PENRITH SELECTIVE HIGH SCHOOL

PRELIMINARY BIOLOGY 2024

WRITTEN EXAMINATION

General Instructions:

Reading time: 5 minutes

Working time: 120 minutes

- Write using black pen. Answers written in pencil could be disqualified from review.
- Diagrams and graphs to be drawn using pencil.
- Additional writing space is provided at the back of the paper. Clearly indicate the questions this space has been used for.
- The multiple choice answer sheet can be separated from the back of this paper but must be submitted together with this examination paper.

Weighting: 30%

Marks: 75

Total Mark:

Student Number ……..

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PART A – MULTIPLE CHOICE QUESTIONS

Attempt Questions 1-15 (1 mark per question)

Allow about 20 minutes for this section

Use the multiple-choice answer sheet for questions 1-15

Question 1:

Homologous structures indicate that the

A) structures are found on both chromatids.
B) organisms received the same allele from both parents.
C) organisms have a common ancestor.
D) organisms use the structure for the same function.

Question 2:

An organism is unable to make organic compounds from inorganic compounds and an external energy source. It needs to obtain organic compounds from its environment by consuming them.

Which type of organism is described above?

A) A heterotroph
B) A producer
C) A photoautotroph
D) A symbiont

Question 3:

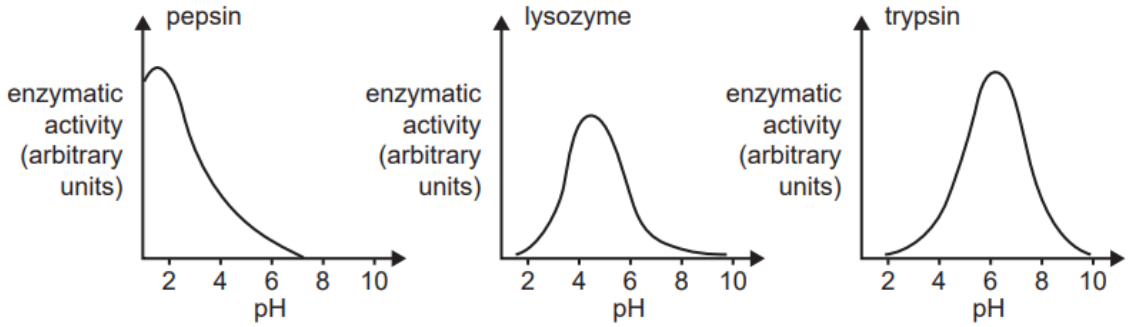
Mitochondria provide ATP in cardiac muscle cells that are organised into cardiac muscle tissue, which combines with other tissues to make the heart which is part of the cardiovascular system of humans.

The statement above describes

A) the hierarchical organisation of a multicellular organism.
B) the benefits of decreasing surface area to volume ratios.
C) the structure of colonial organisms.
D) the reason unicellular organisms are less efficient than multicellular.

Question 4:

Examine the following graphs



From these graphs it is reasonable to infer that at a pH of 4

A) trypsin would be inactive.
B) all the pepsin would be denatured.
C) all three enzymes would lack a functional active site.
D) lysozyme has the highest activity of the three enzymes.

Question 5:

Which of the following statements about the penta-dactyl limb and its significance in comparative anatomy is correct?

A) The penta-dactyl limb is a structure found only in amphibians and serves as evidence of convergent evolution.
B) The penta-dactyl limb is a common anatomical feature in vertebrates, indicating a shared evolutionary ancestor due to its similar bone structure across different species.
C) The penta-dactyl limb is unique to mammals and showcases the process of natural selection in diverse environments.
D) The penta-dactyl limb is an example of divergent evolution seen exclusively in reptiles, demonstrating how similar structures evolve in response to similar environmental pressures.

Question 6:

Toxoplasma Gondii is a parasite which infects over one-third of the world's population. Recent research has indicated the pathogen displays opportunistic abilities, seeking to infect mice which act as a carrier for the parasite. The immune response to *Toxoplasma Gondii* infection results in a permanent structural alteration in the mouse brain, causing mice to lose their innate fear of cat odour and seek out cats so the parasite may be consumed and enter its ideal host; the cat.

Source: https://phys.org/news/2013-09-toxoplasma-infected-mice-unafraid-cats-parasite.html

Infection of this type represents

A) de-evolution of mice to promote unnecessary behavioural risks.
B) evolutionary adaptations by *Toxoplasma Gondii* to promote survival leading to parasitic infection in cats.
C) survival of the fittest reducing the population of parasitic *Toxoplasma Gondii.*
D) co-evolution of *Toxoplasma Gondii* and mice to produce a mutually beneficial relationship.

Question 7:

Facilitated diffusion

A) requires a cell to expend energy.
B) moves molecules against their concentration gradient.
C) is the movement of lipid-soluble molecules across a cell membrane.
D) requires the presence of a membrane protein.

Question 8: **A** **B** **C**

Function	Send blood **from** heart	Send blood **to** heart	Material exchange with tissues
Pressure	High	Low	Low
Lumen Diameter	Narrow	Wide	Extremely narrow (one cell wide)
Wall Thickness	Thick	Thin	Extremely thin (single cell thick)
Wall Layers	Three • Tunica adventitia • Tunica media • Tunica intima	Three • Tunica adventitia • Tunica media • Tunica intima	One • Tunica intima
Muscle & Elastic Fibres	Large amounts	Small amounts	None
Valves	No	Yes	No

The correct description of columns A, B and C is

A) A = Vein, B = Artery, C = Capillary
B) A = Artery, B = Vein, C = Capillary
C) A = Capillary, B = Artery, C = Vein
D) A = Lymph vessel, B = Plasma, C = Lymph

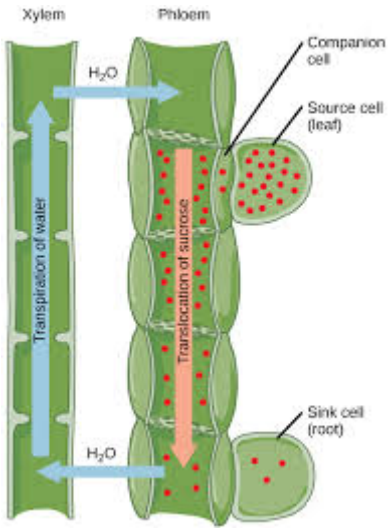
Question 9:

Which of the following best explains how the evolution of leg length in cane toads (Rhinella marina) demonstrates the principles of natural selection?

A) Cane toads with longer legs are more successful at spreading across new territories, showing how advantageous traits can increase in frequency within a population.
B) Cane toads with shorter legs are favoured in all environments, leading to a uniform population with reduced leg length.
C) The leg length of cane toads remains constant over time, illustrating the stability of traits in a well-adapted species.
D) Cane toads with shorter legs face higher predation rates, leading to a decrease in leg length over generations in predator-rich environments.

Question 10:

The diagram shows some features of phloem and xylem.

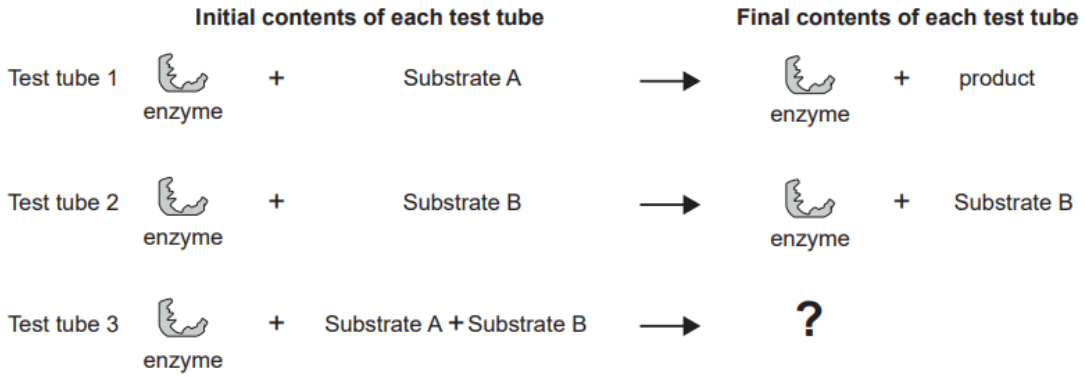


The function of phloem is to

A) transport water from the leaves to the roots
B) transport sugars from the soil to the leaves
C) transport water from the roots to the leaves
D) transport sugars from the leaves all around the plant

Question 11:

A group of Biology students set up an experiment with three test tubes. Each test tube contained the same enzyme and was kept under the same experimental conditions. All concentrations and volumes of substrate and enzyme placed in the test tubes were kept the same. The following diagram shows the initial contents of each test tube and the final contents of test tubes 1 and 2.

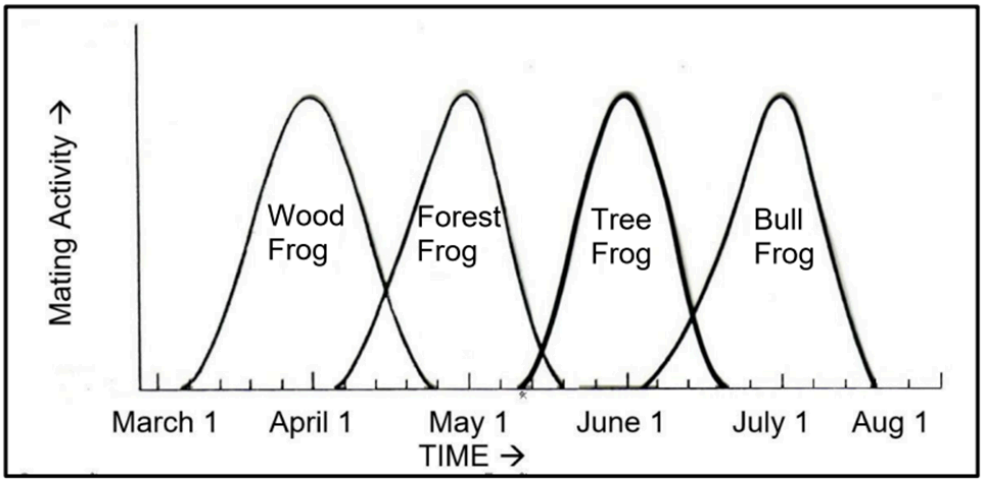


An enzyme-substrate complex was formed in each of the three test tubes. When compared to the final contents of Test tube 1, the concentration of product contained in the final contents of Test tube 3 will

A) be the same because both Substrate A and Substrate B are able to bind to the enzyme at the same time.
B) increase because Substrate A is a substrate that can bind to the enzyme's active site.
C) decrease due to competitive reversible inhibition by Substrate B.
D) be zero due to the presence of an irreversible inhibitor.

Question 12:

The graph below shows the breeding times for different species of frog.



The above graph shows an example of

A) reproductive isolation.
B) natural selection.
C) speciation.
D) biogeography.

Question 13:

A student was investigating four cell types from different organisms. She recorded the results of her microscopic examination of the cells in the table below.

	Cell W	**Cell X**	**Cell Y**	**Cell Z**
Mitochondria	few	many	absent	few
Chloroplasts	present	absent	absent	present
Nucleus	present	present	absent	present

Which one of the following is the correct conclusion that can be drawn from this data?

A) Cell W could be a muscle cell from an insect.
B) Cell X could be a heart-muscle cell from a mammal.
C) Cell Y could be a living leaf cell from a corn plant.
D) Cell Z could be an underground root cell from a pea plant.

Question 14:

Read the following extracts about the history of ideas about photosynthesis and answer the question below.

Ancient Greek scientists

Scientists in ancient Greece believed that plants gained mass only by taking in minerals from the soil. They would not have tested this idea.

Jan Baptist van Helmont (1580-1644)

Van Helmont carried out an experiment to see if the idea from ancient Greece was correct. He grew a willow tree in a weighed amount of soil. After five years, he discovered that the willow tree weighed about 74 kg more than it did at the start. As the weight of the soil had hardly changed, van Helmont concluded that plant growth cannot only be due to minerals from the soil. He thought that the extra plant material had come from the water alone.

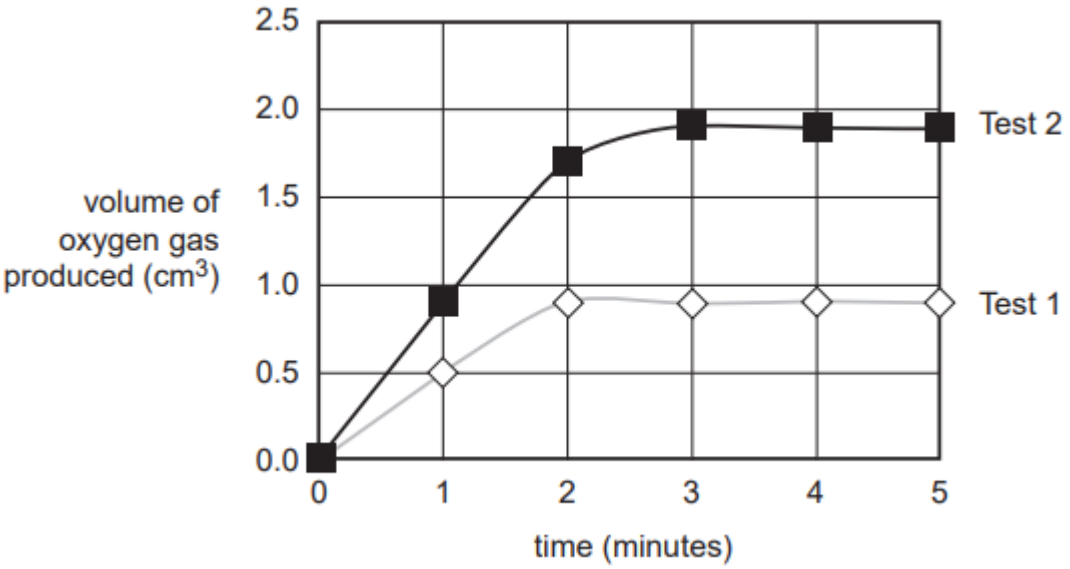
Source:*http://www.bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/green_world/photosynthesisrev2.shtml*

Which of the following statements is correct about the extracts?

A) Both the ancients Greeks and van Helmont were correct in their understanding of photosynthesis.
B) The ancient Greeks were correct and van Helmont was incorrect in their understanding of photosynthesis.
C) Neither the Greeks nor van Helmont were correct in their understanding of photosynthesis.
D) Van Helmont was correct and the Greeks were incorrect in their understanding of photosynthesis.

Question 15:

Hydrogen peroxide is a toxic by-product of many biochemical reactions. Cells break down hydrogen peroxide into water and oxygen gas with the help of the intracellular enzyme catalase. The optimum pH of catalase is 7. A Biology student measured the activity of catalase by recording the volume of oxygen gas produced from the decomposition of hydrogen peroxide when a catalase suspension was added to it. The catalase suspension was made from ground, raw potato mixed with distilled water. The student performed two tests and graphed the results.



Test 1 used 5 mL of 3% hydrogen peroxide solution and 0.5 mL of catalase suspension, and was conducted at 20 °C in a buffer solution of pH 7. Test 2 was carried out under identical conditions to Test 1, except for one factor that the student changed.

An explanation for the results of Test 2 would be that the student

A) increased the concentration of catalase by adding less water to the ground potato.

B) increased the temperature by placing the test tube in a water bath set at 30 °C.

C) used a hydrogen peroxide solution with a higher concentration.

D) added a catalase suspension made from a cooked potato chip.

PART B: SHORT ANSWER QUESTIONS.

Attempt Questions 16 –25

Allow 1 hour and 40 minutes for Part B

Question 16:

The graph below shows the effects of varying the level of the independent variable, X, on the rate of an enzyme-controlled reaction. Lines A, B and C represent three different independent variables which could be X.

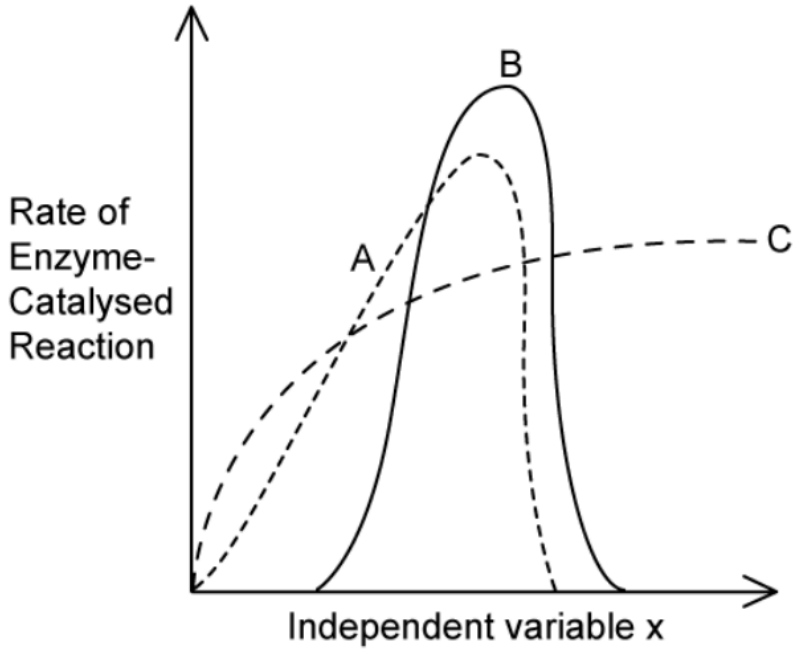


Figure 1: graph showing the effects of varying the level of the independent variable, X, on the rate of an enzyme-controlled reaction.

(a) Identify the independent variables that would cause lines A, B and C. **3 marks**

A: ……..

B:……...

C:……...

(b) Use your knowledge of enzyme activity to explain the changes in reaction rate shown by lines A and C. **4 marks**

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Question 17:

In 2004 a hurricane killed all populations of *Anolis Sagrei* lizards on seven geographically isolated islands. Scientists randomly chose seven males and seven females from a remaining population on a large island. They introduced one male and one female to each of the seven smaller islands. Over the next three years, the scientists noted that the size of the populations increased on each of the seven smaller islands. The scientists measured the genetic diversity within each of the populations and found there was lower genetic diversity in each new population compared with the population on the large island.

(a) Identify the main reason for the lower genetic diversity of the new populations on the smaller islands compared with the population on the large island. **2 marks**

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A separate study conducted by Lapiedra *et al* (2018) placed populations of *Anolis sagrei* lizards on 8 different islands in the Bahamas. Selection of the islands placed the lizards either in isolation from predators or at risk of potential contact with *Leiocephalus carinatus*, a major ground predator of Anolis lizards. The study investigated if Anolis lizards, which ordinarily vary consistently in risk-taking behaviours, behaved differently based on the island they were located on.

The findings of the study are presented in Figure 2.

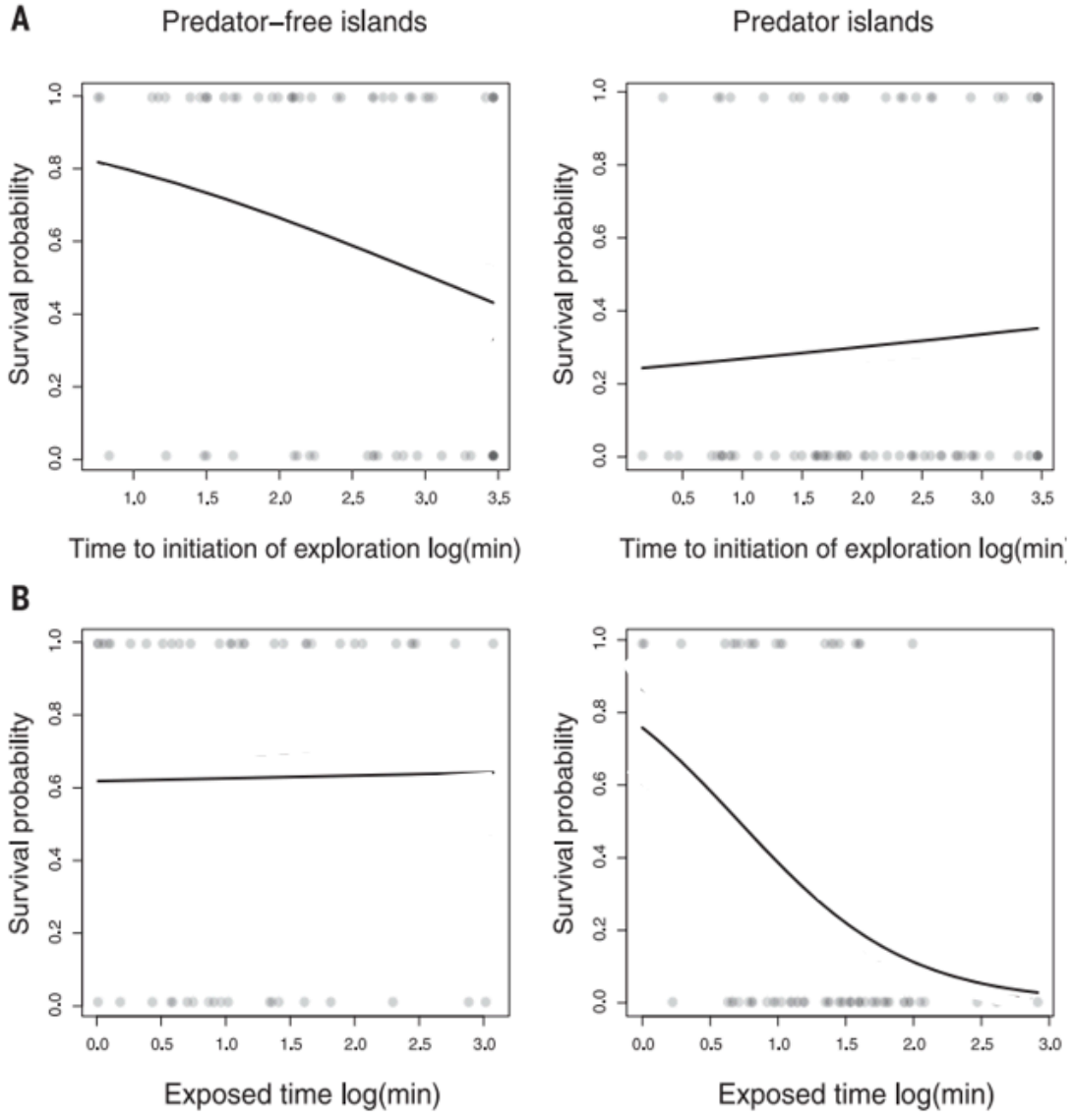

Figure 2: Association between individual variation in behaviour and survival of A.Sagrei females after the 4-month experimental period. (A and B) Time to initiation of exploration in a new environment (A) and time exposed on the ground (B) are represented separately for predator-free versus predator islands. Dots represent individual values for both survivors (dots at top of each panel) and nonsurvivors (dots at bottom of each panel); darker dots are indicative of several individuals having similar values.

(b) With reference to Figure 2, explain how the presence or absence of the predator *Leiocephalus carinatus* influenced the survival of *A.Sagrei* lizards. **5 marks**

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(c) The study by Lapiedra *et al* (2018) concluded that predation of *A.Sagrei* lizards was influenced by ground exposure with evolutionary changes now impacting behavioural dynamics. For each scenario (predator-free islands and predator islands), identify an example of a potential favoured behaviour which may assist in survival and discuss the implications on behavioural adaptation. **4 marks**

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Question 18:

Figure 3 below shows a typical epithelial cell that lines the airways of the lungs. The viscosity of mucus is controlled by the CFTR chloride ion channel. When there is too little water in the mucus, the CFTR channel opens allowing Cl^- to move into the mucus. When active, the CFTR channel also inhibits the sodium channel and limits movement of Na^+ ions into the cell. The resulting high concentration of salt in the mucus draws water out of the cell via osmosis which makes the mucus less viscous.

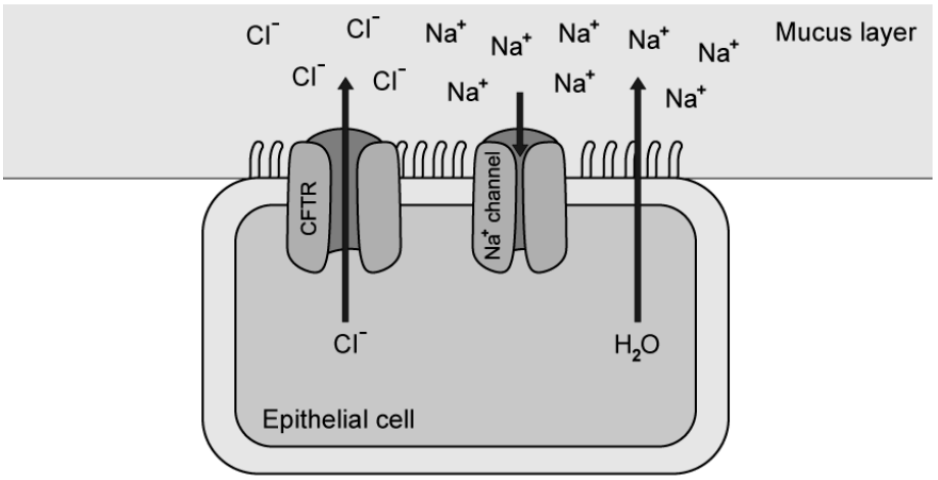

Figure3:Water and ion movement across a typical epithelial cell that lines the airways of the lung.

Cystic fibrosis is a genetic disorder characterised by the build-up of thick sticky mucus that causes severe damage to the respiratory and digestive systems. People with class I cystic fibrosis have inherited two faulty versions of the gene for CFTR which results in an absence of the CFTR channel.

Discuss why patients who have cystic fibrosis produce mucus that is thick and sticky.

4 marks

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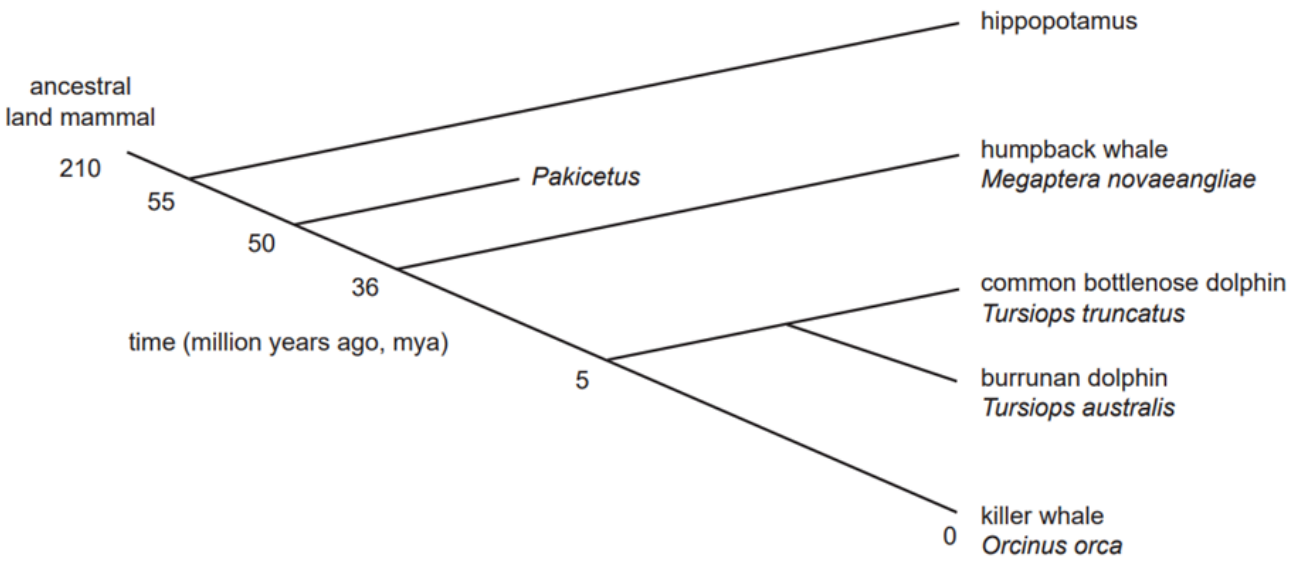
Question 19:

Cetaceans (whales, porpoises and dolphins) are marine mammals belonging to the order Artiodactyla (even-toed hoofed mammals). The closest living relatives of cetaceans are hippopotamuses. Phylogenetic tree A summarises the evolutionary relationships of four present-day cetacean species and the hippopotamus.

Phylogenetic tree A



(a) What does the length of the line that represents the evolution of Pakicetus suggest? **1 mark**

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(b) A fossil named Ambulocetus was found in 1992 and dated at 49 million years old. Some palaeontologists believe that it is a transitional fossil between the ancestral land mammal shown in Phylogenetic tree A and present-day cetaceans. Predict two structural features of the Ambulocetus fossil that would provide evidence to support the hypothesis that it is a transitional fossil and suggest a survival advantage of each feature. **4 marks**

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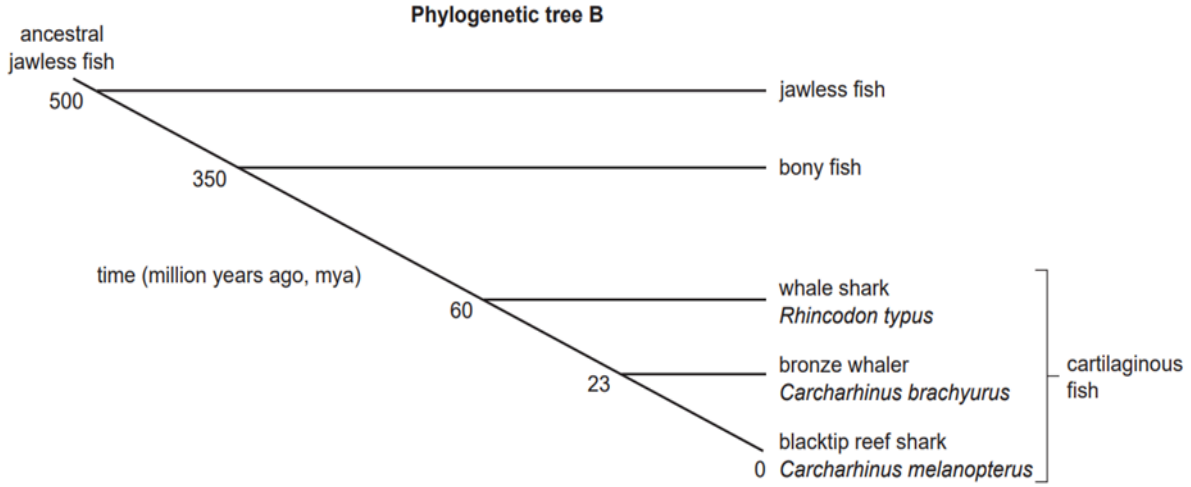
(c) Sharks are marine fish of the class Chondrichthyes (cartilaginous fish). Phylogenetic tree B summarises the evolutionary relationships of three present-day shark species and main fish classes.



QUESTION CONTINUED ON NEXT PAGE

The table below provides information about the present-day species shown in phylogenetic trees A and B.

Marine animal		Average length (m)	Diet
	humpback whale *Megaptera novaeangliae*	16	filters plankton and krill by sucking water into mouth through baleen plates
	common bottlenose dolphin *Tursiops truncatus*	4	hunts fish, squid and crustaceans
	burrunan dolphin *Tursiops australis*	3	hunts fish and squid
	killer whale *Orcinus orca*	10	hunts sea birds, squid, seals, baleen whales, dolphins, fish, sharks and sea turtles depending on location
	whale shark *Rhincodon typus*	12	filters plankton, small squid and fish through filter pads and 300 rows of teeth
	bronze whaler *Carcharhinus brachyurus*	3	hunts squid, bony fish and other cartilaginous fish
	blacktip reef shark *Carcharhinus melanopterus*	2	hunts small bony fish, squid and shrimp

i. Identify a specific example of divergent evolution using two animals from the information, and justify your response. **2 marks**

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ii. Describe one technique which may be used to confirm these two species diverged.

2 marks

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Question 20:

Figure 4 shows some muscle cells and their subcellular structures.

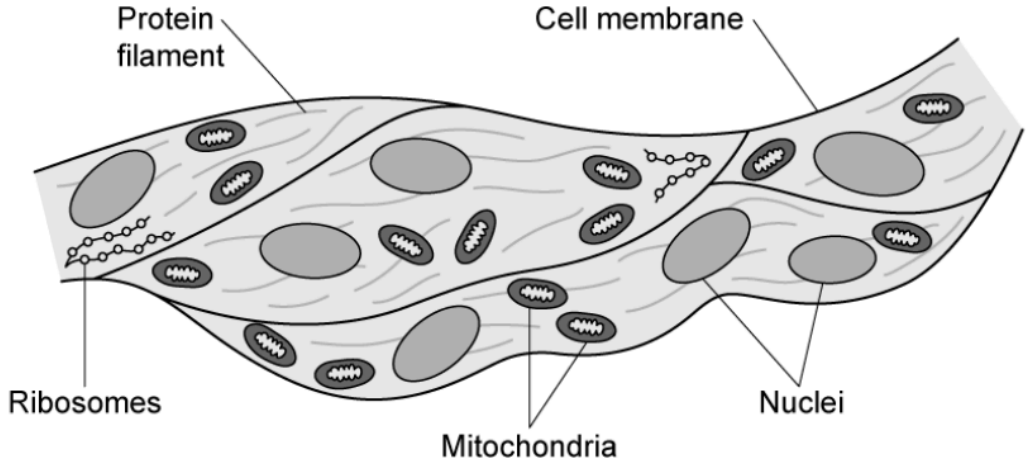

Figure 4: Muscle cells and their subcellular structures.

(a) Discuss why the muscle cell is unable to produce glucose and requires the organism to source glucose from food. **3 marks**

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(b) Explain why muscle cells have many mitochondria. **3 marks**

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Question 21:

Figure 5 shows two cells.

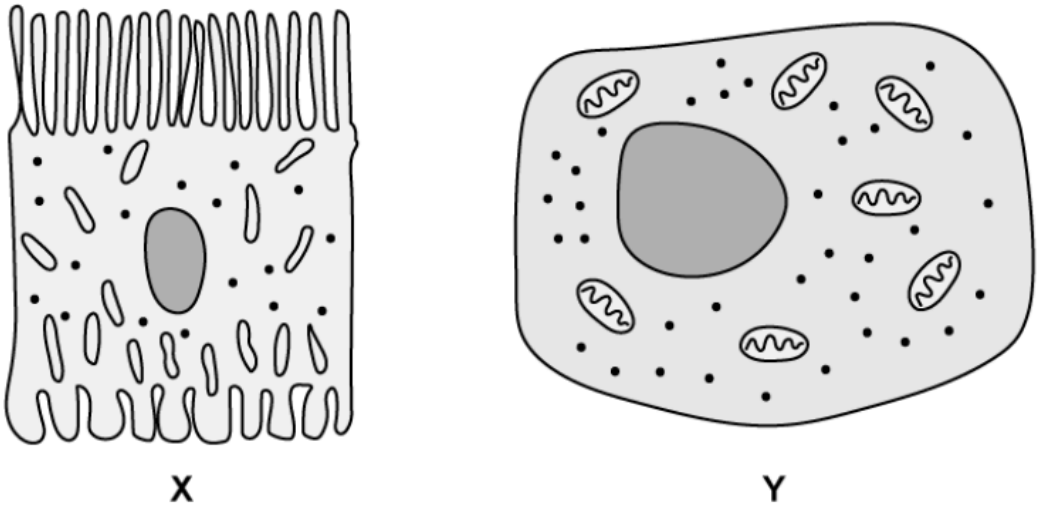

Figure 5: Diagram of two cells.

Justify which cell (X or Y) is better adapted to carrying out diffusion. **3 marks**

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Question 22:

Consider figure 6 showing water transport below.

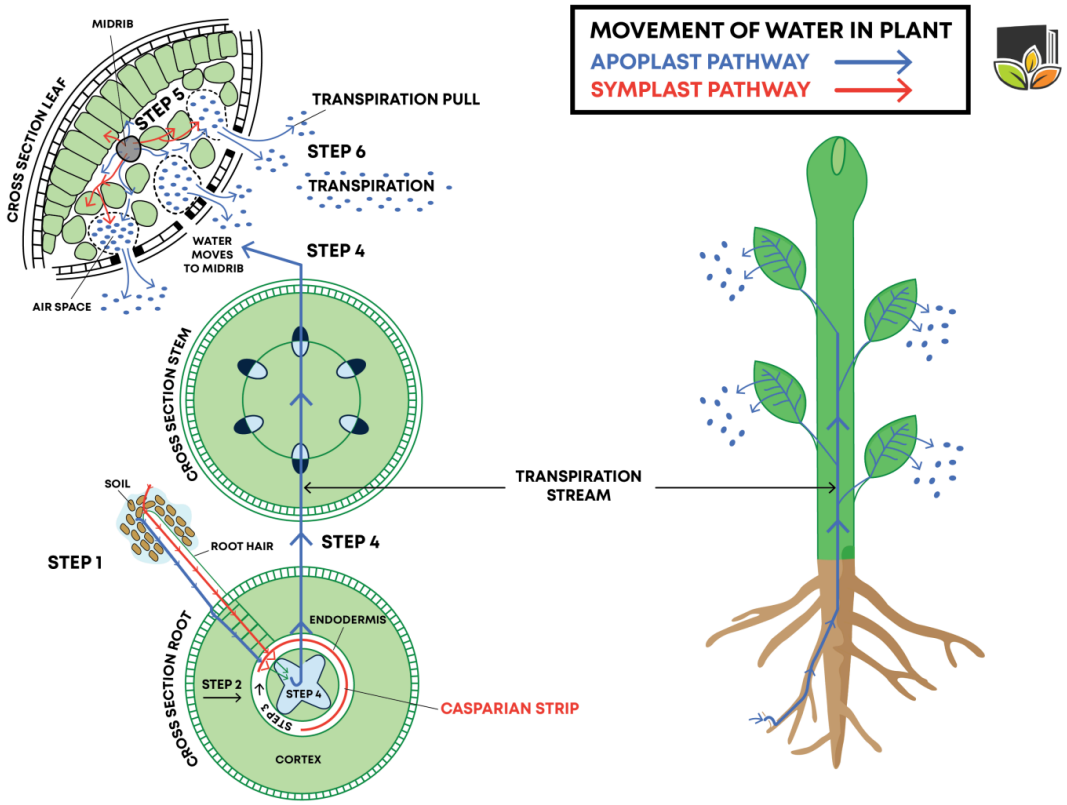

Figure 6: Movement of water in a plant.
(Sourced from: https://leafylearning.co.uk/r2101-going-up-the-pathway-of-water-uptake-in-the-plant/)

(a) Identify the transport mechanism which allows water to enter the plant at step 1.
1 mark

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(b) Explain how forces generated in step 6 of the diagram (transpiration) are transferred to water molecules in the transpiration stream inside the stem of the plant. **4 marks**

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Question 23:

Figure 7 below shows the anatomy of the human oral cavity.

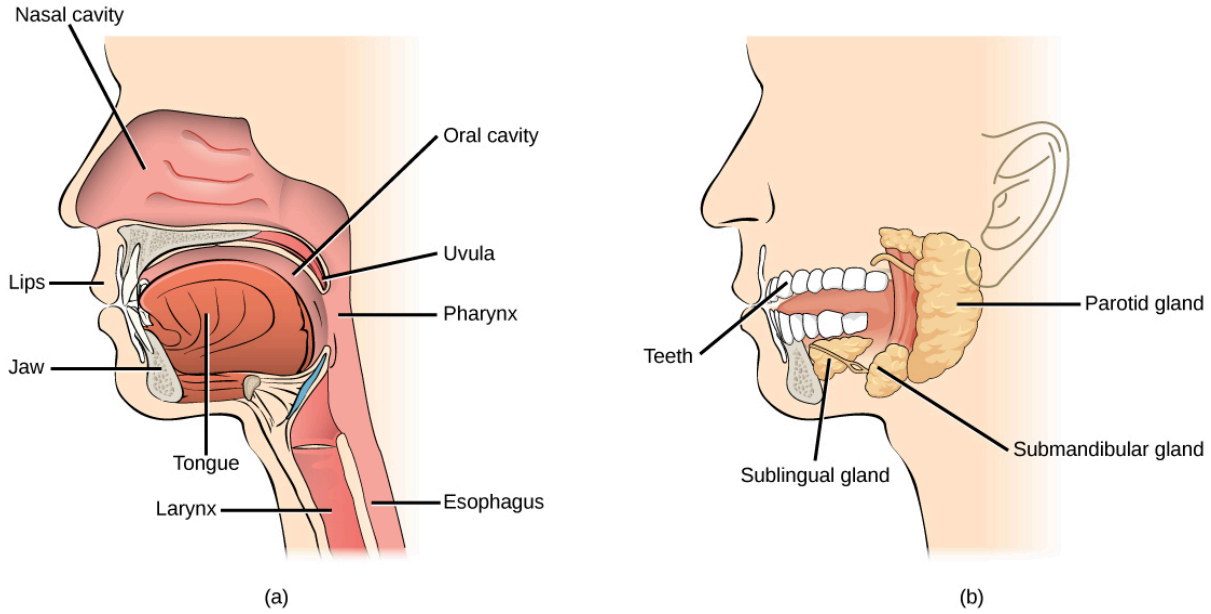

Figure 7: anatomy of the human oral cavity.
(Sourced from: https://courses.lumenlearning.com/wm-biology2/chapter/parts-of-the-digestive-system/)

(a) Describe how one structure shown in figure 7 facilitates physical digestion. **2 marks**

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(b) Diagram b in figure 7 shows the location of salivary glands. Explain how substances in saliva enable the chemical digestion of food to begin. **3 marks**

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Question 24:

Table 1 below shows the composition of gases in atmospheric and exhaled air.

Gas	Atmospheric air, %	Exhaled air, %	Change, %
Nitrogen, N_2	79	79	0
Oxygen, O_2	21	16	-5
Carbon dioxide, CO_2	0.04	4	+3.96
Water vapour	Variable	Saturated or 1%	-

Table 1: composition of gases in atmospheric and exhaled air.
(Sourced from: https://www.bbc.co.uk/bitesize/guides/zsry39q/revision/5)

Explain how the structure of alveoli helps to bring about the changes shown in table 1. Include a relevant diagram in your response **6 marks**

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EXAMINATION CONTINUED ON NEXT PAGE

Question 25:

The diagram below shows a simplified model of the open circulatory system of a gastropod mollusc.

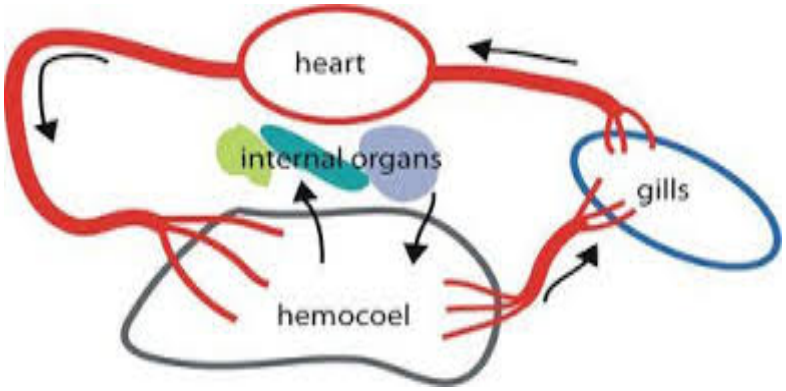

Figure 8: simplified model of the open circulatory system of a gastropod mollusc. (Sourced from: https://flexbooks.ck12.org/cbook/ck-12-advanced-biology/section/15.20/primary/lesson/mollusk-structure-and-function-advanced-bio-adv/)

Compare this circulatory system with the closed system of a mammal. **4 marks**

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END OF EXAMINATION

ADDITIONAL WRITING SPACE **(Clearly indicate which question/s this space has been used for)**

STUDENT NUMBER ……..

MULTIPLE CHOICE ANSWER SHEET

Place an X in the correct cell to indicate your response. If you make a mistake, completely scribble out the incorrect response and clearly label your correct answer.

	A	B	C	D
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