nodules 2.* [image online] Available at: <https://commons.wikimedia.org/wiki/File:Medicago_italica_root_nodules_2.JPG> [Accessed 16 July 2020].

graph
Fujikake, H., Yamazaki, A., Ohtake, N., Sueyoshi, K., Matsuhashi, S., Ito, T., Mizuniwa, C., Kume, T., Hashimoto, S., Ishioka, N.-S., Watanabe, S., Osa, A., Sekine, T., Uchida, H., Tsuji, A. and Ohyama, T., 2003. [Soybean root nodule growth]. *Journal of Experimental Botany*, 54(386), pp.1379–1388. REFERENCE REDACTED.

4. Chargaff, E., 1951. Structure and function of nucleic acids as cell constituents. *Federation proceedings*, 10(3), pp.654–659.

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will not be marked.

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will not be marked.

SPEC/4/BIOLO/HP1/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

Specimen paper

Biology

Higher level

Paper 1B

10 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut
	Correct point (automatically awards 1 mark when stamped)	
	These are annotations which can be used to show which marking point was used to award a mark. It is easier to use these than to pick up the tick stamp and then the text box (they each automatically award 1 mark when stamped)	
	Quality marks awarded for clarity and structure (these each automatically award 1 mark when stamped)	
	Pointer (use when you want to delete an annotation or change colour)	
	Benefit of the doubt	
	Error carried forward	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Omission/incomplete	
	Too vague	
	No working shown	
	Unclear	

Annotation	Explanation	Shortcut
	This is a dynamic annotation; it can be used to surround work	
	This is a dynamic, vertical wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	This is a dynamic, horizontal wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	Valid part (to be used when more than one element is required to gain the mark eg: drawings)	
	Same as	
	Or words to that effect	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required)	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	
	Similarity (to identify elements in an unclear comparison)	
	Highlight, stamp and drag out to highlight an area of the script	
	Text box used for additional marking comments. It can be linked to a specific tick if that is appropriate	
	Seen; to be stamped on parts of a question or option which have been left blank	
0	Zero; to be used when a question part is not worthy of credit. Awards zero for the question part	

You **must** make sure you have looked at all pages. Please put the  annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that are blank or where the candidate has crossed out his/her work.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

Subject Details: Biology HL Paper 1B Markscheme

Candidates are required to answer **all** questions in Paper 1B. 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 semicolon (;) 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 word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

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

7. An alternative markscheme is indicated in the "Answers" column under heading **ALTERNATIVE 1** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

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

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

11. 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.

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

13. 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.

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

Question			Answers	Notes	Total
1.	a	i	sucrose concentration		1
1.	a	ii	a. surface area; b. varies with size (and shape) ***OR*** is a variable that affects osmosis ***OR*** would have affected the rate of osmosis/diffusion/movement of water into/out of the tissue ***OR*** is a variable that needs to be controlled;		2
1.	b		initial masses/size of beetroot pieces were (slightly) different ***OR*** (relative changes in mass allow for a) fair comparison between pieces at different concentrations with (slightly) different initial mass		1
1.	c		a. water enters the pieces of beetroot tissue; b. (water enters) by osmosis; c. pressure potential rises; d. increasing the water potential (of the tissue); e. until an equilibrium is reached / no further **net** movement of water; f. the cells/tissue is/are turgid;	*Accept ψ_s for solute potential, ψ_p for pressure potential and ψ for water potential.*	3

Question			Answers	Notes	Total
2.	**a**		to track their movement / make them detectable		**1**
2.	**b**	**i**	rER		**1**
2.	**b**	**ii**	a. production of polypeptides/proteins/translation; b. (production of proteins that are) insoluble/bound for export/for insertion in the membrane;		**2**
2.	**b**	**iii**	high levels of radioactive amino acids appear first in X and later in Golgi		**1**
2.	**c**		a. water diffuses (through the plasma membrane) via aquaporins ***OR*** aquaporins allow water movement/secretion of fluid; b. the rate of water transport by aquaporins is not very high (so many are required);		**1**
2.	**d**		a. the sequence of amino acids determines the tertiary structure of a protein; b. tertiary structure is the folding of a polypeptide chain; c. R groups of amino acids can be polar or non-polar; d. the protein folds due to interaction with water/the aqueous environment; e. (the protein folds due to) R group interactions; f. example of R group interaction H/covalent/ionic bond/disulphide bridges;		**4**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>3.</td><td>a</td><td></td><td>a. symbiotic relationship between two (unrelated) species
OR
to the benefit of both species;
b. bacteria get organic molecules AND plant gets nitrates;</td><td></td><td>2</td></tr>
<tr><td>3.</td><td>b</td><td></td><td><table>
<tr><td>Rhizobium</td><td>Fabaceae</td></tr>
<tr><td>prokaryote</td><td>eukaryote;</td></tr>
<tr><td>circular DNA</td><td>linear DNA/chromosomes;</td></tr>
<tr><td>membrane bound organelles absent
(accept a specific example)</td><td>membrane bound organelles present;
(accept a specific example)</td></tr>
<tr><td>70S ribosomes</td><td>80S ribosomes;</td></tr>
<tr><td>small</td><td>large;</td></tr>
</table></td><td>Some form of distinction MUST be made.
e.g. ‘<u>Rhizobium</u> is small’ would be insufficient. However, ‘smaller’ implies a distinction</td><td>2</td></tr>
<tr><td>3.</td><td>c</td><td></td><td>distantly related species are more likely to have different characteristics/metabolisms (so are more likely to provide for each others’ requirements)</td><td></td><td>1</td></tr>
<tr><td>3.</td><td>d</td><td></td><td>a. with additional nitrate, nodule size does not change/remains small;
b. without additional nitrate, nodule size increases (over time);
c. (suggests that) nitrate inhibits nodule growth;
d. when nitrate is scarce, nodule growth ensures nitrate supply from a larger bacterial population;
e. (suggests that) mutualism is affected by environmental conditions;</td><td></td><td>3</td></tr>
</table>

Question			Answers	Notes	Total
4.	**a**		adenine/guanine		**1**
4.	**b**		a. the only ratios that are 1:1 are between A:T and C:G; b. ratios of A:G and T:C are not 1:1 in any of the experimental organisms;		**2**
4.	**c**		overall ratio of purines:pyrimidines in all experimental organisms is 1:1 but yeast G:C ratios represent an anomaly		**1**
4.	**d**		a. same four bases found across a variety of organisms; b. pattern of ratios in the data is common / comparable across the organisms shown ***OR*** same complementary base pairing; c. this suggests a common ancestor;		**2**
4.	**e**		*Evidence for a relationship* a. eukaryote genomes (tend to be) larger than prokaryote genomes; b. most DNA sequences in higher eukaryotic genomes are non-coding; c. introns occur within eukaryotic genes; *Evidence against a relationship* d. no relationship between genome size and complexity within the eukaryotes; e. example given; e.g. *Amoeba proteus* genome 100x larger than *Homo sapiens* genome;		**4**

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Specimen paper

Candidate session number

2 hours 30 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.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

0000 – 6003

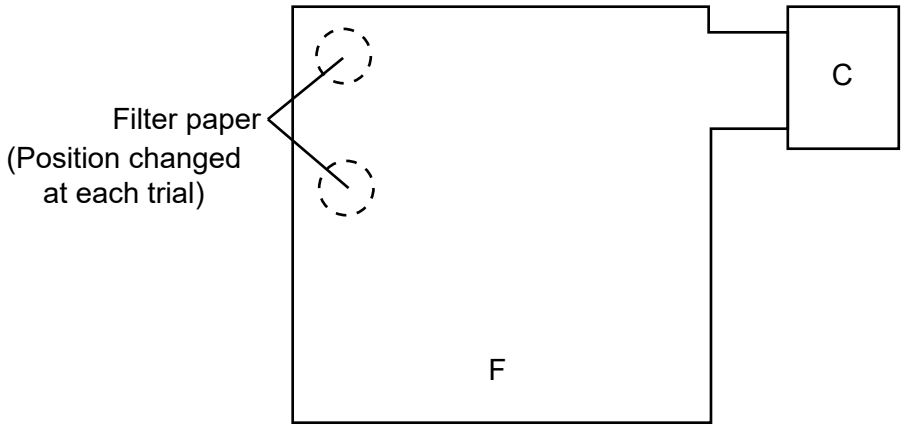
Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Squirrels (small mammals) have evolved several defences against predators. One method adopted by California ground squirrels (*Otospermophilus beecheyi*) against rattlesnakes (*Crotalus oreganus*) is to chew moulted rattlesnake skins, then lick their own fur so they take on the scent of a rattlesnake.

An experiment tested the amount of time rattlesnakes spent studying and flicking their tongue at filter papers soaked in different liquids. The snakes were released from chamber C into foraging area F and observed for 30 minutes. There were two filter papers in area F. One was a control paper soaked in distilled water. The other was soaked in one of three types of scent:

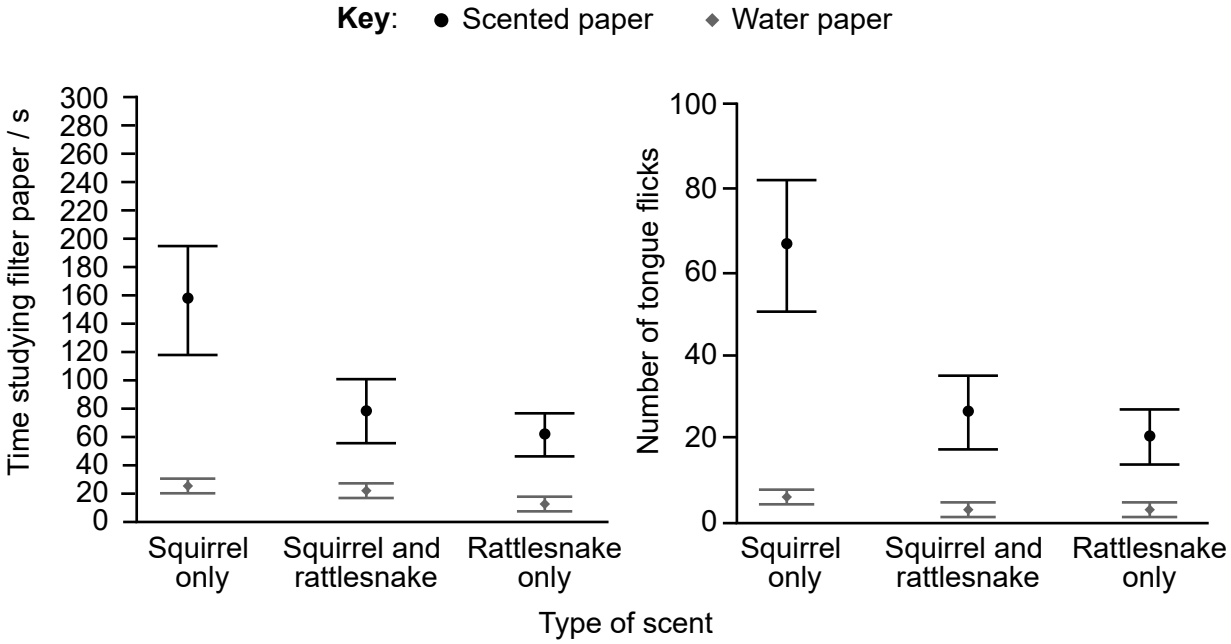
- squirrel scent
- a mixture of squirrel and rattlesnake scent
- rattlesnake scent.



(This question continues on the following page)

(Question 1 continued)

The graphs show the results of the experiment.



[Source: adapted from Clucas, B., Owings, D.H. and Rowe, M.P., 2008. *Proc Biol Sci*, 275(1636), pp.847–852. https://doi.org/10.1098/rspb.2007.1421 REDACTED.]

(a) Calculate the difference in mean time spent studying squirrel-scented filter paper with and without rattlesnake scent. [1]

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(b) Outline the conclusions that can be drawn from the control results. [2]

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(Question 1 continued)

(c) The positions of the filter papers were changed for every trial. Outline **one** reason that this was necessary. [1]

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(d) Suggest a reason for rattlesnake scent lowering the chances of snake attacks on squirrels. [1]

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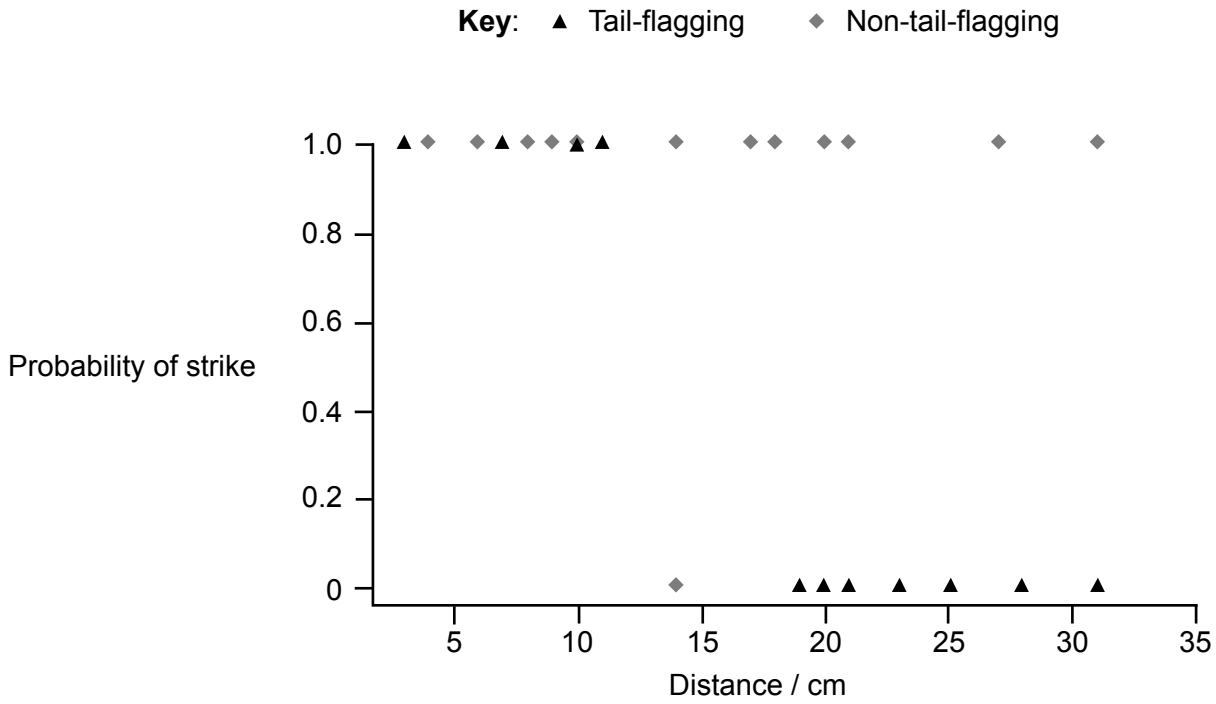
The researchers observed that when squirrels saw a rattlesnake, they waved their tail from side-to-side so that they were more visible to the rattlesnakes (tail-flagging). The graph shows the probability of a snake strike at different distances on tail-flagging and non-tail-flagging squirrels.



[Source: adapted from Barbour, M.A. and Clark, R.W., 2012. *Proceedings of the Royal Society B*, [e-journal] https://doi.org/10.1098/rspb.2012.1112 REDACTED.]

(This question continues on the following page)

(Question 1 continued)

(e) Compare and contrast the effect of tail-flagging with non-tail-flagging on strike probability. [2]

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(f) Estimate the distance between squirrel and snake where there is a 50 % chance of a strike at a tail-flagging squirrel. [1]

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(g) Suggest a reason for the behaviour of snakes towards tail-flagging squirrels. [1]

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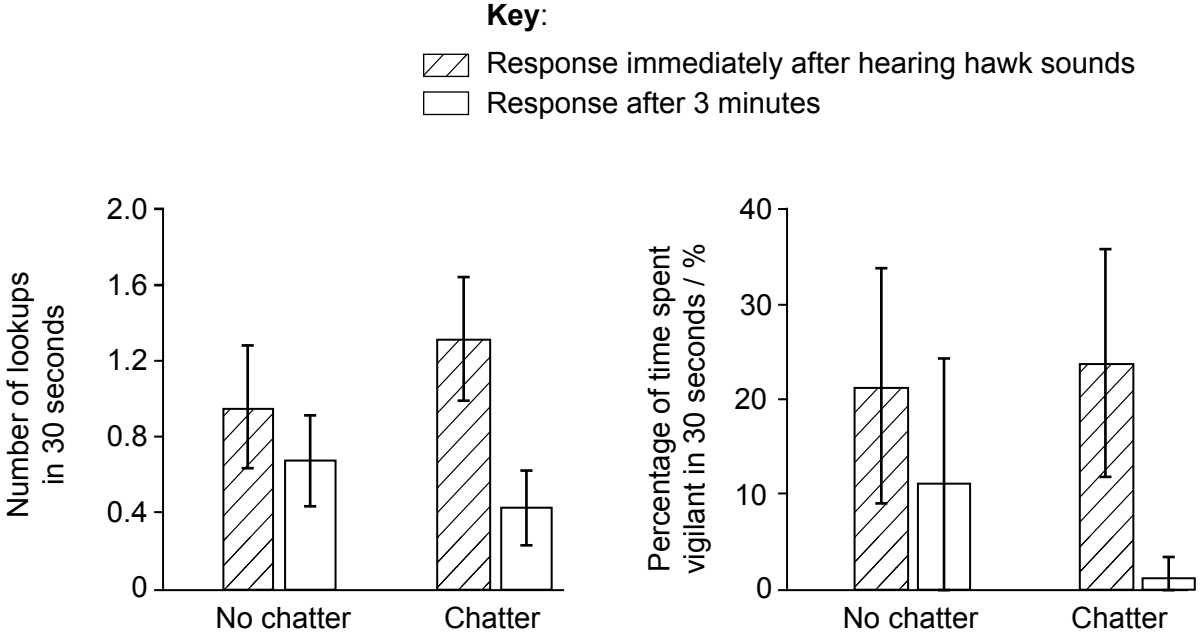
(This question continues on the following page)

(Question 1 continued)

When played a recording of the call of a red-tailed hawk (*Buteo jamaicensis*), foraging grey squirrels (*Sciurus carolinensis*) in the wild became more vigilant and looked up from their feeding more often. In the habitat of the squirrels, there are also sounds made by songbirds which chatter to each other when there is no imminent threat. The charts show the response of the squirrels in the 30 seconds immediately after the scare of hearing hawk sounds and after 3 minutes, both with and without bird chatter playing.



[Source: adapted from Lilly, M.V., Lucore, E.C. and Tarvin, K.A., 2019. *PLoS ONE*, 14(9): e0221279. https://doi.org/10.1371/journal.pone.0221279. REDACTED.]

(h) State the conditions that led to the squirrels making the least mean number of lookups. [1]

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(This question continues on the following page)

(Question 1 continued)

(i) Discuss briefly whether the sound of bird chatter represents a significant difference in the vigilance of squirrels immediately after they have heard the sound of a hawk. [2]

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(j) Using the data in the bar charts, analyse the effect of bird chatter on the behaviour of squirrels. [3]

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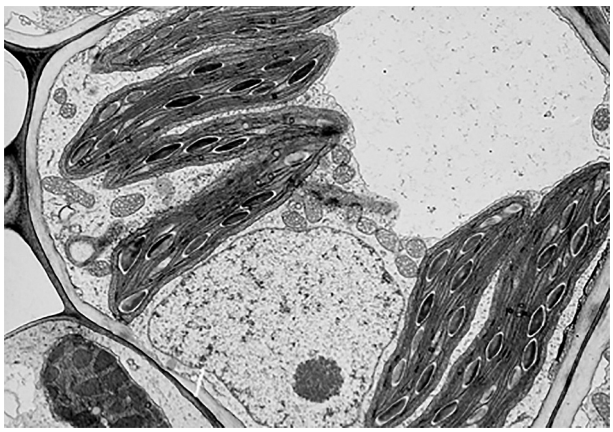
2. The cytoplasm in eukaryotic cells is compartmentalized into membrane-bound organelles, as seen in this electron micrograph of a plant cell.



(a) State **two** membrane-bound organelles that are common to both plant and animal cells. [2]

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(b) (i) State **one** organelle that is found in a plant cell but not in an animal cell. [1]

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(ii) State **one** organelle that is common to prokaryotic and eukaryotic cells. [1]

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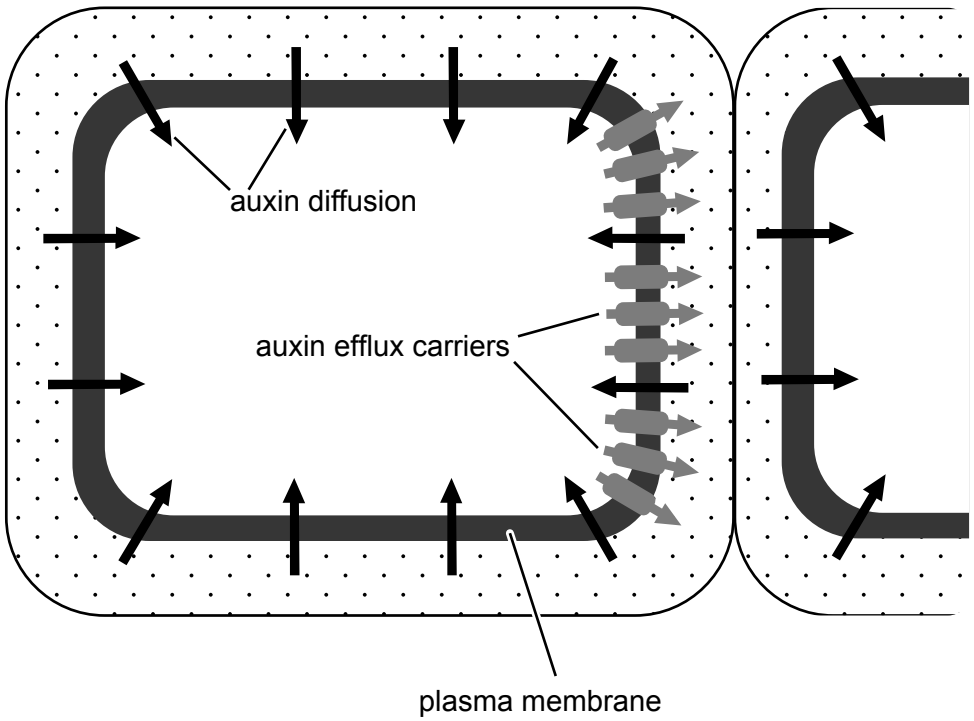
3. The diagram shows the movement of auxin across the plasma membrane of a plant cell as well as the position of auxin efflux carriers.



(a) (i) Annotate the diagram, using an arrow, to show the direction of the net flow of auxin through the cell. [1]

(ii) Identify an environmental factor that causes auxin efflux carriers to be concentrated on one side of a cell. [1]

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(b) (i) Predict the difference that could be seen using a microscope between plant meristematic cells grown in media with and without auxin. [1]

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(ii) State the hormone that interacts with auxin to integrate shoot growth. [1]

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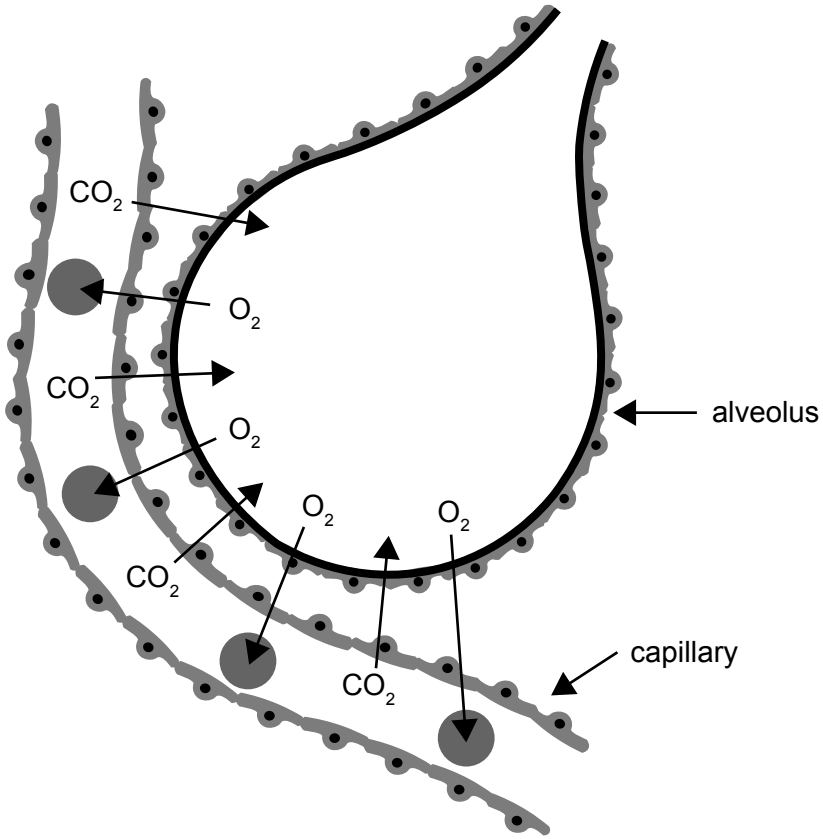
4. Multicellular organisms need efficient exchange surfaces where molecules can move between tissues and their surroundings. In mammals, gas exchange takes place in the alveoli of the lungs.



(a) Describe how the exchange of gases is brought about between the alveoli and the blood. [3]

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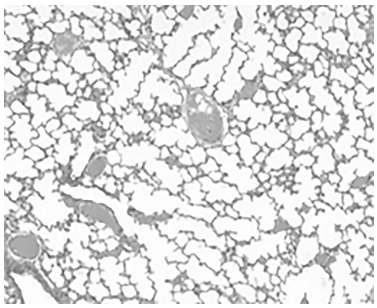
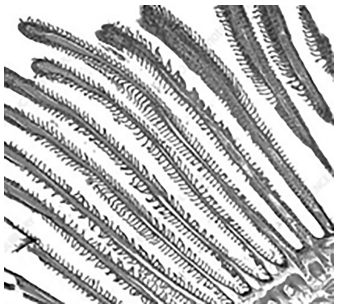
(Question 4 continued)

The images show the lungs of a human and the gills of a fish taken with a light microscope.



Alveoli in the lungs of a human



Gills from a fish

(b) Describe **two** features common to the exchange surfaces of alveoli and gills. [2]

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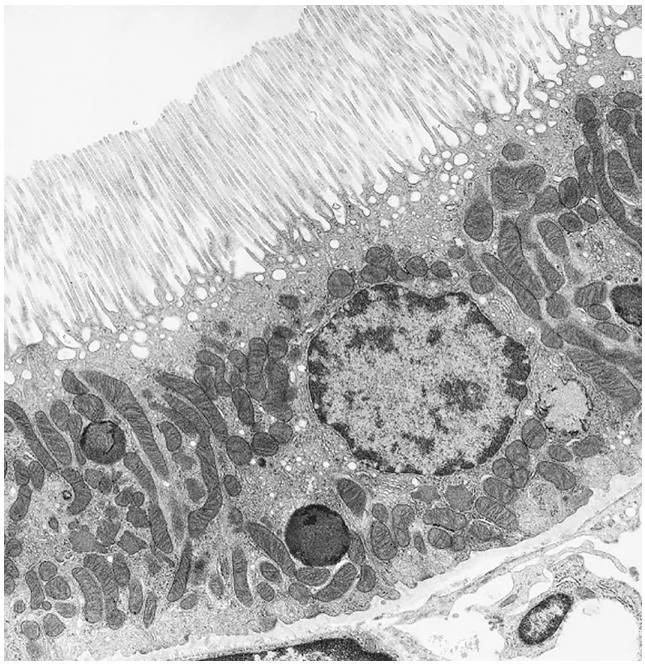
(This question continues on page 13)

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

Answers written on this page
will not be marked.

(Question 4 continued)

The image shows cells from the wall of a proximal convoluted tubule of a rat kidney.



(c) Outline the visible features of these cells that adapt them for reabsorption of materials from the glomerular filtrate. [2]

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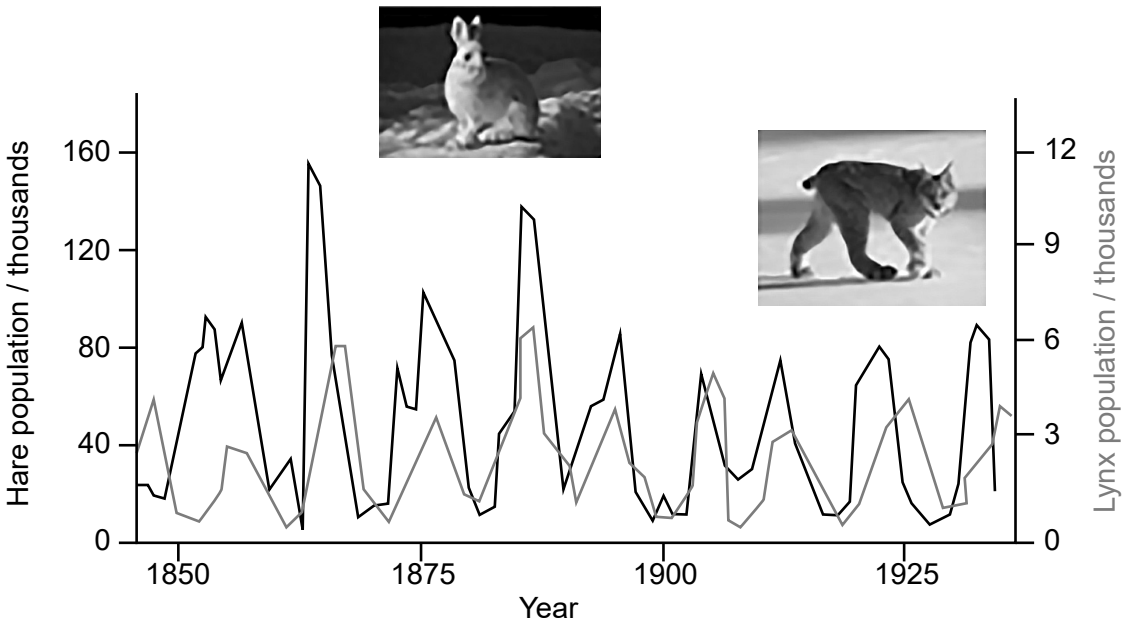
5. Predation may result in a cyclic pattern of population changes, as for example in the case of the lynx, *Lynx canadensis* (predator), and the hare, *Lepus americanus* (prey).



(a) The predator benefits from a predator-prey relationship by obtaining food. Suggest how the hare population could benefit from this relationship. [1]

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(b) Outline the factors that contribute to the carrying capacity of prey organisms in a predator-prey relationship. [2]

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(This question continues on the following page)

(Question 5 continued)

(c) (i) Outline how the hare population size can be estimated using the mark-release-recapture method. [2]

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(ii) State **one** assumption that is made when using this method to estimate population size. [1]

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6. In humans, sex is determined genetically and human populations have approximately equal numbers of males and females in each generation.

(a) Outline how sex is determined in humans. [2]

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(b) Down syndrome is a genetic condition in which the cells of an individual contain three copies of chromosome 21. Explain how non-disjunction leads to trisomy 21. [3]

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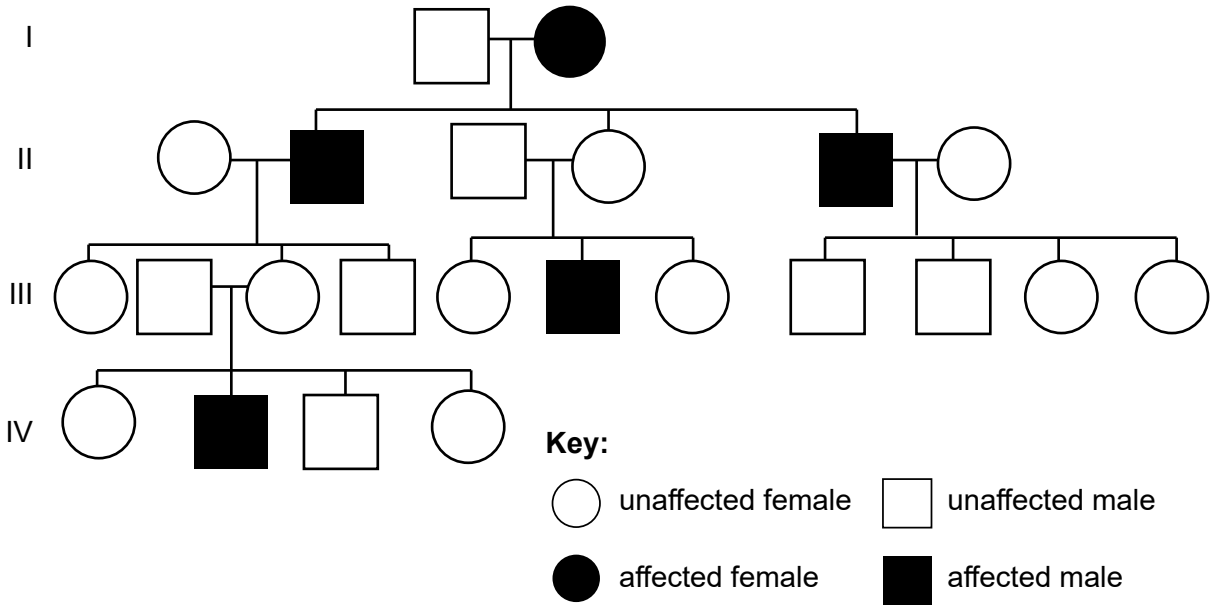
(Question 6 continued)

(c) The pedigree chart shows the inheritance of hemophilia in a human family over four generations. Symbols represent the phenotype of the individual.



Explain the evidence from this chart that the condition may be sex-linked. [2]

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

Answers written on this page
will not be marked.

7. Two alleles of a gene influence body colour in *Drosophila*. The dominant allele B results in a brown body colour while the recessive allele b codes for black body. In addition, two alleles of another gene determine wing shape; normal wings (V) are dominant over vestigial wings (v).

In a dihybrid cross between a double heterozygote for body colour and wing shape (BbVv) and a homozygous recessive for both traits (bbvv), the following offspring were obtained:

- brown body, normal wings: 29
- brown body, vestigial wings: 8
- black body, normal wings: 10
- black body, vestigial wings: 33

(a) Identify the recombinant phenotypes amongst the offspring. [1]

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(b) Explain whether these results fit the predicted Mendelian ratios for this cross. [2]

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(c) Outline the statistical test that could be used to provide more evidence of the type of inheritance. [2]

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Section B

Answer **two** questions. One additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

8. There are a number of advantages to specificity.

(a) Explain how vaccination can result in specific immunity to a viral disease. [7]

(b) Outline the role of membrane proteins in the movement of specific ions at specific times in the transmission of nerve impulses. [4]

(c) Describe the barriers that exist to hybridization between species. [4]

9. Various mechanisms can lead to inhibition in biological systems. A toxin is a substance capable of disrupting metabolic processes in organisms.

(a) Describe how toxins such as DDT might concentrate in the bodies of birds. [4]

(b) Toxins often act as inhibitors. Compare and contrast competitive and non-competitive enzyme inhibition. [7]

(c) Rotenone is a naturally occurring toxin that blocks the electron transport chain in insects and fish. Outline the consequences of exposure to a toxin like rotenone for cell respiration. [4]

10. Changes in the form of biological molecules lead to changes in their function.

(a) Outline the role of UV radiation as a mutagen. [4]

(b) Explain how the function of DNA is linked to its molecular structure. [7]

(c) Describe the use of gene knockout technology in research. [4]

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References:

2. *Electron micrograph of cells from the leaf of a corn plant*, n.d. [image online] Available at: <http://innolearn.weebly.com/bio-cell.html> [Accessed 9 December 2020].

3a. Smith, R.S., 2008. The Role of Auxin Transport in Plant Patterning Mechanisms. *PLoS Biol*, 6(12): e323. https://doi.org/10.1371/journal.pbio.0060323.

4b. Left image:
[*Alveoli in the lungs of a human*], n.d. [image online] Available at: <http://medcell.med.yale.edu/histology/respiratory_system_lab.php#slides> [Accessed 9 December 2020].

Right image:
[*salt water fish gills histology*], n.d. [image online] Available at: <https://br.pinterest.com/pin/255297872605284426/> [Accessed 9 December 2020].

4c. *Transmission electron micrograph of the S1 segment of a rat proximal tubule*, n.d. [image online] Available at: <https://abdominalkey.com/anatomy-of-the-kidney/> [Accessed 9 December 2020].

5. Wani, n.d. [*Hare and lynx populations*]. [image online] Available at: <https://www.cleanpng.com/png-cat-snowshoe-hare-eurasian-lynx-lotkavolterra-e-3913514/> [Accessed 29 July 2020].

SPEC/4/BIOLO/HP2/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

Specimen paper

Biology

Higher level

Paper 2

20 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut
	Correct point (automatically awards 1 mark when stamped)	
	These are annotations which can be used to show which marking point was used to award a mark. It is easier to use these than to pick up the tick stamp and then the text box (they each automatically award 1 mark when stamped)	
	Quality marks awarded for clarity and structure (these each automatically award 1 mark when stamped)	
	Pointer (use when you want to delete an annotation or change colour)	
	Benefit of the doubt	
	Error carried forward	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Omission/incomplete	
	Too vague	
	No working shown	
	Unclear	

Annotation	Explanation	Shortcut
	This is a dynamic annotation; it can be used to surround work	
	This is a dynamic, vertical wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	This is a dynamic, horizontal wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	Valid part (to be used when more than one element is required to gain the mark eg: drawings)	
	Same as	
	Or words to that effect	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required)	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	
	Similarity (to identify elements in an unclear comparison)	
	Highlight, stamp and drag out to highlight an area of the script	
	Text box used for additional marking comments. It can be linked to a specific tick if that is appropriate	
	Seen; to be stamped on parts of a question or option which have been left blank	
0	Zero; to be used when a question part is not worthy of credit. Awards zero for the question part	

You **must** make sure you have looked at all pages. Please put the  annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that are blank or where the candidate has crossed out his/her work.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

Subject Details: Biology HL Paper 2 Markscheme

Candidates are required to answer **all** questions in Section A and **two** out of **three** questions in Section B. Maximum total = **80 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 semicolon (;) 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 word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

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

7. An alternative markscheme is indicated in the "Answers" column under heading **ALTERNATIVE 1** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

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

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

11. 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.

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

13. 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.

14. 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]** for quality 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.

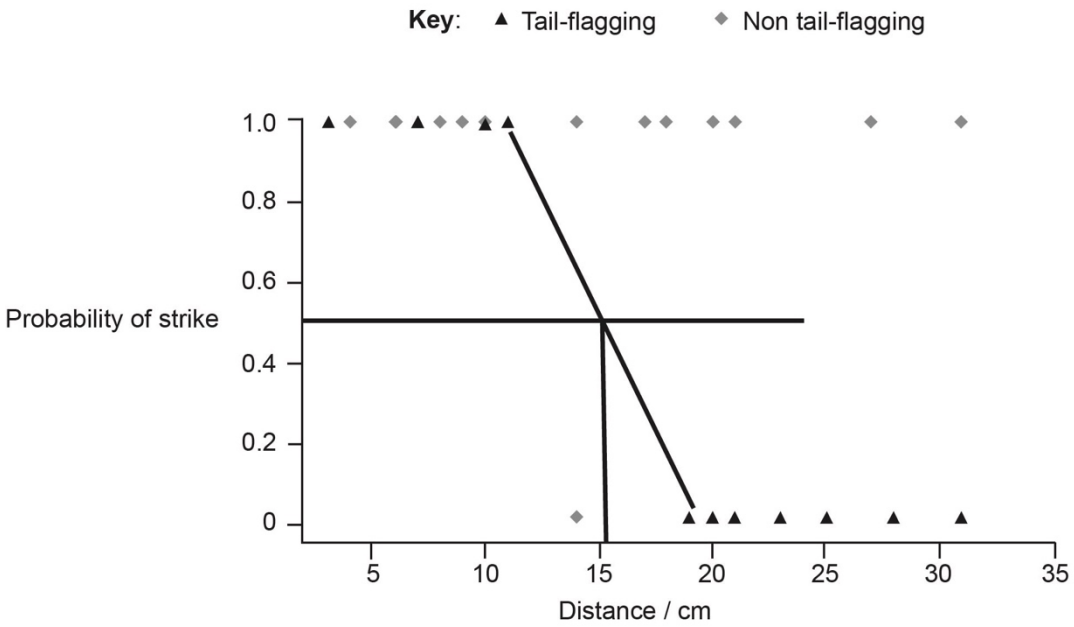
- Candidates that score very highly on the content marks need not necessarily automatically gain **[1]** for quality (and *vice versa*).

Section A

Question			Answers	Notes	Total
1.	a		80s	*Units required. Accept value in the range 75s – 85s*	1
1.	b		a. snakes spend some time/very short time studying the controls/filter paper ***OR*** fewer tongue flicks at the controls/filter paper; b. filter paper itself is not a factor in the experimental results;		2
1.	c		so that the snakes were choosing according to scent and not learning by position / OWTTE		1
1.	d		masks the scent of the squirrel / suggests presence of rival snake / OWTTE		1
1.	e		a. both have a high probability of a strike at shorter distances (from each other); b. at greater distances (from each other) low chance of strike on tail flaggers but high on non-tail flaggers;		2

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**f**		14 (cm)  	*Accept range 12 to 16 cm*	**1**
1.	**g**		a. squirrel is alert, so strike is likely to miss; b. resources/energy wasted so snakes do not strike;		**1**
1.	**h**		with chatter ***AND*** 3 minutes after hearing hawk sounds		**1**

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**i**		a. there is no significant difference in the two; b. bars nearly the same height / large overlap of error bars; c. do not know sample size so conclusions may not be reliable (if sample size is small) ***OR*** need to perform a suitable statistical test;		**2**
1.	**j**		a. the data supports the suggestion that squirrels listen to bird chatter ***OR*** reassuring to hear bird chatter because it indicates no imminent threat/hawk has gone away; b. with no chatter the squirrels looked up more often (than with chatter) ***OR*** with chatter the squirrels looked up less often (than with no chatter); c. with no chatter the squirrels were more vigilant (than with chatter) ***OR*** with chatter the squirrels were less vigilant (than with no chatter); d. the data shows no significance in the response without chatter ***OR*** the data only shows a significant difference in the response with chatter ***OR*** large error bars mean conclusions may be unreliable;		**3**

Question			Answers	Notes	Total
2.	**a**		a. nucleus; b. mitochondria; c. Golgi apparatus; d. ER/rough ER; e. smooth ER; f. vacuole/vesicle;		**2**
2.	**b**	**i**	a. chloroplasts; b. large/central vacuole;		**1**
2.	**b**	**ii**	a. plasma membrane; b. ribosomes;		**1**
3.	**a**	**i**	arrow pointing from inside the cell to the right outside (accept arrow with its entirety in the cell/below the cell)		**1**
3.	**a**	**ii**	gravity/light		**1**
3.	**b**	**i**	the cells would be larger/longer with auxin		**1**
3.	**b**	**ii**	cytokinin		**1**

Question			Answers	Notes	Total
4.	**a**		a. concentration in blood is lower than air / blood arriving at alveoli is oxygen poor/deoxygenated; b. oxygen moves into blood by diffusion; c. oxygen concentration in alveolar air lower than in atmospheric air; d. ventilation occurs ***OR*** alveolar air replaced by (oxygen rich) atmospheric air; e. flow of blood in capillaries maintains concentration gradient;	Allow converse for CO_2 for MP a, b and c	**3**
4.	**b**		a. rich capillary supply; b. epithelium is one cell thick; c. moist surface; d. large surface area / high surface area to volume ratio;		**2**
4.	**c**		a. plasma membrane has microvilli / is highly folded; b. large numbers of mitochondria (to supply energy for active transport); c. many vesicles formed by endocytosis;		**2**

Question			Answers	Notes	Total
5.	**a**		ensures a habitat is sustainable for the prey/limits damage to the ecosystem (as a result of overpopulation)/removes genetically weaker individuals/prevents overgrazing/prevents overpopulation		**1**
5.	**b**		a. the size of the predator population (influences the prey population); b. resources/food may be limiting; c. transfer of pathogens/pests/disease (influences the prey population);		**2**
5.	**c**	**i**	a. sample captured, marked and released; b. ratio of marked individuals in a second sample determined; c. equals ratio of marked sample to entire population/use Lincoln index;		**2**
5.	**c**	**ii**	a. low levels of immigration/emigration between sampling events; b. distribution/mortality/survival not affected by capture/marking; c. trap avoidance minimal; d. reproduction patterns/rates not affected;		**1**

Question			Answers	Notes	Total
6.	**a**		a. pair of sex chromosomes / X and Y chromosomes; b. X and Y sperm produced in equal numbers; c. egg is X and if fertilized by X sperm leads to a female child; d. egg is X and if fertilized by Y sperm leads to a male child;		**2**
6.	**b**		a. sex cell normally contains one copy (of chromosome 21); b. (because of nondisjunction) fail to separate properly; c. in first or second meiotic division; d. sex cell contains two copies (of chromosome 21); e. this sex cell (with two copies) fertilizes normal sex cell (with one copy); f. non-disjunction (of chromosome 21) more frequent in females/increases with age;		**3**
6.	**c**		a. mostly males affected; b. sons of affected father are unaffected; c. sons of affected mother are affected;		**2**

Question			Answers	Notes	Total
7.	a		brown body vestigial wings ***AND*** black body, normal wings		1
7.	b		a. independent assortment predicts 1:1:1:1 ***OR*** this (mendelian) ratio not seen / recombinants less frequent/parental types more frequent; b. suggests linkage ***OR*** small numbers so could be a result of differential survival;		2
7.	c		a. calculate expected numbers; b. assume no selective advantage to any of the genotypes; c. calculate chi square value; d. (if tabulated value is exceeded then) significant difference/reject null hypothesis/alleles do not sort independently/alleles linked;		2

Section B

Question			Answers	Notes	Total
8.	**a**		a. vaccinations are specific to a specific disease; b. vaccines contain non-self antigens/antigens from pathogens; c. can be live relative/attenuated version of the virus; d. trigger a primary immune response (without causing the disease); e. lymphocytes with specific receptors (are activated and) produce memory cells; f. (memory cells) cause a faster production of antibodies on a second exposure/exposure to the disease; g. (memory cells) provide long term immunity;		**7**
8.	**b**		a. (during depolarization) Na^+ channels open; b. allowing Na^+ to flow into the axon; c. (during repolarization) K^+ channels open; d. allowing K^+ to flow out of the axon; e. the Na^+/K^+ pump returns the (axon) membrane to the resting potential; f. by moving $3Na^+$ out and $2K^+$ in;		**4**

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
8.	**c**		a. courtship behaviour is often complex and unique to a species; b. (at several stages in courtship ritual) rejection occurs if characteristic behaviour not exhibited; c. species-specific egg fertilization; d. compatibility of acrosome with vitelline layer; e. inability of successfully attached wrong species sperm to develop continuity with egg membrane; f. sterility of interspecific hybrids; g. due to differences in chromosome number;		**4**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>9.</td><td>a</td><td></td><td>a. some toxins/DDT are persistent/degrade slowly (once released into the environment);
b. (some toxins/DDT) enter the food chain through producers/lower trophic levels;
c. (some toxins/DDT) are passed on to higher trophic levels in the food chain;
d. (they are) difficult to excrete / are not excreted;
e. (they) accumulate in fatty tissues of animals;
f. higher trophic levels/top consumers have higher/the highest concentration of pesticides in their bodies;
g. they bioaccumulate/biomagnify;</td><td></td><td>4</td></tr>
<tr><td>9.</td><td>b</td><td></td><td>
<table>
<tr><td>Competitive inhibition</td><td>Non-competitive inhibition</td></tr>
<tr><td colspan="2">Similarities:</td></tr>
<tr><td colspan="2">slow down enzyme activity;</td></tr>
<tr><td colspan="2">interact with R chains of amino acids at the surface of enzyme molecule;</td></tr>
<tr><td colspan="2">Differences:</td></tr>
<tr><td>inhibitor binds to active site</td><td>does not bind to active site</td></tr>
<tr><td>inhibitor does not bind to allosteric site;</td><td>inhibitor binds to allosteric site;</td></tr>
<tr><td>substrate cannot bind due to blockage of active site</td><td>substrate cannot bind due to disruption/change in shape of active site;</td></tr>
<tr><td>inhibition is reversible</td><td>inhibition is (usually) permanent;</td></tr>
<tr><td>inhibitor has similar shape to substrate</td><td>inhibitor does not have similar shape to substrate;</td></tr>
<tr><td>can be reversed by increasing substrate concentration</td><td>adding substrate does not reduce inhibition;</td></tr>
</table>
a valid example of each;</td><td>Answers must have at least one similarity for 7 max.</td><td>7 max</td></tr>
</table>

(continued…)

(Question 9 continued)

Question			Answers	Notes	Total
9.	**c**		a. lower rate of aerobic respiration / inhibits aerobic respiration; b. reduced NAD (not oxidised) accumulates; c. fewer/no electrons (from reduced NAD and FADH) to be transported by carriers; d. less/no energy to transfer protons (from matrix to intermembrane space); e. proton gradient cannot be maintained; f. less/no diffusion of protons through ATP synthase; g. ADP is not phosphorylated / less ATP produced / no energy to produce ATP; h. oxygen not binding to protons / accepting electrons / no water formed;		**4**

Question			Answers	Notes	Total
10.	**a**		a. affects/damages/causes change in oncogenes/errors in DNA repair; b. UV radiation might alter complementary base pairing/break hydrogen bonds/fuse bases; c. double helix may uncoil; d. strands may separate/break; e. DNA sequence may be altered/DNA bases may re-connect to different bases after separating; f. DNA strand may break into pieces / fragments of DNA may be lost;		**4**
10.	**b**		a. DNA base sequence provides information; b. gene expression / genes provides a template for the construction of a protein; c. transcription occurs / mRNA is built using DNA as a template; d. DNA nucleotide structure described/sugar and phosphate and base; e. polymer of nucleotides makes a DNA strand; f. DNA has two anti-parallel strands; g. complementary base pairs/A pairs with T and C with G; h. strands linked by hydrogen bonding between bases; i. double helix shape / helix held by hydrogen bonds;	*Accept points in clearly labelled diagram*	**7**
10.	**c**		a. gene knockout technology is a genetic engineering technique/intentional alteration in the sequence of a gene; b. making a gene inactive; c. using site specific nucleases / CRISPR; d. researcher observes changes in phenotype of organism; e. allows researcher to determine function of the gene; f. entire library of knockout organisms exists; g. made available to researchers;		**4**

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 1A

Specimen Paper

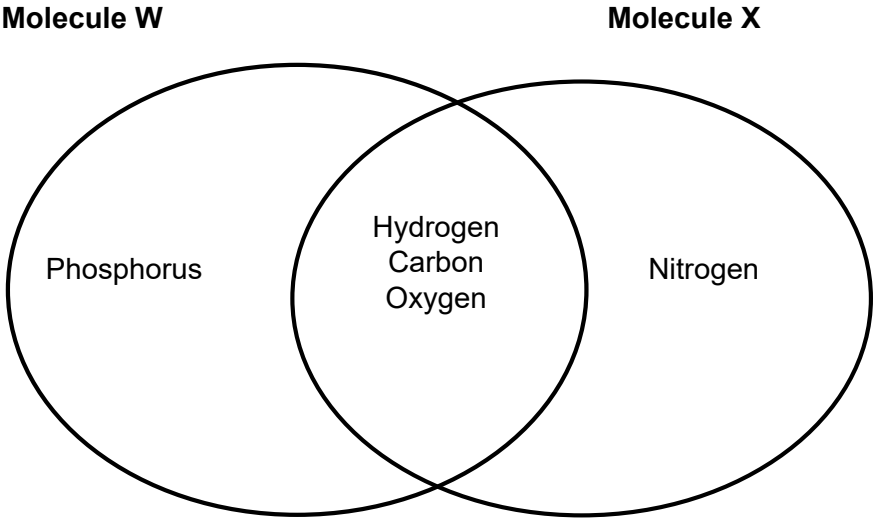
1 hour 30 minutes [Paper 1A and Paper 1B]

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- A calculator is required for this paper.
- The maximum mark for paper 1A is **[30 marks]**.
- The maximum mark for paper 1A and paper 1B is **[55 marks]**.

0000 – 6004

1. The diagram shows the elements present in two organic molecules, W and X.
Which molecules could W and X be?



	Molecule W	Molecule X
A.	monosaccharide	amino acid
B.	nucleic acid	triglyceride
C.	phospholipid	protein
D.	triglyceride	fatty acid

2. What is a consequence of the ability of water to form many intermolecular hydrogen bonds?

A. Ice has a higher density than water and floats, providing habitats for fish-eating mammals.

B. Light can pass through water, so algae can photosynthesise.

C. Some small invertebrates can walk on water surfaces.

D. Small amounts of energy are needed to change water from one state to another, so that evaporation rates and condensation rates are rapid.

3. Which molecules are produced during the hydrolysis of a triglyceride molecule?

A. Water and glycerol

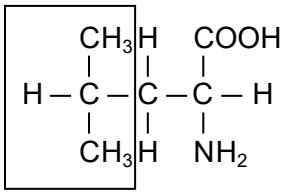
B. Fatty acids and glycerol

C. Water and fatty acids

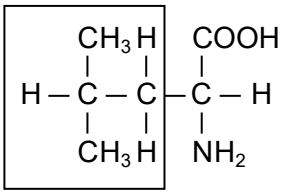
D. Water and lipids

4. The diagrams show the structure of leucine, an essential amino acid. Which diagram highlights the part of leucine that distinguishes it from other amino acids?

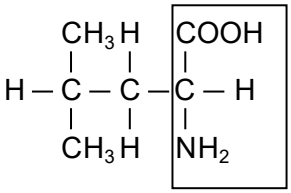
A.



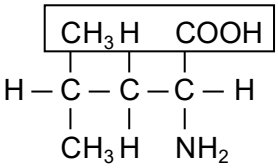
B.



C.



D.



5. What is a common feature of enzymes?

A. They all react with substrates.

B. They all decrease the rate of reaction.

C. They are all secreted from cells in vesicles.

D. They all bind to the active site of their substrate.

6. What distinguishes aerobic respiration from anaerobic respiration in humans?

A. Mitochondria are only used in anaerobic respiration.

B. Aerobic respiration yields lower quantities of ATP.

C. Only aerobic respiration can use glucose as a starting substrate.

D. Only aerobic respiration produces carbon dioxide.

7. What is a reason that Taq polymerase is a suitable enzyme for use in the polymerase chain reaction (PCR)?

A. It can work at a wide range of pH.

B. It works at higher temperatures than most enzymes.

C. It can separate two strands of DNA.

D. It allows DNA to be replicated without the use of primers.

8. A strand of DNA containing four codons with base sequence ACT GTA CTC TAC mutates, changing the base sequence to ACT ATG CTC TAC. What type of mutation has occurred?

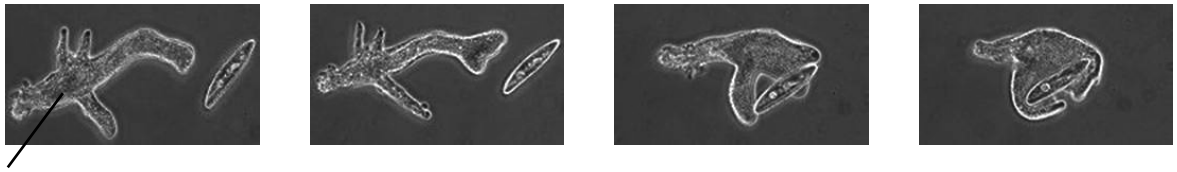
A. Insertion

B. Substitution

C. Deletion

D. Degeneracy

9. The series of images shows two unicellular organisms found in ponds and lakes.



Which functions of life are being shown in these images by organism X?

A. Metabolism and growth

B. Excretion and reproduction

C. Homeostasis and metabolism

D. Response and nutrition

10. Which is a feature of phloem sieve tube cells?

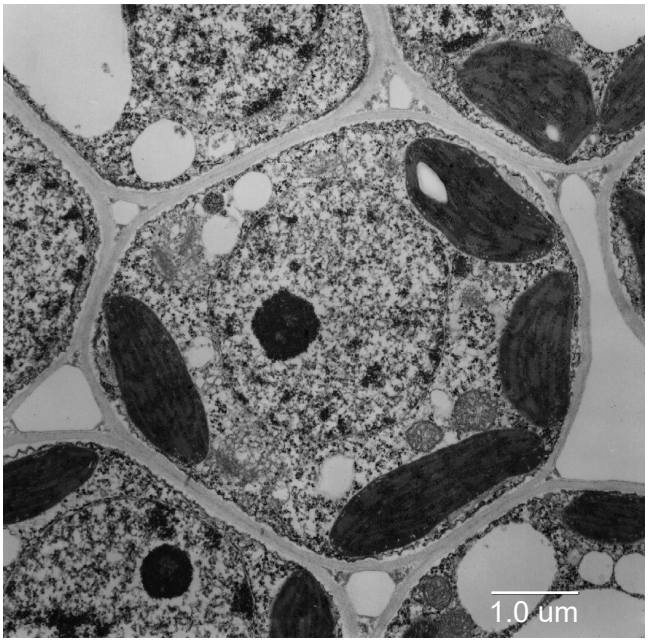
A. Numerous chloroplasts

B. No nucleus

C. Lignified walls

D. No cytoplasm

11. What can be identified in the electron micrograph?



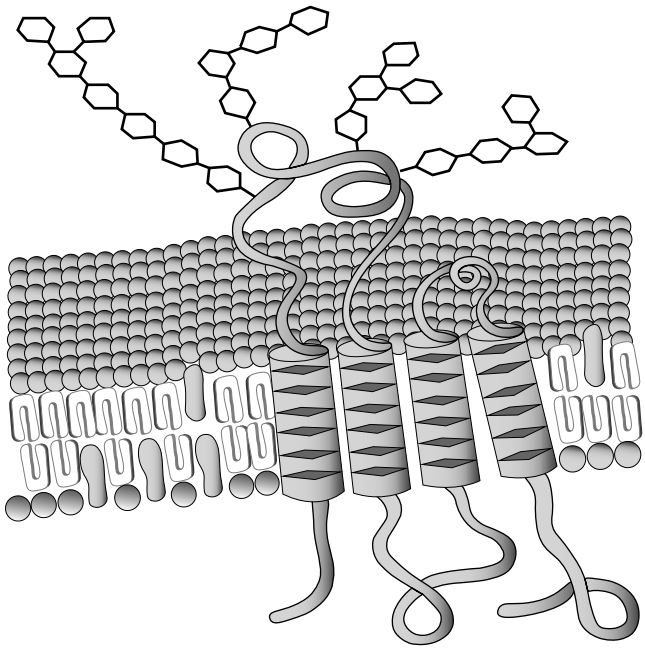
A. Plant cells with cell walls, nuclei and chloroplasts

B. Plant cells with chloroplasts and large central vacuoles containing nuclei

C. Several prokaryotes with cell walls and cytoplasm

D. Animal cells with prominent mitochondria

12. The image shows a glycoprotein embedded in the phospholipid bilayer of a cell membrane.



Which features of this glycoprotein can be deduced from the image?

A. It is a peripheral protein that allows attachment to neighbouring cells.

B. It is a channel protein that provides hydrophilic channels for carbohydrate transport.

C. It is an integral protein that may be involved in cell recognition.

D. It is a transport protein that increases the permeability of the membrane to glucose.

13. How is the Na/K ion ratio established during the resting potential phase of neuron activity?

	Na ions	**K ions**
A.	Actively transferred in	Actively transferred out
B.	Actively transferred out	Actively transferred in
C.	Passively diffused in	Passively diffused out
D.	Passively diffused out	Passively diffused in

14. What is a function of histones?

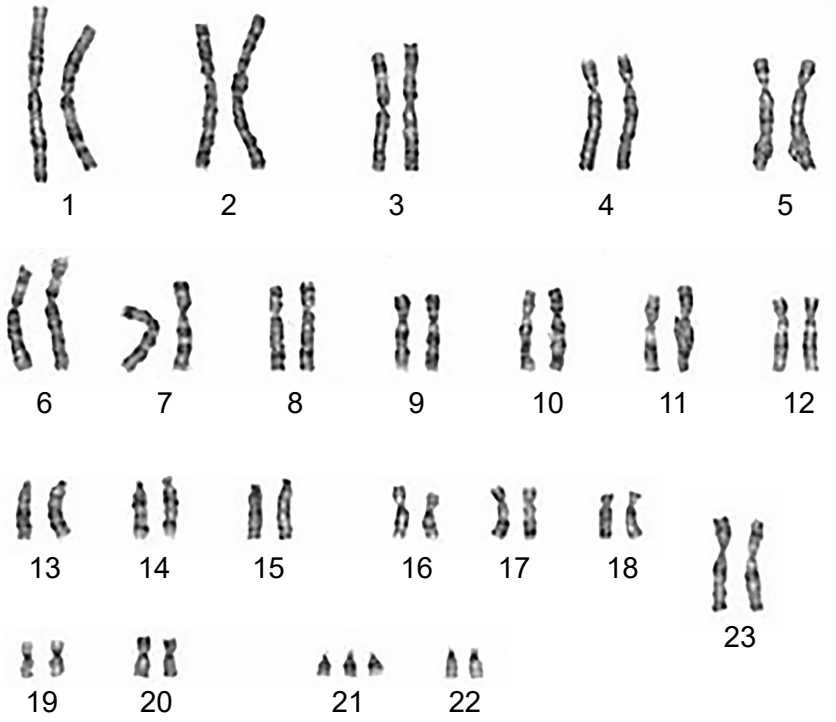
A. Supercoiling of DNA during binary fission in prokaryotes

B. Synthesis of proteins

C. Formation of microtubules during mitosis

D. Condensation of DNA

15. The karyogram shows a chromosome abnormality in a human female.



What could cause the abnormality to arise?

A. Failure of homologous chromosomes to separate during gamete formation

B. Chromosome 21 replicating after fertilization

C. A gene mutation of the mother's chromosomes during cell division

D. Polyploidy occurring during anaphase I of meiosis in both parents

16. Which term describes the whole of the genetic information of an organism?

A. Genome

B. DNA

C. Gene pool

D. Allele frequency

17. What occurs at gas exchange surfaces in the lungs of mammals?

I. Gases diffuse across a moist surface.
II. Concentration gradients are maintained by ventilation.
III. Water is lost.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

18. What is always a consequence of the evaporation of water from mesophyll cells in leaves of a healthy plant?

A. Plasmolysis occurs in mesophyll cells.

B. Photosynthesis stops.

C. Stomata close to reduce transpiration.

D. Water moves up the stem in the xylem.

19. What conveys messages from the central nervous system to an endocrine gland?

A. Sensory neurons

B. Hormones

C. Interneurons

D. Motor neurons

20. Which cell is a component of the innate immune system?

A. T lymphocyte

B. Phagocyte

C. B lymphocyte

D. B memory cell

21. How would the body respond to a rise above normal body temperature?

	Type of feedback	**Response**
A.	positive	increased secretion from sweat glands
B.	positive	spread limbs to increase surface area
C.	negative	vasodilation of skin blood vessels
D.	negative	shivering

22. The first day of the menstrual cycle is when menstruation begins. What occurs around day 15 of the cycle?

A. Formation of a corpus luteum

B. The placenta starts to secrete progesterone

C. The end of menstruation

D. Blood progesterone concentration reaches its maximum

23. What can lead to the emergence of analogous structures?

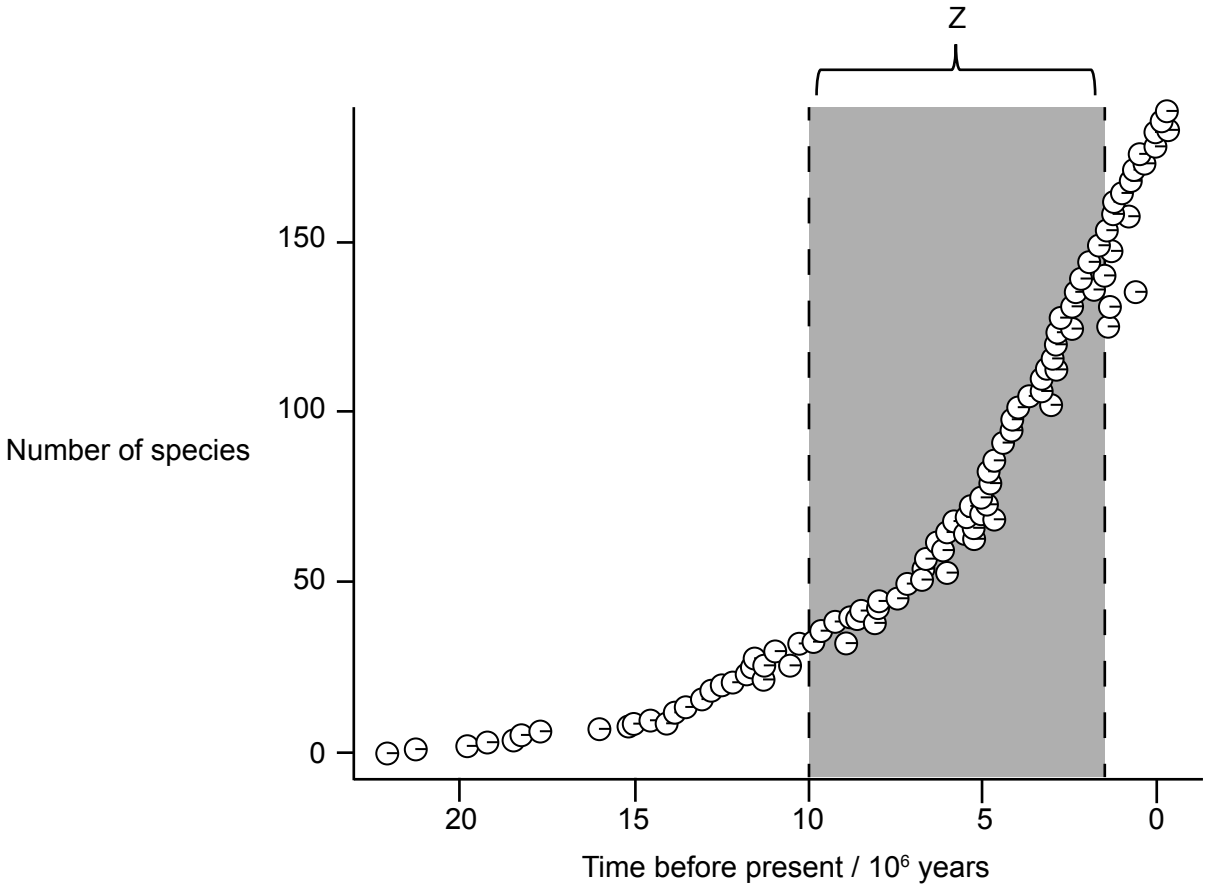
A. Divergent evolution from a recent common ancestor

B. Convergent evolution of unrelated species

C. Splits in the fundamental niche of a species

D. Splits in the realized niche of a species

24. The number of hummingbird species in South America has increased continuously as shown in the graph.



What could be a reason for the increase in the number of hummingbird species during the period labelled Z?

A. Food and shelter are plentiful and there is little intraspecific competition.

B. Closely related species can coexist indefinitely in the same niche.

C. A wide range of unoccupied potential niches exists, leading to adaptive radiation.

D. There are few limiting factors on the population size of hummingbirds.

25. The preferred temperature ranges for three species of trout that are found together in freshwater lakes in North America are shown.

Lake trout (*Salvelinus namaycush*)	Rainbow trout (*Oncorhynchus mykiss*)	Brown trout (*Salmo trutta*)
6–13 °C	12–18 °C	11–23 °C

What can be deduced from this information?

I. The niches for all three species overlap.
II. Brown trout have the most specialized niche.
III. Lake trout can avoid competition by living in colder water.

A. I only

B. II only

C. I and III only

D. I, II and III

26. Which row of the table describes a type of nutrition?

	Type of nutrition	**Source of energy**	**Source of carbon**	**Method of acquiring energy**
A.	**Autotrophic**	sunlight	organic molecules containing carbon	respiration
B.	**Heterotrophic**	sunlight	carbon dioxide	photosynthesis
C.	**Mixotrophic**	sunlight and energy-rich organic molecules	carbon dioxide and organic molecules containing carbon	photosynthesis and ingestion
D.	**Consumer**	energy-rich organic molecules	organic molecules containing carbon	photosynthesis and respiration

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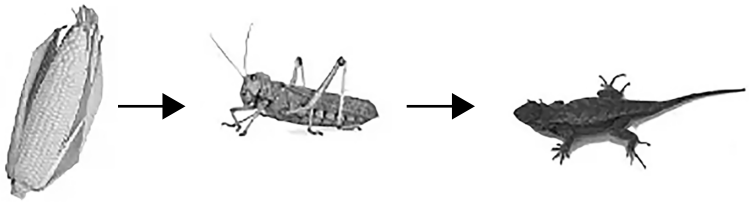
27. With respect to the food chain shown in the image, what is the role of the locust?



maize locust lizard

A. Secondary consumer

B. Parasite

C. Chemoautotroph

D. Herbivore

28. Black walnut (*Juglans nigra*) secretes the chemical juglone into the soil surrounding its roots. Juglone inhibits cell respiration in other species of plants. What does this example illustrate?

A. Mutualism

B. Intraspecific competition

C. Allelopathy

D. Parasitism

29. Which is a density-independent limiting factor for a kangaroo?

A. A forest fire

B. Predation

C. Climate change

D. Eutrophication

30. What is an outcome of natural selection?

A. Evolution

B. Mutations

C. Reproductive isolation

D. Variation

Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

9. LeavingBio, n.d. [*Unicellular organisms*]. [image online] Available at: <http://leavingbio.net/amoeba/> [Accessed 28 July 2020].

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

Markscheme

Specimen paper

Biology

Standard level

Paper 1A

2 pages

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

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 1B

Specimen Paper

Candidate session number

1 hour 30 minutes [Paper 1A and Paper 1B]

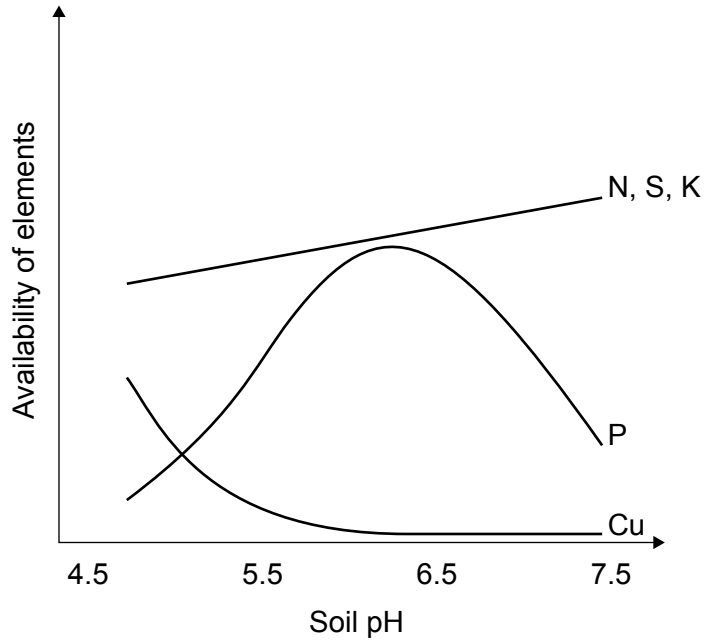
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for paper 1B is **[25 marks]**.
- The maximum mark for paper 1A and paper 1B is **[55 marks]**.

0000 – 6005

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The addition of some forms of nitrogen fertilizer to soil can lead to acidification. As a strategy to combat this, farmers will often undertake 'liming' to combat acidification. This involves adding lime to return the pH to neutral.



Certain soil pH levels are associated with copper (Cu) deficiency in cattle.

(a) Explain how a copper deficiency in soil could lead to a copper deficiency in a cow. [2]

. . . . . .

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. . . . . .

(b) Deduce with a reason which action (fertilizing or liming) could lead to a copper deficiency in a cow. [2]

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(This question continues on the following page)

(Question 1 continued)

(c) Copper-deficient cows are more susceptible to infections and do not respond as well to vaccinations. Suggest a role for copper in cows. [1]

. . . . . .

. . . . . .

(d) Phosphorous deficiency leads to poor growth of plants.

(i) State an example of a soil pH where phosphorous deficiency might result. [1]

. . . . . .

. . . . . .

(ii) List two biochemicals important to life that have phosphorous as a raw material. [1]

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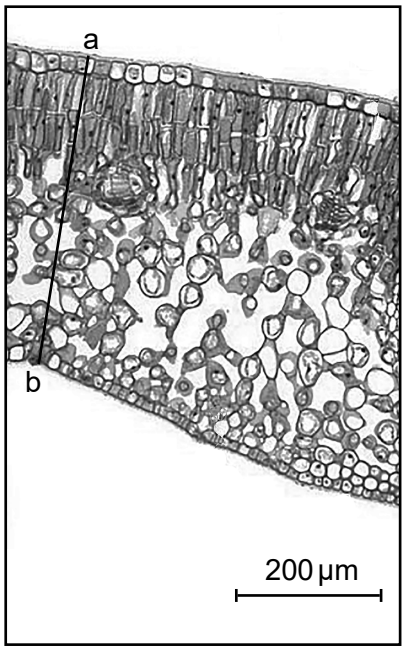
2. The micrograph shows a transverse section of a leaf from a flowering plant.



200 µm

(a) Draw a plan diagram in the right-hand box with labels to show the distribution of tissues in this transverse section of a leaf. [3]

(b) Calculate the actual thickness of the leaf, from upper to lower surface along the line a–b, showing your working. [2]

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(c) Suggest a reason for using a lower power objective lens when first focusing on a slide under the microscope. [1]

. . . . . .

. . . . . .

(d) Identify **one** adaptation of the leaf for the absorption of light visible in this micrograph. [1]

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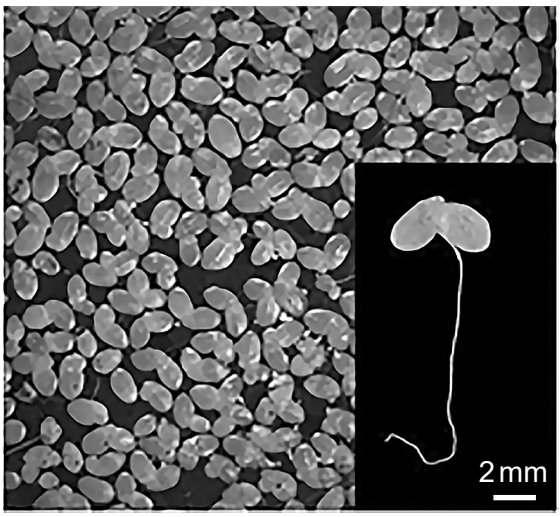
3. Duckweed (*Lemna minor*) is a small flowering plant that floats on water. Duckweed can reproduce rapidly using asexual reproduction, giving rise to dense populations.



A group of students investigated the effect of temperature on the rate of population growth of duckweed. They set up three culture dishes using 500ml of filtered pond water with a pH of 7.0. The culture dishes were given a small starting population of plants and each dish was incubated at a fixed temperature (15, 20 or 25 °C).

The number of duckweed plants in each dish was counted over several weeks. The data are summarized in the table.

Time / weeks	**Number of plants at a given temperature**		
	15 °C ± 1 °C	**20 °C ± 1 °C**	**25 °C ± 1 °C**
0	5	5	5
1	10	14	15
2	31	37	50
3	38	76	80
4	24	115	117
5	23	168	177

(a) Outline what indicates that temperature is the independent variable in this experiment. [1]

. . . . . .

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(This question continues on the following page)

(Question 3 continued)

(b) Identify the temperature that gives the highest overall population growth rate over the experimental period. [1]

. . . . . .

. . . . . .

(c) Explain how temperature can influence population growth in a species such as *Lemna minor*. [2]

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(d) Suggest how the reliability of this investigation could be improved. [1]

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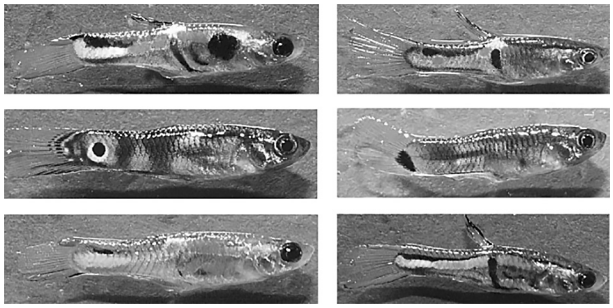
4. The images show examples of adult male guppies (*Poecilia reticulata*).



(a) State the name of the genus to which the guppy belongs. [1]

. . . . . .

. . . . . .

(b) Outline Linnaeus's morphological concept of species. [1]

. . . . . .

. . . . . .

(c) (i) Two alternative hypotheses were suggested:

- the guppies were from a single interbreeding population
- the guppies were not from a single interbreeding population.

Explain, with a reason, which hypothesis is stronger. [1]

. . . . . .

. . . . . .

(ii) Suggest how additional evidence could be used to further test which hypothesis is supported. [2]

. . . . . .

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(This question continues on the following page)

(Question 4 continued)

(d) Suggest an adaptive advantage for these guppies of having striking colour patterns. [1]

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Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

1. Jamieson, J.D. and Palade, G.E., 1967. Intracellular transport of secretory proteins in the pancreatic exocrine cell. *Journal of Cell Biology*, 34, pp.597–615.

2. Houseman, J. and Ford, M., 2014. *Dicot leaf L*. [image online] Available at: <https://commons.wikimedia.org/wiki/File:Dicot_leaf_L.jpg> [Accessed 28 July 2020].

3. *Lemna minor*, 2015. [image online] Available at: <https://www.semanticscholar.org/paper/Darwin-Wallace-Demons%3A-survival-of-the-fastest-in-Kutschera-Niklas/a2e3531fa8c1920d2bd4d04871bfeb19ed2143f0> [Accessed 8 December 2020].

4. Jones, J.C., Gunter, H.M. and Meyer, A., 2008. Will he still look good with the lights on? Spectral tuning of visual pigments in fish. *Journal of Biology*, [e-journal] 7(26). Available at: <https://jbiol.biomedcentral.com/articles/10.1186/jbiol86> [Accessed 28 July 2020].

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

Answers written on this page
will not be marked.

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

Answers written on this page
will not be marked.

SPEC/4/BIOLO/SP1/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

Specimen paper

Biology

Standard level

Paper 1B

10 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut
	Correct point (automatically awards 1 mark when stamped)	
	These are annotations which can be used to show which marking point was used to award a mark. It is easier to use these than to pick up the tick stamp and then the text box (they each automatically award 1 mark when stamped)	
	Quality marks awarded for clarity and structure (these each automatically award 1 mark when stamped)	
	Pointer (use when you want to delete an annotation or change colour)	
	Benefit of the doubt	
	Error carried forward	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Omission/incomplete	
	Too vague	
	No working shown	
	Unclear	

Annotation	Explanation	Shortcut
	This is a dynamic annotation; it can be used to surround work	
	This is a dynamic, vertical wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	This is a dynamic, horizontal wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	Valid part (to be used when more than one element is required to gain the mark eg: drawings)	
	Same as	
	Or words to that effect	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required)	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	
	Similarity (to identify elements in an unclear comparison)	
	Highlight, stamp and drag out to highlight an area of the script	
	Text box used for additional marking comments. It can be linked to a specific tick if that is appropriate	
	Seen; to be stamped on parts of a question or option which have been left blank	
0	Zero; to be used when a question part is not worthy of credit. Awards zero for the question part	

You **must** make sure you have looked at all pages. Please put the  annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that are blank or where the candidate has crossed out his/her work.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

Subject Details: Biology SL Paper 1B Markscheme

Candidates are required to answer **all** questions in Paper 1B. Maximum total = **25 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 semicolon (;) 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 word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

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

7. An alternative markscheme is indicated in the "Answers" column under heading **ALTERNATIVE 1** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

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

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

11. 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.

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

13. 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.

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

Question			Answers	Notes	Total
1.	**a**		a. the plants are unable to absorb copper; b. cows eat the copper-deficient plants;		**2**
1.	**b**		a. liming; b. as Cu becomes less bioavailable at neutral/basic pH;		**2**
1.	**c**		creation of antibodies / white blood cell function;		**1**
1.	**d**	**i**	any pH value above pH 7 or below 5.5;		**1**
1.	**d**	**ii**	a. nucleic acids /DNA/ RNA/nucleotides; b. ATP/phospholipids;		**1**

Question			Answers	Notes	Total
2.	**a**		a. palisade mesophyll; b. spongy mesophyll; c. lower epidermis; d. upper epidermis; e. xylem/phloem/vascular bundle;	*1 mark for each correctly labelled tissue shown as a layer in proportion:*	**3**
2.	**b**		a. correct measurement of the line on the image (+/-1mm); b. correct calculation and including units*;*	*Allow ECF – ruler measurements +/- 1mm*	**2**
2.	**c**		a. it is easier to find the specimen using a low power objective lens ***OR*** there is a larger field of view/depth of focus; b. it is easier to locate the most interesting part of the specimen with a low power objective lens; c. most microscopes are calibrated so that once in focus using the low power objective lens they will be close to focus using the higher power, so this helps focusing; d. reduced risk of cracking the slide;		**1**
2.	**d**		a. double layer of palisade cells; b. palisade layer on upper surface; c. dimensions of palisade cells maximize light absorption; d. thin/transparent epidermis/cuticle;		**1**

Question			Answers	Notes	Total
3.	**a**		actively varied/manipulated (by the experimenter)/OWTTE		**1**
3.	**b**		25 °C		**1**
3.	**c**		a. temperature is a limiting factor (for enzymes) ***OR*** other limiting factors are influenced by temperature ***OR*** temperature is closer to the optimum temperature (of the enzymes); b. at higher temperature exchange of materials is more efficient; c. plants are reproducing/photosynthesising slowly at lower temperature / vice versa; d. dying faster than reproducing at lower temperature / vice versa;		**2**
3.	**d**		a. (larger culture dishes with) bigger starting duckweed populations; b. several replicates at each temperature; c. apply (appropriate) statistical analysis;		**1**

Question			Answers	Notes	Total
4.	**a**		*Poecilia*		**1**
4.	**b**		group of organisms with (visible) shared traits		**1**
4.	**c**	**i**	a. same population, as the fish have similar body morphology **OR** same population, as colour variation could be normal within the population; b. different population, as the fish show variety in pattern/colour;		**1**
4.	**c**	**ii**	a. observe (courtship/mating) behaviour when they are together; b. carry out DNA analysis; c. gather information about reproductive isolation;		**2**
4.	**d**		a. sexual selection / OWTTE; b. camouflage;		**1**

Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 2

Specimen paper

Candidate session number

1 hour 30 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.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

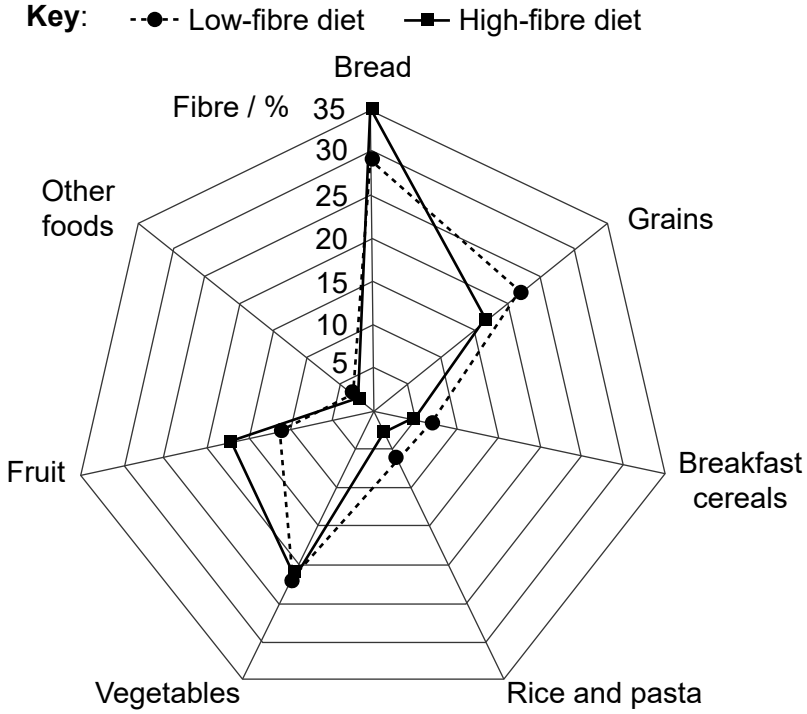
16 pages

0000 – 6006

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. A long-term study looked at the effect of diets with differing fibre content in 543 children between the ages of 8 months and 9 years. The children were divided into groups according to the amount of fibre in their diet. The chart shows the sources of fibre for the 9-year-olds as a percentage of the total fibre intake.



[Source: adapted from Ruottinen, S., Lagström, H.K., Niinikoski, H., Rönnemaa, T., Saarinen, M., Pahkala, K.A., Hakanen, M., Viikari, J.S.A. and Simell, O., 2010. *The American Journal of Clinical Nutrition*, 91(3), pp.651–661. REDACTED.]

(a) (i) State the source of fibre that provides 5 % of the fibre intake for those in the high-fibre group. [1]

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(ii) State the percentage of the daily fibre intake obtained from fruit by the low-fibre group. [1]

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(Question 1 continued)

(b) Compare and contrast the fibre intake of the two groups. [2]

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(c) Explain whether it is possible to determine from the data which group eats the most grains in a day. [2]

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(d) Suggest with a reason, based on the data in the chart, **one** food that should be increased for children on the low-fibre diet. [2]

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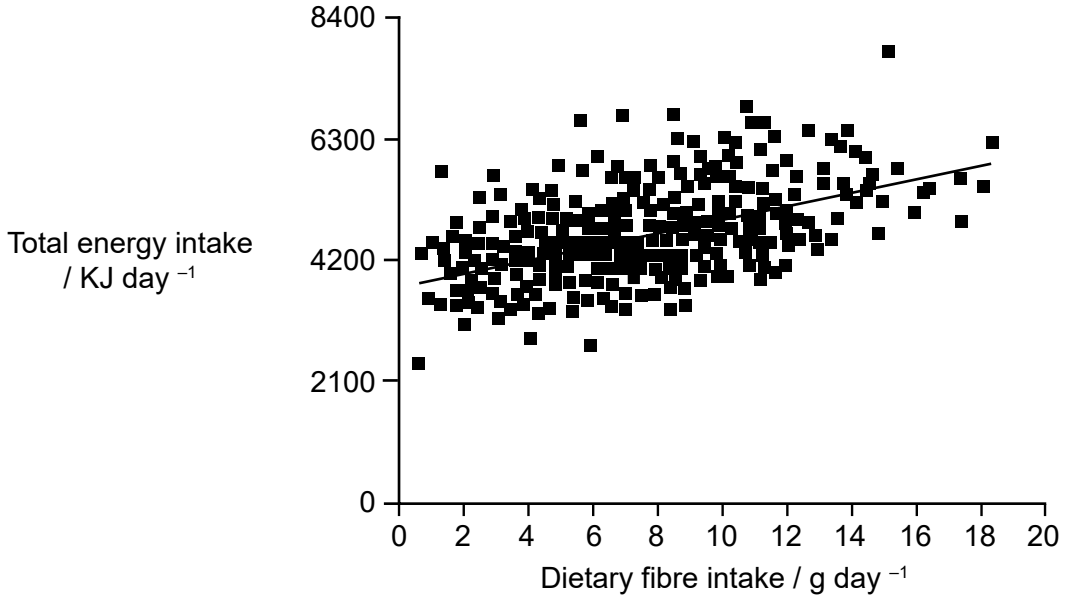
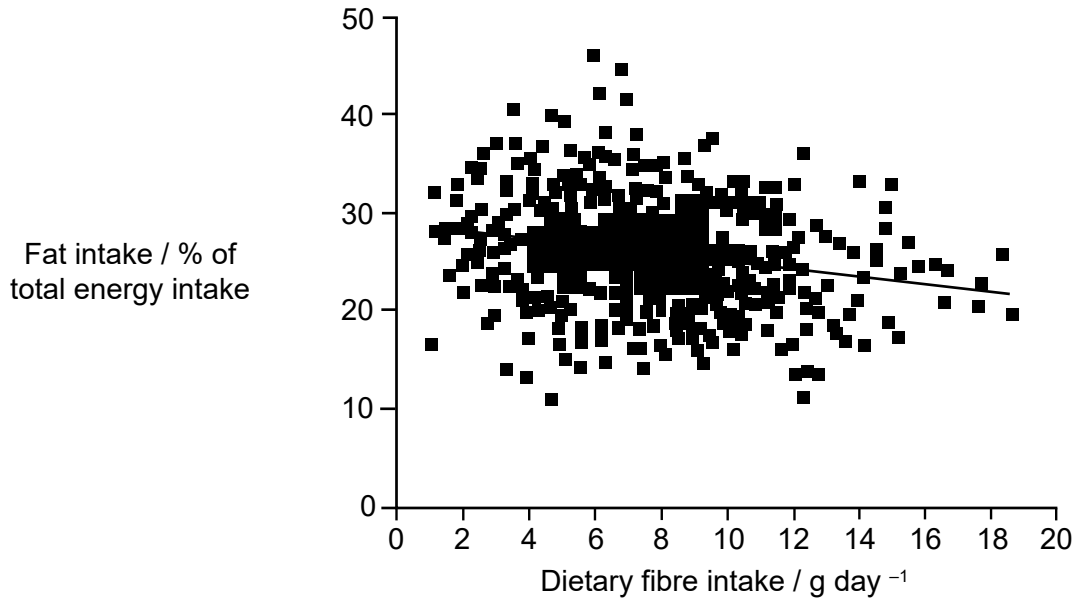
(Question 1 continued)

The graphs show how the energy intake of the 13-month-old children varied with the daily intake of fibre and the percentage of this energy that came from fat.





[Source: adapted from Ruottinen, S., Lagström, H.K., Niinikoski, H., Rönnemaa, T., Saarinen, M., Pahkala, K.A., Hakanen, M., Viikari, J.S.A. and Simell, O., 2010. *The American Journal of Clinical Nutrition*, 91(3), pp.651–661. REDACTED.]

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(Question 1 continued)

(e) Compare the effect of increasing daily dietary fibre intake on total energy intake and percentage of total energy from fat. [1]

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(f) Fibre is known to have no energy value. Suggest a reason for the relationship between dietary fibre intake and total energy intake. [1]

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(g) Discuss whether the study supports the hypothesis that high-fibre diets are healthy for children. [1]

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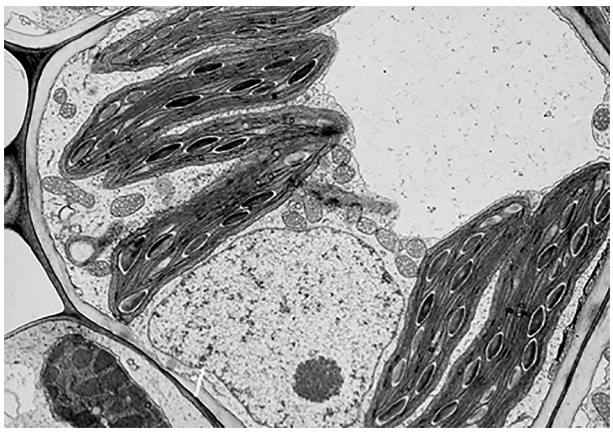
Please **do not** write on this page.

Answers written on this page
will not be marked.

2. The cytoplasm in eukaryotic cells is compartmentalized into membrane-bound organelles, as seen in this electron micrograph of a plant cell.



(a) State **two** membrane-bound organelles that are common to both plant and animal cells. [2]

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(b) (i) State **one** organelle that is found in a plant cell but not in an animal cell. [1]

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(ii) State **one** organelle that is common to prokaryotic and eukaryotic cells. [1]

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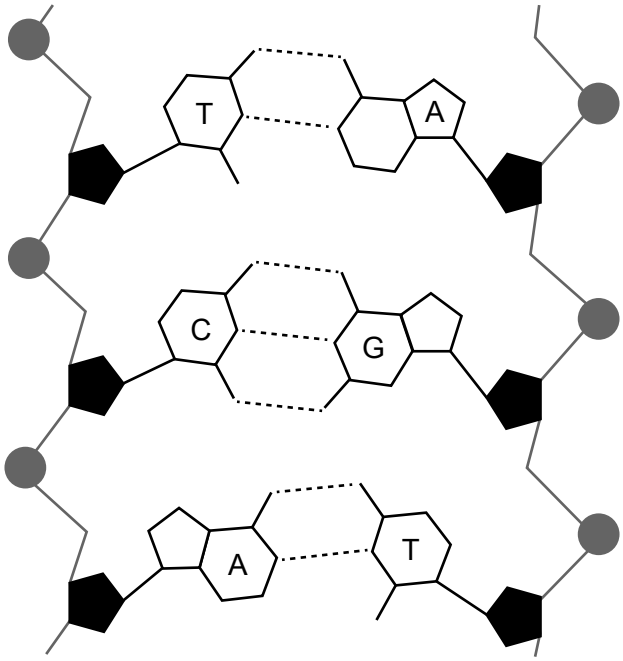
3. The diagram shows a short stretch of DNA with complementary base pairing.



(a) Identify **two** features of DNA shown in this diagram that distinguish it from RNA. [2]

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(b) Explain the significance of complementary base pairing in DNA. [3]

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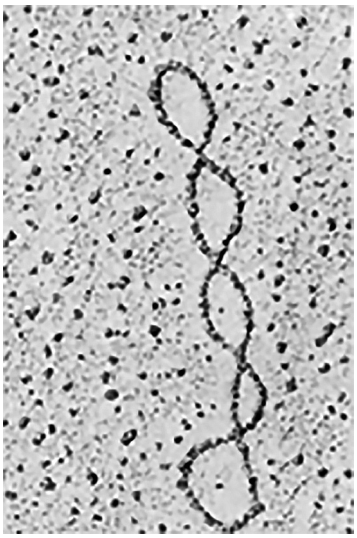
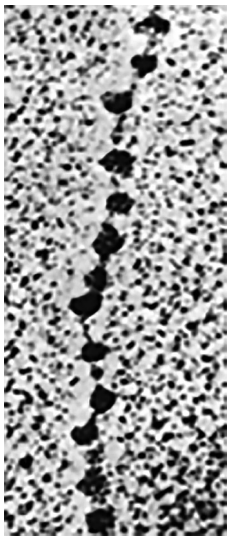
(Question 3 continued)

The images are electron micrographs of DNA from a prokaryote and from a eukaryote.



Prokaryote DNA



Eukaryote DNA

(c) Distinguish between the structure of DNA in prokaryotes and eukaryotes. [2]

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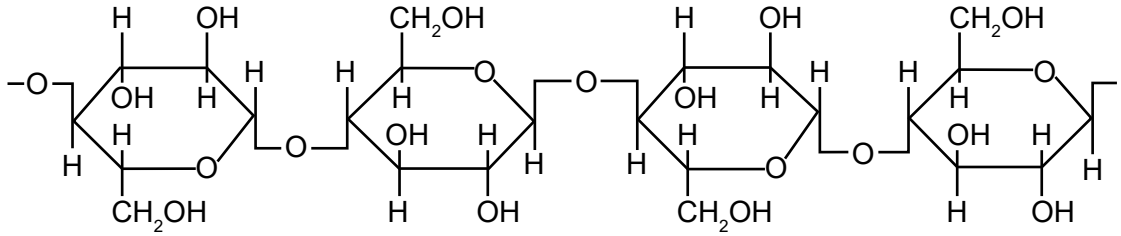
4. The structure of part of a cellulose molecule is shown.



(a) Identify the monomer from which cellulose is composed. [1]

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(b) Explain how the structure of cellulose is related to its function. [3]

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5. Many flowering plants require an animal pollinator in order to transfer pollen from one flower to another.

(a) Explain the type of ecological relationship between the hummingbird and the flower on which it feeds. [2]

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(b) State **one** way that plants attract animal pollinators. [1]

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(c) Hummingbirds have few natural predators. Suggest **one** type of behaviour that an animal such as a hummingbird can display to reduce the risk of predation while it is feeding. [1]

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6. In humans, sex is determined genetically and human populations have approximately equal numbers of males and females in each generation.

(a) Outline how sex is determined in humans. [2]

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(b) Explain how sexual reproduction gives rise to genetic variation. [2]

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Section B

Answer **one** question. One additional mark is available for the construction of your answer. Answers must be written within the answer boxes provided.

7. Mutations have a range of consequences for organisms.

(a) Outline how mutation can lead to cancer. [4]

(b) Outline **one** example of a human disease caused by an autosomal recessive allele. [4]

(c) Explain the role of mutations in evolution. [7]

8. Biological systems are sensitive to temperature changes, so they have mechanisms to resist temperature changes.

(a) Explain the mechanisms involved in thermoregulation in humans. [7]

(b) Explain the relationship between temperature and the activity of enzymes. [4]

(c) Distinguish between the thermal properties of air and water as they relate to the habitat of animals. [4]

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References:

2. *Electron micrograph of cells from the leaf of a corn plant*, n.d. [image online] Available at: <http://innolearn.weebly.com/bio-cell.html> [Accessed 9 December 2020].

3c. Left image:
Polder, L., 1992. [*Prokaryote DNA*]. [image online] Available at: <http://www.siumed.edu/~bbartholomew/images/chapter29/F29-17.jpg> [Accessed 9 December 2020].

Right image:
[*Eukaryote DNA*], n.d. [image online] Available at: <http://www.mun.ca/biology/desmid/brian/BIOL2060/BIOL2060-18/18_22.jpg> [Accessed 9 December 2020].

5. UC Davis School of Veterinary Medicine, n.d. [*Hummingbird*]. [image online] Available at: <https://hummingbirds.vetmed.ucdavis.edu/help-us-protect-hummingbirds> [Accessed 30 July 2020].

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

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

Specimen paper

Biology

Standard level

Paper 2

16 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut
	Correct point (automatically awards 1 mark when stamped)	
	These are annotations which can be used to show which marking point was used to award a mark. It is easier to use these than to pick up the tick stamp and then the text box (they each automatically award 1 mark when stamped)	
	Quality marks awarded for clarity and structure (these each automatically award 1 mark when stamped)	
	Pointer (use when you want to delete an annotation or change colour)	
	Benefit of the doubt	
	Error carried forward	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Omission/incomplete	
	Too vague	
	No working shown	
	Unclear	

Annotation	Explanation	Shortcut
	This is a dynamic annotation; it can be used to surround work	
	This is a dynamic, vertical wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	This is a dynamic, horizontal wavy line that can be expanded (for instance, to highlight a section of irrelevant work)	
	Valid part (to be used when more than one element is required to gain the mark eg: drawings)	
=	Same as	
WTTE	Or words to that effect	
Adv	Advantage / pro (to identify elements in an unclear discussion when pairs are required)	
Dis	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
diff	Difference (to identify elements in an unclear comparison)	
sim	Similarity (to identify elements in an unclear comparison)	
	Highlight, stamp and drag out to highlight an area of the script	
	Text box used for additional marking comments. It can be linked to a specific tick if that is appropriate	
SEEN	Seen; to be stamped on parts of a question or option which have been left blank	
0	Zero; to be used when a question part is not worthy of credit. Awards zero for the question part	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, use the “ZERO” annotation to award zero marks. Where a candidate has not attempted the part question, use the “SEEN” annotation to show you have looked at the question. RM™ Assessor will apply “NR” once you click complete.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “SEEN” on any additional pages that are blank or where the candidate has crossed out his/her work.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

Subject Details: Biology SL Paper 2 Markscheme

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 semicolon (;) 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 word is indicated in the "Answers" column by a slash (/). Either word can be accepted.

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

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

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

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

11. 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.

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

13. 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.

14. 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]** for quality 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]** for quality (and *vice versa*).

Section A

Question			Answers	Notes	Total
1.	**a**	**i**	Breakfast cereals		**1**
1.	**a**	**ii**	12%	*Allow 11 – 13*	**1**
1.	**b**		*Similarity* e.g. a. both groups get most of their fibre from bread ***OR*** both get least from other sources ***OR*** both have similar % from vegetables. *Do not accept "amounts"* ***OR*** both have similar sources / show a similar pattern; *Difference* e.g. b. high gets bigger % from fruit etc.;	*For differences allow any answer where the % are different so long as the candidates state which is bigger/smaller.*	**2**
1.	**c**		a. the data shows % of their daily intake, not quantities they take in; b. although the graph shows the low group takes in a higher percentage of grains, it may be a higher percentage of a small amount / OWTTE;		**2**
1.	**d**		a. bread/fruit; b. it makes up a higher percentage of high-fibre diets than low-fibre diets;		**2**
1.	**e**		increasing fibre intake increases total energy intake and lowers the percentage of energy from fat		**1**

(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**f**		the foods containing fibre must have energy rich molecules/carbohydrates in it		**1**
1.	**g**		*The study does support the hypothesis:* a. the data shows those with high fibre have more energy (required for growth and development/meeting daily needs); b. children with high fibre diets eat less fat (and less chance of heart disease/obesity);		**1**

Question			Answers	Notes	Total
2.	**a**		a. nucleus; b. mitochondria; c. Golgi apparatus; d. ER/rough ER; e. smooth ER; f. vacuole/vesicle;		**2**
2.	**b**	**i**	a. chloroplasts; b. large/central vacuole;		**1**
2.	**b**	**ii**	a. plasma membrane; b. ribosomes;		**1**

3	**a**		a. double stranded; b. thymine/T present / uracil/U absent; c. 1:1 A:T and C:G;		**2**
3.	**b**		a. can be used to explain the structure/dimensions of the molecule; b. (complementary base pairing means) adenine always with thymine **AND** cytosine always with guanine; c. ensures continuity of genetic information results from replication; d. stable arrangement of antiparallel strands; e. complementary base pairing provides a guide for (reliable) DNA transcription;	*Accept A, T, C and G*	**3**
3.	**c**		a. in prokaryotes circular whereas in eukaryotes linear; b. in eukaryotes associates with histones whereas in (most) prokaryotes not/naked DNA in prokaryotes;	*Allow "in eukaryotes forms nucleosomes whereas in prokaryotes not" as this is HL only*	**2**

Question			Answers	Notes	Total
4.	**a**		(beta-) glucose		**1**
4.	**b**		a. stable (covalent) bonds between monomers ensure that the molecule is strong/rigid/inelastic; b. absence of branching allows fibres to pack closely/form hydrogen bonds; c. cross linkages/hydrogen bonds provide strength/stability/resists digestion; d. chain molecules allow for structure / strength; e. (beta-) glucose molecules provide energy (to organisms that can digest cellulose);		**3**

5.	**a**		a. <u>interspecific</u> since it is between two species; b. <u>mutualistic</u> since both organisms benefit; c. (trophic relationship is) plant is a producer **AND** hummingbird is a primary consumer/herbivore;		**2**
5.	**b**		a. colour/patterns on flower parts; b. scent; c. providing nutrients/nectar;		**1**
5.	**c**		a. feed at a time when the predator is not active; b. remain very active/alert while feeding; c. mimic another organism; d. exaggerate their size;		**1**

Question			Answers	Notes	Total
6.	**a**		a. genetically determined/determined by (pair of) sex chromosomes/X and Y chromosomes; b. sperm carry either an X or a Y chromosome; c. egg is X and if fertilized by X sperm leads to a female child / XX female ***OR*** egg is X and if fertilized by Y sperm leads to a male child / XY male;		**2**
6.	**b**		a. recombination of parental alleles during fertilization; b. fertilized egg contains a mixture of paternal and maternal chromosomes; c. crossing over/meiosis gives rise to new combinations of alleles;		**2**

Section B

Question			Answers	Notes	Total
7.	a		a. mutations are random changes in the sequences of genes/DNA; b. (mutation) may involve addition/deletion/substitution/inversion of DNA bases; c. (mutations) in tumour suppressor genes/oncogenes; d. uncontrolled cell division/mitosis occurs; e. abnormal cells cannot perform their function; f. they divide repeatedly to form tumours;		**4**
7.	b		a. name of condition e.g. PKU / other example; b. mutation in the gene for (the enzyme) phenylalanine hydroxylase (PAH) / if other example used name of gene that is mutated; c. outline of inheritance pattern, e.g. both parents need to carry the recessive allele; d. (without dietary modification, result is) toxic build-up of phenylalanine in the blood / low levels of tyrosine / symptoms if other example used; e. phenylalanine is not converted to tyrosine (by the enzyme) / effect of the mutation on the protein/enzyme/metabolism if other example used; f. requires dietary modification (as treatment) / treatment for other example used;		**4**

(continued…)

(Question 7 continued)

Question			Answers	Notes	Total
7.	**c**		a. new phenotypes/traits may result from mutations; b. mutations increase variation/differences between individuals in a population/species; c. individuals with new phenotype/trait may have more chances of survival; d. (more chances of survival) in a changing environment / presence of selection pressures; e. (selection pressure can be) intraspecific competition/abiotic factor; f. natural selection occurs; g. individuals with (advantageous) mutation have longer life spans/live longer; h. (so) more chances of reproduction; i. mutated gene passed on to new generations; j. allele frequencies change in the population over time; k. evolution is a consequence of natural selection;		**7**

Question			Answers	Notes	Total
8.	**a**		a. normal body temperature is 37ºC; b. peripheral thermoreceptors detect environmental temperature; c. supporting conscious behaviour to avoid temperature extremes, e.g. wearing more clothing; d. sends messages to hypothalamus/temperature control centre of the brain; e. the hypothalamus sends messages to pituitary gland; f. (pituitary) releases TSH; g. stimulating thyroxin release from thyroid; h. thyroxin controls metabolic rate / production of heat; i. muscle random contraction/shivering to generate heat; j. (brown) adipose tissue burns fat to generate waste heat; k. vasoconstriction to conserve heat / vasodilation to exchange heat with the environment;		**7**

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
8.	**b**		a. as temperature increases, the rate of molecular motion increases; b. increasing the frequency of collision between enzyme and substrate; c. increasing the rate of reaction; d. until an optimum temperature is reached; e. with further increase in temperature, enzymes denature;		**4**
8.	**c**		a. water has a (much) higher specific heat capacity (than air); b. water requires more energy gain/loss to change temperature; c. (water) provides more stable thermal habitats than air / temperature of water bodies remains more constant than air temperature; d. water has a higher thermal conductivity than air; e. more heat is transferred from organisms to water than to air; f. water is a good evaporative coolant and air is not; g. aquatic mammals have (proportionally) more body fat as insulation;		**4**