This paper is the Intermediate Biology Olympiad 2023.

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Some questions may have been altered or removed compared to the version of this paper used during the competition period. This is a download of an online, interactive paper, so the formatting is also sub-optimal.

Students are not expected to have memorised all the facts assessed, or be familiar with all the topics presented. Their biological intuition and problem solving is being assessed.

Answers are not provided.*

** Mark schemes are not provided as these papers do not resemble typical revision aids. Each topic is bespoke to a particular year. Students can use the papers as inspiration and should complete their own research to enhance their understanding. We also provide the papers here to ensure all students have access to them, whereas no one outside of UKBC has access to mark schemes.*

Intermediate Biology Olympiad 2023

This was one 60 minute paper.

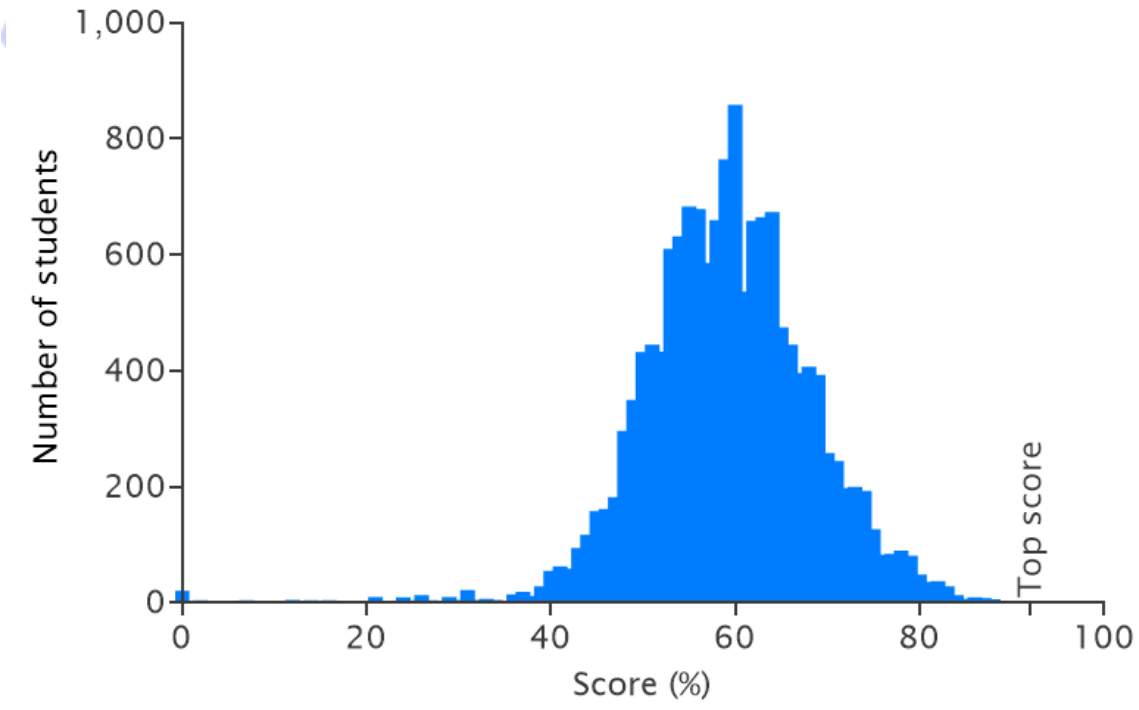
You may use a calculator.

It is recommended that you have a pen and paper to hand for rough work.

No marks are subtracted for incorrect answers.

Some questions have more than one answer you need to choose. For some questions, you need to put the answers in the correct order.

Award	**Percentage score**	**Percentage of students who took part**
Gold	73.55%	5%
Silver	68.26%	10%
Bronze	63.64%	15%
Highly Commended	60.33%	15%
Commended	57.36%	15%



Duration: 60 minutes
Total marks: 121

Question 1

Part 1 of 2

Why are leaves usually green?

Green plants. By anyaka - Flickr, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=987468

2 marks

Choose ONE

a) To camouflage them from herbivores.

b) Because they mainly absorb green light.

c) To attract pollinators.

d) Because chlorophyll is green.

e) Because green is the predominant colour in sunlight.

Part 2 of 2

What roles do plant roots have?

Tree roots. By Mr Poortom - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=3741079

8 marks

Choose as many as appropriate

a) Fertilising neighbouring plants during sexual reproduction.

b) Anchor the plant in soil.

c) Absorb sugar and protein from soil.

d) Absorb water from soil.

e) 'Plug into' a network of fungal hyphae (like roots) to gather nutrients.

f) Communicate with soil fungi, bacteria and other plants.

g) Store energy.

h) Absorb carbon dioxide.

Question 2

Part 1 of 2

'Anting' is a behaviour of birds when they land on an ants' nest to aggravate them. The ants spray formic acid into the bird feathers which acts as an insecticide, fungicide and bactericide.

By J.M.Garg - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=2820542

Part 2 of 2

What is the closest description of the way the bird behaves towards the ants?

2 marks

Choose ONE

a) The bird is like a herbivore.

b) The bird is like a carnivore.

c) The bird is like a parasite.

d) The bird is altruistic.

e) The bird is spiteful.

Question 3

Part 1 of 2

Seagulls often steal crisps from tourists at the beach.Scientists scattered crisp packets around an empty area, but the seagulls rarely pecked at them, and did not eat them.Next, the scientist started eating from their own packet of crisps. Many gulls came to investigate the scattered crisp packets and eat from them whilst the scientist was eating.The scientists were able to repeat this observation several times with different brands of crisp packets. They also noticed that the gulls mainly pecked at crisp packets which matched the colour of the one the scientist was eating from.

Part 2 of 2

Are each of these statements true or false?

5 marks

Mark the following as TRUE or FALSE

a) Seagulls instinctively eat from crisp packets.

TRUE FALSE

b) Eating crisps is learned by conditioning.

TRUE FALSE

c) Eating crisps is learned by social learning.

TRUE FALSE

d) If repeated with the same gulls and brand of crisps, they are likely to start eating all the colours, irrespective of what the scientist eats.

TRUE FALSE

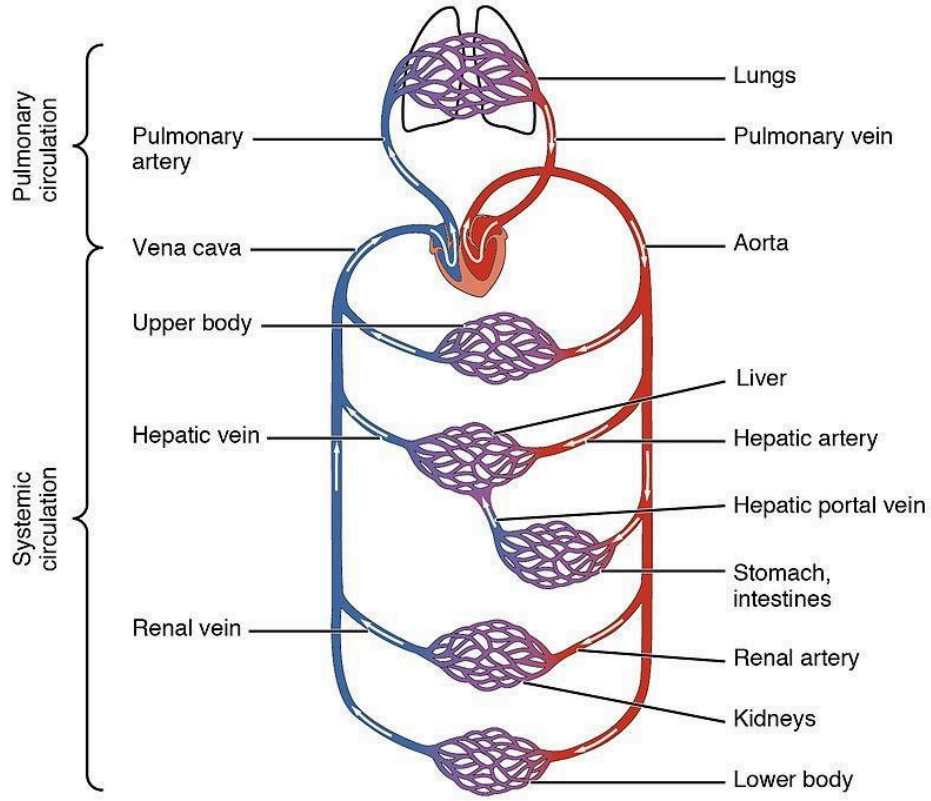
e) The gulls just prefer the same flavour of crisps as the scientist.

TRUE FALSE

Question 4

Part 1 of 2

The diagram shows blood flow around the human body.



Modified from OpenStax College, CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons

Part 2 of 2

Indicate whether each of the following statements is true or false.

7 marks

Mark the following as TRUE or FALSE

a) Food absorbed into blood from the digestive system is detoxified and metabolised in the liver before travelling to the heart.

TRUE FALSE

b) Almost all the blood leaving the heart passes through capillaries before returning to the heart.

TRUE FALSE

c) All arteries carry oxygenated blood.

TRUE FALSE

d) Heart muscle absorbs the oxygen it needs from the blood as it flows through the atria and ventricles.

TRUE FALSE

e) Veins have thick muscular walls which enable them to pump blood back to the heart.

TRUE FALSE

f) Blood travelling once from the left ventricle to the right ventricle (completing a single lap of the circuit) supplies nutrients to several organs.

TRUE FALSE

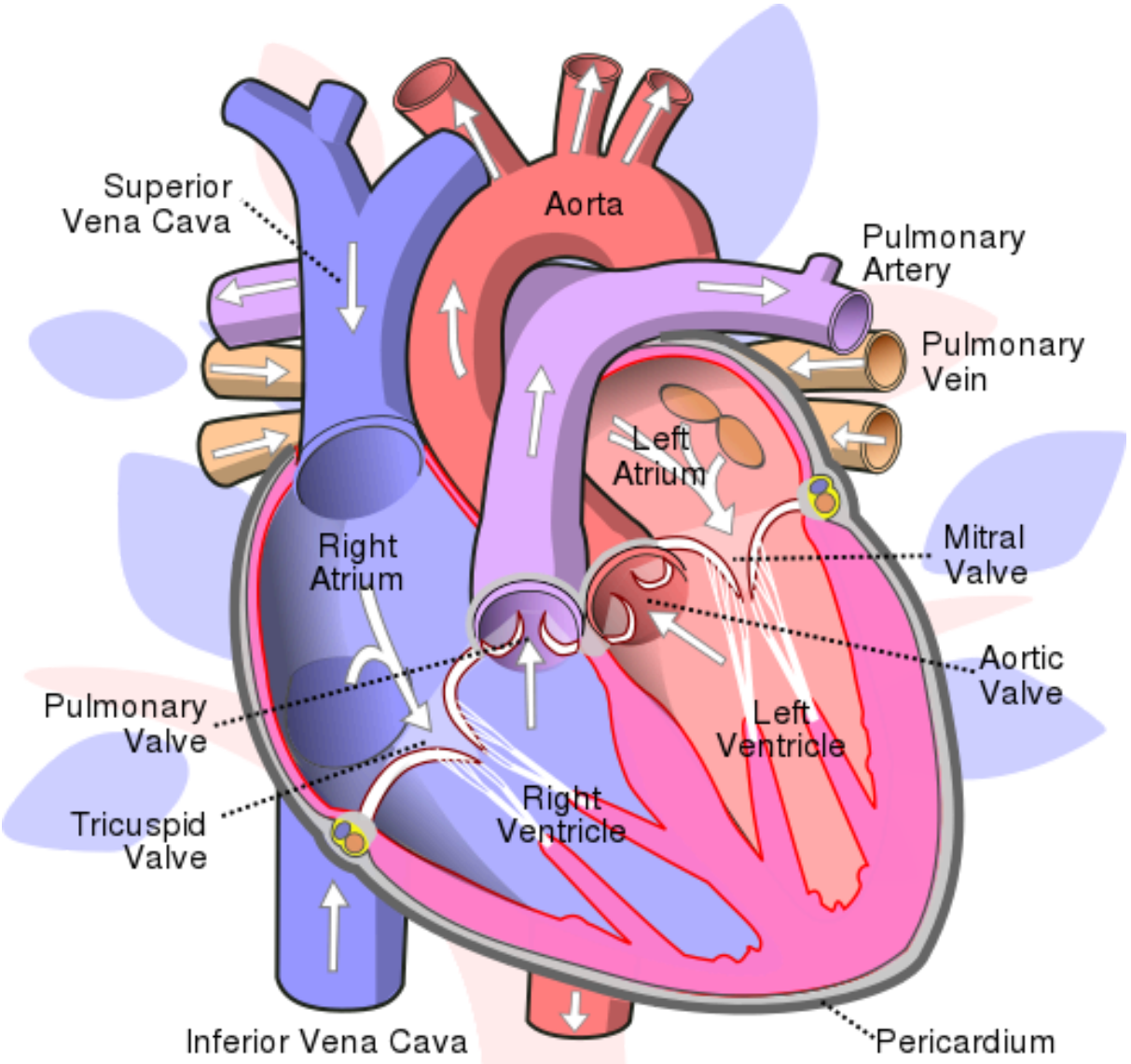
g) A large blood clot in the lungs can prevent blood flowing around the entire body (circulatory collapse).

TRUE FALSE

Question 5

Part 1 of 6

The diagram shows parts of the heart.

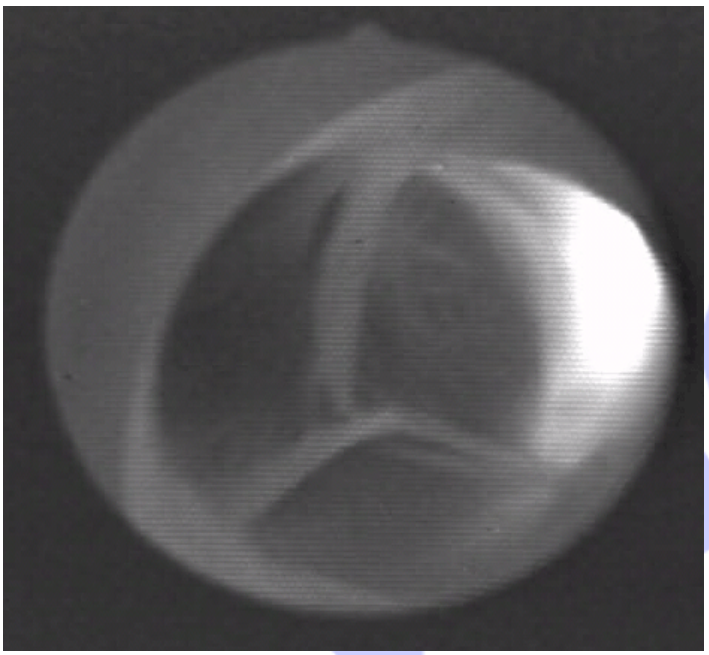


Part 2 of 6

The animation shows heart contractions.

Part 3 of 6

Heart valves ensure that blood can only flow in one direction. Each valve opens and closes depending on the pressure either side of it.This is a film of the aortic valve opening and closing. Where was the camera located in order to film this?



2 marks
Choose ONE

a) Left ventricle.

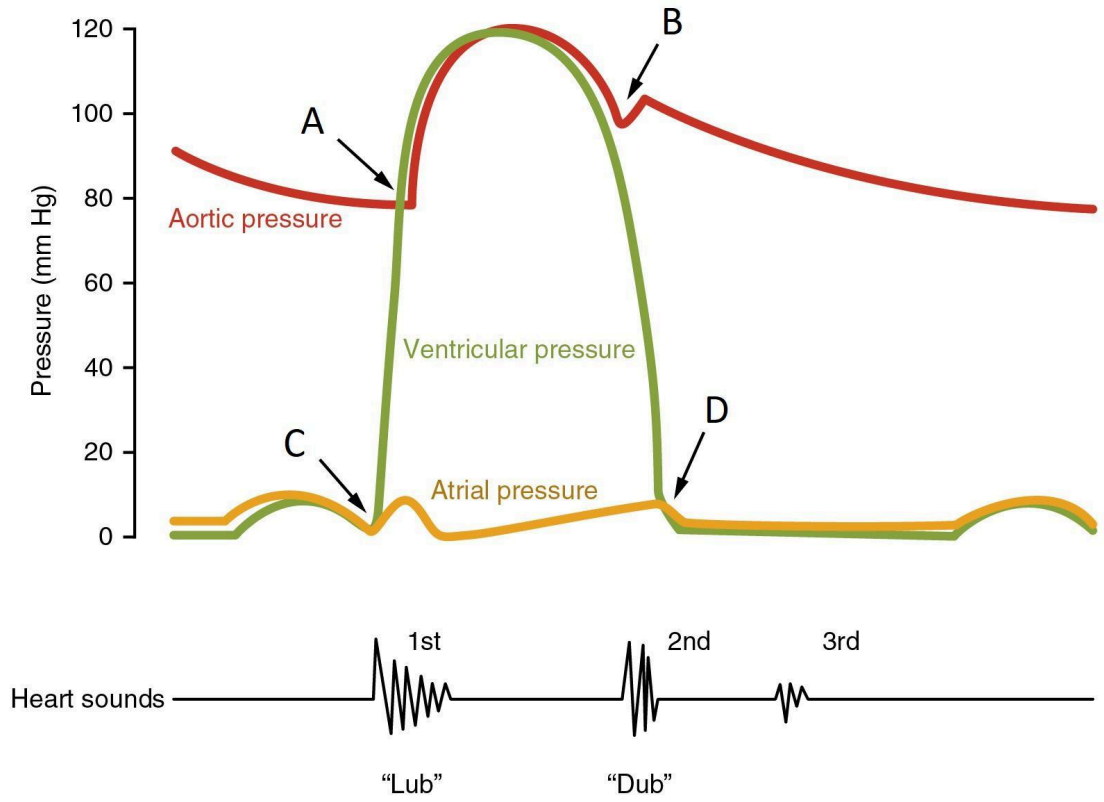
b) Aorta.

c) Left atrium.

d) Right ventricle.

Part 4 of 6

Study the graph below which shows the pressure inside the aorta, left ventricle and left atrium.



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0 mark

Choose ONE

Part 5 of 6

What is happening at the points indicated by each letter?

4 marks

Groups

A

B

C

D

Put into the groups above

a) The mitral valve opens.

b) The mitral valve closes.

c) The aortic valve opens.

d) The aortic valve closes.

Part 6 of 6

If the aorta becomes stiffer (less elastic) due to build up of fatty and scared tissue, then...

4 marks

Mark the following as TRUE or FALSE

a) Maximum pressure in the ventricle will increase.

TRUE FALSE

b) Maximum pressure in the aorta will increase.

TRUE FALSE

c) Mean pressure (over a cardiac cycle) in the aorta will increase.

TRUE FALSE

d) Minimum pressure in the aorta will increase.

TRUE FALSE

Question 6

Part 1 of 2

Humans and horses are very unusual in being able to produce large quantities of sweat.Other mammals expose their tongues, ears, etc to cool down.

Sweaty horse

Part 2 of 2

Compared to other **mammals** of a similar size, shape, and metabolic rate, in similar conditions, what effects does sweating have on humans and horses?

4 marks

Choose as many as appropriate

a) Better endurance when exercising.

b) Increased need to eat salty food / fluids.

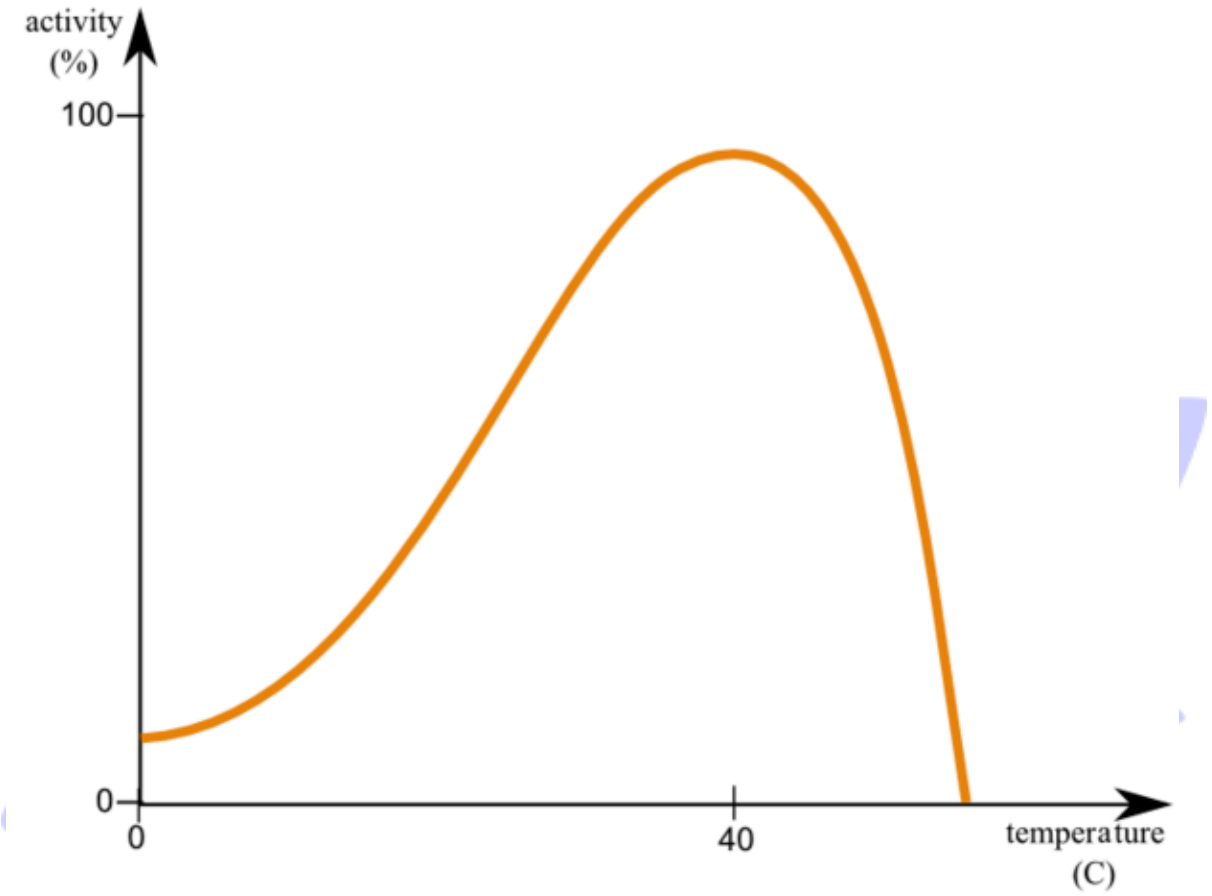
c) Increased panting.

d) Survival in very high heat is more affected by humidity.

Question 7

Part 1 of 2

The rate of an enzyme catalysed reaction varies with temperature. A graph of activity against temperature often looks like this:



By Gal m - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=2924145

Part 2 of 2

Which factors account for different parts of the shape of this curve?(i.e. Do *not* tick factors which are either incorrect, or irrelevant, to *all* parts of the curve).

8 marks

Choose as many as appropriate

a) Increasing temperature increases the solubility of enzyme and/or substrate.

b) Increasing temperature causes enzyme and substrate to collide more often.

c) Increasing temperature causes substrate to move to fast for the enzyme to react.

d) Hotter molecules are more likely too have sufficient activation energy to react.

e) Increasing temperature 'melts' disulphide bonds.

f) Increasing temperature alters the shape of the active site.

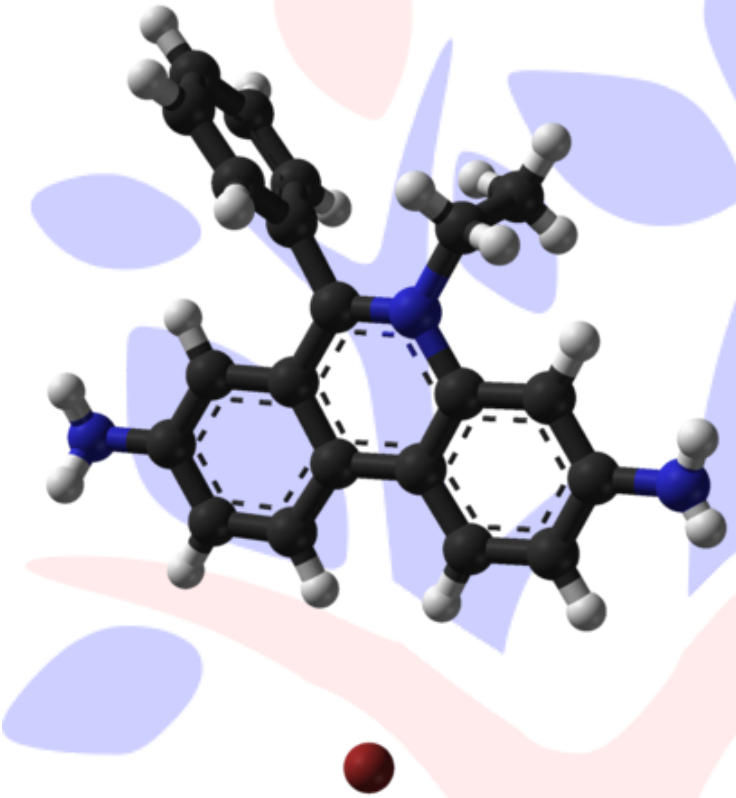
g) Increasing temperature 'melts' hydrogen bonds.

h) Increasing temperature causes the substrate to breakdown before the enzyme can use it.

Question 8

Part 1 of 2

A chemist invents a fluorescent dye.Its structure is a 'flat' series of aromatic rings.Water quenches the fluorescence of the dye, but if it slots tightly into a hydrophobic space, it fluoresces extremely brightly.What biological molecules would this dye stain well?



By Ben Mills - Own work, Public Domain

2 marks

Choose ONE

a) Protein

b) Starch

c) Disaccharides

d) Lipids

e) DNA

f) Steroids

Part 2 of 2

Emulsions are stable suspensions of water-insoluble substances. Substances which help emulsions form (emulsifiers) can make capsules and vesicles

which are essential for transporting natural and medicinal substances to cells.Which biological molecules are good emulsifiers?

5 marks

Choose as many as appropriate

a) Lipids

b) Phospholipids

c) Polycyclic aromatic hydrocarbons

d) Cholesterol

e) Sugars

Question 9

Part 1 of 9

Acetylation is an important metabolic process which takes place in the human liver and gut. The enzyme N-Acetyltransferase 2 (NAT2) acetylates certain antibiotics. The NAT2 gene is located on chromosome 8. There are multiple alleles of the NAT2 gene in the human population.* People homozygous for the *NAT2*5* alleles are 'slow acetylators'.* People homozygous for the wild type *NAT2*WT* allele are described as 'fast acetylators'.* Heterozygous patients are described as 'intermediate acetylators'.Slow acetylators take longer to breakdown some medicinal drugs.

Part 2 of 9

How would you describe the *NAT2*5* allele's mode of inheritance?

2 marks

Choose ONE

a) Autosomal codominant

b) Autosomal dominant

c) X-linked recessive

d) Autosomal recessive

e) Y-linked dominant

Part 3 of 9

50% of Europeans are slow acetylators. Using the Hardy-Weinberg equation, which describes the genotypic frequencies of an ideal population, calculate the allele frequency of the *NAT2*5* allele.

$$p + q = 1$$
$$p^2 + 2pq + q^2 = 1$$

p: frequency of wild type allele
q: frequency of *NAT2*5* allele
p^2: frequency of homozygous wild type genotype
$2pq$: frequency of heterozygous genotype
q^2: frequency of homozygous *NAT2*5* genotype

Part 4 of 9

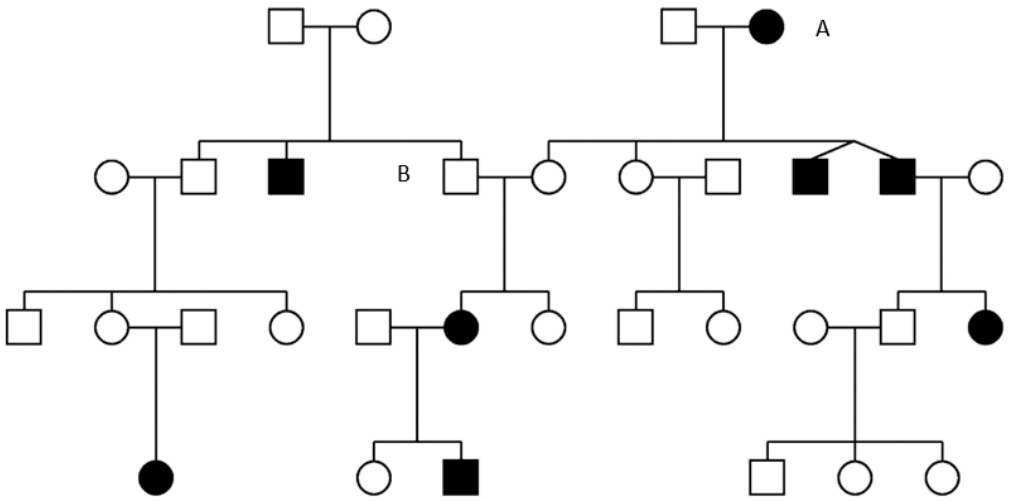
Type your answer to 2 decimal places.

2 marks
Write something below

Part 5 of 9
5% of Canadian Inuits are slow acetylators. What proportion of them are intermediate acetylators?*Type your answer as a percentage to the nearest whole number. You do not need to worry about the '%' sign.*

4 marks
Write something below

Part 6 of 9
You receive a family tree. However, some information is missing. What is the genotype of individual A?



2 marks
Choose ONE
a) *NAT2*WT*/*NAT2*WT*

b) *NAT2*WT*/*NAT2*5*

c) *NAT2*5*/*NAT2*5*

Part 7 of 9
What is the genotype of individual B?

2 marks
Choose ONE
a) *NAT2*WT*/*NAT2*WT*

b) *NAT2*WT*/*NAT2*5*

c) *NAT2*5*/*NAT2*5*

Part 8 of 9

What is the phenotype of individual B?

2 marks

Choose ONE

a) "Intermediate acetylator"

b) "Slow acetylator"

c) "Fast acetylator"

Part 9 of 9

A and B are both hospitalized for pneumonia. The doctors want to prescribe them the antibiotic isoniazid, which is metabolised by the *NAT2* enzyme. Too high doses of isoniazid can cause bad side effects.To avoid toxic side effects, which one of them is prescribed a **lower** isoniazid dose?

2 marks

Choose ONE

a) A

b) B

c) Both the same

Question 10

Part 1 of 6

You are a food safety tester who has received 4 crates of milk to test for melamine contamination. Melamine is a non-protein nitrogen-containing organic molecule that was used as a pesticide.The Kjeldahl test is used to measure the organic nitrogen content of samples. You heat 1 litre of milk with sulfuric acid, then with NaOH, to release the organic nitrogen content as ammonia. The NH_3 gas is then added to a known volume of standard acid. The change in the pH value of the acid directly correlates to the amount of organic nitrogen in the sample. The way you get the "Kjeldahl protein content" of the milk is by multiplying the amount of NH_3 released (Total Kjeldahl nitrogen in g) by the milk-specific conversion factor. With the following information, calculate the per litre "Kjedahl protein content" (mg) of each sample as estimated by the Kjeldahl method.

Milk conversion factor: 6.38

Molar mass of NH_3: 17 g/mol

Milk sample	Total Kjedahl nitrogen (mmol/L)
A	29.5
B	25.8
C	58
D	13.4

Part 2 of 6

Indicate whether each of the following statements is true or false.

5 marks

Mark the following as TRUE or FALSE

a) Milk sample A has a higher "Kjedahl protein content" than milk sample C.

TRUE FALSE

b) 5 litres of milk B contains 16g of "Kjedahl protein".

TRUE FALSE

c) A higher Total Kjedahl nitrogen value means the sample has less organic nitrogen.

TRUE FALSE

d) The "Kjedahl protein content" of milk C is 6300 mg/mL.

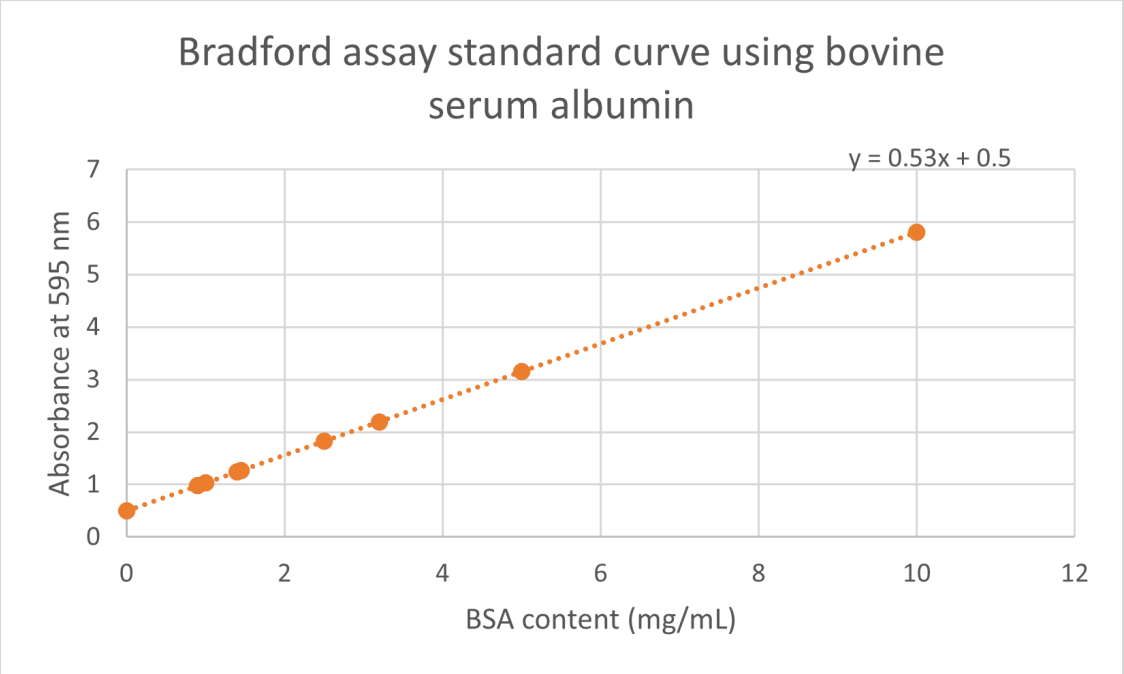
TRUE FALSE

e) The "Kjedahl protein content" in 3 litres of milk D is 4.35g.

TRUE FALSE

Part 3 of 6

Next, you conduct a Bradford test. This uses the Coomassie blue dye, which changes its colour from brown to blue when it binds to amino acids. This colour change can be measured by taking the sample's absorbance readings at 595 nm. First you measure the absorbance of a dilution series of bovine serum albumin (a common blood protein from cows) of known concentration.



BSA curve by me

Part 4 of 6

Next you measured the absorbance of the milk samples.

Milk sample	Bradford Assay absorbance at 595 nm
A	2.20
B	0.98
C	1.24
D	1.27

Part 5 of 6

Indicate whether each of the following statements is true or false.

5 marks

Mark the following as TRUE or FALSE

a) The equation to calculate the "Bradford protein content" using the absorbance of a sample is (Abs-0.53)/0.5, where Abs is the absorbance at 595 nm.

TRUE FALSE

b) The "Kjedahl protein content" of sample A is equal to its "Bradford protein content".

TRUE FALSE

c) The "Bradford protein content" of sample B is higher than its "Kjedahl protein content".

TRUE FALSE

d) The non-zero absorbance of the 0 mg/mL BSA solution might be because the spectrophotometer was not zero-ed (blanked) before use.

TRUE FALSE

e) A BSA solution of 11.3 mg/mL would have an absorbance at 595 nm of 6.42.

TRUE FALSE

Part 6 of 6

Given the above information, which milks are safe and which (if any) are contaminated with melamine?

4 marks

Groups

Safe

Melamine Contaminated

Put into the groups above

a) C

b) A

c) D

d) B

Question 11

Part 1 of 2

The modern understanding of natural selection is that traits are only adaptations when they cause the genes which contribute to them to tend to become more common.Not all simple traits are adaptations, and not all adaptations are optimised.Humans have often pondered why pathogens, such as HIV or smallpox, usually kill us despite dead people being unable to spread the organism.

A man dying of Smallpox in an English hospital, 1896 -The Wellcome Collection

Part 2 of 2

Which of these explanations are likely explanations for why at least some viruses may kill humans.

7 marks

Choose as many as appropriate

a) Killing humans prevents them spreading immunity to other humans.

b) Killing humans makes the survivors 'fitter'.

c) Some humans are less 'resistant' (e.g. malnourished or sick) than average and the virus kills them 'accidently'.

d) Some viruses infect humans from another species which is more resistant, so have not optimised their strategy to humans.

e) Dying people seek help of others which the virus can infect.

f) Adaptations which help the virus spread, such as rapid replication, have non-adaptive consequences which also kill the host.

g) In the long-term, natural selection is usually **not** the most important shaper of most traits.

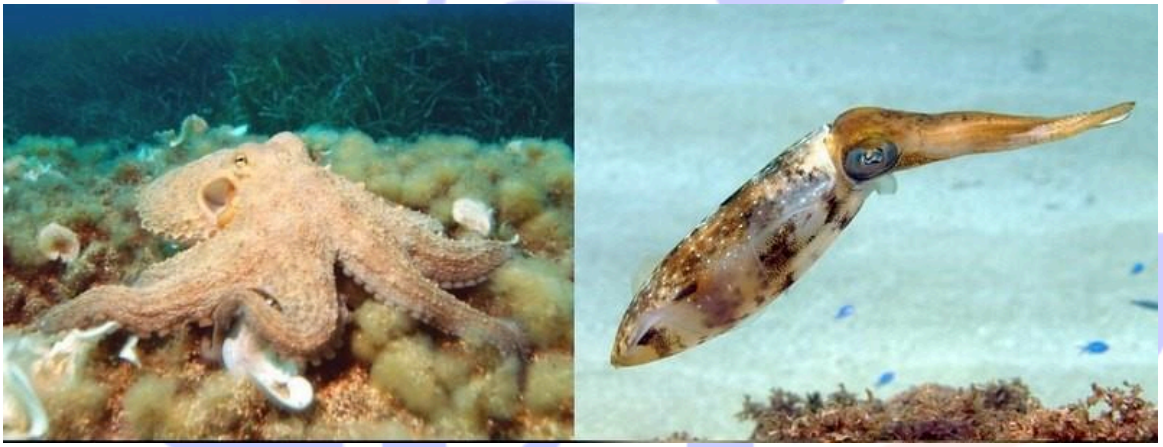
Question 12

Part 1 of 8

Cannibalism is the eating of individuals of the same species. Cannibalism is common in a variety of animal species.Cannibalism provides nutrition and reduces competition for resources.

Part 2 of 8

Cephalopods (including squids and octopi) are predators. Some of them are cannibals.



Left: Octopus (Albert Kok, CC BY-SA 3.0); Right: Caribbean Reef Squid (Nick Hobgood, CC BY-SA 3.0)

Part 3 of 8

For 3 years, scientists measured the cannibalism and biomass of a population of cephalopods in the open sea (pelagic squids) and on the bottom of the sea (benthic octopi). They also measured the rate of biomass creation (known as productivity) of the ecosystem.Analysing the figure below, select whether the following statements are True or False:

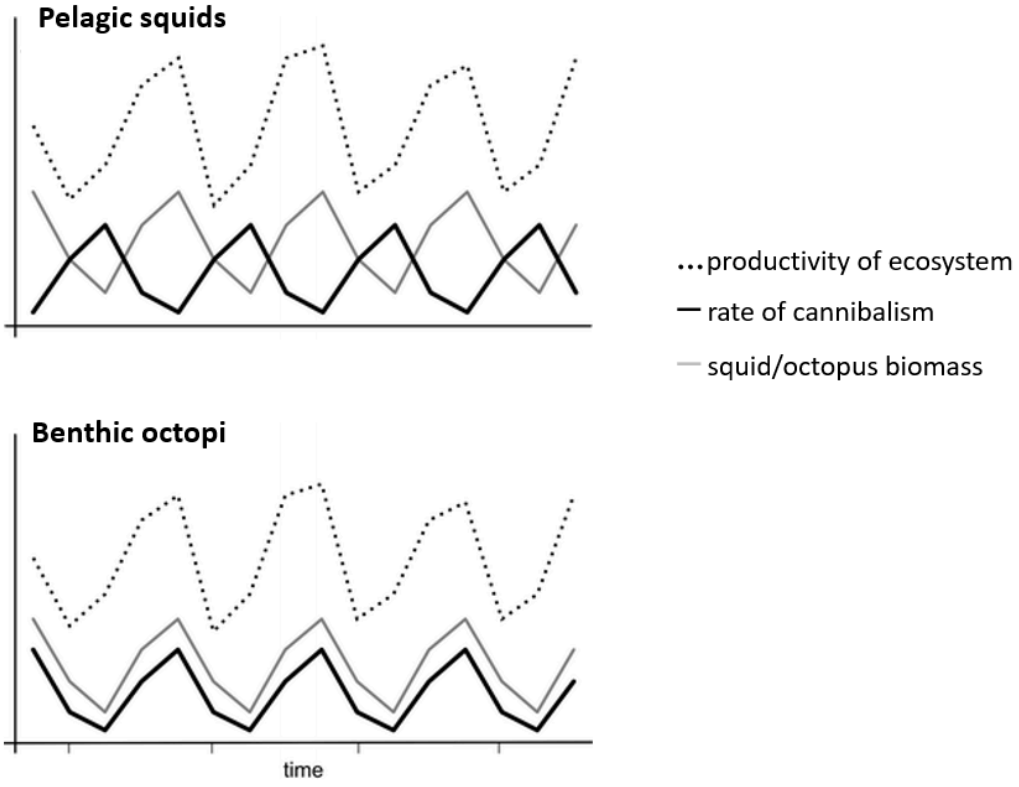


Image adapted from Ibáñez & Keyl, 2009

5 marks

Mark the following as TRUE or FALSE

a) The productivity of the benthic ecosystem changes in a cyclic manner.

TRUE FALSE

b) When the productivity of the pelagic ecosystem increases, squid biomass also increases.

TRUE FALSE

c) Benthic octopi resort to cannibalism when food is scarce.

TRUE FALSE

d) The cannibalism of pelagic squids is density dependent.

TRUE FALSE

e) Pelagic squid cannibalism leads to a decrease in its biomass.

TRUE FALSE

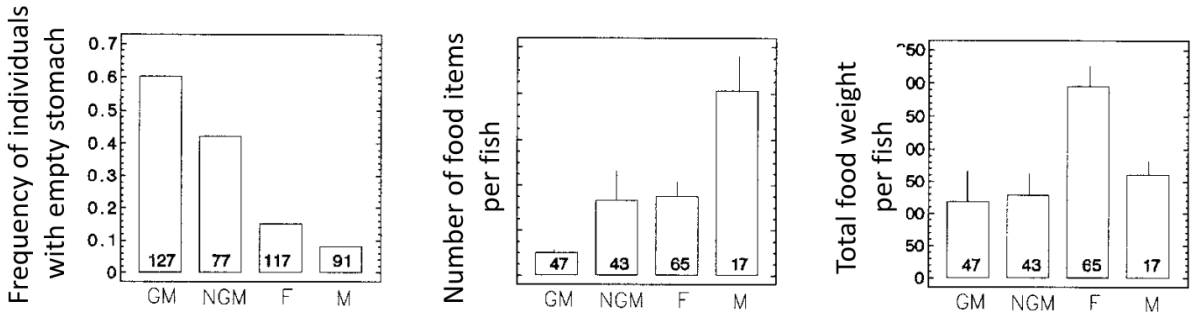
Part 4 of 8

European bullheads are freshwater river fish. They eat their own eggs!

European bullheads, credit Woluhar, CC BY-SA 3.0

Part 5 of 8

Usually, bullhead fish eat small crustaceans and insect larvae. Scientists observed the feeding habits of male and female bullheads throughout their breeding season.The fish could be categorised according to their behaviour: * females in breeding season, * nesting males that guard their eggs, * nesting males that do not guard their eggs, * non-mating males.The numbers within the columns indicate the sample size of each category.Using the figures below, decide which statements are true or false.



GM: guarding males
NGM: non-guarding males in breeding season
F: females in breeding season
M: males not in breeding season

Adapted from Marconato, Bisazza & Fabris, 1993

5 marks

Mark the following as TRUE or FALSE

a) Females go without feeding more often than nesting males.

TRUE FALSE

b) To determine total food weight, more non-breeding males were captured than guarding males.

TRUE FALSE

c) Assuming equal success rates, egg-guarding males foraged less than non-egg guarding males.

TRUE FALSE

d) The frequency of empty stomachs was higher in non-guarding males than guarding males.

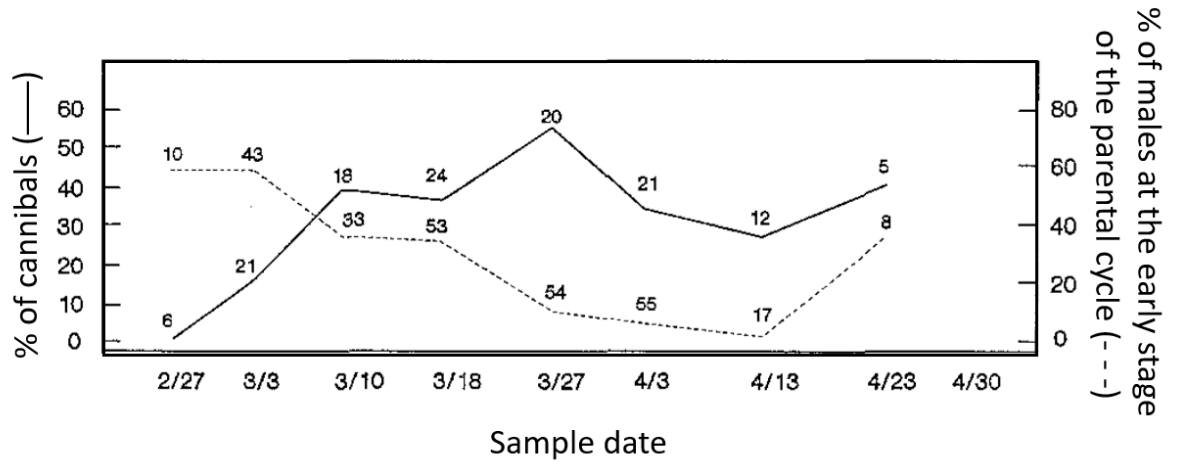
TRUE FALSE

e) Breeding females had a higher amount of food weight in their stomachs compared to all male fish.

TRUE FALSE

Part 6 of 8

To determine the proportion of cannibals in the guarding male bullhead fish population, scientists observed their behaviour through their breeding season (end of February to the end of April).The numbers on the graph show the sample size for each observation.Is each statement true or false?



Adapted from Marconato, Bisazza & Fabris, 1993

4 marks

Mark the following as TRUE or FALSE

a) Most bullhead males did not cannibalise their eggs at any point during the observation.

TRUE FALSE

b) The percentage of guarding males that ate their eggs fluctuated through the observation period.

TRUE FALSE

c) Most of the males were early-stage parents at the end of March.

TRUE FALSE

d) There is an inverse relationship between the percentage of cannibals and the proportion of early parental stage males.

TRUE FALSE

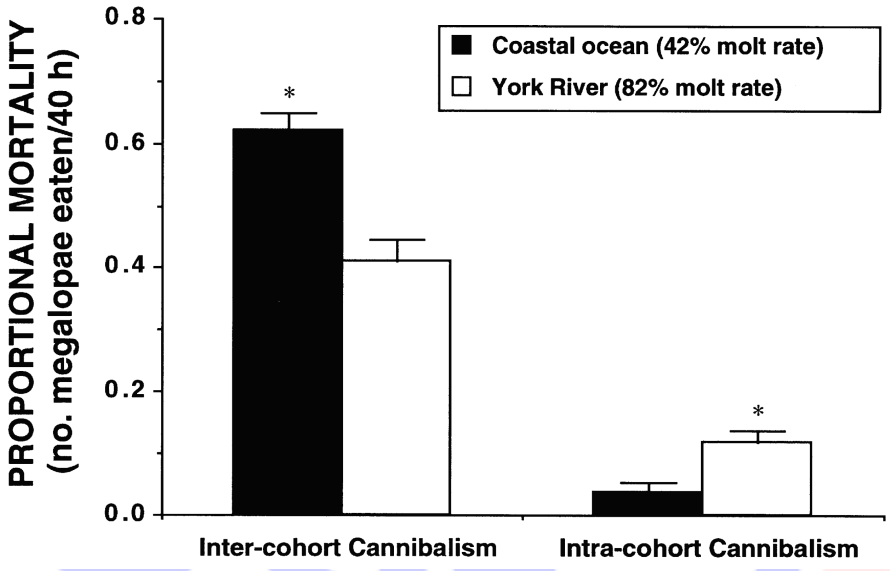
Part 7 of 8

Blue crabs are crustaceans that live in the Atlantic Ocean and the Gulf of Mexico.Their Latin names translate to "savoury beautiful swimmers", which the blue crabs surely appreciate, since they are known to also eat other blue crabs.

Atlantic Blue Crab (Callinectes sapidus), The Children's Museum of Indianapolis, CC BY-SA 3.0

Part 8 of 8

Blue crabs go through the process of moulting, where they shed their exoskeleton to grow.Some juvenile blue crabs supplement their diet by eating younger members of their species. This "predator-prey" phenomenon is called *inter-cohort* cannibalism.Some other blue crabs cannibalise individuals within their age group. This is called *intra-cohort* cannibalism.Scientists were curious whether the moulting rate of blue crabs influenced the amount of cannibalism, so they caught some very young blue crabs (megalopae) and put them in a tank. To create inter-cohort cannibalism, they also added a few bigger crabs (juveniles) to act as predators to the megalopae.Based upon their findings in the figure below, decide which statements are True or False. *The stars indicate statistically significant differences compared to the other population*



From Moksnes et al, 1997

5 marks

Mark the following as TRUE or FALSE

a) York River blue crabs have a higher moulting rate than coastal ocean blue crabs.

TRUE FALSE

b) Total cannibalism was more frequent in coastal ocean blue crabs than York River crabs.

TRUE FALSE

c) Inter-cohort cannibalism was more frequent than intra-cohort cannibalism in both coastal ocean and York River blue crab populations.

TRUE FALSE

d) Juveniles are more likely to eat moulting megalopae.

TRUE FALSE

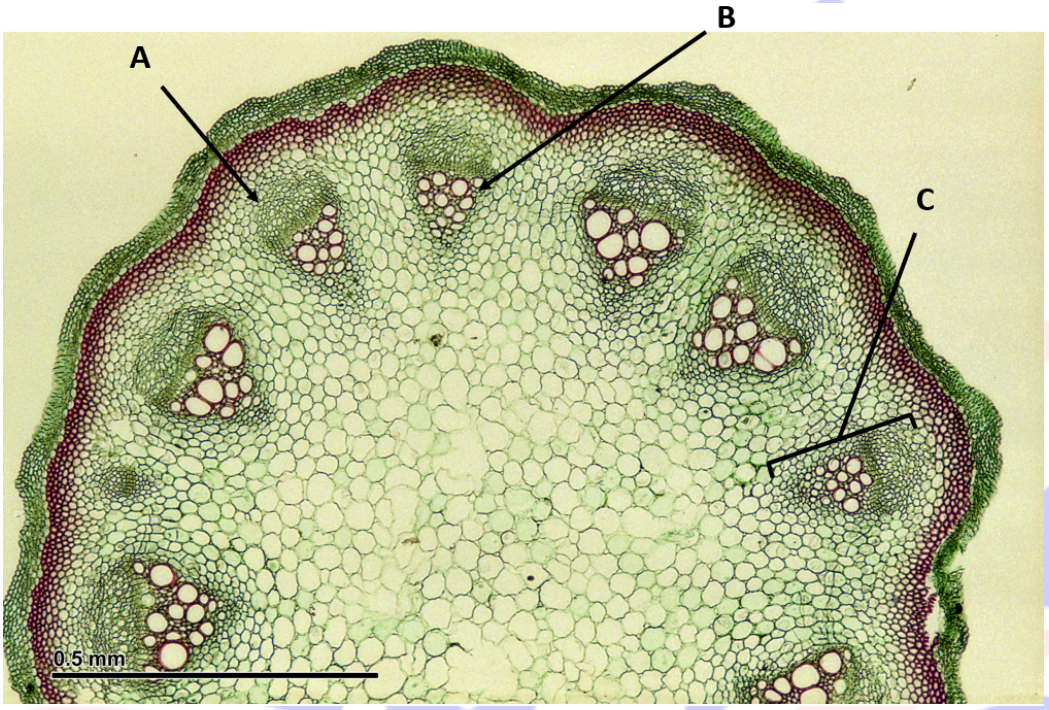
e) Megalopae are more likely to eat moulting megalopae.

TRUE FALSE

Question 13

Part 1 of 6

The diagram shows the anatomy of a plant stem.



Cross-section of a dicot stem (edited from Josef Reischig/Wikimedia Commons CC BY SA 3.0)

Part 2 of 6

Match the label to the tissue.

3 marks

Groups

A

B

C

Not labelled on the picture

Put into the groups above

a) Vascular bundle (the plant 'circulatory system')

b) Xylem (transports from roots)

c) Phloem (actively transports fluids from the leaves)

d) Pith ('filler' cells)

e) Cambium (actively dividing cells)

Part 3 of 6

Are the following statements either true or false?

3 marks

Mark the following as TRUE or FALSE

a) The xylem transports sugar to the leaves.

TRUE FALSE

b) The epidermis surrounds the plant's transport system.

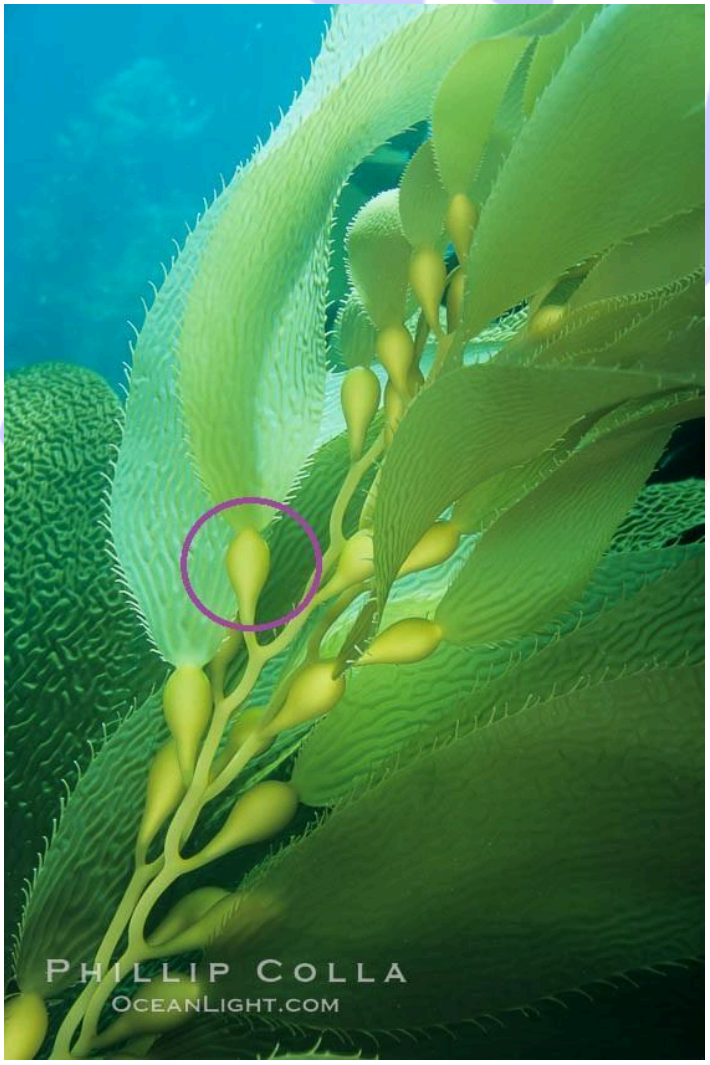
TRUE FALSE

c) The cambium allows roots and stems to increase in radius .

TRUE FALSE

Part 4 of 6

The image shows a seaweed (multicellular algae)



Underwater algae (Copyright © Phillip Colla / Oceanlight.com)

Part 5 of 6

What is the purpose of the structure circled on the picture above?

1 mark
Choose ONE
a) It is the excretory organ of the algae.

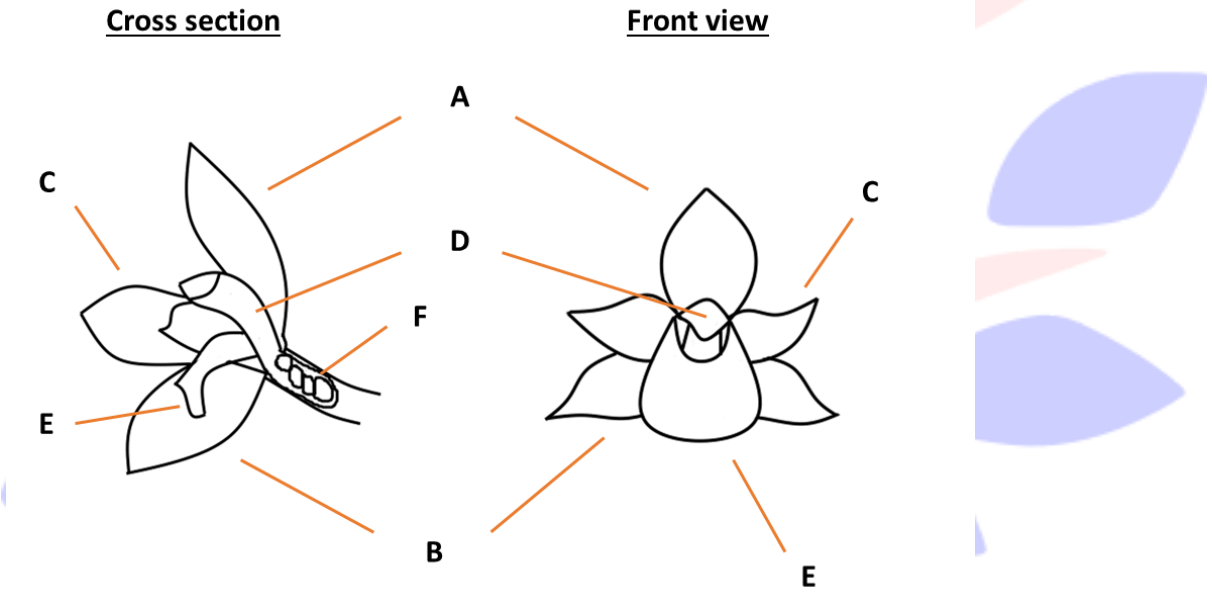
b) It helps the alga float.

c) It contains nitrogen fixing bacteria.

d) It is the alga's flower.

Part 6 of 6

The diagram shows a schematic of an orchid flower.Parts marked with the same letter are the same structures shown from different angles.



Orchid flower drawn by Kim Ngan Luu Hoang
5 marks
Mark the following as TRUE or FALSE
a) Structure A is a sepal which encloses the flower when it is a developing bud.

TRUE FALSE
b) Pollinators land on structure B, called the lip.

TRUE FALSE
c) Structure C is a petal which attracts pollinators.

TRUE FALSE
d) Structure E is the endosperm.

TRUE FALSE
e) Structure F contains the male reproductive cells.

TRUE FALSE