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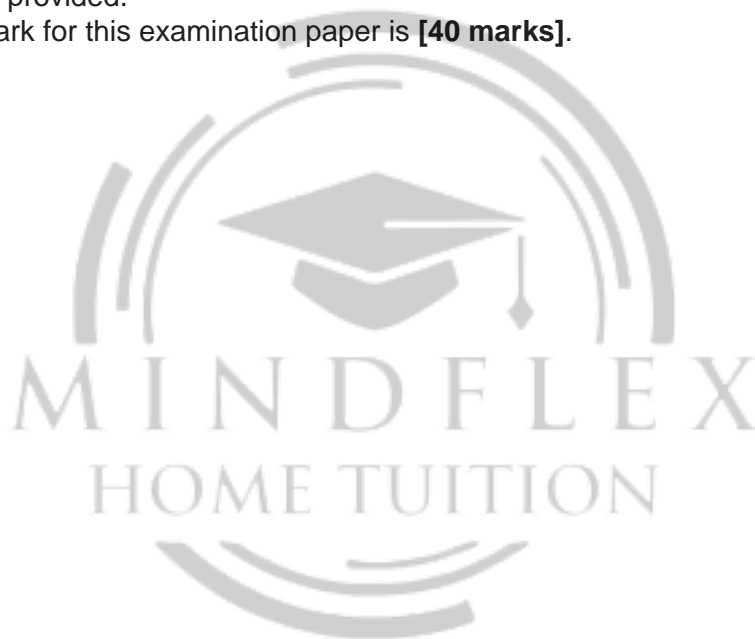
Biology
Higher level
Paper 1

Friday 4 November 2016 (morning)

1 hour

Instructions to candidates

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



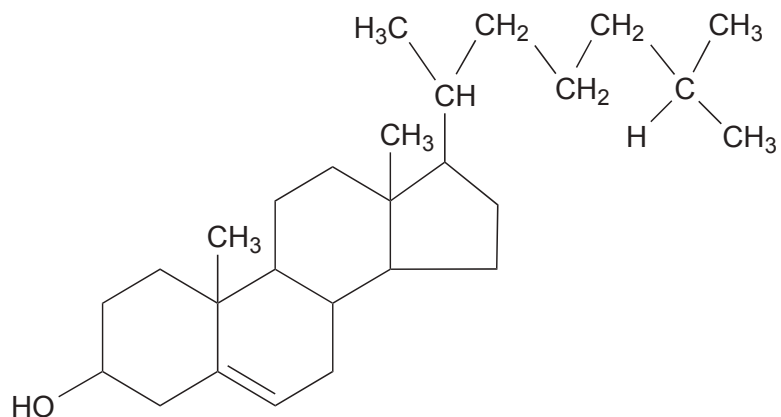
1. Which feature of striated muscle cells allows them to be considered as a possible exception to the cell theory?
 - A. They are found in multicellular organisms.
 - B. They contain more than one nucleus.
 - C. They are specialized for movement.
 - D. They do not carry out mitosis.

2. Which characteristic of stem cells makes them useful for treating Stargardt's disease?
 - A. They can differentiate into retinal cells.
 - B. They are readily available from especially created embryos.
 - C. They transport white blood cells to the eyes.
 - D. They divide by binary fission so provide sufficient cells.

3. The cell membrane model proposed by Davson–Danielli was a phospholipid bilayer sandwiched between two layers of globular protein. Which evidence led to the acceptance of the Singer–Nicolson model?
 - A. The orientation of the hydrophilic phospholipid heads towards the proteins
 - B. The formation of a hydrophobic region on the surface of the membrane
 - C. The placement of integral and peripheral proteins in the membrane
 - D. The interactions due to amphipathic properties of phospholipids

4. The giant marine alga *Halicystis ovalis* is able to move sodium ions from vacuoles to the surrounding seawater through active transport. Which condition or feature is required for this mode of transport?
 - A. Movement from a region of higher sodium concentration to a region of lower sodium concentration
 - B. A partially permeable surface
 - C. Membrane fluidity
 - D. Transmembrane proteins

5. The diagram shows a molecular structure.



Which type of molecule is shown?

- A. Amino acid
 - B. Lipid
 - C. Carbohydrate
 - D. Nucleotide
6. Which properties explain the ability of water to dissolve solutes?
- I. Polarity of water molecules
 - II. High specific heat capacity of water
 - III. Hydrogen bonding
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

7. Olive oil may reduce the risk of coronary heart disease. What is/are the compound(s) responsible for the health benefits of olive oil?
- I. Cis unsaturated fatty acids
 - II. Trans unsaturated fatty acids
 - III. Saturated fatty acids
- A. I only
 - B. I and II only
 - C. II and III only
 - D. I, II and III
8. A fever in a normally healthy adult during an illness is not usually a problem and can be regarded as a defence mechanism. However, a fever higher than 41 °C might be dangerous. What is the cause of the possible damage due to a high fever?
- A. Loss of body mass
 - B. Muscle damage due to shivering
 - C. Overactive metabolic enzymes
 - D. Spread of infection
9. It is possible to attach β -galactosidase to alginate beads for use in the production of lactose-free milk. What are enzymes that have been attached in this way called?
- A. Inhibited
 - B. Immobilized
 - C. Catalysed
 - D. Activated
10. What is produced by somatic-cell nuclear transfer?
- A. Adult sheep
 - B. Cloned embryos
 - C. Rooted stem-cuttings
 - D. Genetically modified food

11. What is the major health issue resulting from the Chernobyl nuclear accident in 1986?
- A. Coronary thrombosis
 - B. Cholera
 - C. Sex-linked diseases
 - D. Thyroid cancer
12. The diploid number of chromosomes in humans (*Homo sapiens*) is 46 and the diploid number of chromosomes in rice (*Oryza sativa*) is 24. What does this indicate about diploid chromosome numbers?
- A. Plant species have a lower diploid number of chromosomes than animals.
 - B. Members of a species have the same diploid number of chromosomes.
 - C. The evolutionary progress of species is determined by the diploid number of chromosomes.
 - D. The complexity of the organisms is correlated to the diploid number of chromosomes.

13. What description is matched with the correct phase in meiosis I?

A.	Prophase I	recombination occurs only between sister chromatids
B.	Metaphase I	homologous chromosomes join together at each end of the cell
C.	Anaphase I	homologous chromosomes are pulled apart
D.	Telophase I	two diploid nuclei are produced

14. What is the classification of an organism that is able to make organic compounds from inorganic nutrients?
- A. Autotroph
 - B. Consumer
 - C. Detritivore
 - D. Saprotroph

15. How is peat formed?
- A. From methanogenic archaeans under anaerobic and acidic conditions in deep sea vents
 - B. From partially decomposed organic matter under anaerobic and acidic conditions in waterlogged soils
 - C. From porous limestone under high pressure, aerobic and alkaline conditions in ocean beds
 - D. From bituminous coal under high pressure, anaerobic and acidic conditions below ground
16. What contributes to rising atmospheric concentrations of carbon dioxide and increases in average global temperature?
- A. An increase in the shorter wavelength radiation emitted by Earth
 - B. An increase in longer wavelength radiation emitted by Earth
 - C. An increase in the combustion of fossilized organic matter
 - D. The depletion of ozone in the stratosphere
17. Which evidence for evolution do the common features in the bone structure of vertebrate limbs provide?
- A. Adaptive radiation
 - B. Divergent radiation
 - C. Convergent evolution
 - D. Discontinuous variation
18. What is the major contributor to the increase in antibiotic resistance in bacteria?
- A. Sexual reproduction
 - B. Mutation
 - C. Natural selection
 - D. New antibiotics

19. The scientific name of the great egret has recently been changed from *Casmerodius albus* to *Ardea alba*.



[Source: <http://images.freeimages.com/images/previews/218/ardea-alba-2-1250856.jpg>, by sxc]

What is a possible reason for the reclassification of egrets?

- A. Allopatric speciation
 - B. Discovery of different ancestry
 - C. A change in the mating behaviours
 - D. Change in habitat and geographic range
20. What is the main method of transport of monosaccharides such as fructose across the intestinal epithelium?
- A. Osmosis
 - B. Facilitated diffusion
 - C. Endocytosis
 - D. Active transport
21. What is the position of heart valves when blood pressure is highest in the aorta?

	Atrioventricular valves	Semilunar valves
A.	open	closed
B.	closed	open
C.	closed	closed
D.	open	open

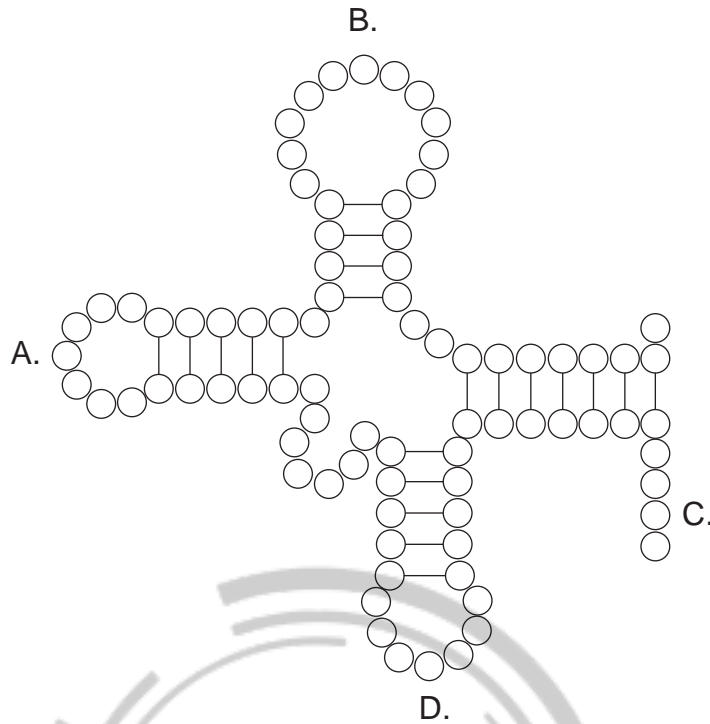
22. In Florey and Chain's experiment, eight mice were infected with lethal doses of *Streptococcus* bacteria. The four mice given penicillin survived, but the untreated mice died. What can be concluded from these results?
- A. The experiment should be repeated with more mice.
 - B. There is a causal relationship between the use of penicillin and antibiotic resistance in bacteria.
 - C. Penicillin can be used to treat bacterial infections in humans.
 - D. Penicillin may have played a role in the recovery of the four mice.

23. Which conditions are correct for inspiration?

	Muscles contracted	Pressure in thorax
A.	external intercostal	decreases
B.	internal intercostal	increases
C.	diaphragm	increases
D.	abdominal	decreases

24. The decline in European honeybee (*Apis mellifera*) populations may be linked to neonicotinoid pesticides. What effect do these pesticides have on the nervous system of insects?
- A. They prevent acetylcholinesterase from breaking down acetylcholine.
 - B. They inhibit depolarization in the presynaptic neuron which increases the levels of acetylcholine.
 - C. They produce an inhibitor that promotes the binding of acetylcholine.
 - D. They block synaptic transmission by binding with postsynaptic acetylcholine receptors.
25. Which hormone controls circadian rhythms?
- A. Thyroxin
 - B. Melatonin
 - C. Leptin
 - D. Glucagon

26. Where does a tRNA-activating enzyme attach the appropriate amino acid to the tRNA molecule?



27. What does post-transcriptional modification of eukaryotic mRNA include?

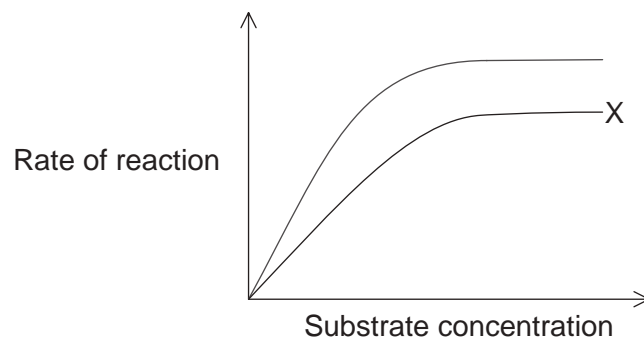
- I. Introns are removed from mRNA.
- II. Exons are joined together to form mature mRNA.
- III. A 5' cap and 3' poly-A tail are added to mRNA.

- A. I only
- B. I and III only
- C. II and III only
- D. I, II and III

28. Variations in the types of antibodies are produced by mRNA splicing. What is an advantage of this process?

- A. Reduces the size of mRNA required for the translation of antibodies
- B. Increases the number of different antibodies that can be synthesized
- C. Ensures that one gene codes for one antibody
- D. Speeds up transcription of antibodies

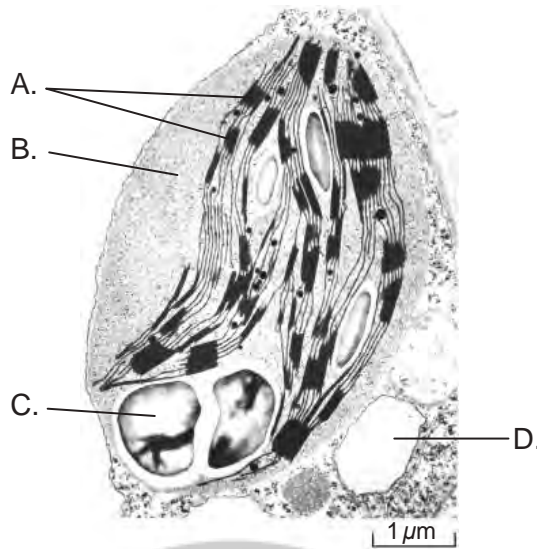
29. The graph shows an example of an enzyme-catalysed reaction.



What does the curve labelled X represent?

- A. No inhibition
 - B. Competitive inhibition
 - C. Non-competitive inhibition
 - D. Reversible inhibition
30. Which process requires oxygen in aerobic cell respiration?
- A. Oxidation of triose phosphate
 - B. Reduction of hydrogen carriers
 - C. Maintaining an oxygen concentration gradient in mitochondria
 - D. Accepting electrons at the end of the electron transport chain

31. The electron micrograph shows part of a plant cell. Where do the light-independent reactions of photosynthesis take place?



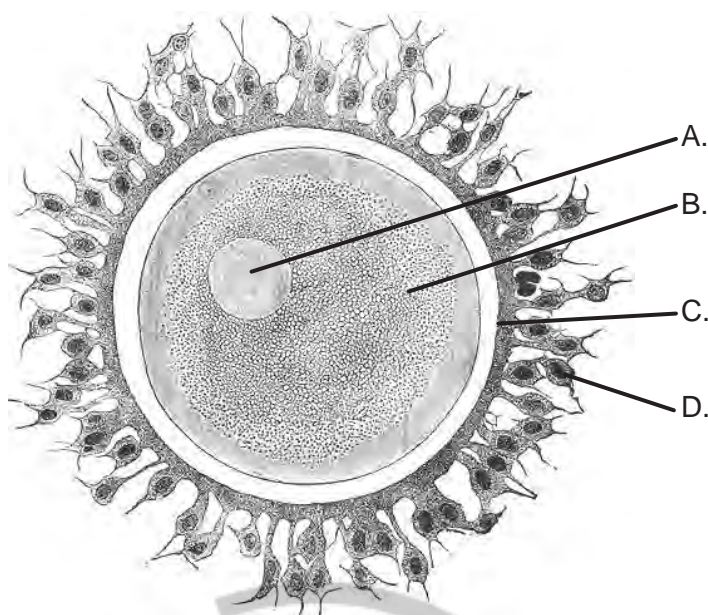
[Source: adapted from <http://themicroscopicplant.weebly.com>]

32. Excessive irrigation can cause increased salinity in the soil. What effect does this have on water transport in the plant roots?
- A. Decreases movement of water from soil into the root
 - B. Absorption of water with a higher solute concentration
 - C. Increases movement of water from soil into the root
 - D. Absorption of water with a lower solute concentration
33. Chrysanthemums are an important commercial flower. As a short-day plant, how can growers induce chrysanthemums to flower out of season?
- A. Expose plants to short bursts of light for 24 hours
 - B. Expose plants to 15 hours of continuous light
 - C. Expose plants to 12 hours of light and 12 hours of darkness
 - D. Expose plants to 15 hours of continuous darkness

34. What is/are the effect(s) of auxin in plants?
- I. Increasing the rate of cell elongation in stems
 - II. Changing the pattern of gene expression in shoot cells
 - III. Detecting the direction of light
- A. I only
 - B. I and II only
 - C. II and III only
 - D. I, II and III
35. Some of the ratios that Morgan investigated in genetic crosses did not correspond with expected Mendelian ratios. What was the cause?
- A. The genetic crosses used insects rather than plants.
 - B. The results were counted more reliably than Mendel's.
 - C. The genes in the genetic crosses were linked.
 - D. *Drosophila* has more genes than plants.
36. Fossil records show that black bears increased in size during the Ice Age and decreased in size with warmer temperatures. What type of selection do these changes in size represent?
- A. Allopatric
 - B. Directional
 - C. Disruptive
 - D. Stabilizing

37. What is **directly** responsible for allergic symptoms, including a runny nose or itchy eyes?
- A. Pathogens
 - B. Histamine
 - C. T-lymphocytes
 - D. Antigens
38. What is required for a skeletal muscle to exert force?
- A. Extensor and flexor muscles
 - B. Synovial joints
 - C. Attachment to bones
 - D. Ligaments
39. Which kidney adaptation would be expected in the desert kangaroo rat (*Dipodomys deserti*)?
- Removed for copyright reasons
- A. Increased nephron density
 - B. Longer proximal convoluted tubule
 - C. Longer loop of Henle
 - D. Increased ADH receptors on the collecting duct

40. Where does the acrosome reaction occur?



[Source: Adapted from <http://upload.wikimedia.org/wikipedia/commons/8/81/Gray3.png>]



Markscheme

November 2016

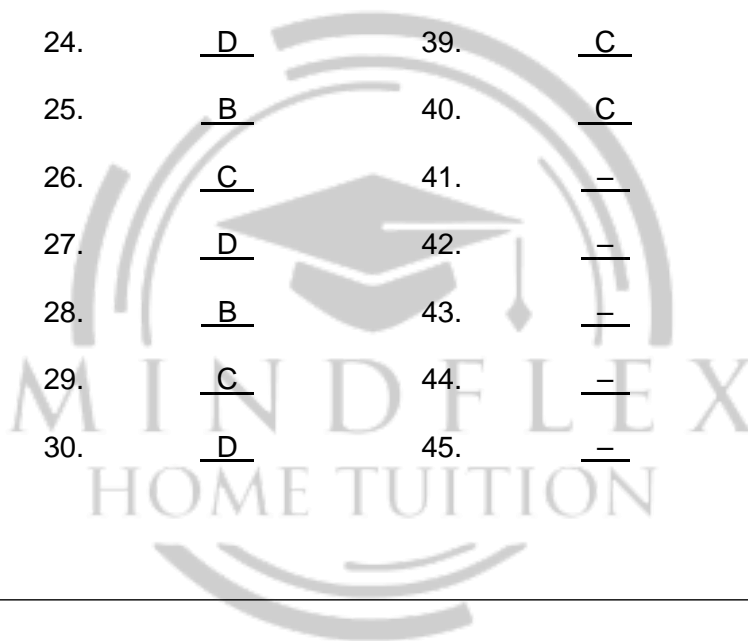

Biology

Higher level

Paper 1

2 pages

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



Biology
Higher level
Paper 2

Friday 4 November 2016 (morning)

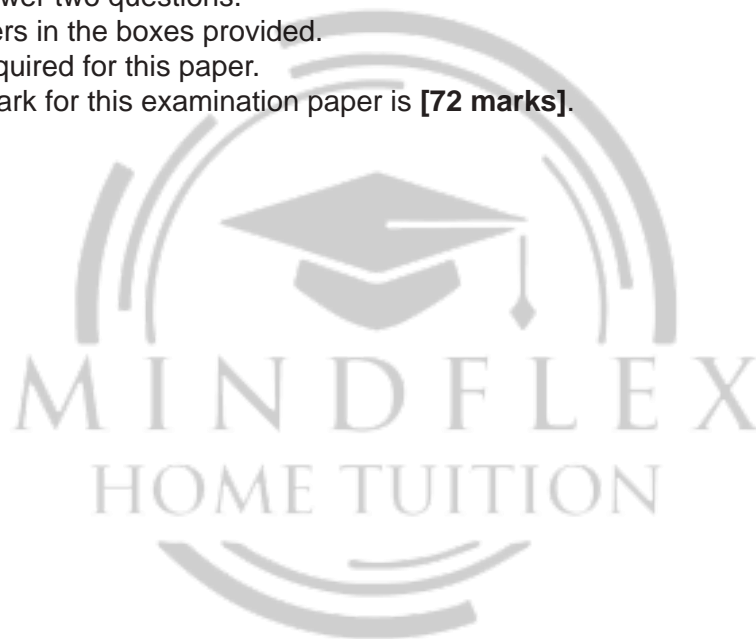
Candidate session number

2 hours 15 minutes

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Instructions to candidates

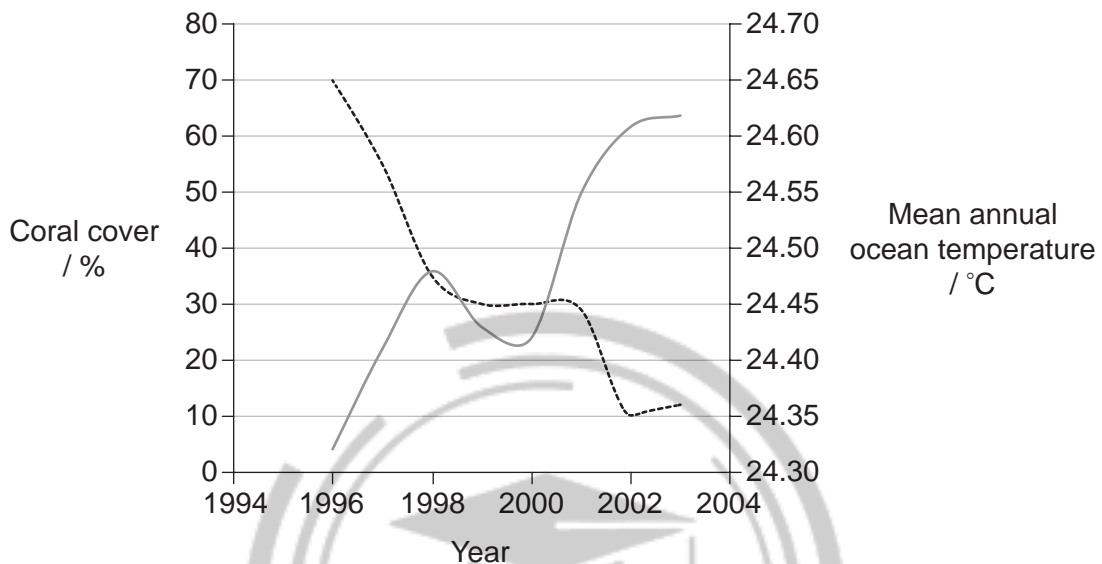
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination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



Section A

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

1. Coral reefs are among the most spectacular ecosystems on Earth. They support a rich diversity of life and provide economic benefits to the people who use them. In Papua New Guinea in the Pacific Ocean north of Australia the following data were collected. Coral cover is the percentage of the reef surface covered by live hard coral.



Key: ----- percentage coral cover ——— ocean temperature

[Source: adapted from Jones et al. (2004), The Encyclopedia of Earth, Patterns of Coral Loss]

- (a) Calculate the difference in coral cover in 1996 and 2002. No working required. [1]

..... %

- (b) Describe the evidence that the ocean temperature has an effect on coral cover. [2]

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(Question 1 continued)

(c) Suggest causes for the changes in ocean temperature.

[2]

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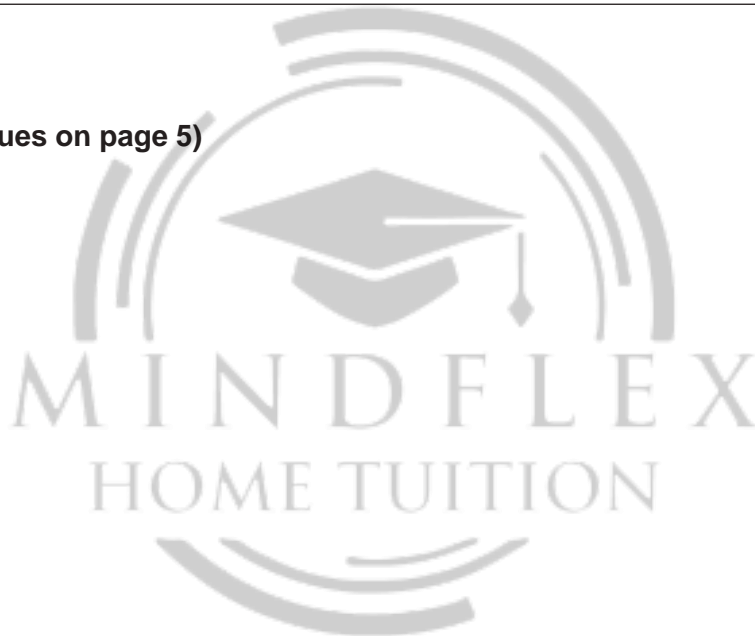
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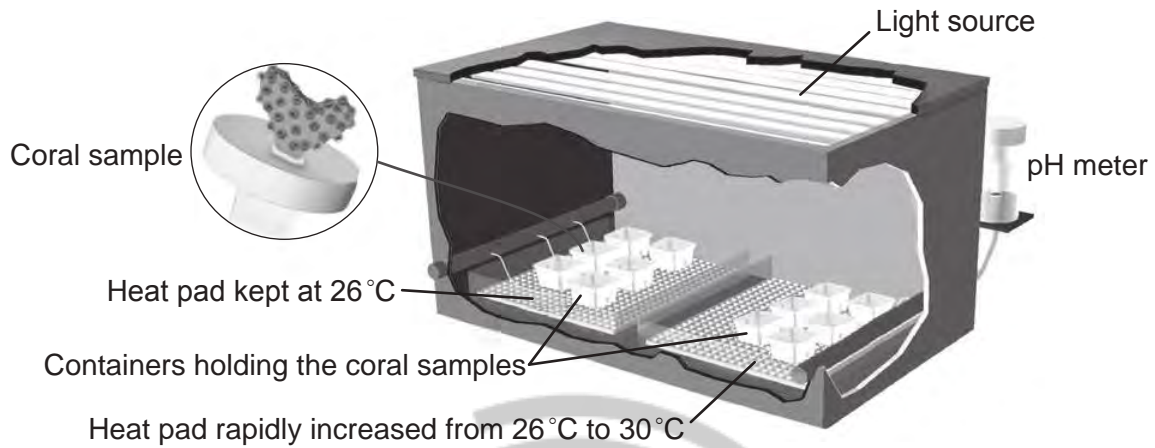
Please **do not** write on this page.

Answers written on this page
will not be marked.

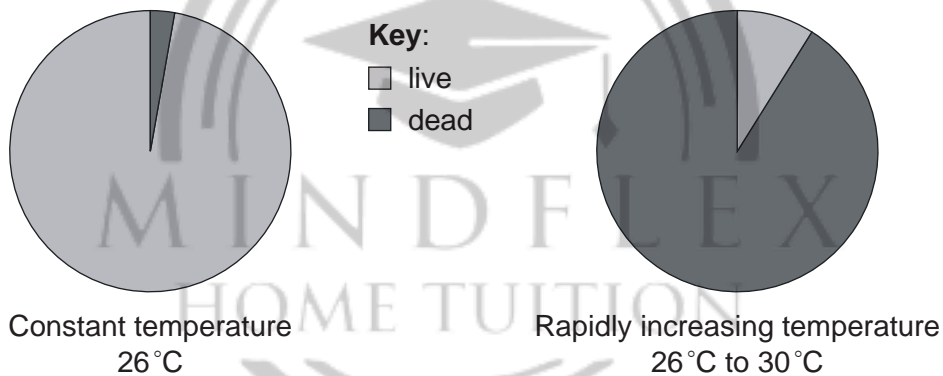


(Question 1 continued from page 3)

In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26 °C and half of them were rapidly increased to 30 °C.



The pie charts show the percentage of live and dead tissues at the end of the experiment.



[Source: Adapted from Mace G. Barron, Cheryl J. McGill, Lee A. Courtney, and Dragoslav T. Marcovich, "Experimental Bleaching of a Reef-Building Coral Using a Simplified Recirculating Laboratory Exposure System," *Journal of Marine Biology*, vol. 2010, Article ID 415167, 8 pages, 2010. doi:10.1155/2010/415167]

- (d) Identify **one** advantage of conducting this experiment in the laboratory rather than in the ocean. [1]

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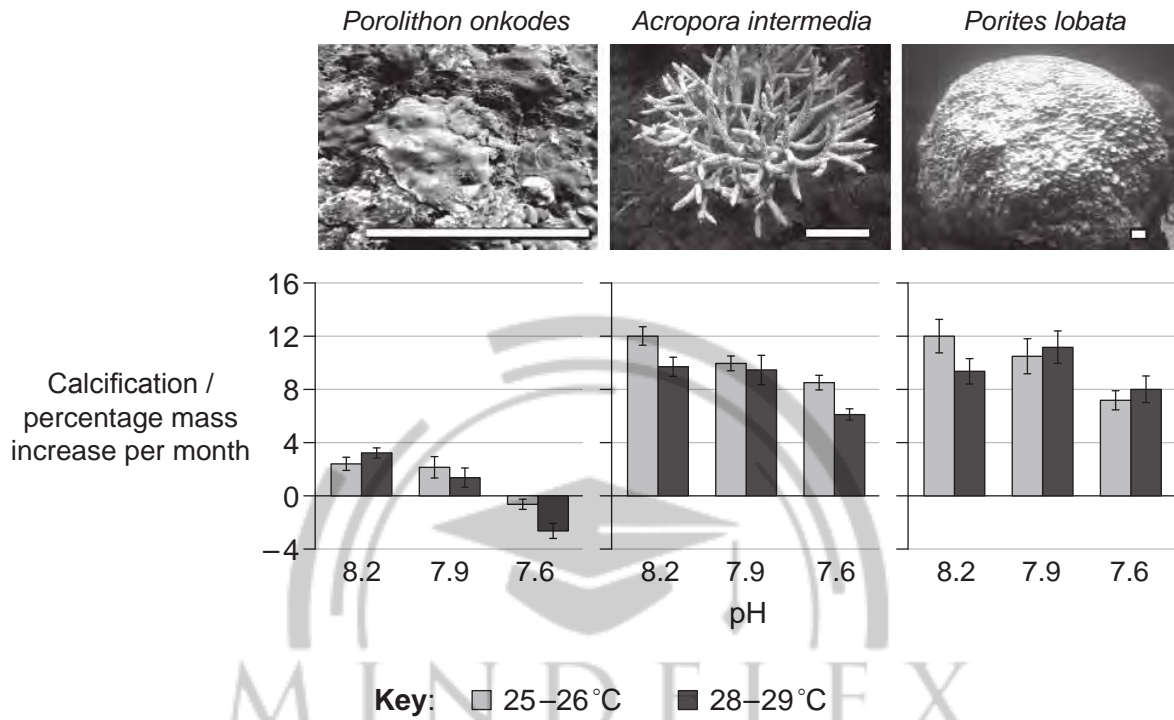
- (e) Comment on whether the experimental data supports the observed data from the ocean. [1]

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(This question continues on the following page)

(Question 1 continued)

Acidification of the world's oceans is an increasing threat to the health of oceanic life including coral reefs. Corals perform calcification to create their calcium carbonate exteriors. An experiment was conducted on Heron Island, Southern Great Barrier Reef, Australia. For the experiment the pH was altered by dissolving carbon dioxide in the water. Three different coral species were used, with each test group at two different temperature ranges and three different pH values. The white line in each photograph represents 5 cm.



[Source: Adapted from K. R. N. Anthony, D. I. Kline, G. Diaz-Pulido, S. Dove, and O. Hoegh-Guldberg, "Ocean acidification causes bleaching and productivity loss in coral reef builders," *PNAS*, vol. 105 no. 45, 17442–17446, Copyright 2008 National Academy of Sciences, U.S.A.]

- (f) (i) Describe the trend in calcification when the pH is decreased at 25–26 °C. [1]

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(This question continues on the following page)

(Question 1 continued)

- (ii) In environmental studies, a critical value is the level at which a population declines or shows signs of poor health. Suggest a critical pH for *P. onkodes*. [1]

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- (iii) Using all of the data, comment on the hypothesis that ocean acidification in warming seas will have the same effect on all species of coral. [1]

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- (g) Suggest another marine animal that has parts made of calcium carbonate and may therefore be damaged due to ocean acidification. [1]

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- (h) Outline causes of ocean acidification. [2]

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(Question 1 continued)

- (i) Discuss the need for international cooperation to solve the problems of declining coral populations.

[3]

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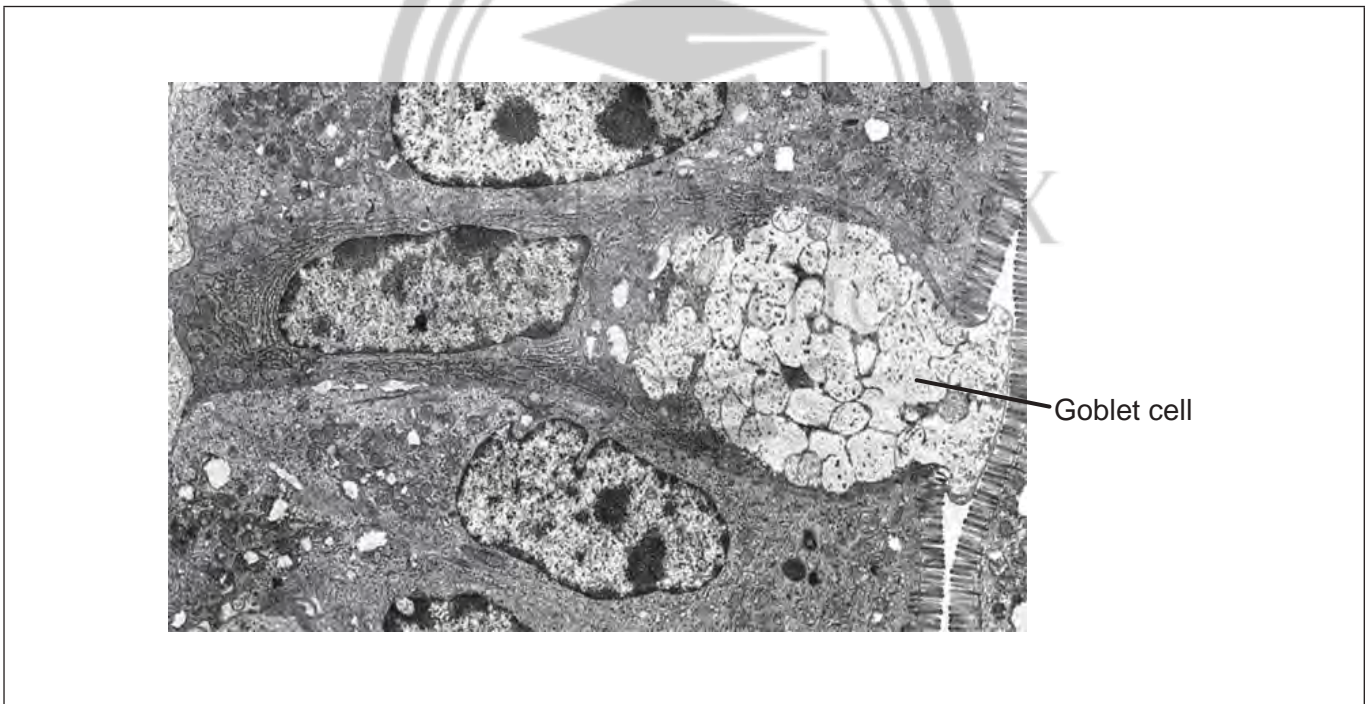
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2. (a) The image is an electron micrograph of the lining of the small intestine.



[Source: adapted from A. L. Mescher (2009), *Junqueira's Basic Histology: Text and Atlas*, 12th Edition, © 2009 McGraw-Hill Education]

- (i) Label the microvilli using the letter M and a nucleus using the letter N.

[1]

(This question continues on the following page)



(Question 2 continued)

(ii) State the function of the goblet cell. [1]

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(iii) Deduce, with a reason, whether or not the goblet cell is likely to divide. [1]

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(b) Explain how the cell cycle is controlled. [4]

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3. (a) Identify the following processes as **either** anabolism **or** catabolism by placing a tick (✓) in the correct box. [2]

Process	Anabolism	Catabolism
Light-independent reactions of photosynthesis	<input type="checkbox"/>	<input type="checkbox"/>
Glycolysis	<input type="checkbox"/>	<input type="checkbox"/>

- (b) Outline the importance of enzymes to metabolic processes. [4]

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4. (a) List **two** causes of variation within a gene pool. [2]

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- (b) Describe how variation contributes to evolution by natural selection. [3]

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- (c) Outline what is required for speciation to occur. [3]

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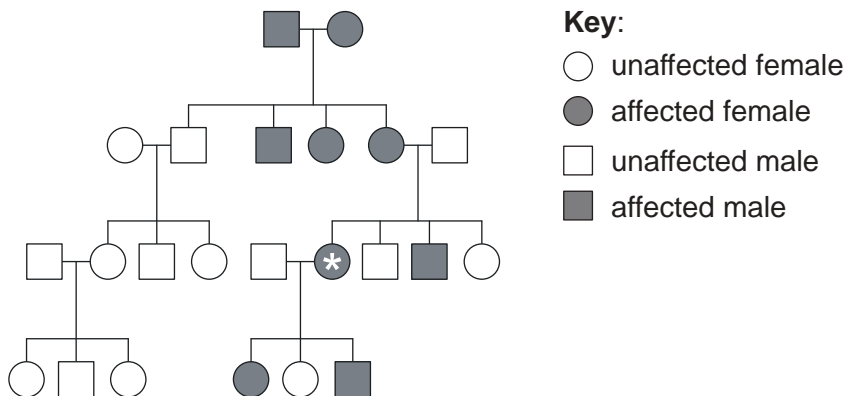
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5. This is a pedigree chart of a family with hypophosphatemia, an X-linked condition, in which bone deformities occur because of poor absorption of phosphates into the blood.



- (a) Using the pedigree chart, deduce the type of allele that causes hypophosphatemia. [2]

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MIND FLEX

- (b) Identify the genotype of the individual marked with a star in the pedigree chart, using appropriate symbols for your answer. [1]

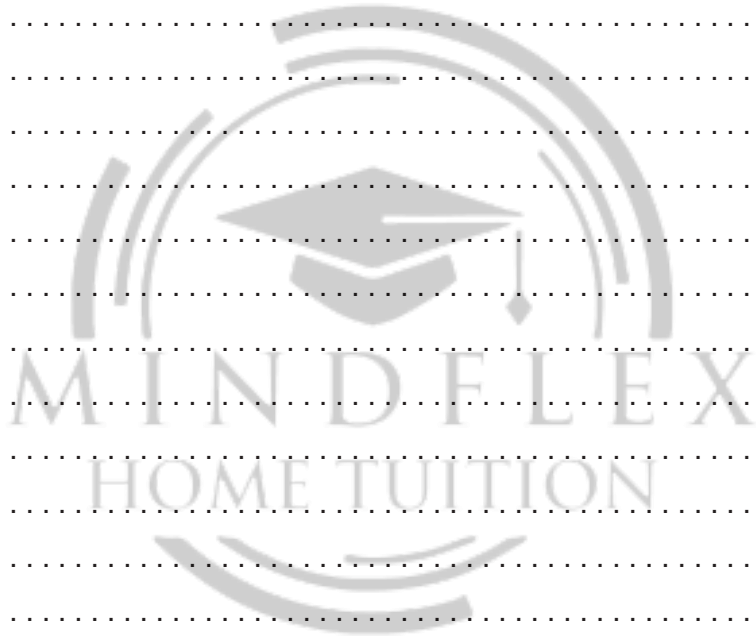
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Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Write your answers in the boxes provided.

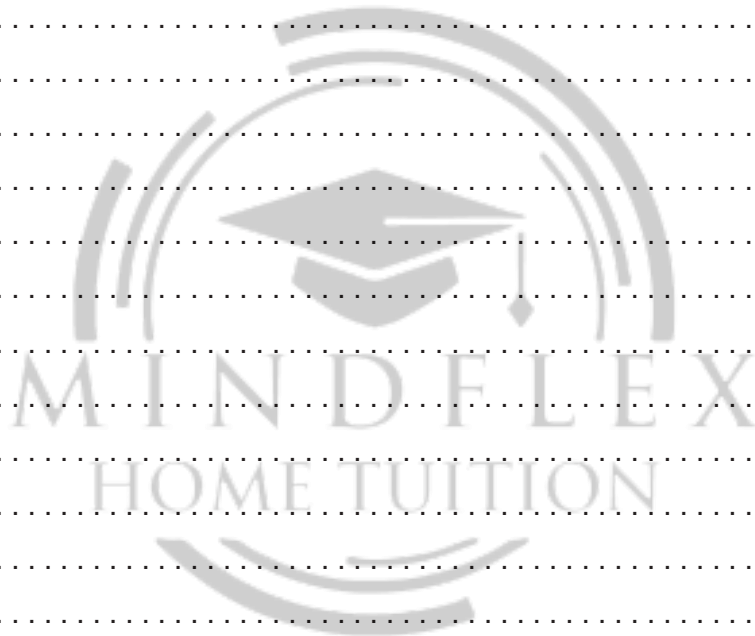
6. The human circulatory system is structured to serve the organs and tissues of the body efficiently.
- (a) Explain how circulation of the blood to the lungs and to other systems is separated in humans and what the advantages of this separation are. [8]
 - (b) Describe what happens in alveoli. [4]
 - (c) Distinguish between the composition of the blood of the renal artery and the blood of the renal vein. [3]
7. Angiospermophyta are vascular flowering plants.
- (a) Describe the transport of organic compounds in vascular plants. [4]
 - (b) The flowers of angiospermophyta are used for sexual reproduction. Outline **three** processes required for successful reproduction of angiospermophyta. [3]
 - (c) Growth in living organisms includes replication of DNA. Explain DNA replication. [8]
8. In ecosystems, energy is used to convert inorganic compounds into organic matter. Energy enters ecosystems through producers.
- (a) Explain the processes by which light energy is converted into chemical energy. [8]
 - (b) Producers extract phosphates and nitrates from soil. Outline how these ions are used in the synthesis of organic molecules. [3]
 - (c) Describe how energy flows through and is used by organisms in ecosystems. [4]

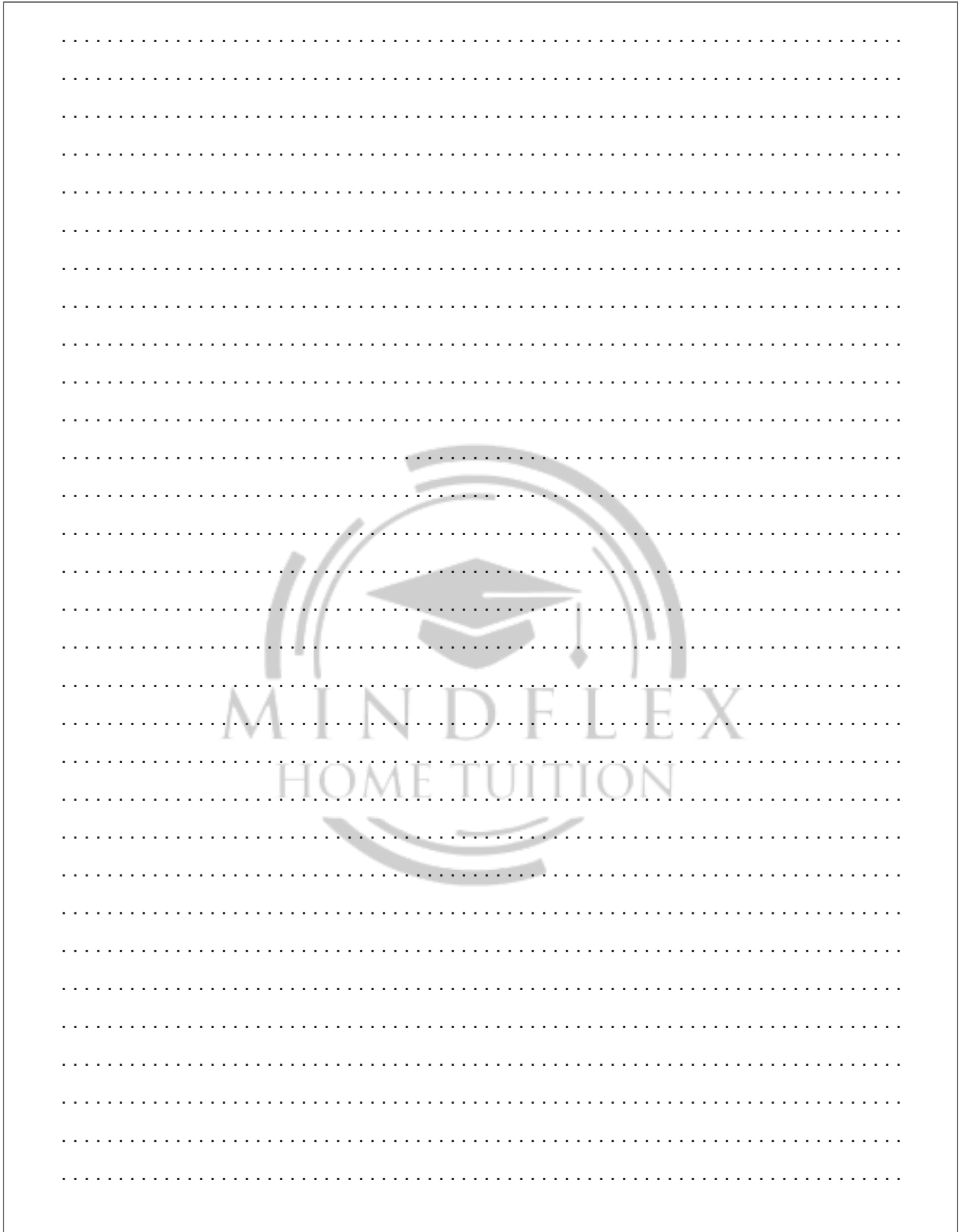




A large rectangular area containing horizontal dotted lines for writing. A faint watermark logo is centered in the middle of the page, featuring a graduation cap and the text "MINDFLEX HOME TUITION".







MINDFLEX
HOME TUITION



Biology
Higher level
Paper 3

Monday 7 November 2016 (morning)

Candidate session number

1 hour 15 minutes

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Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[45 marks]**.

Section A	Questions
Answer all questions.	1 – 3

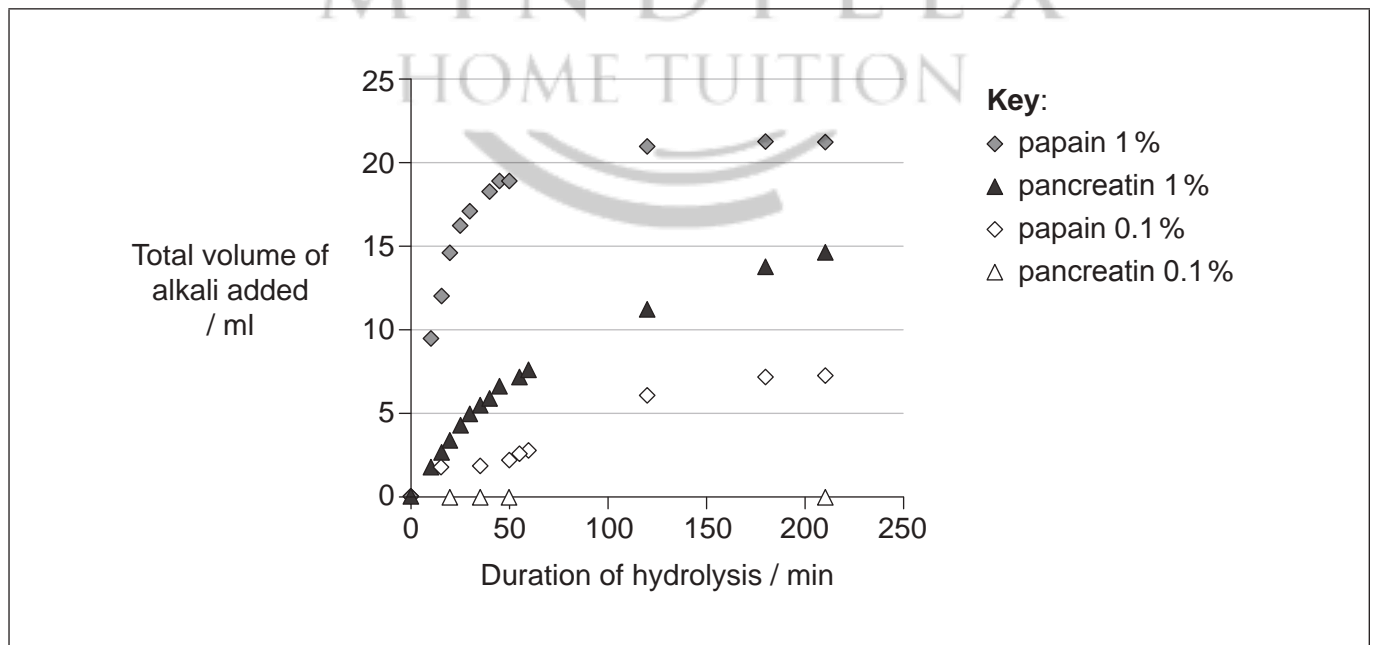
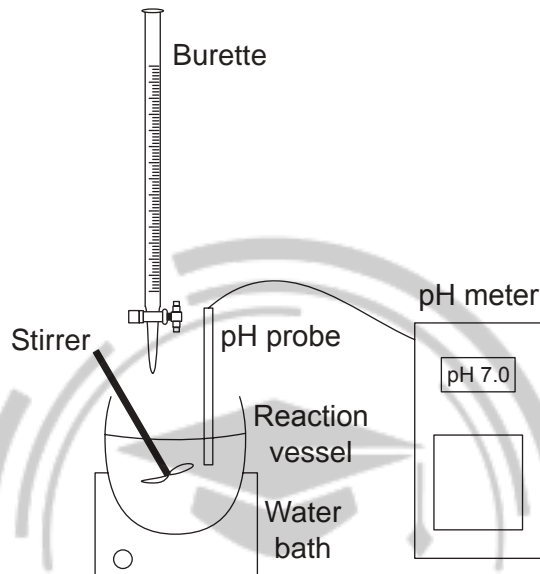
Section B	Questions
Answer all of the questions from one of the options.	
Option A — Neurobiology and behaviour	4 – 8
Option B — Biotechnology and bioinformatics	9 – 13
Option C — Ecology and conservation	14 – 18
Option D — Human physiology	19 – 23



Section A

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

1. The rate of hydrolysis of fish proteins using the enzymes papain and pancreatin was monitored using the apparatus shown. The pH decreased with the progress of hydrolysis, so alkali in the burette was added as necessary in order for the hydrolysis to proceed at constant pH. The rate of protein hydrolysis was measured as the amount of alkali added. Measurements were taken at constant conditions of temperature and pH for two enzyme concentrations, 1% and 0.1%.



[Source: adapted from "A Study of the Enzymatic Hydrolysis of Fish Frames Using Model Systems", written by Aristotelis T. Himonides, Anthony K. D. Taylor, Anne J. Morris, published by *Food and Nutrition Sciences*, Vol. 2 No. 6, 2011. Copyright © 2011 SciRes.]

(This question continues on the following page)



(Question 1 continued)

- (a) State the effect of enzyme concentration on the hydrolysis of proteins. [1]

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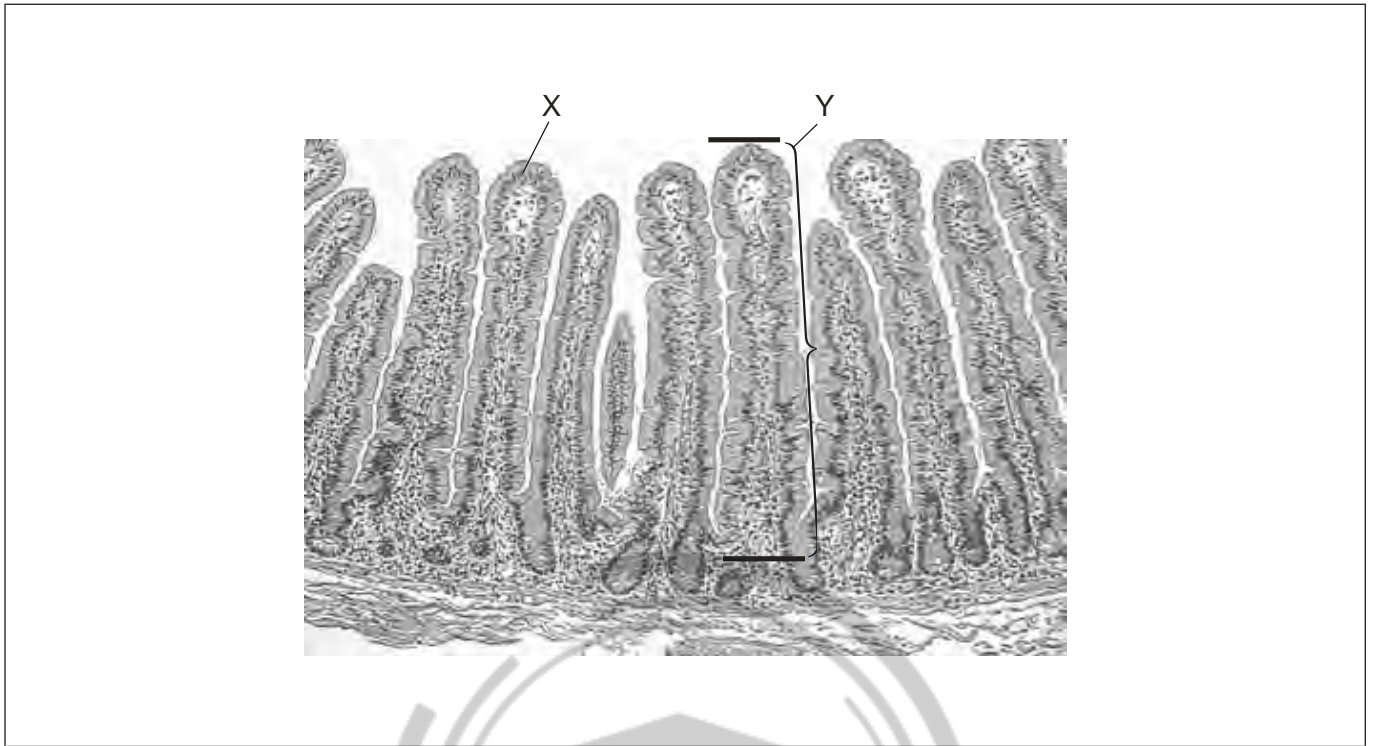
- (b) Sketch on the graph the curve expected if the hydrolysis were performed using papain 0.5%. [1]

- (c) Explain what would happen to fish protein hydrolysis if no alkali were added to the reaction vessel. [3]

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2. The micrograph shows a section of an organ in the human body.



[Source: adapted from Stacey E. Mills (ed.), *Histology for Pathologists*, 3rd Edition, Copyright ©2007, Lippincott Williams & Wilkins.]

(a) State from which organ the section was taken. [1]

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(b) Identify the layer of tissue found at X. [1]

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(This question continues on the following page)



(Question 2 continued)

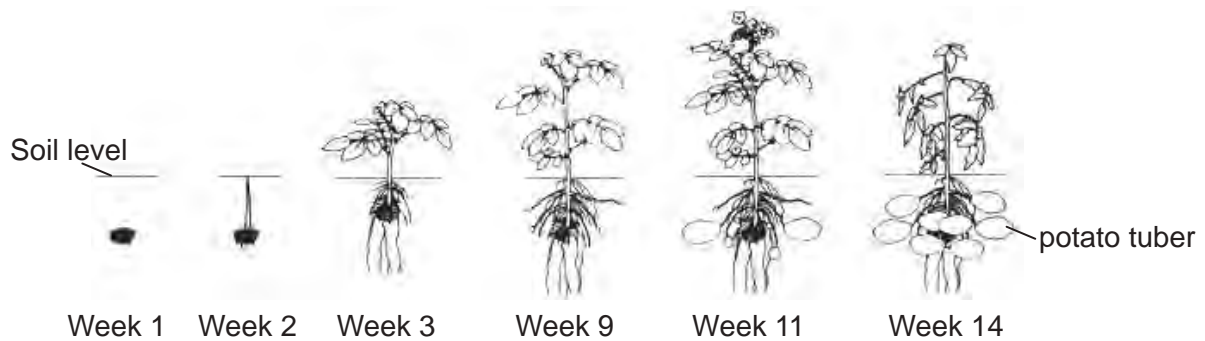
- (c) The actual length of the structure labelled Y is 0.8 mm between the two black lines. Calculate the magnification of the micrograph. Working should be shown. [2]

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- (d) One of the functions of this organ is absorption. On the micrograph, draw an arrow showing the direction of absorption. [1]

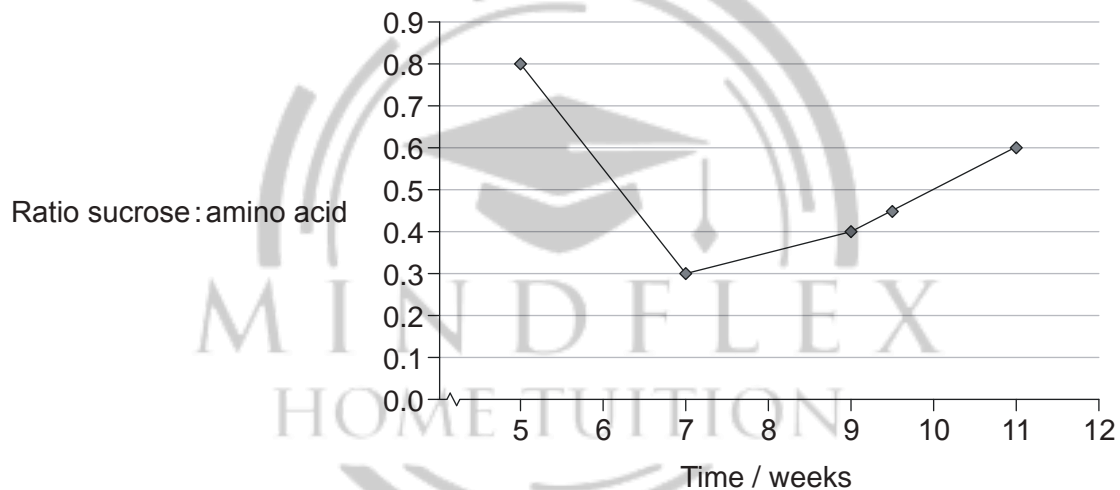


3. The diagram shows the development of potato plants (*Solanum tuberosum*) over 14 weeks. New tubers start growing from week 9. These are modified underground stems serving as a starch reserve and bearing buds from which new plants arise.



[Source: adapted from <http://humanitiespotato.weebly.com/potato-production.html>]

Scientists planted several potato plants in a greenhouse. The sucrose and amino acids in potato plant phloem exudates were measured during several weeks.



[Source: adapted from A. J. Karley, A. E. Douglas, W. E. Parker, Amino acid composition and nutritional quality of potato leaf phloem sap for aphids. *Journal of Experimental Biology* 2002 205: 3009-3018. © The Company of Biologists Limited 2002.]

- (a) Describe briefly how scientists obtained leaf phloem sap from the potato plants. [2]

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(This question continues on the following page)



(Question 3 continued)

- (b) Suggest reasons for different amounts of sucrose in the leaf phloem sap of the potato plants.

[3]

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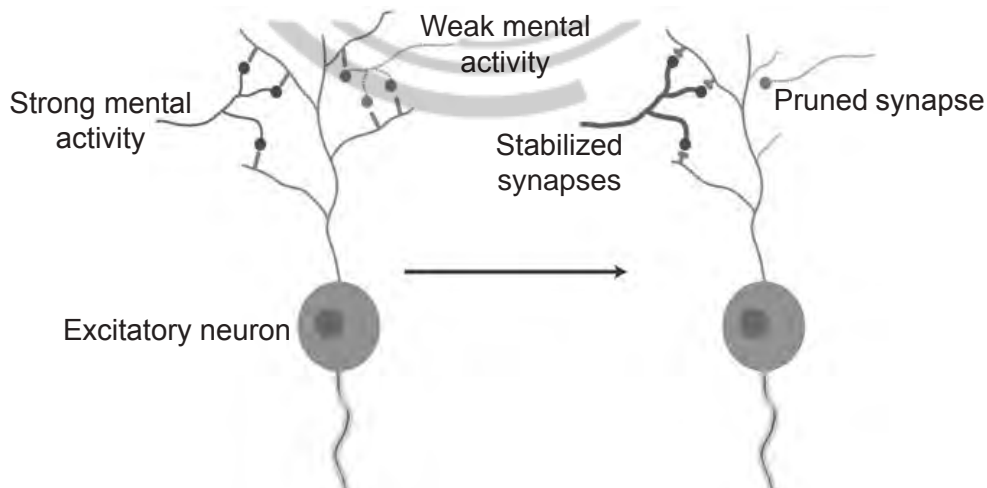
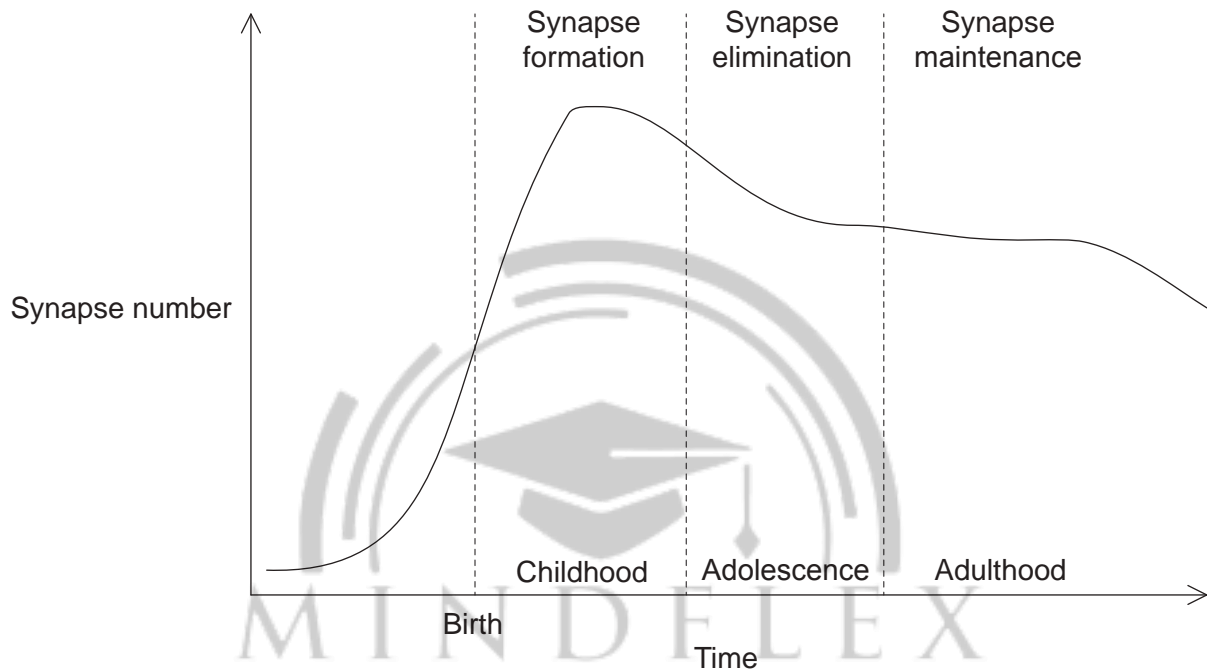


Section B

Answer **all** of the questions from **one** of the options. Write your answers in the boxes provided.

Option A — Neurobiology and behaviour

4. Defects in the formation of synapses could be the cause of neurological disorders such as Alzheimer's disease that affects the ability to think and remember clearly. It is more frequent in people older than 65 years of age. The graph shows the changes in synapse number over time. The diagram shows activity-related neural development.



[Source: adapted from Doll, C. A. and Broadie, K. (2014), Impaired activity-dependent neural circuit assembly and refinement in autism spectrum disorder genetic models. *Frontiers in Cellular Neuroscience* 8: 30. doi: 10.3389/fncel.2014.00030. Copyright © 2014 Doll and Broadie.]

(Option A continues on the following page)



(Option A, question 4 continued)

- (a) State what happens to unused neurons. [1]

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- (b) Predict how mental activity might delay the onset of Alzheimer's disease. [2]

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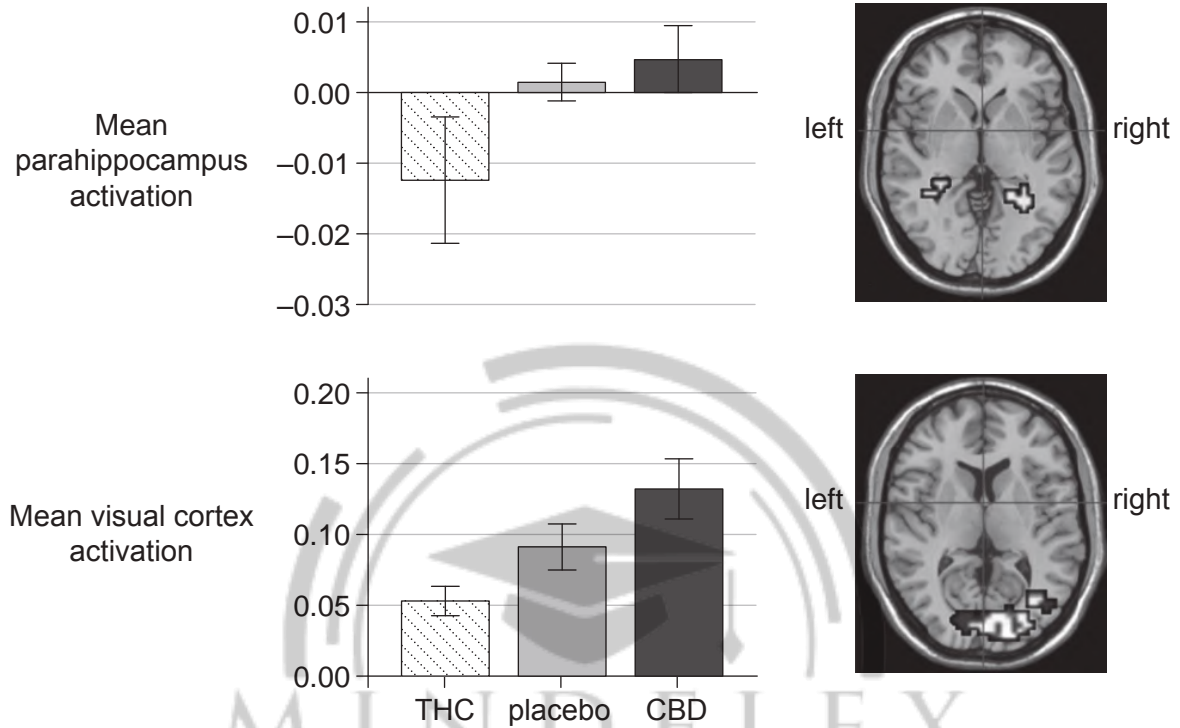
- (c) Autism appears early in life and affects how a person communicates and relates to others. There is evidence that autism could be caused by a surplus of synapses. Using all of the information provided, suggest **two** possible causes of a surplus of synapses in people with autism. [2]

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(Option A continues on the following page)

(Option A continued)

5. D-9-tetrahydrocannabinol (THC) and cannabidiol (CBD), the two main psychoactive ingredients of the *Cannabis sativa* plant, have distinct symptomatic and behavioural effects. Functional magnetic resonance imaging (fMRI) was used in healthy volunteers to examine their effects on the parahippocampus, an area of the brain related to emotions and on the visual cortex. The effects are as shown.



[Source: adapted from S. Bhattacharyya et al. (2010), "Opposite effects of delta-9-tetrahydrocannabinol and cannabidiol on human brain function and psychopathology." *Neuropsychopharmacology*, 35:3, pages 764–774. Copyright © 2010 American College of Neuropsychopharmacology]

- (a) Outline the benefits of using fMRI in this experiment. [2]

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(Option A continues on the following page)

(Option A, question 5 continued)

- (b) Compare and contrast the effects of THC and CBD on the areas of the brain studied. [3]

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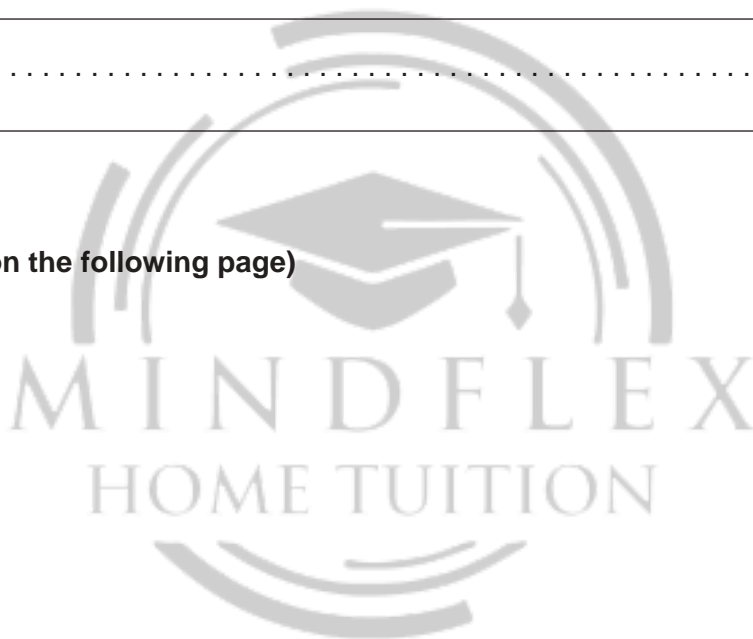
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- (c) State the function of the visual cortex. [1]

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(Option A continues on the following page)



(Option A continued)

6. (a) Outline the neural control of the process of swallowing. [3]

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- (b) Describe an example of learned behaviour. [3]

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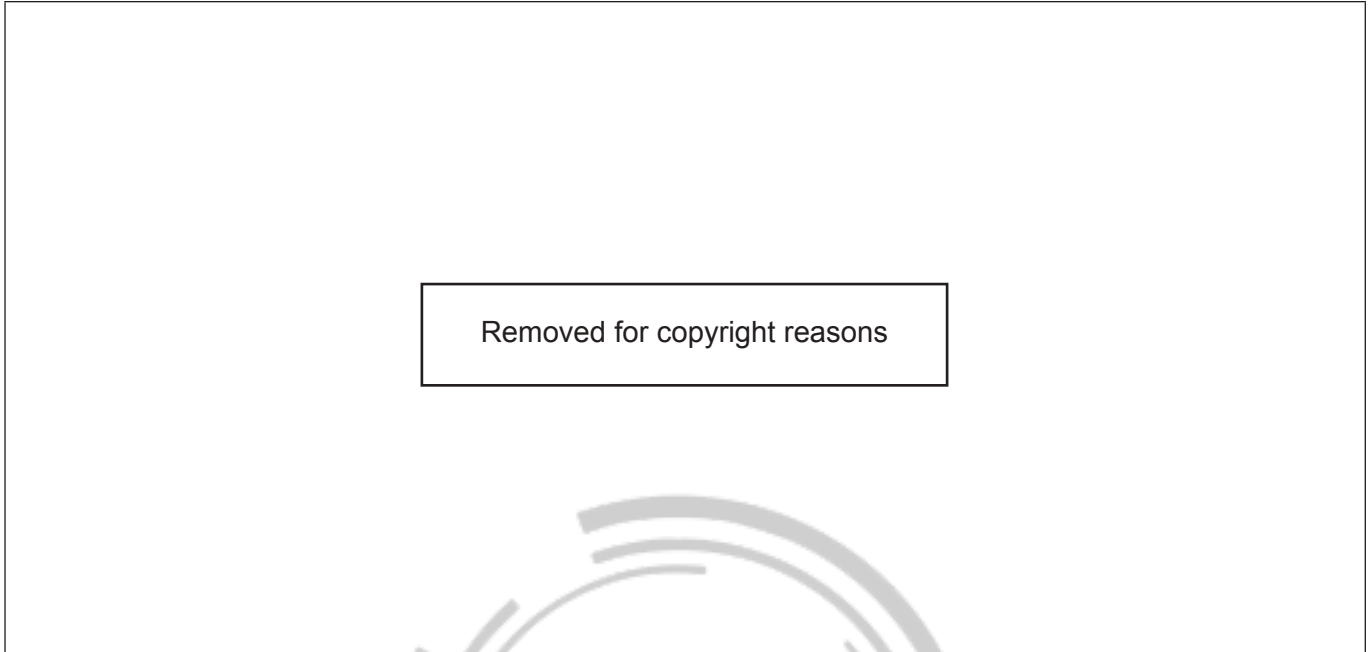


(Option A continues on the following page)



(Option A continued)

7. (a) The diagram shows the human ear. Label parts I, II and III. [3]



- (b) State the function of the bones in the middle ear. [1]

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- (c) Explain the role of the hair cells in the cochlea. [3]

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(Option A continues on the following page)



Option B — Biotechnology and bioinformatics

9. Lipid A is a phospholipid that makes up the external layer of the outer membranes of most Gram-negative bacteria. LpxC is an enzyme involved in the biosynthesis of lipid A. In this experiment, a lawn of the Gram-negative bacterium *Escherichia coli* was grown on a nutrient agar plate. Shortly after inoculation, before the lawn is formed, discs containing different test compounds were placed on top. The Petri dish shows the results after 24 hours incubation.



Key:

- disc 1: LpxC inhibitor
- disc 2: mutated LpxC inhibitor
- disc 3: ampicillin
- disc 4: control

[Source: © International Baccalaureate Organization 2016]

- (a) Outline the effect of disc 3 on the bacterial lawn. [2]

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- (b) Outline the effect of mutating the LpxC inhibitor. [1]

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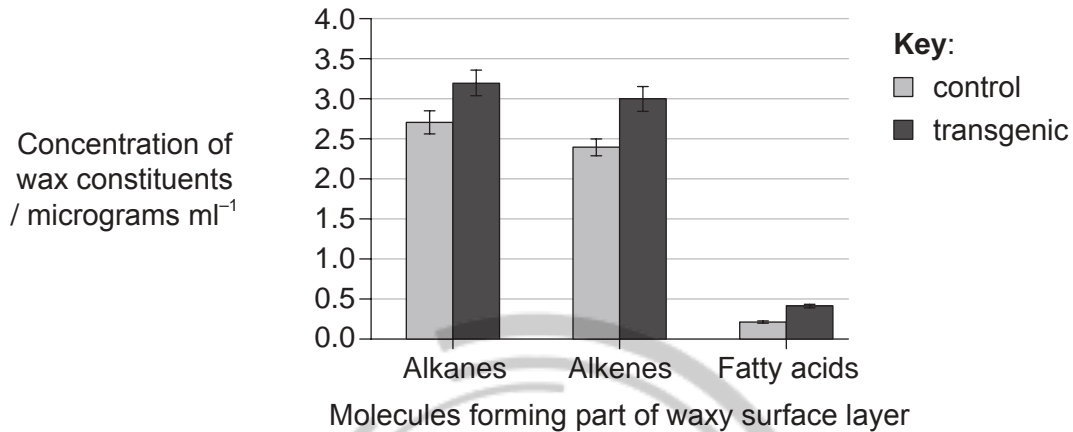
- (c) Predict the results obtained with disc 1 in a Gram-positive bacterial lawn. [1]

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(Option B continues on the following page)

(Option B continued)

10. Crop genetic engineering was performed to improve drought tolerance in tomato plants (*Solanum lycopersicum*) by adding a gene from an edible fungus (*Flammulina velutipes*). The cotyledons of tomato plants were cut and co-cultivated with *Agrobacterium tumefaciens* containing the transgenic Ti plasmid. Plates containing kanamycin were used to select for transgenic cotyledons. The graph shows concentrations of three constituents of the wax that coats wild type plants (control) and transgenic tomato plants.



[Source: Reprinted by permission of Nature Publishing Group. (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3517979/>)
Reprinted by permission from Macmillan Publishers Ltd: *Nature*, 'Expression of a fungal sterol desaturase improves tomato drought tolerance, pathogen resistance and nutritional quality' by Ayushi Kamthan *et al.* 2, p. 951. (2012).]

- (a) Outline the use of kanamycin in the selection of transgenic cotyledons. [2]

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- (b) State how the sequence of the target gene from the fungus could be identified using a bioinformatics tool. [1]

(Option B continues on the following page)



(Option B, question 10 continued)

- (c) Suggest whether the results of this experiment show that these transgenic tomato plants are more resistant to drought. [2]

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- (d) One method of inserting new genes into plants is by gene gun.



[Source: adapted from www.genomicon.com]

Outline how a gene gun inserts genes into plants. [2]

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(Option B continues on page 19)

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will not be marked.



(Option B continued)

12. The genetic code is the information encoded within the mRNA sequence that is translated into proteins by living cells. The codon table is shown.

		Second position								
		U		C		A		G		
First position	U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys (C)	U
		UUC		UCC		UAC		UGC		C
		UUA	Leu (L)	UCA		UAA	STOP	UGA	STOP	A
		UUG		UCG		UAG		UGG	Trp (W)	G
	C	CUU	Leu (L)	CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)	U
		CUC		CCC		CAC		CGC		C
		CUA		CCA	CAA	Gln (Q)	CGA	A		
		CUG		CCG	CAG		CGG	G		
	A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)	U
		AUC		ACC		AAC		AGC		C
		AUA		ACA	AAA	Lys (K)	AGA	Arg (R)	A	
		AUG	Met (M)	ACG	AAG	AGG	G			
	G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)	U
		GUC		GCC		GAC		GGC		C
		GUA		GCA	GAA	Glu (E)	GGA	A		
		GUG		GCG	GAG		GGG	G		

The first part of the cytochrome c protein sequence alignment of mold fungus (*Neurospora*), horse (*Equus*), human (*Homo*), corn (*Zea*) and rice (*Oryza*) is shown using the amino acids as a one letter code.

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Neurospora  ----MGFSAGDSKKGANLFKTRCAQCHTLEEGGKNGKIGPALHGLFGRKTGSVDGYAYTDA
Equus       -----MGDVEKGKKIFVQKCAQCHTVEKGGKHKHTGPNLHGLFGRKTGQAPGFSYTDA
Homo        -----MGDVEKGKKIFIMKCSQCHTVEKGGKHKHTGPNLHGLFGRKTGQAPGYSYTA
Zea         MASFSEAPPGNPKAGEKIFKTKCAQCHTVDKGAGHKQGPNLNGLFGRQSGTTAGYSYSAG
Oryza       MASFSEAPPGNPKAGEKIFKTKCAQCHTVDKGAGHKQGPNLNGLFGRQSGTTTPGYSYSTA
          * : : * : : * . * : * * * * : : * . : * * * : * * * * * : : * . * : : * : .
    
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[Source: © International Baccalaureate Organization 2016]

(a) State the bioinformatics tool used to obtain the alignment. [1]

(b) State the meaning of the dash (-) in the alignment. [1]

(Option B continues on the following page)

(Option B, question 12 continued)

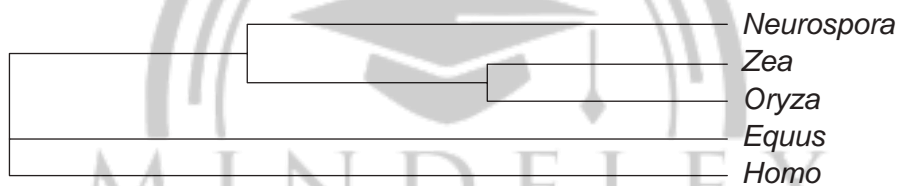
- (c) (i) Identify the longest amino acid sequence where there are no differences amongst the five genera. [1]

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- (ii) Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in (c)(i) must be identical for the five genera. [1]

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The alignment was used to obtain a cladogram of these organisms.



- (d) Describe briefly how the cladogram was obtained. [2]

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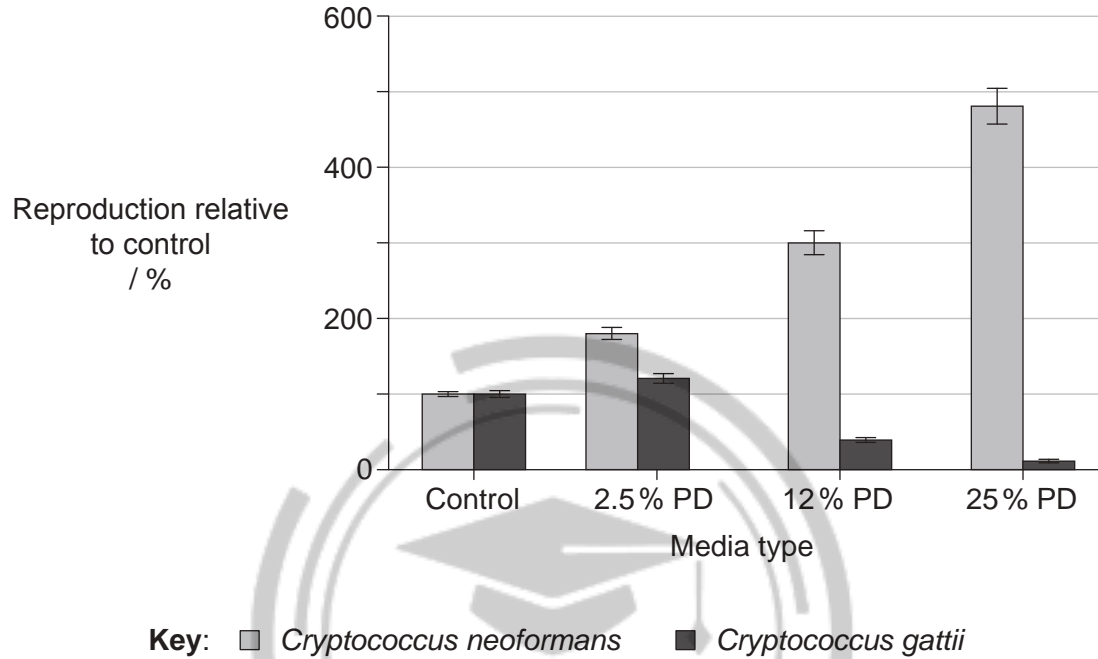
- (e) Determine which **two** genera are most closely related according to their cytochrome c protein sequence. [1]

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(Option B continues on the following page)

Option C — Ecology and conservation

14. *Cryptococcus neoformans* and the closely related species *Cryptococcus gattii* are human fungal pathogens. The reproduction of these yeast species on increasing concentrations of pigeon droppings (PD) was examined to determine whether they occupy the same or different ecological niches. The results for reproduction are expressed as a percentage relative to the control.



[Source: adapted from K. Nielsen et al. (2007), "*Cryptococcus neoformans* Mates on Pigeon Guano: Implications for the Realized Ecological Niche and Globalization". *Eukaryotic Cell*, vol. 6, pp. 949–959, DOI: 10.1128/EC.00097-07. Amended with permission from American Society for Microbiology]

Suggest how this experiment shows that pigeon droppings represent a realized ecological niche for *C. neoformans* and a fundamental (but not a realized) niche for *C. gattii*.

[3]

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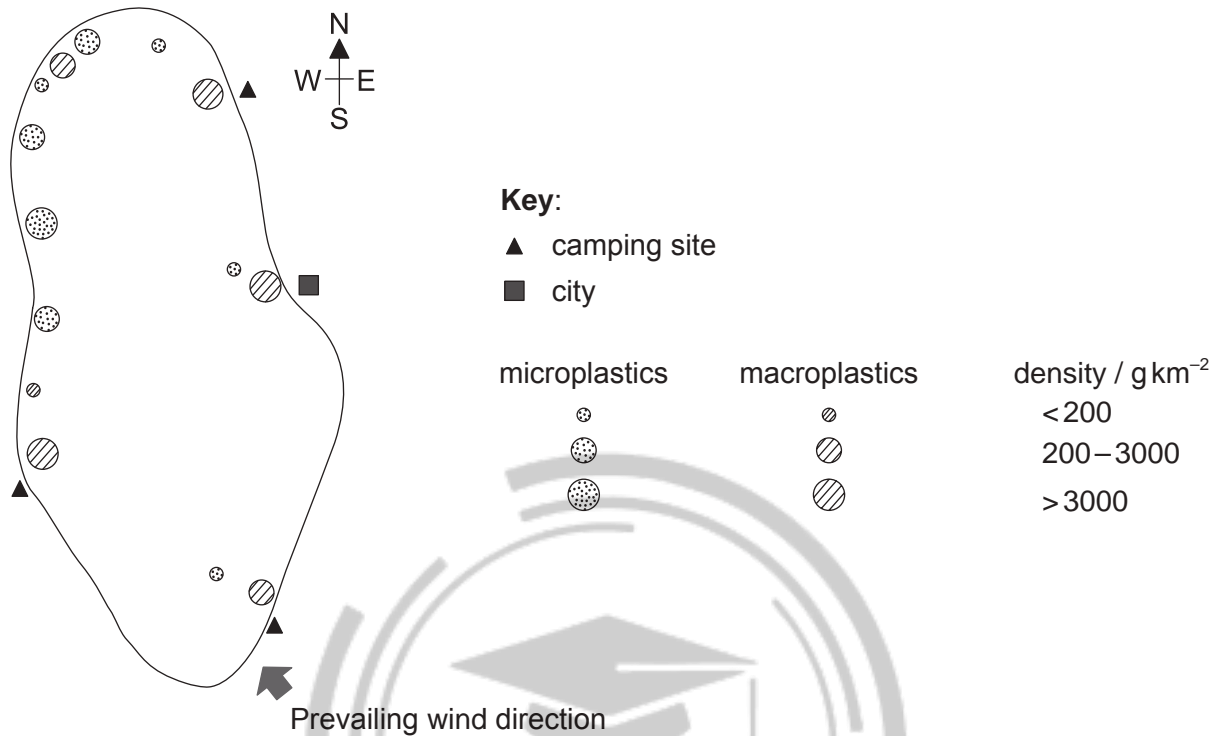
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(Option C continues on the following page)

(Option C continued)

15. The sketched map shows the density of microplastics and macroplastics found in a lake within a national park.



[Source: © International Baccalaureate Organization 2016]

- (a) Predict **one** example of macroplastic pollution that is likely to be found in this lake. [1]

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- (b) State **two** possible effects on organisms of microplastic pollution. [2]

1.
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2.
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(Option C continues on the following page)



(Option C, question 15 continued)

- (c) Outline the effect of wind on the distribution of plastic pollution in this lake. [2]

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- (d) Suggest changes in the management of the national park that could reduce the amount of macroplastic pollution. [3]

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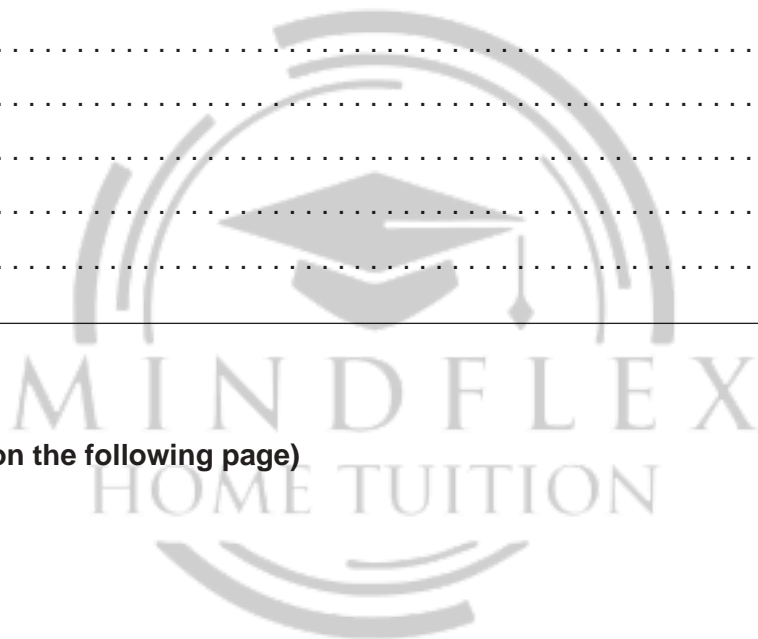
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(Option C continued)

16. Forest fires are very common in the Amazon forest. A study was performed to see the relationship between forest fragmentation, fire and management.

(a) Describe **one** method that could have been used to estimate the population size of a given tree in a forest after fire damage had occurred. [3]

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(b) Outline how the edge effect can affect diversity in forests. [3]

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(Option C continues on the following page)

(Option C, question 16 continued)

- (c) The number of plants in two fields of approximately the same size was counted.

Type of plant	Field 1	Field 2
Daisy (<i>Bellis perennis</i>)	307	18
Dandelion (<i>Taraxacum officinale</i>)	332	48
Buttercup (<i>Ranunculus repens</i>)	361	934
Total	1000	1000

Compare and contrast the richness and the evenness of the two fields.

[2]



(Option C continues on the following page)

(Option C continued)

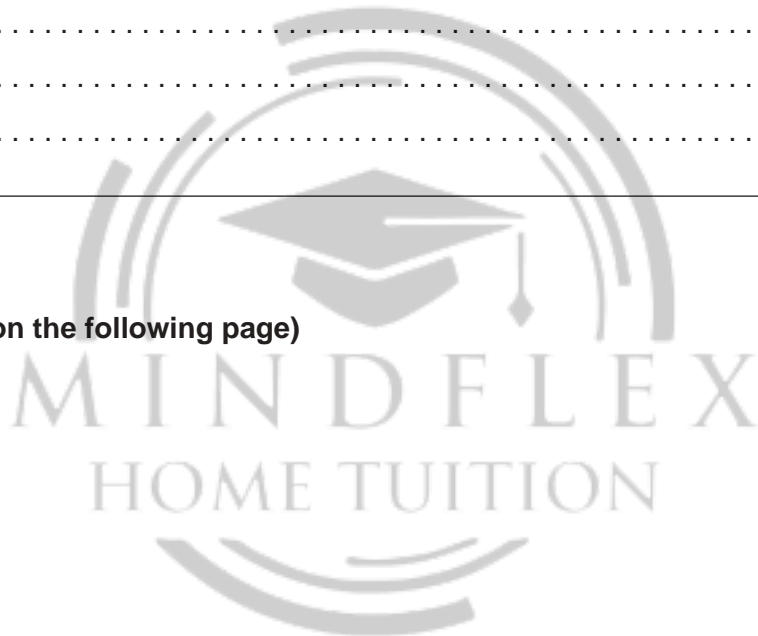
17. (a) State **two** bottom-up factors affecting algal blooms. [2]

1.
2.

(b) Explain how top-down factors control algal blooms. [3]

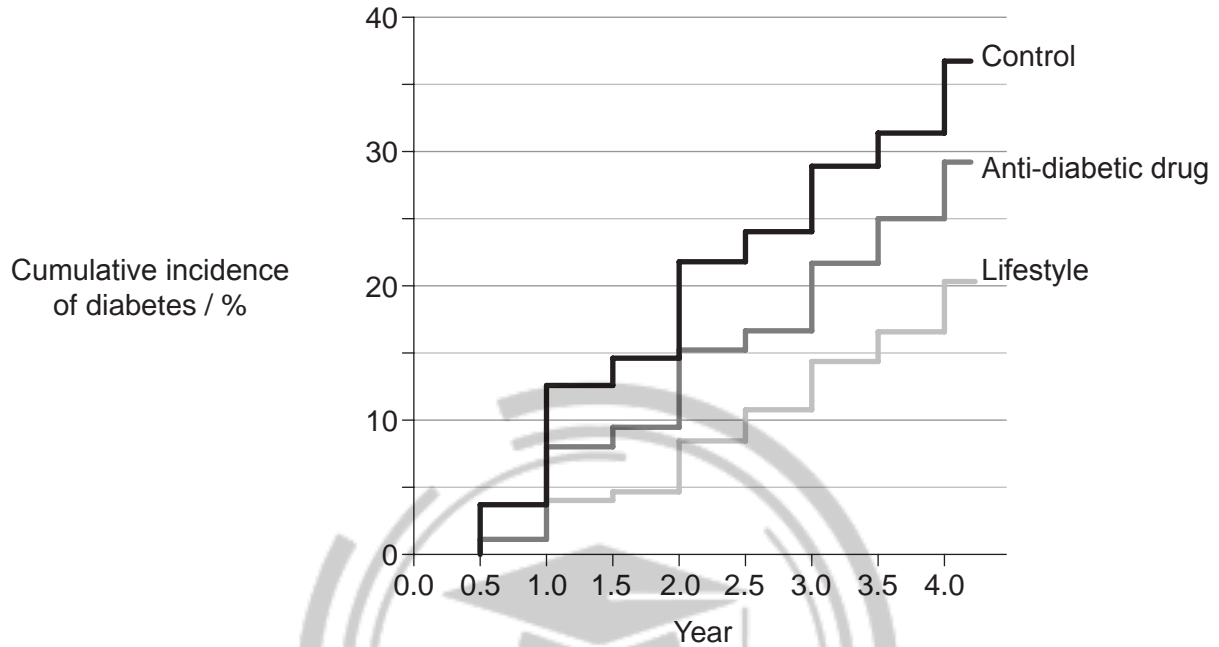
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Option D — Human physiology

19. A study was undertaken to determine the most effective method to delay the onset of type II diabetes in high-risk patients. Three groups were given either a placebo (control), a medicine that suppresses glucose production by the liver (anti-diabetic drug) or a lifestyle-modification program (lifestyle). The results for four years are shown in the graph.



[Source: adapted from Berry, Colin, Jean-Claude Tardif, and Martial G. Bourassa. "Coronary Heart Disease in Patients With Diabetes." *Journal of the American College of Cardiology* 49.6 (2007): 631-642. Web. 19 Jan. 2017.]

- (a) Analyse the use of the anti-diabetic drug in delaying the onset of type II diabetes. [2]

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- (b) List features that would increase a person's risk of developing diabetes. [2]

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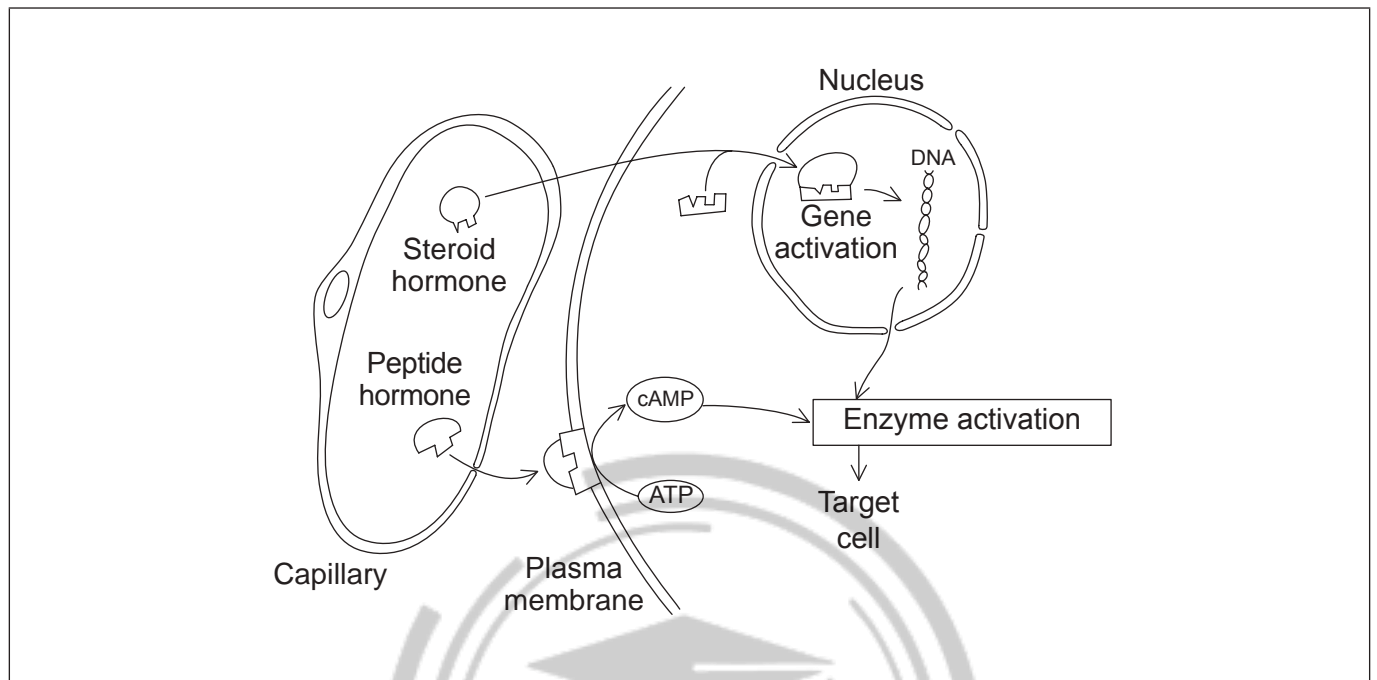
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(Option D continued)

20. The diagram demonstrates the action of steroid and peptide hormones in a section of cell and adjacent capillary.



[Source: © International Baccalaureate Organization 2016]

- (a) On the diagram, label a
 - (i) second messenger. [1]
 - (ii) gene regulatory protein. [1]
- (b) Outline **one** characteristic of steroid hormones that allows them to readily diffuse through cell membranes. [1]

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- (c) Compare and contrast the mechanisms of action of peptide and steroid hormones. [2]

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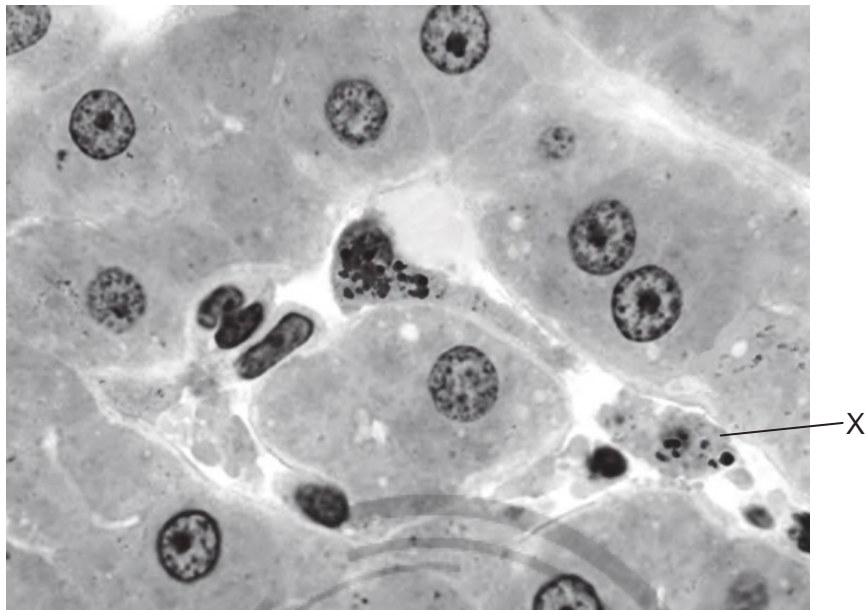
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(Option D continued)

21. The micrograph shows a section through the human liver.



[Source: Dr Thomas Caceci, Virginia Tech/Carilion School of Medicine.]

(a) The cell labelled X is only found in the liver and is associated with the wall of a sinusoid.

(i) Identify cell X.

[1]

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(ii) Outline the function of cell X.

[2]

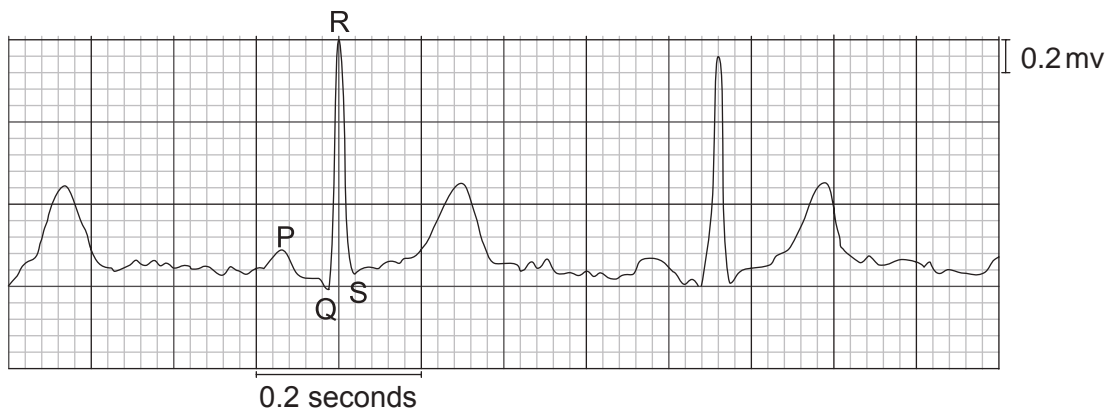
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(Option D continued)

22. The electrocardiogram (ECG) of a normal patient after exercise is shown.



[Source: © International Baccalaureate Organization 2016]

- (a) Using the R–R interval in this ECG, calculate the heart beats per minute (bpm) of this patient. Show your working. [2]

..... bpm

- (b) Describe the electrical activity that occurs in the heart during the P wave. [1]

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- (c) Explain why the QRS wave has a larger amplitude than a P wave. [2]


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(Option D continues on the following page)

(Option D continued)

23. Explain, using an oxygen dissociation curve, how hemoglobin supplies oxygen to respiring tissues and how the Bohr shift increases the supply.

[6]



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End of Option D





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