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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.*

British Biology Olympiad 2024

This was split into 2 papers of 45 minutes each.

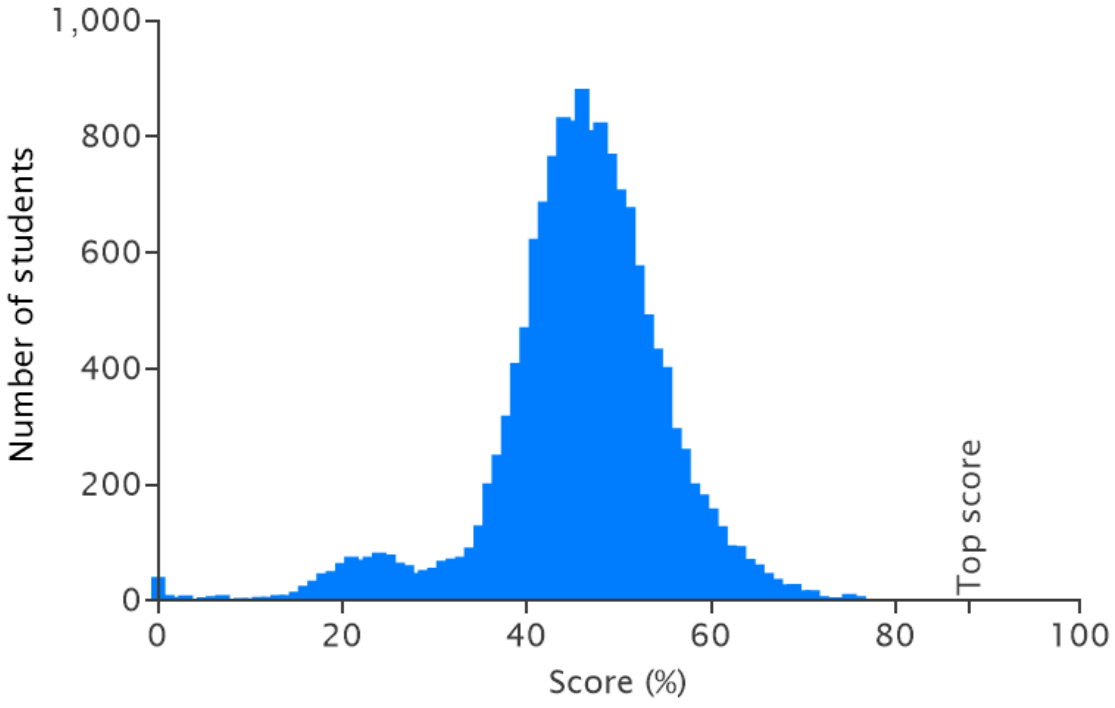
You may use a calculator.

It is recommended that you have 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	58.96%	5%
Silver	53.80%	10%
Bronze	50.03%	15%
Highly Commended	47.23%	15%
Commended	44.84%	15%



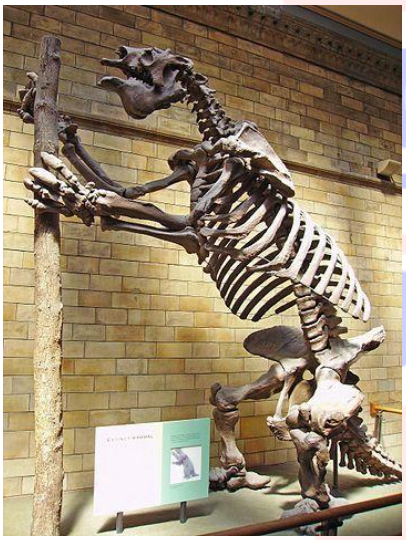
British Biology Olympiad 2024 Paper 1

Duration: 45 minutes
Total marks: 94

Question 1

Part 1 of 3

Extinctions caused by humans can disrupt the evolutionary trajectory of organisms which survive.For example, avocados will go extinct without farmers because the giant sloths that once ate them are gone.



Giant Ground Sloth, Natural History Museum (London) By Thilo Parg - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=41805108

Part 2 of 3

The fastest herbivore on earth is the American pronghorn (top speed ~60 mph). Whereas, the fastest predator living in America is the wolf (top speed ~40 mph).Why is the pronghorn so fast?



By Alan D. Wilson, CC BY-SA 3.0,
https://commons.wikimedia.org/w/index.php?curid=996377

2 marks

Choose ONE

a) 'Running for your life versus dinner' principle: herbivores are always much faster than their predators.

b) Evolutionary arms race with recently extinct predators, such as the American cheetah.

c) Pleiotropy: genes which happen to make the pronghorn fast have other, beneficial, functions.

d) Adaptation: extreme speed is useful for other things than running away, such as finding food quickly.

e) Training: young pronghorns become fast due to play and copying adults.

Part 3 of 3

Madagascan lemurs are terrified of objects and shadows mimicking birds-of-prey. They have specific alarm calls for birds, despite being far too big for living birds to attack. There are bones of Giant Eagles on Madagascar, but these went extinct 3,600 years ago.What type of behaviour probably describes the lemurs' alarm calls?



Artwork of giant eagle attacking lemur

2 marks

Choose ONE

a) Conditioning - they associate distress calls with seeing the birds.

b) Mimicry - they copy the calls of other lemurs when seeing the birds.

c) Learning and culture - young learn to make the calls from adults.

d) Instinct - the distress calls in response to birds are genetically controlled.

e) Insight / logic - the lemurs realise that a large shadow / bird could be a threat without experiencing it directly.

Question 2

Part 1 of 5

Holly trees growing in enclosures without herbivores often grow smooth leaves.Holly trees exposed to herbivores often grow spikey leaves.



Holly leaves

Part 2 of 5

What explains this phenomenon?

2 marks

Choose ONE

a) Learning (to protect themselves from deer).

b) Evolution by natural selection (trees exposed to herbivores evolve spikes).

c) Evolution by genetic drift.

d) Phenotypic plasticity in response to environmental signals.

e) Disease caused by exposure to herbivores.

Part 3 of 5

Insect numbers in Europe have dropped by ~75% since 1990.Scientists measured pansies growing near Paris over the last 30 years. Compared to historical pansies, living pansies have the same overall weight and produce a similar number of seeds, but have 10% smaller flowers and produce 20% less nectar.Pansies live only one season, and can self-pollinate.



Pansy flower

Part 4 of 5

What explains changing pansies?

2 marks

Choose ONE

a) Learning (to be less reliant on insects).

b) Evolution by natural selection (to be less reliant on insects).

c) Evolution by genetic drift (to be less reliant on insects).

d) Phenotypic plasticity in response to environmental signals.

e) Disease / ill health (caused by the changing environment).

Part 5 of 5

What do you expect to happen to flowers growing alongside pansies which cannot self-pollinate?

3 marks

Choose ONE

a) Constant flower size, but increased numbers of seeds.

b) Constant flower size, but decreased numbers of seeds.

c) Increased flower size, and increased numbers of seeds.

d) Increased flower size, but decreased numbers of seeds.

e) Decreased flower size, but constant numbers of seeds.

Question 3

Part 1 of 6

Cataglyphis fortis is a species of ant found in the Tunisian desert. Scientists investigated how ants navigate. They took ants which were on their way back to their nests and either removed the ends of their legs (left), attached stilts (middle) or left them as they were (right), before returning them to the same spot.*C. fortis* with:* stilts overshot the nest.* stumps undershot the nest.* normal legs successfully found their nest.



Desert Ants (Cataglyphis fortis)

Part 2 of 6

True or false?

2 marks

Mark the following as TRUE or FALSE

a) *C. fortis* keep track of how far they've travelled from the nest.

TRUE FALSE

b) *C. fortis* measures distance by the number of footsteps it takes.

TRUE FALSE

c) *C. fortis* navigate using markers in the sand.

TRUE FALSE

Part 3 of 6

If the ants were using the sun / moon to help navigate...

2 marks

Mark the following as TRUE or FALSE

a) ... ants would become confused if they are spun around many times.

TRUE FALSE

b) ... putting the ants back down an equal distance away on the opposite side of the nest would **not** affect how easily they found the nest.

TRUE FALSE

Part 4 of 6

If the ants were using chemotaxis to help navigate...

2 marks
Mark the following as TRUE or FALSE
a) ... stilts / stumps probably would **not** affect how easily they found the nest.

TRUE FALSE
b) ... ants would become confused if they are spun around many times.

TRUE FALSE
c) ... putting the ants back down an equal distance away on the opposite side of the nest would **not** affect how easily they found the nest.

TRUE FALSE

Part 5 of 6

Compared to the desert, forests have more permeant features, less wind and less risk of over-heating.If the scientists repeat their experiment with leafcutter ants...



Leafcutter ants, by pluckytree, Flickr, CC BY-NC-ND 2.0 DEED

2 marks
Choose as many as appropriate
a) Leafcutter ants with stilts would overshoot their nests.

b) Leafcutter ants are more likely than *C. fortis* to find their way home in the pitch black.

c) Leafcutter ants are more likely than *C. fortis* to follow 'roads' around their territory.

Part 6 of 6

Some species of ant often move between lines of unmoving soldier ants.What are the plausible reasons for this?



3 marks

Choose as many as appropriate

a) Ants lack navigational skill to find their way if they stray away from the soldiers.

b) The soldiers stop the worker ants from escaping and setting up a new colony.

c) The soldiers ensure boundaries with other territories are respected.

d) The soldiers stop the workers straying into danger.

e) The soldiers protect the workers from attack.

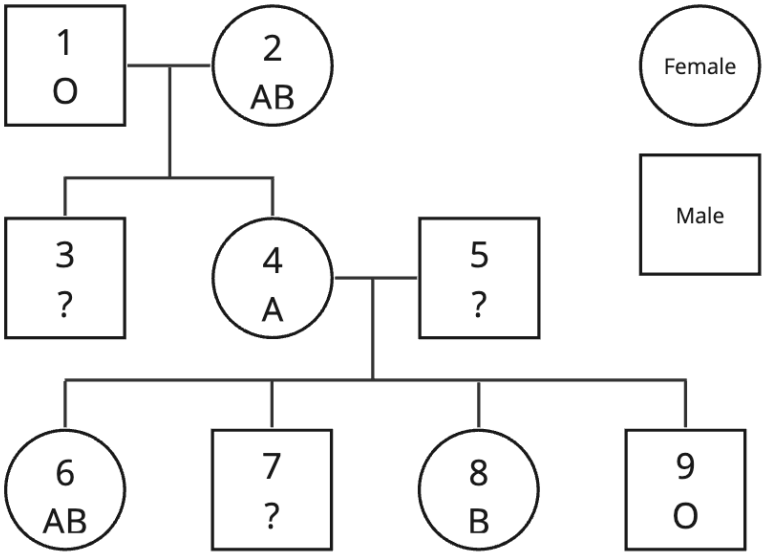
f) Foraging is more efficient if workers can travel in 'lanes' along known 'roads'.

g) Compared to forest ants, desert ants are more likely to use 'roads' guarded by soldiers.

Question 4

Part 1 of 5

Below is a family tree showing the blood types of each family member.



The ABO blood groups of a family

Part 2 of 5

What blood type(s) could person 3 have?

2 marks

Choose as many as appropriate

a) AB

b) A

c) B

d) O

Part 3 of 5

What blood type(s) could person 5 have?

2 marks

Choose as many as appropriate

a) AB

b) A

c) B

d) O

Part 4 of 5

What blood type(s) could person 7 have?

2 marks
Choose as many as appropriate
a) AB

b) A

c) B

d) O

Part 5 of 5

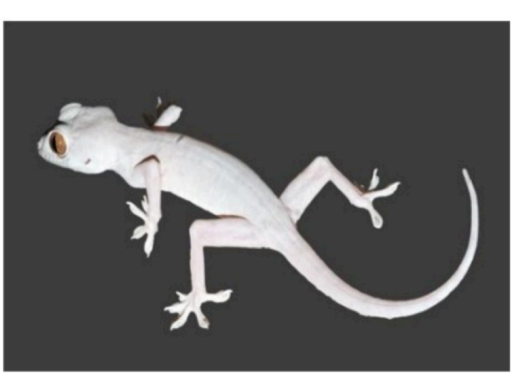
If people with the same genotype as 8 and 9 have a child together, what is the chance the child has blood type O?*Give a number as a percentage or frequency(decimal)*

3 marks
Write something below
_____

Question 5

Part 1 of 3

Lizards occupy a wide variety of habitats and are therefore very diverse in appearance.



1



2



3



4

Part 2 of 3

Part 3 of 3

Sort the lizards into the most likely groups.

4 marks

Groups

Lives in limestone caves

Ground dwelling predator ofmammals / birds

Lives in a hot desert

Tree climbingpredators

Nocturnal

Burrowing

Put into the groups above

a) 6

b) 7

c) 3

d) 8

e) 4

f) 1

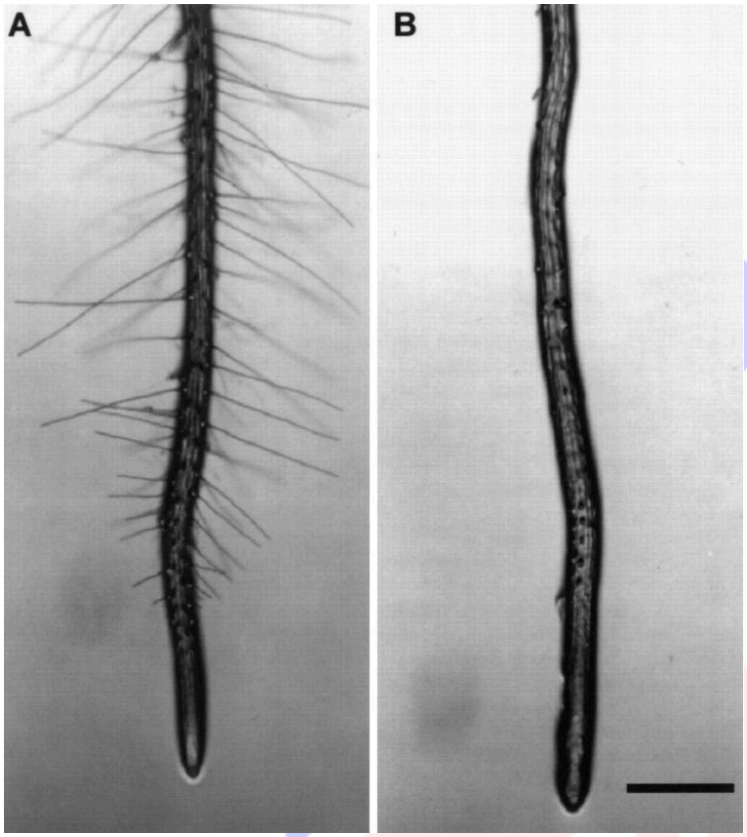
g) 2

h) 5

Question 6

Part 1 of 2

The image shows plant roots.



Scale bar, 100 µm, Bruno Favery et al. 2001

Part 2 of 2

True or false?

2 marks

Mark the following as TRUE or FALSE

a) More water is taken up at the tip of the root than the middle

TRUE FALSE

b) Water uptake in the root is an active process

TRUE FALSE

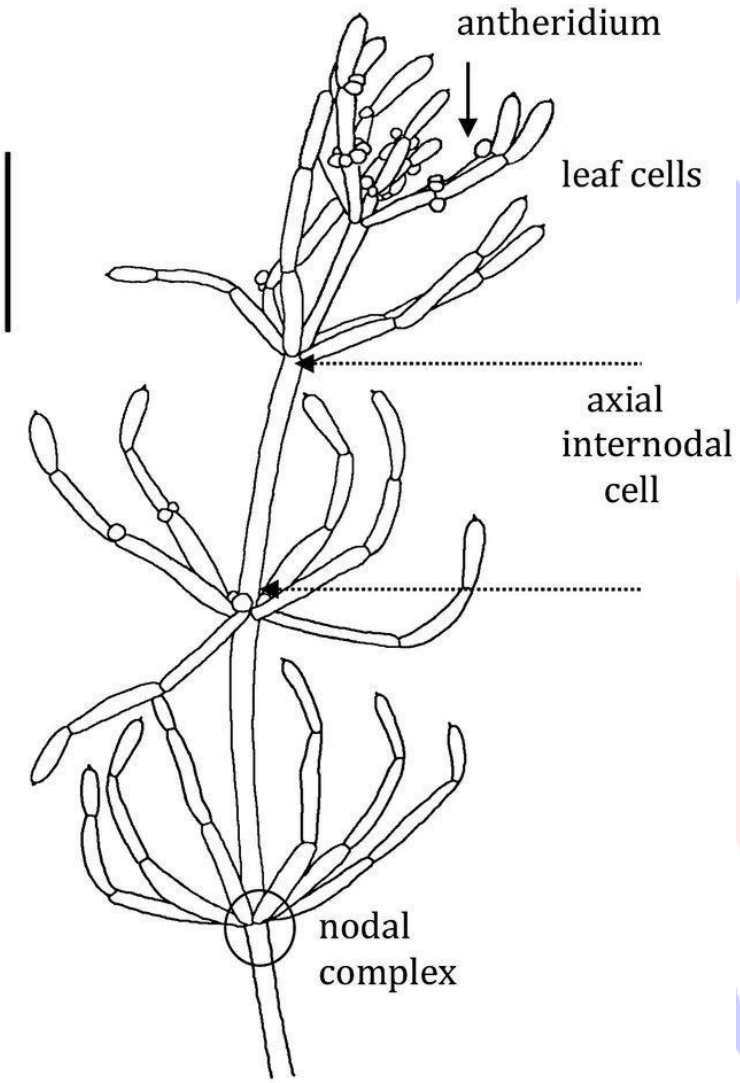
c) Plant B is better adapted to live in a desert

TRUE FALSE

Question 7

Part 1 of 3

Cytoplasmic streaming was discovered 1774. Below is a video of an internodal cell of *Chara corallina* under a light microscope, playing at 1x speed.



A schematic of Chara corallina; Beilby 2015 CC BY 4.0

Part 2 of 3

Part 3 of 3

True or false?

4 marks

Mark the following as TRUE or FALSE

a) *C. corallina* relies on passive diffusion to move nutrients around the plant

TRUE FALSE

b) Like most plants, *C. corallina* has a single vacuole.

TRUE FALSE

c) This video shows *C. corallina* must have two separate streams of cytoplasm, rather than one circular flow.

TRUE FALSE

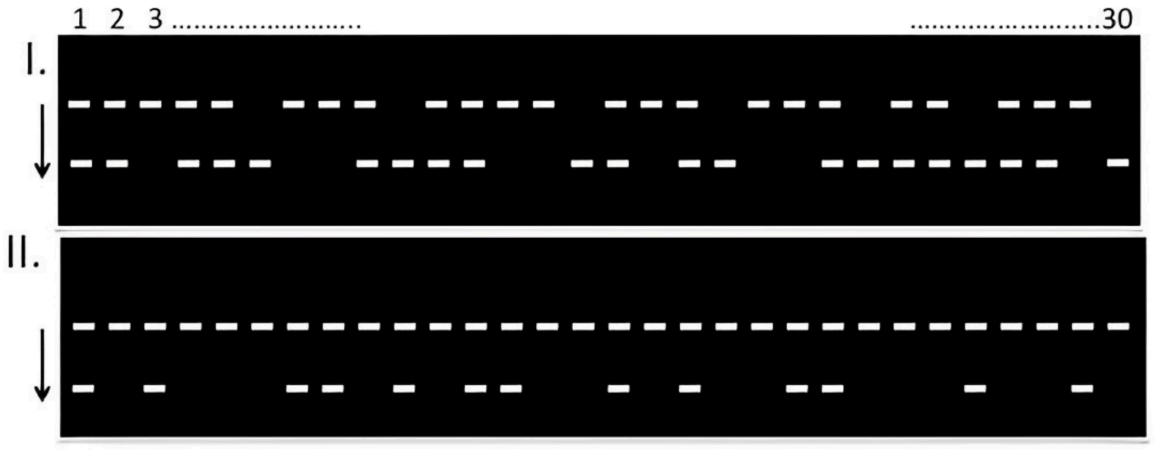
d) *C. corallina* cytoplasmic streaming is the same speed at 12˚C as 1˚C.

TRUE FALSE

Question 8

Part 1 of 4

Gregor Mendel described the inheritance of round and wrinkled peas. He showed the round (R) phenotype was dominant over wrinkled (r).The wrinkled phenotype is caused by an insertion of a transposable element into the gene SBE1.A geneticist made two independent crosses (I and II) between peas with different genotypes. 30 progeny from each cross were analysed by PCR. They used a pair of primers targeting flanking sides of SBE1. The PCR products were resolved by agarose gel electrophoresis. Each lane shows the results of one progeny.



The downward arrow denotes the direction of migration.

A PCR gel

Part 2 of 4

Which allele produces a longer PCR product?

1 mark
Choose ONE
a) R

b) r

Part 3 of 4

What were the genotypes of the parents in cross I?

2 marks
Choose ONE
a) RR x RR

b) RR x Rr

c) RR x rr

d) Rr x Rr

e) Rr x rr

f) rr x rr

Part 4 of 4

What were the genotypes of the parents in cross II?

1 mark

Choose ONE

a) RR x RR

b) RR xRr

c) RR x rr

d) Rr x Rr

e) Rr x rr

f) rr x rr

Question 9

Part 1 of 6

Only female mosquitoes suck blood.Male mosquitoes instead drink the nectar of mosquito-pollinated flowers.Mosquitoes are believed to have first evolved in the Jurassic period (201 - 145 million years ago). Flowering plants first became widespread in the Cretaceous (100 million years ago).



The oldest fossil

Part 2 of 6

Part 3 of 6

Which statements could explain the evolution of blood-sucking in mosquitoes?

2 marks

Choose as many as appropriate

a) Both sexes of the first mosquitoes only sucked blood.

b) Both sexes of the first mosquitoes only drank nectar.

c) Both sexes of the first mosquitoes fed on fluids from parts of plants other than flowers.

d) Different sexes of mosquitoes have always had different feeding habits.

Part 4 of 6

In 2023, Scientists discovered two fossilised mosquitoes trapped in amber for 130 million years. They were both males of the same species. They both had mouthparts adapted for sucking blood.

Part 5 of 6

Which statements *could* explain the evolution of blood-sucking in mosquitoes?

2 marks
Choose as many as appropriate
a) Both sexes of the first mosquitoes only sucked blood. Males switched to drinking nectar when flowering plants became widespread.

b) Both sexes of the first mosquitoes only fed on fluids from parts of plants other than flowers. Females then adapted to sucking blood as males adapted to drinking nectar when flowering plants became widespread.

c) Modern mosquitoes are *not* descended from the same species as the fossil. Most species of mosquitoes have always had sexes with different feeding habits, but males switched to sucking blood in a few species.

Part 6 of 6

Based on the available evidence, which is the *most likely* explanation of the evolution of mosquitoes?

2 marks
Choose ONE
a) Both sexes of the first mosquitoes only sucked blood. Males switched to drinking nectar when flowering plants became widespread.

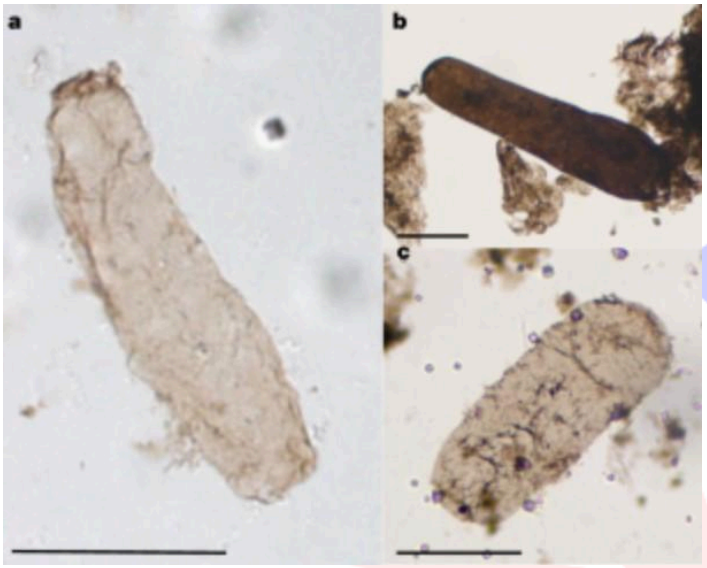
b) Both sexes of the first mosquitoes only fed on fluids from parts of plants other than flowers. Females then adapted to sucking blood as males adapted to drinking nectar when flowering plants became widespread.

c) Modern mosquitoes are *not* descended from the same species as the fossil. Most species of mosquitoes have always had sexes with different feeding habits, but males switched to sucking blood in a few species.

Question 10

Part 1 of 3

In 2024, scientists reported finding fossilised microorganisms which contained folded internal membranes which looked like thylakoids. At 1.75 billion years old, these are the oldest fossilised thylakoids.*True or false?*



Demoulin, C.F., Lara, Y.J., Lambion, A. et al. Oldest thylakoids in fossil cells directly evidence oxygenic photosynthesis. Nature 625, 529–534 (2024). https://doi.org/10.1038/s41586-023-06896-7

3 marks

Mark the following as TRUE or FALSE

a) The organism certainly had chloroplasts.

TRUE FALSE

b) The organism certainly had mitochondria.

TRUE FALSE

c) Organisms like this could be responsible for the 'oxygen catastrophe'(the accumulation of free O_2 in the atmosphere).

TRUE FALSE

d) The organism was probably a cyanobacteria.

TRUE FALSE

e) The organism likely absorbed green light.

TRUE FALSE

Part 2 of 3

Why are key photosynthetic reactions carried out within/on membranes?

3 marks

Choose ONE

a) To maximise the surface area for the reaction.

b) To maximise the amount of enzymes and pigments which can fit in the cell.

c) So potential gradients can be established to power other reactions.

d) To minimise the distance light and substrates must travel through the cell.

e) Because the substrates are hydrophobic.

Part 3 of 3

True or false?

3 marks

Mark the following as TRUE or FALSE

a) In plants, glucose moves into the chloroplast, where it enters the citric acid (Krebs) cycle.

TRUE FALSE

b) Plant mitochondria produce ATP that can be used to drive essential cell reactions.

TRUE FALSE

c) Plant chloroplasts carry out biosynthesis reactions and assimilate inorganic molecules.

TRUE FALSE

d) Mitochondria can produce ATP only in the presence of oxygen.

TRUE FALSE

Question 11

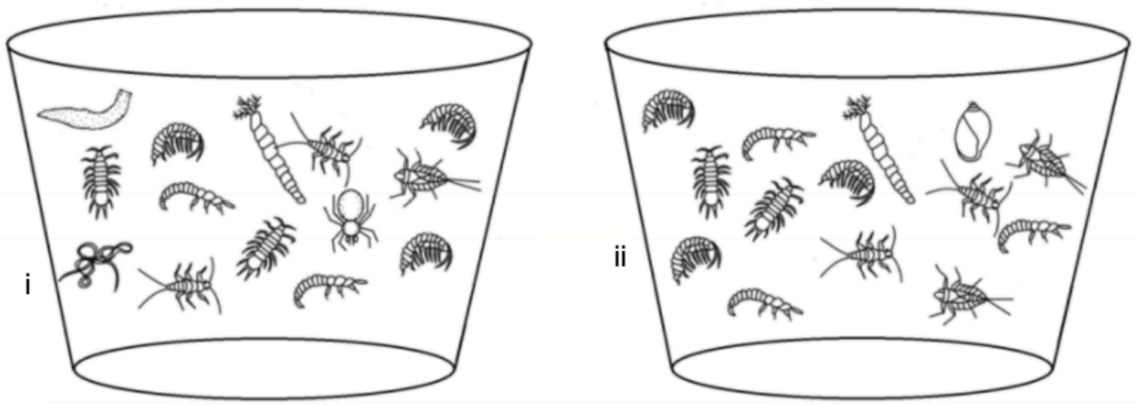
Part 1 of 4

In ecology, the similarity of two communities (A and B) can be measured by calculating the Sorensen-Dice coefficient (DSC).* A and B are the number of species in the two communities.* A∩B is the number of species common to both communities.

$$\text{DSC} = 2\frac{A \cap B}{A + B}$$

Part 2 of 4

In the figure below, you can see two samples of invertebrates, collected from two small rivers, i and ii respectively.



Part 3 of 4

Calculate DSC for i and ii.

5 marks

Write something below

Part 4 of 4

The DSC between rivers i and iii is greater than that between i and ii.Therefore, i and iii are...

1 mark

Choose ONE

a) ... more similar than i and ii.

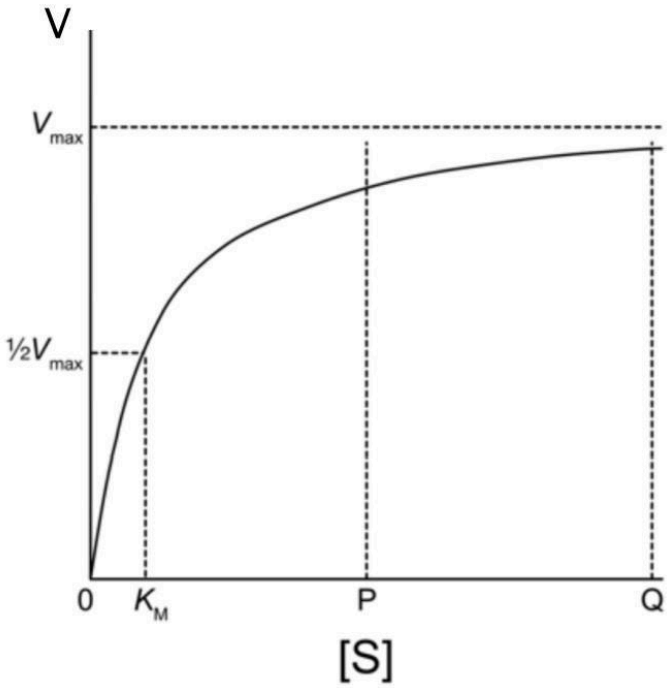
b) ... less similar than i and ii.

Question 12

Part 1 of 2

The Michaelis-Menten equation describes the relationship between substrate concentration ([S]) and enzymatic reaction rate (v).* V *~max* = the maximum rate.* K□ = represents the affinity of enzymes to particular substrates.A reaction catalysed by glucose oxidase is used to measure blood glucose concentration.The blood sample is applied to a strip containing immobilised glucose oxidase. A non-enzyme catalyst oxidises the H_2O_2 and the meter records the flow of electrons (electrical current).

$$v = \frac{V_{max} \times [S]}{K_M + [S]}$$



$$\text{Glucose} + O_2 \xrightarrow[\text{oxidase}]{\text{Glucose}} \text{Gluconolactone} + H_2O_2$$

$$H_2O_2 \xrightarrow{\text{Catalyser}} O_2 + 2H^+ + 2e^-$$

Part 2 of 2

True or false?

5 marks

Mark the following as TRUE or FALSE

a) Among isoenzymes with the same V *~max* value but different K□ values, the enzyme with the lowest K□ value works best at the lowest substrate concentrations.

TRUE FALSE

b) For the meter to accurately measure blood glucose concentration, the glucose oxidase used should have a broad substrate specificity.

TRUE FALSE

c) For the meter to accurately measure blood glucose concentration, the reaction on the strip should be in the P–Q range of the substrate concentration (see the image).

TRUE FALSE

d) The two-step reaction on the test strip is essentially irreversible in real-world conditions.

TRUE FALSE

e) An acidic buffer facilitates oxidation of H_2O_2.

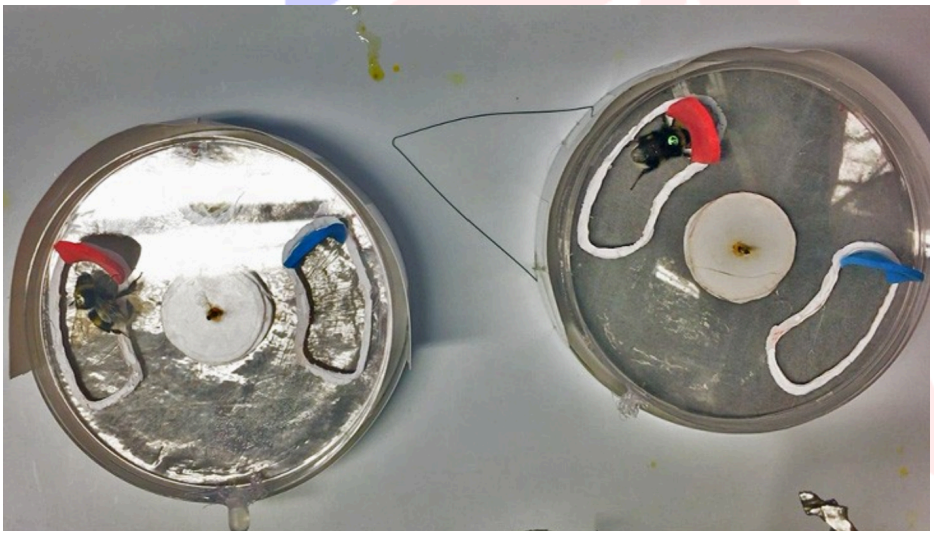
TRUE FALSE

Question 13

Part 1 of 3

Scientists in London created a puzzle box for bees. The bees could pull on either a blue tab, or a red tab, to access a nectar reward.Scientists trained some bees by only giving reward for pulling the blue tab ("*blue-trained*"), and some only for pulling the red tab ("*red-trained*").Scientists then put the trained bees into colonies of fresh bees with puzzle boxes which could be opened with either tab.

Colony	Trained bee	Duration of experiment	Number of puzzles solved	% of pulls on blue
1	Red	6 days	437	3
2	Red	6 days	182	1
3	Red	12 days	980	1
4	Blue	6 days	565	99
5	Blue	6 days	219	99
6	Blue	12 days	1006	98
7	None	6 days	6	50
8	None	6 days	5	40
9	None	12 days	41	12
10	None	12 days	269	6



Bees in puzzle boxes

Part 2 of 3

Bees solve the problem by:

1 mark
Choose ONE
a) Instinct

b) Learning

c) Reflex

d) Random chance

e) Logic

Part 3 of 3

True or False?

4 marks

Mark the following as TRUE or FALSE

a) Bees are able to teach other bees.

TRUE FALSE

b) Bees solve the puzzle more quickly in the presence of trained bees.

TRUE FALSE

c) Without training, bees prefer the red tab to the blue tab.

TRUE FALSE

d) Only some bees are good 'teachers'.

TRUE FALSE

e) All members of a hive tend to use the same solution even if they are aware of alternatives.

TRUE FALSE

Question 14

Part 1 of 5

Carnivorous sea snails feed on a bivalve-shelled mollusc.

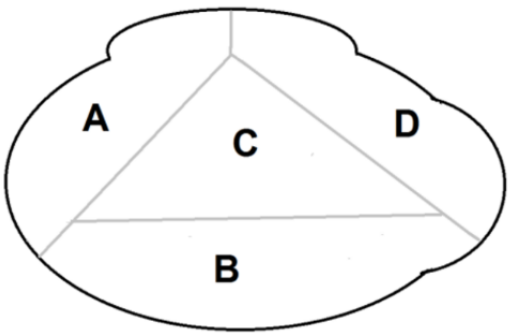


Closed and opened bivalve shells

Part 2 of 5

The sea snails drill through bivalve shells to inject poison, which relaxes the bivalve muscle that holds their shell shut.Scientists divided the surface of prey shells into four areas with equal size:A – anterior area.B – basal area.C – central area.D – distal area.100 dead prey shells were analysed. The number of holes drilled by hunting snails in different areas, and their combinations, are shown in the Table.

Drilling position	A	B	C	D	A & B	A & C	A & D	B & C	B & D	C & D	A, B & D	A, C & D	0 holes
Number of shells with these holes	23	5	6	25	4	4	16	1	3	5	1	1	6



Part 3 of 5

True or false?

4 marks

Mark the following as TRUE or FALSE

a) Hunting snails prefer to drill the anterior end of prey and avoid the distal end of shells.

TRUE FALSE

b) Prey probably have two muscles, the first in area A and the second in area D.

TRUE FALSE

c) Hunting snails are probably the major cause of death for these prey.

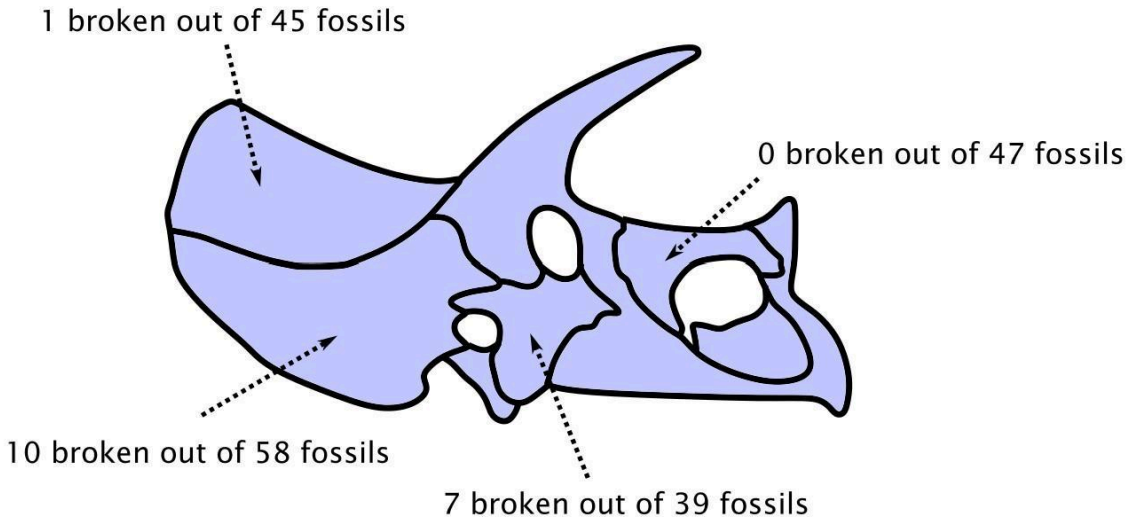
TRUE FALSE

d) The majority of attacks are likely to be fatal.

TRUE FALSE

Part 4 of 5

Some fossilised skulls of triceratops (a type of dinosaur) show injuries sustained while the animal was *alive*.Injuries in the highlighted bones were assessed.



Part 5 of 5

True or false?

3 marks

Mark the following as TRUE or FALSE

a) Nasal bones are the most abundant fossils.

TRUE FALSE

b) The large bone forming the bottom of the collar had the highest frequency of breaks.

TRUE FALSE

c) The distribution of injuries is better explained by combats between triceratops males, rather than *Tyrannosaurus rex* attacks. (*T. rex* was tall).

TRUE FALSE

d) The pattern is explained by larger bones being more likely to get damaged.

TRUE FALSE

Question 15

Part 1 of 12

Drosophila melanogaster (fruit fly) is a common laboratory model animal.Wild *D. melanogaster* and *D. simulans* have broad ranges but do not live on the Seychelles archipelago. *D. sechellia* lives only on the Seychelles. The plant *Morinda citrifolia* also lives only on the Seychelles. This question examines how *Drosophila* choose where to lay eggs. 50 flies of each species were placed in a petri dish with 4 different fruits and the eggs laid on each fruit were counted.



Evolution of Drosophila and Oviposition Choice Assay, Raquel Álvarez-Ocaña et al (2023), CC BY 4.0 DEED

Part 2 of 12

Part 3 of 12

True or false?

2 marks

Mark the following as TRUE or FALSE

a) *Drosophila melanogaster* will lay eggs on any of the four fruits.

TRUE FALSE

b) *Drosophila melanogaster* and *Drosophila sechellia* lay similar numbers of eggs.

TRUE FALSE

c) The results could be explained if *Morinda citrifolia* has a tasteless, smelless poison of unadapted *Drosophila*.

TRUE FALSE

Part 4 of 12

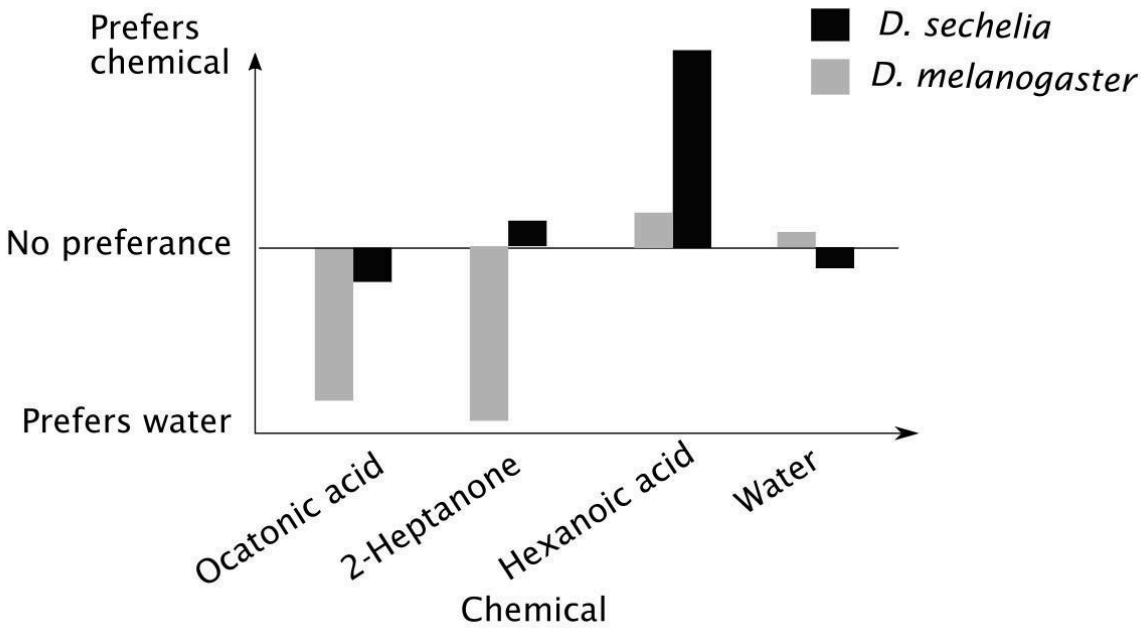
Similar results were recorded when:* The choice assay was carried out in the dark.* The fruits were painted different colours.*True or false?*

1 mark
Mark the following as TRUE or FALSE
a) Vision plays an essential role in correct fruit choice.

TRUE FALSE
b) Vision plays the primary role in correct fruit choice when it is available.

TRUE FALSE

Part 5 of 12
Two wells in a petri dish contained either water (left hand well) or a chemical abundant in *Morinda citrifolia* fruit (right hand well). The proportion of flies choosing either the water or the chemical was recorded.



Part 6 of 12
True or false?

1 mark
Mark the following as TRUE or FALSE
a) If the chemicals are neither attractive nor repulsive, the fruit flies tend to favour the left-hand well.

TRUE FALSE
b) It is more important to carry out the experiment with many different flies of each species than repeatedly with the same flies.

TRUE FALSE
c) It is important only fertilised females were used for the study.

TRUE FALSE

Part 7 of 12
How does *D. sechellia* respond to each chemical?

1 mark
Groups
Encourages egg laying

Minimal effect onegg laying

Suppresses egglaying

Put into the groups above
a) 2-Heptanone

b) Octanoic Acid

c) Hexanoic Acid

Part 8 of 12
How does *D. melanogaster* respond to each chemical?

1 mark
Groups
Encourages egg laying

Minimal effect onegg laying

Suppressesegg laying

Put into the groups above
a) Octanoic Acid

b) Hexanoic Acid

c) 2-Heptanone

Part 9 of 12
Which chemical (chemical X) is most important for *D. sechellia* to sense *Morinda citrifolia* fruit?

1 mark
Choose ONE
a) Octanoic Acid

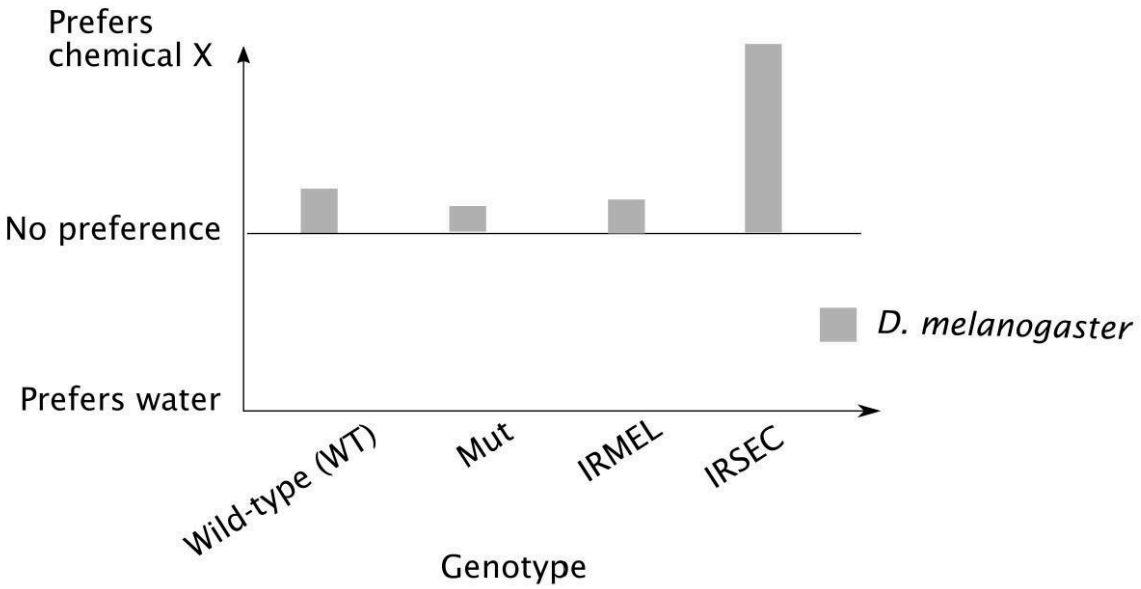
b) 2-Heptanone

c) Hexanoic Acid

d) None

Part 10 of 12
Chemical X is sensed by a receptor called Ionotropic receptor 75b (Ir75b). Scientists made mutant *D. melanogaster* flies which did not express Ir75b.

These flies then had the *D. melanogaster* Ir75b or *D. sechellia* Ir75b reintroduced. Assays were carried out to assess their preference for chemical X or water.Key:* WT - *D. melanogaster** mut - *D. melanogaster* with no Ir75b* IRMEL - *D. melanogaster* with reintroduced *D. melanogaster* Ir75b* IRSEC - *D. melanogaster* with reintroduced *D. sechellia* Ir75b



Part 11 of 12

True or false?

2 marks

Mark the following as TRUE or FALSE

a) *D. melanogaster* Ir75b causes flies to avoid *Morinda citrifolia* fruit.

TRUE FALSE

b) *D. sechellia* Ir75b is sufficient to determine fruit choice in the absence of other cues.

TRUE FALSE

Part 12 of 12

Which is the most likely hypothesis?

2 marks

Choose ONE

a) IRSEC flies will choose to lay eggs on *Morinda citrifolia* fruit over grapes.

b) IRSEC flies will **not** choose to lay eggs on *Morinda citrifolia* fruit.

c) IRSEC flies will be conflicted on whether to lay eggs on *Morinda citrifolia* fruit.

d) Mut flies will choose to lay eggs on *Morinda citrifolia* fruit over grapes.

British Biology Olympiad 2023 Paper 2

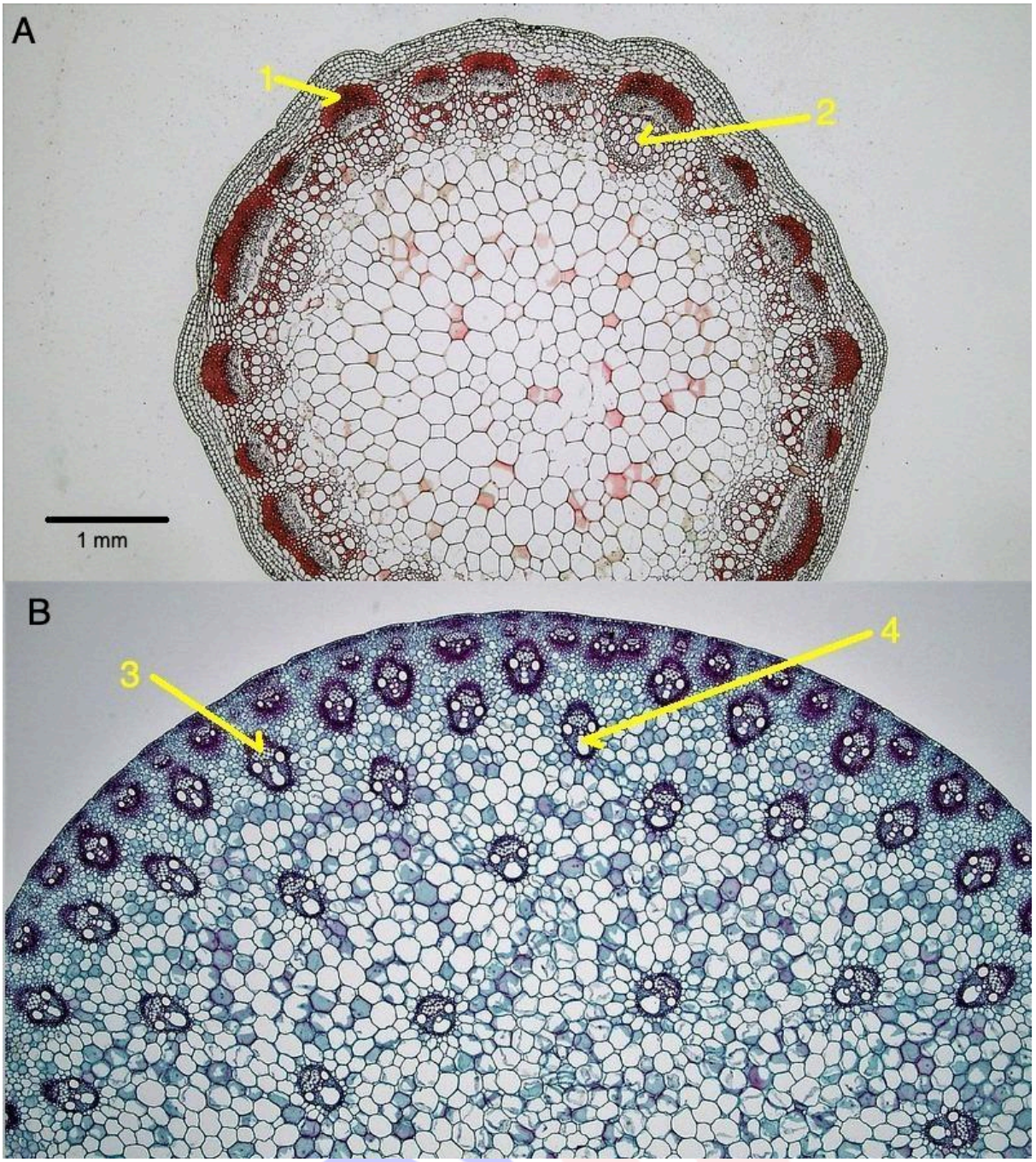
Duration: 45 minutes

Total marks: 98

Question 1

Part 1 of 5

The xylem and phloem move resources between the roots and shoots of plants.Micrographs A and B were originally taken at 40x magnification, then digitally manipulated to the size shown on your screen.



Micrographs of sections

Part 2 of 5

To the nearest mm, how wide is the sample in A?*(It does not matter whether or not you type the unit, mm)*

3 marks

Write something below

Part 3 of 5

The micrograph could have been taken at 100x magnification and then digitally manipulated to be the same size as shown.How would this micrograph differ from the micrograph shown in the question?

2 marks
Mark the following as TRUE or FALSE
a) The scale bar would be smaller.

TRUE FALSE
b) The image would be at higher resolution.

TRUE FALSE
c) It would have been harder to fit the whole sample into the field of view.

TRUE FALSE
d) To take this micrograph, the scientist would need a different type of microscope and dye.

TRUE FALSE

Part 4 of 5
Which label(s) are of phloem or xylem?

2 marks
Groups
Phloem

Xylem

Put into the groups above
a) 3

b) 4

c) 2

d) 1

Part 5 of 5
Which substances are transported in the phloem, xylem or neither?

3 marks
Groups
Phloem

Xylem

Neither

Put into the groups above
a) Starch

b) Water

c) Glucose

d) Sucrose

e) Amino Acids

f) Potassium

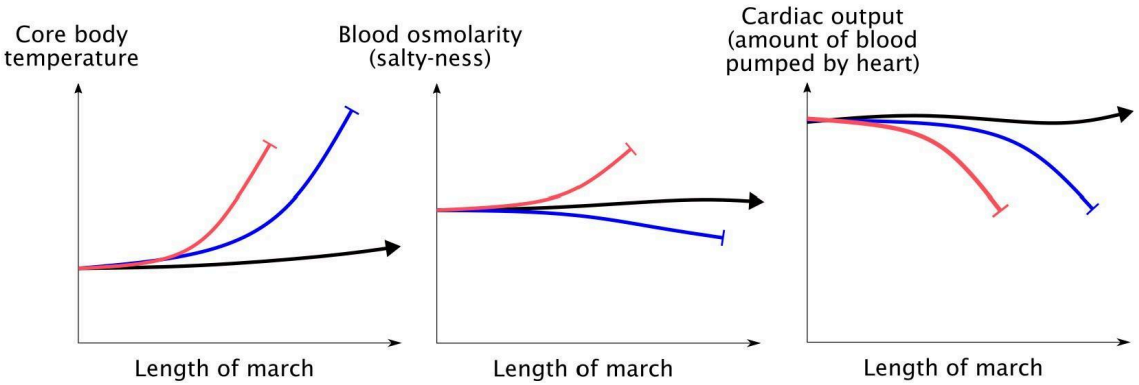
Question 2

Part 1 of 5

In an experiment, soldiers were ordered to march through a hot desert until exhaustion.· One group (red) had no food or water.· The second (blue) group had access to limitless water.· The third group (black) had access to both limitless water and limitless savoury (salty, low energy) food.

Part 2 of 5

Cardiac output is always proportional to the pressure of blood in the great veins. This is because the heart cannot suck blood through vessels (they collapse); it can only pressurise the blood which the great veins deliver to it. In turn, the pressure of blood in the great veins depends on the volume of blood in the body.Camels are adapted to withstand larger swings in osmolarity and core temperature than other mammals.Camels and humans both have the very rare ability to sweat. Sweat is mostly water, with a small amount of salt. (Note: camel humps do not provide water either directly or indirectly).



Part 3 of 5

True or false?

4 marks

Mark the following as TRUE or FALSE

a) The change in blood osmolarity in the blue group is adaptive and helps them to last longer.

TRUE FALSE

b) The blue group drinks more water than the black group.

TRUE FALSE

c) Circulatory failure is the proximate ('final straw') cause of exhaustion in these conditions.

TRUE FALSE

d) Of the three groups, camels would follow a trajectory most similar to the blue group (but extended). *Assume the camels do **not** eat or drink.*

TRUE FALSE

e) A group given unlimited dry food, but not water, would last longer than the red group.

TRUE FALSE

Part 4 of 5

Antidiuretic hormone (ADH, also known as vasopressin) is usually released from the pituitary gland in proportion to blood osmolarity (higher blood osmolarity leads to more ADH release).* ADH acts in the kidney to increase water reabsorption.

Part 5 of 5

Some patients have tumours which secrete ADH (syndromes of inappropriate ADH secretion).

2 marks

Mark the following as TRUE or FALSE

a) These patients have more concentrated urine than normal.

TRUE FALSE

b) These patients have higher blood osmolarity than normal.

TRUE FALSE

c) The patients should be given restricted access to fluids.

TRUE FALSE

Question 3

Part 1 of 7

Some shrubby trees have very extensive surface and deep roots. Most grasses have fewer roots, but can grow very fast from their base which is protected from grazers.In a mixed grassland / shrubland, which habitat type is favoured by each of the climate changes?



Arizona

3 marks

Groups

Grasses dominating over shrubs

Shrubs invading grassland

Desert with few plants

Put into the groups above

a) Reduced rainfall

b) Reduced rainfall withcattle ranching

c) Increased rainfall

Part 2 of 7

What type of process drives the habitat transitions from grassland to shrubby forest and back?

2 marks

Choose ONE

a) Disease

b) Competitive exclusion

c) Maladaptation

d) Hybridisation

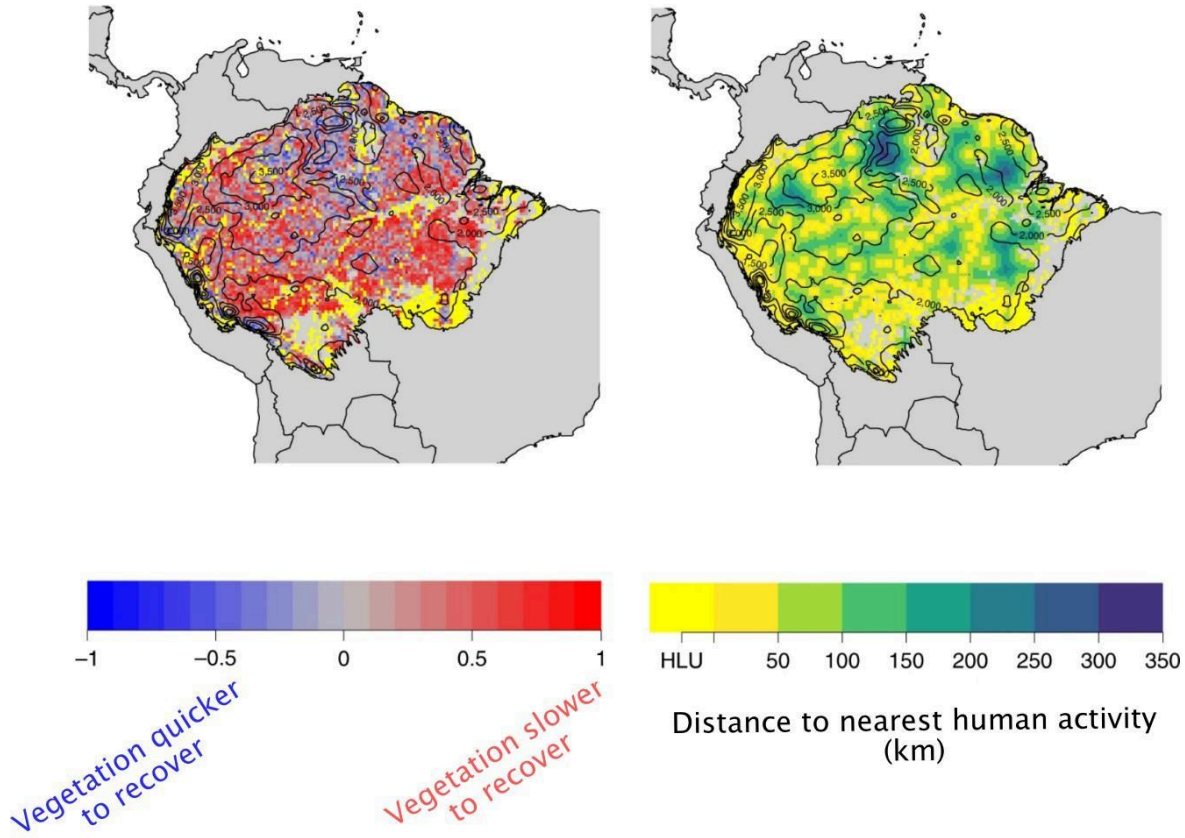
e) Migration

Part 3 of 7

Diverse biomes are complex systems which return to their equilibrium position after disruptions. However, if conditions are pushed too far for too long, they may suddenly switch to a new equilibrium following disruption, and not revert even if conditions improve (ecosystem collapse).The Amazon rainforest may be temporarily self-sustaining, even though global weather patterns may already favour savannah. Scientists searched for evidence of ecosystem instability in the Amazon.

Part 4 of 7

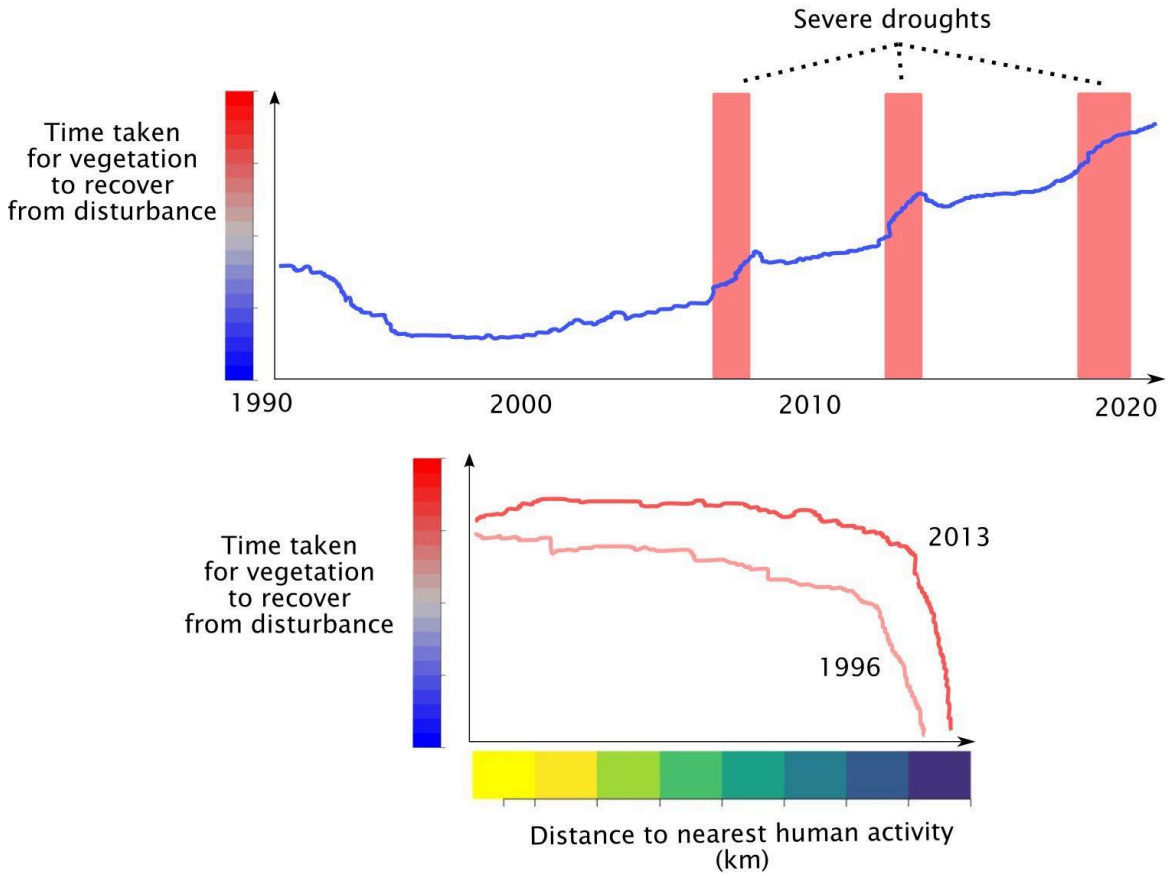
For 100 km² areas, satellites measured: * The amount of vegetation (including all layers of the canopy), * The distance to human activity.For each area, scientists calculated a statistic correlated with the time it takes vegetation to revert to baseline after disturbance.



Boulton, C.A., Lenton, T.M. & Boers, N. Pronounced loss of Amazon rainforest resilience since the early 2000s. Nat. Clim. Chang. 12, 271–278 (2022). https://doi.org/10.1038/s41558-022-01287-8

Part 5 of 7

The data were plotted for the amazon as a whole.



Boulton, C.A., Lenton, T.M. & Boers, N. Pronounced loss of Amazon rainforest resilience since the early 2000s. Nat. Clim. Chang. 12, 271–278 (2022). https://doi.org/10.1038/s41558-022-01287-8

Part 6 of 7

Which areas of the satellite data should be excluded from the analyses to determine whether the Amazon rainforest biome has become unstable?

2 marks

Choose ONE

a) Areas bordering other biomes.

b) Areas containing rivers and lakes.

c) Areas near the centre of the Amazon.

d) Areas containing ongoing human activity (farms, roads, houses, mines etc).

e) Areas in different countries.

Part 7 of 7

True or false?

4 marks

Mark the following as TRUE or FALSE

a) The rainforest is taking longer to revert after disturbance now than in the past.

TRUE FALSE

b) There is a strong correlation between the distance of an area to human activity and how long it takes to revert.

TRUE FALSE

c) These data show extreme droughts may have pushed the Amazon closer to a tipping point.

TRUE FALSE

d) These data show it is already too late to save the Amazon.

TRUE FALSE

e) These data show reforesting deforested areas is likely to improve the resilience of the rest of the Amazon.

TRUE FALSE

f) The statistical variance in amount of vegetation is likely to have increased over time.

TRUE FALSE

g) These data show the Amazon has become more sensitive to human activity over time.

TRUE FALSE

Question 4

Part 1 of 3

Many organisms alter their physiology to suit the environment.Iron is an essential nutrient but bio-available iron is scarce. *Pseudomonas aeruginosa* is a bacteria which can survive in both low- and high-iron environments. It can infect humans, but also live outside. The liver produces an iron chelating protein called transferrin. Transferrin keeps the concentration of free-iron in the blood very low.*P. aeruginosa* can create two siderophores. Siderophores are iron chelators which are released into the environment where they can bind iron, diffuse back towards the bacterium and be reabsorbed.* Pyoverdine has a very low K *~d* (dissociation constant) and is 'expensive' to make.* Pyocheline has a high K *~d* and is 'cheap' to make.



Pseudomonas aeruginosa; source: CDC

Part 2 of 3

True or false?

4 marks

Mark the following as TRUE or FALSE

a) When infecting humans, *P. aeruginosa* will tend to make more of both siderophores.

TRUE FALSE

b) In a high-iron environment, a mutant *P. aeruginosa* without pyoverdine may be slightly fitter than wild-type.

TRUE FALSE

c) Pyoverdine from pathogenic *P. aeruginosa* has a lower K *~d* than transferrin.

TRUE FALSE

d) *P. aeruginosa* receive more benefit from siderophores when they are surrounded by other *P. aeruginosa* bacteria which are also producing siderophores.

TRUE FALSE

e) The production of siderophores is likely to be controlled by both iron availability and quorum sensing.

TRUE FALSE

Part 3 of 3

For the following metabolic processes, decide whether iron is an essential nutrient.

3 marks

Groups

Iron is essential

Iron is **not** essential

Put into the groups above

b) Cellular respiration

c) Oxygen transport in humans.

d) Light capture by chlorophyll.

a) Oxygen transport in horseshoe crabs,some true crabs and crustaceans.

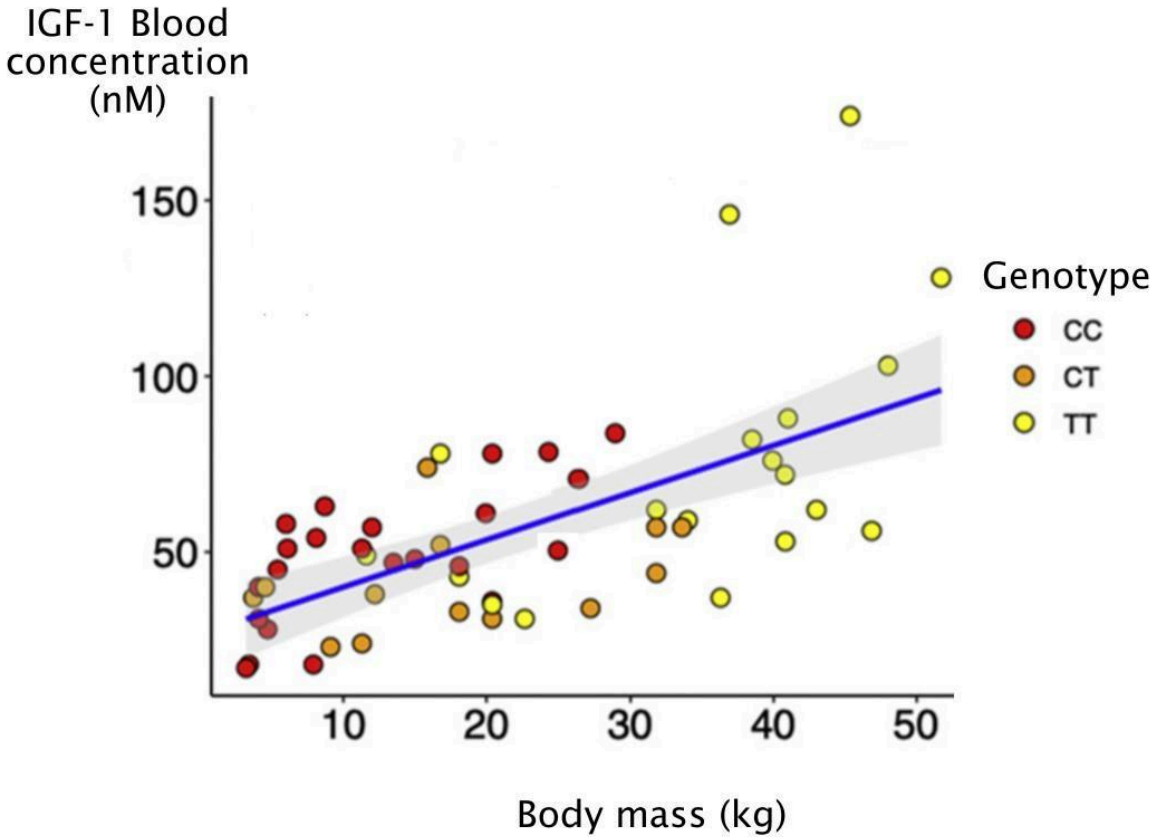


Blood being collected from horseshoe crabs

Question 5

Part 1 of 5

Domestic dogs (*Canis lupus familiaris*) are a subspecies of grey wolves (*Canis lupus*). Dogs are unique for their extremely large range of body sizes.Scientists sequenced a region of DNA around the IGF1 (insulin-like growth factor 1) gene in thousands of dogs. They found a frequent C vs T mutation.The genotype of IGF1 was plotted against dog body mass, and against levels of IGF in serum (blood).



Part 2 of 5

Which of these hypotheses are supported by this data?

3 marks

Choose as many as appropriate

a) The T allele is fully dominant to the C allele, which is fully recessive, in controlling dog size.

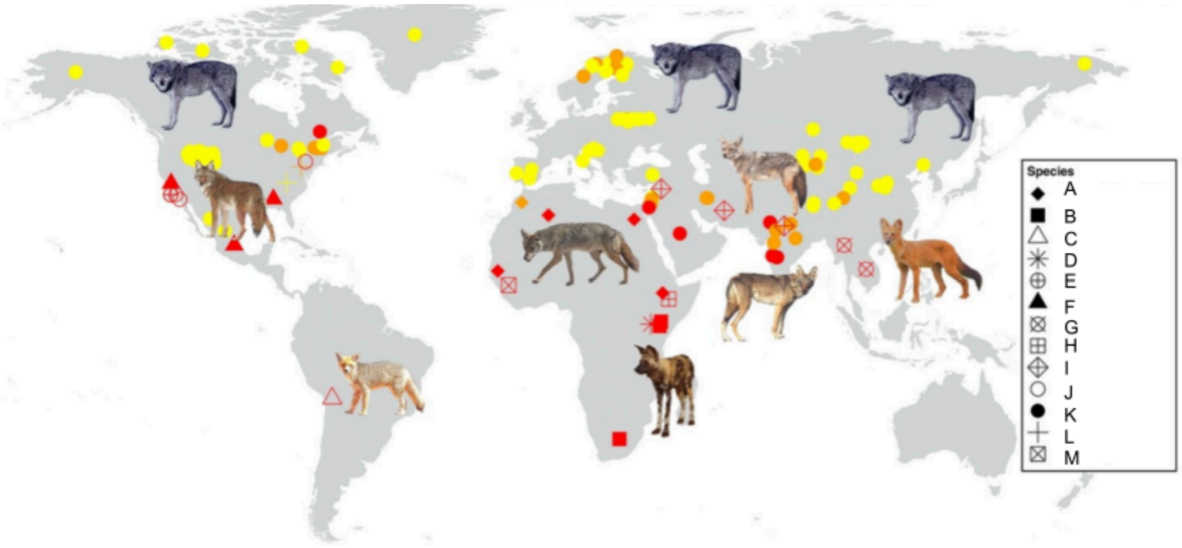
b) IGF1 controls the majority of size variation of dogs.

c) The C/T SNP must only influence body size through changing levels of IGF1 in serum.

d) IGF1 alleles *cause* some degree of body size change.

Part 3 of 5

Next, scientists sequenced IGF1 in individuals from species across the canid (dog) family.**Key:**A Golden WolfB Hunting DogC Andean FoxD Black JackalE Island FoxF CoyoteG DholeH Ethiopian WolfI Golden JackalJ Grey FoxK **Grey Wolf**L Red WolfM Striped JackalColours give the specimen's genotype according to the previous graph.



Part 4 of 5

Which of these hypotheses is most likely?

2 marks

Choose ONE

a) The most recent common ancestors of domestic dogs were homozygous for the T allele.

b) The most recent common ancestors of domestic dogs were heterozygous for the T/C alleles.

c) The most recent common ancestors of domestic dogs were homozygous for the C allele.

Part 5 of 5

Which of these hypotheses is most likely?

2 marks

Choose ONE

a) The C mutation in domestic dogs appeared recently, and separately to the C allele found in other canid species.

b) The T mutation first appeared in wolves.

c) The T allele is older than the C allele.

Question 6

Part 1 of 4

Overall, >20% of the original neanderthal genome survives as alleles in the modern human gene pool.However, modern humans do **not** contain any Neanderthal alleles in either their y-chromosomes, or their mitochondria.



Reconstruction of Neanderthal with typical features.

Part 2 of 4

Which of these are *possible* explanations for these observations?

4 marks

Choose as many as appropriate

a) The only fertile offspring of *H. sapiens* and *H. neanderthalensis* were daughters of neanderthalensis men and sapiens women.

b) The only fertile offspring of *H. sapiens* and *H. neanderthalensis* were sons of neanderthalensis women and sapiens men.

c) The only fertile offspring of *H. sapiens* and *H. neanderthalensis* were daughters of neanderthalensis women and sapiens men.

d) Genetic drift: the Neanderthal Y and mitochondrial DNA was lost from the modern human gene pool by chance.

e) Natural selection: sapiens' Y and mitochondrial DNA was 'fitter' than neanderthalensis'.

Part 3 of 4

In 2020, the first Y-chromosomes from many *H. sapiens*, *H. neanderthalensis* and Denisovans (extremely ancient *H. sapiens*) across the world were sequenced.The Neanderthal Y-chromosomes were very similar to modern humans', whereas every other Neanderthal chromosome is much more similar to Denisovans' than modern humans'.



Denisovan tooth By Thilo Parg - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=41805108

Part 4 of 4

Which hypothesis is most likely about the spread of Y-chromosomes?

3 marks

Choose ONE

a) Only certain combinations of parent-child sexes were fertile.

b) Genetic drift explains the patterns.

c) Natural selection: the modern human Y-chromosome was fitter than the Neanderthal Y-chromosome.

d) This finding does not provide evidence in favour of any particular hypothesis.

e) The Y-chromosome of any hominin is only compatible with one species and cannot be spread by cross breeding.

Question 7

Part 1 of 6

Human blood contains red blood cells, plasma (a fluid rich in antibodies), and platelets. Platelets are membrane-bound fragments that bud off specialized cells and help blood clotting.All human cells express A, B or O antigens on their surface, each from an allele of the ABO gene. The O antigen can be thought of as being absent.For blood donations, red blood cells can be highly purified, then donated. Platelets cannot be highly purified and are usually donated within a significant amount of donor plasma. If antibodies bind to either donor or recipient red blood cells, they are attacked and the byproducts rapidly kill the recipient. If antibodies bind to platelets, not very much happens but the platelets might not last quite as long.



By Whoisjohngalt - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=93709314

Part 2 of 6

During a *red blood cell* donation, which combinations of blood donation are okay?

	Recipient AB	Recipient A	Recipient B	Recipient O
Donor **AB**	1	2	3	4
Donor **A**	5	6	7	8
Donor **B**	9	10	11	12
Donor **O**	13	14	15	16

3 marks

Groups

Good for patient

Bad for patient

Put into the groups above

a) 16

b) 9

c) 4

d) 3

e) 11

f) 8

g) 10

h) 12

i) 1

j) 2

k) 14

l) 15

m) 6

n) 5

o) 7

p) 13

Part 3 of 6

During a *platelet* donation, which combinations of blood donation are okay?

	Recipient AB	Recipient A	Recipient B	Recipient O
Donor **AB**	1	2	3	4
Donor **A**	5	6	7	8
Donor **B**	9	10	11	12
Donor **O**	13	14	15	16

5 marks

5 marks

Groups

Quite good for patient

Bad for patient

Very good for patient

Put into the groups above

a) 15

b) 14

c) 10

d) 13

e) 5

f) 8

g) 6

h) 1

i) 11

j) 4

k) 3

l) 12

m) 9

n) 2

o) 7

p) 16

Part 4 of 6

Reactions to badly ABO-matched blood transfusions are very quick even though the recipient may not have ever received a donation before.Which definitions describe this kind of immunity?

3 marks

Choose as many as appropriate

a) Adaptive

b) Innate

c) Humoral

d) Cross-reactivity between antigens

e) Autoimmunity

f) Non-specific immunity

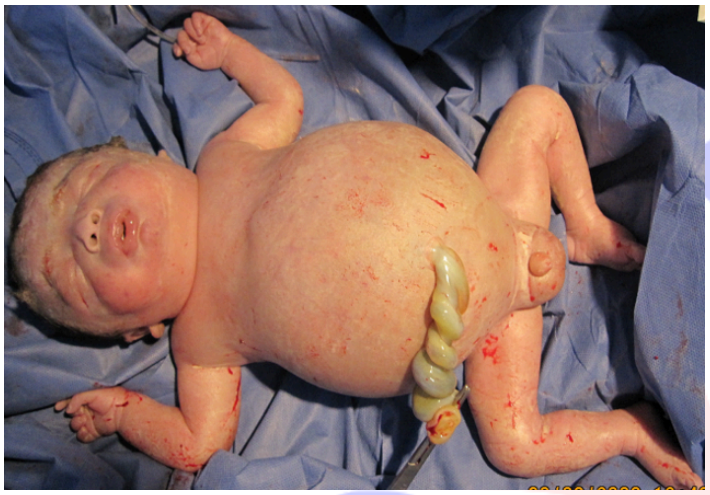
g) Passive immunity

Part 5 of 6

All human cells can also express immune-triggering rhesus (Rh+) antigens on their surface, or express less immunogenic rhesus antigens (Rh-).People become rhesus intolerant if they are exposed to miss-matched material.

Part 6 of 6

Foetal blood cells may leak into the blood stream of a pregnant mother. All mothers pass their circulating antibodies to the developing foetus through their placenta.What situations increase the chance of the baby being harmed by blood group incompatibility with the mother?



Newborn with severe rhesus disease. By Benkerroum Zineb, Lachiri Boutaina, Lazrak Ikram, Moussaoui Rahali Driss, Dehayni Mohammed - https://panafrican-med-journal.com/content/article/22/137/full/, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=132866773

4 marks

Groups

More likely baby is harmed

Less likely baby is harmed

Put into the groups above

a) The mother is Rh+.

b) The father is Rh+ and the mother is Rh-(the foetus is unknown).

c) This is the first pregnancy.

d) The Rh- mother previously had an abortion of a Rh+ foetus.

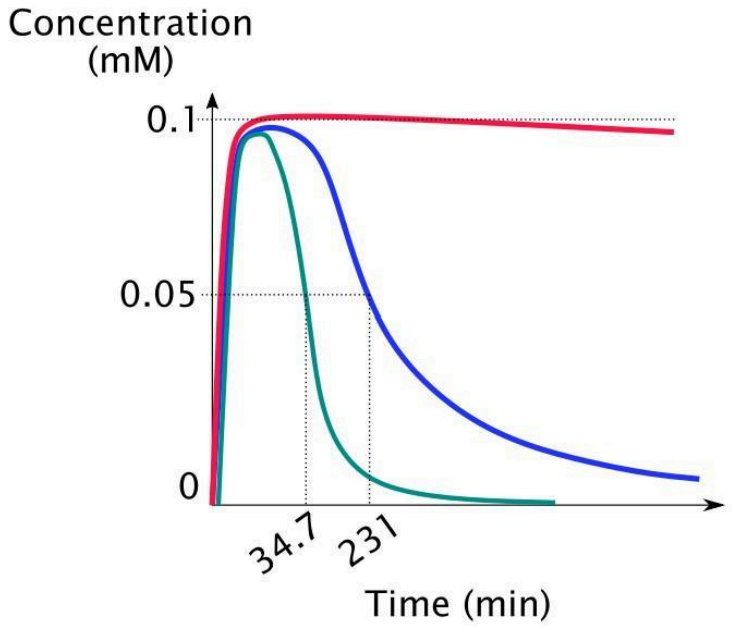
e) A drug is used to cover-up rhesus antigens.

f) A newborn very sick due to blood-group incompatibility is breast fed by its mother.

Question 8

Part 1 of 6

* Inulin is a soluble inert (non-reactive, non-toxic) 4 kDa (small) polymer. * Dextran is a soluble inert 500 kDa (very large) polymer. Both are handled by the kidney as you would expect for **non**-actively transported molecules of their size.Para-aminohippurate (PAH) is unusual because it is completely removed from plasma as it moves past a nephron (i.e. it is actively transported into the urine).All molecules were tagged with different colour fluorescent dyes and intravenously injected into pigs. The injection was a one-off and contained 0.75 millimoles of each molecule.Plasma concentration of each molecule over time was then measured with a fibreoptic fluorescence imager inserted into a blood vessel.



Part 2 of 6

The equation for exponential decay is* $A = A_0e^{-kT}$Which can be rearranged as* $K = \ln(A_0/A)/T$Where* A = the amount remaining* A_0 = the initial amount* k is the chance that each molecule is lost per unit time (i.e. proportion of blood filtered per minute).* T = timeNote: ln(2) ~ 0.693

Part 3 of 6

Calculate the plasma volume of the pig. Give your answer in litres to one decimal place.*It doesn't matter if you type the unit, L, or not*.

3 marks

Write something below

Part 4 of 6

For subsequent parts, take the plasma volume of the pig to be 10 litres.

Part 5 of 6

Calculate the renal plasma flow of the pig (how much plasma flow the kidneys receive).Give your answer in l/min to tone decimal place.*It doesn't matter if you type the unit, l/min, or not*.

2 marks

Write something below

Part 6 of 6

Calculate the glomerular filtration rate of the pig (how much plasma the Bowman's capsule excretes before any reabsorption).Give your answer in l/min to two decimal places.*It doesn't matter if you type the unit, l/min, or not*.

3 marks

Write something below

Question 9

Part 1 of 3

* Humans have about 20,000 protein-coding genes.* Assume the average (mean) human protein weighs 50 kDa.* The average amino acid weighs 110 Da.Use this information to estimate the total length, in base pairs, of coding sequence in the human genome.*Give your answer to the nearest million base-pairs. (It does not matter if you type the unit, 'Mbp' million base pairs or not).*

4 marks

Write something below

Part 2 of 3

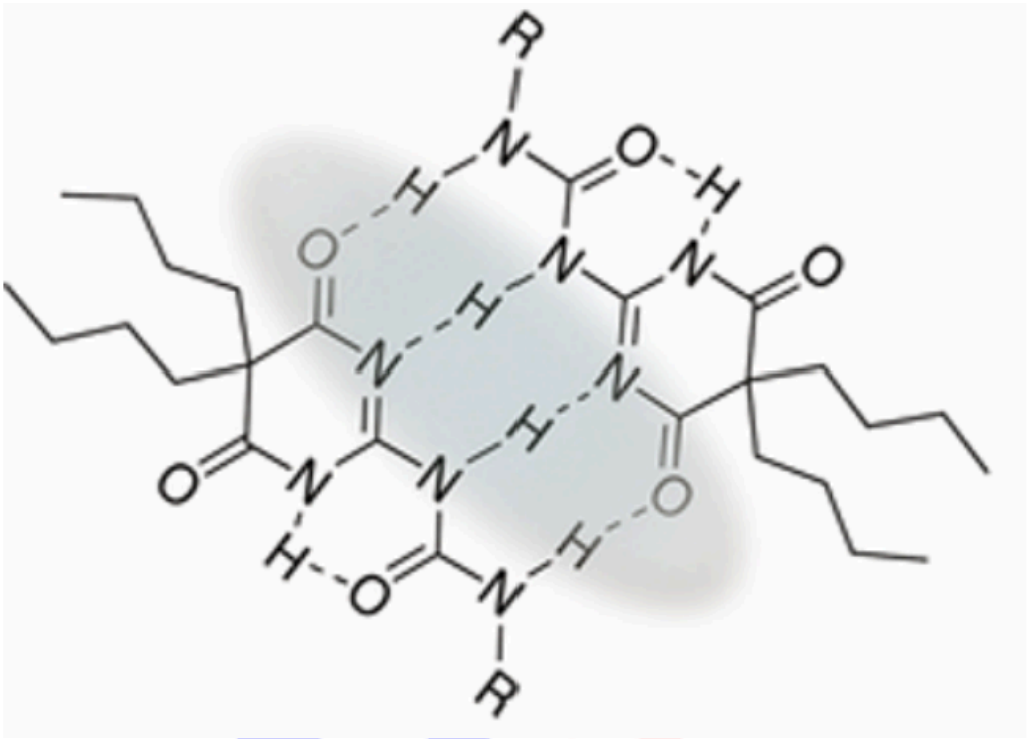
An alien plant has 100 million base pairs of protein-coding sequence in its genome.The alien uses 20 different amino acids (like us) but has 3 different DNA base pairs (A/T, G/C and X/Y).Calculate the maximum total length of protein sequence (in amino acids) this alien could encode.*Give your answer to the nearest million amino acids. (It does not matter if you type the unit, 'million amino acids', or not).*

3 marks

Write something below

Part 3 of 3

The chemical structure of an X/Y base pair is shown.Which DNA sequence has the highest melting temperature?



2 marks

Choose ONE

a) ATTATAAAATAAT

b) GCGCGCCCCGGCG

c) GCGG

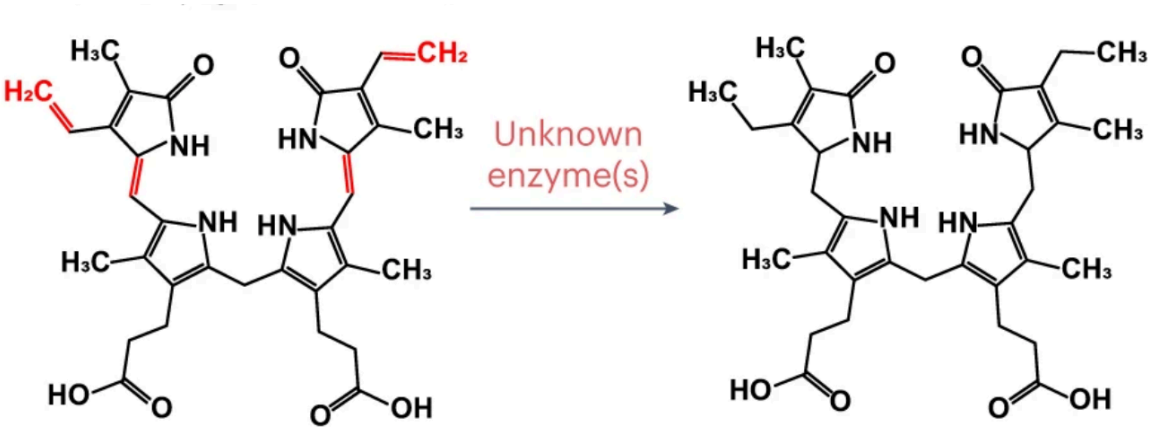
d) ATGCYGAYTCTX

e) XYXYYXYXXYXXY

Question 10

Part 1 of 8

When dead/damaged red blood cells are recycled, the haem they contain must be detoxified. *An outline of the haeme degradation pathway:** Haeme → → bilirubin → urobilinogen → urobilin Urobilin makes urine yellow.If bilirubin cannot be processed into urobilinogen, it builds up in the blood. This can cause jaundice (a person turning yellowish) and is toxic.The enzyme which converts bilirubin to urobilinogen (see image) was unknown until 2024.



The conversion of bilirubin to urobilinogen

Part 2 of 8

What features does the unknown enzyme have?

3 marks

Mark the following as TRUE or FALSE

a) Catalyses a reduction reaction.

TRUE FALSE

b) Probably uses ATP.

TRUE FALSE

c) Probably uses NADH or FADH/$FADH_2$.

TRUE FALSE

d) Catalyses a condensation reaction.

TRUE FALSE

Part 3 of 8

Scientists showed **only** gut bacteria produce the unknown enzyme.How could this be proved?

3 marks

Choose ONE

a) Bacteria grown in the lab are able to convert bilirubin to urobilinogen.

b) Bioinformatic analyses show gut bacteria have genes which look like those that could convert bilirubin to urobilinogen.

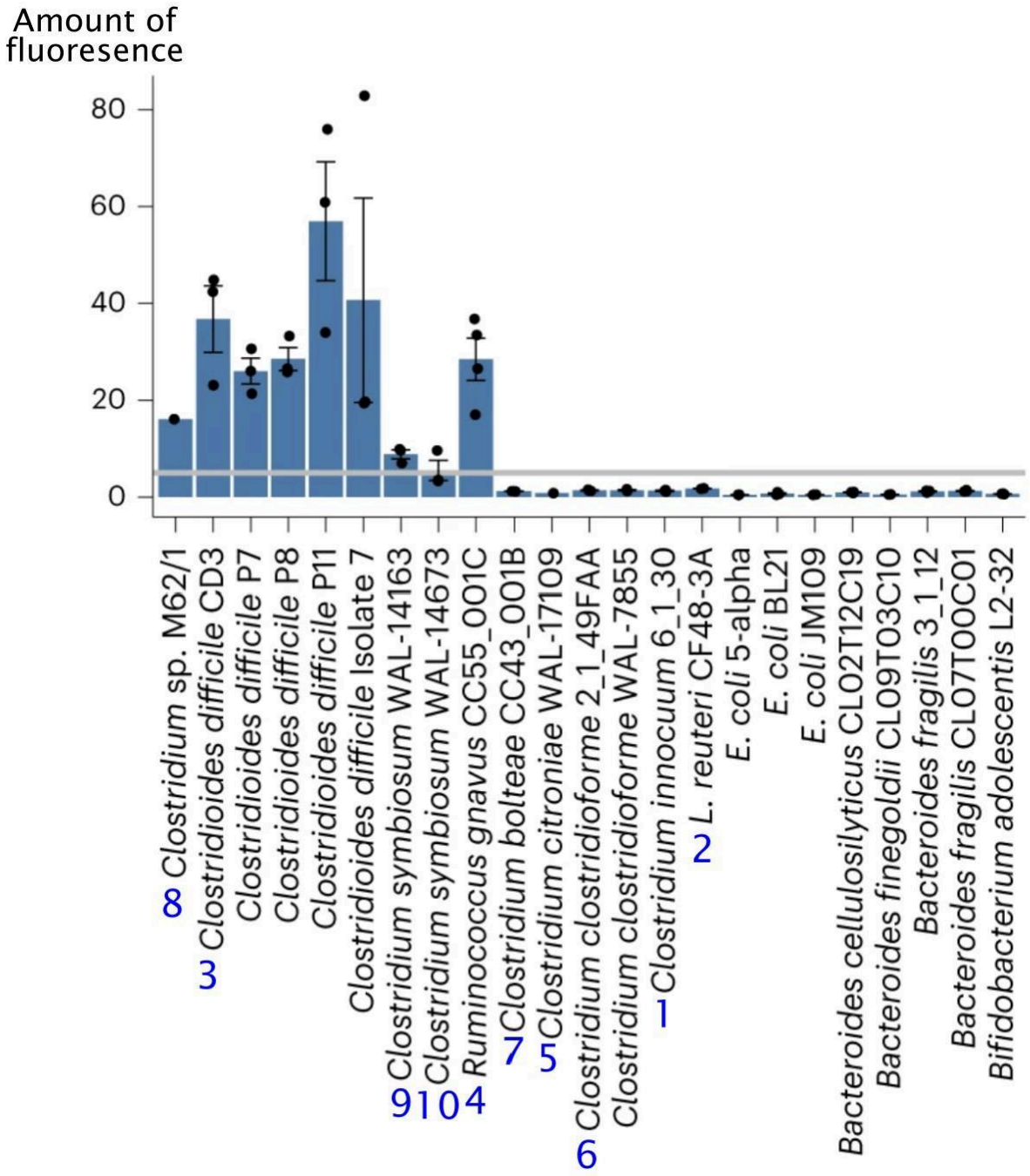
c) Rats grown in sterile conditions with their entire gut microbiome killed are unable to convert bilirubin to urobilinogen.

d) Bioinformatic analyses show humans do **not** have genes which look like those that could convert bilirubin to urobilinogen.

e) Urobilinogen is useful for bacteria to use in some of their reactions.

Part 4 of 8

Gut bacteria were grown on bilirubin agar plates which turn fluorescent in the presence of urobilinogen.(The numbers match species on a later diagram)



Part 5 of 8

For the interpretations of the assay results to be reliable...

2 marks

Mark the following as TRUE or FALSE

a) *Clostridioides difficile CD3*, which is known to convert bilirubin to urobilinogen, gave the expected results.

TRUE FALSE

b) All of the bacteria must also be grown in the absence of bilirubin and not produce fluorescence.

TRUE FALSE

c) There must be equal numbers of bacteria on all of the plates.

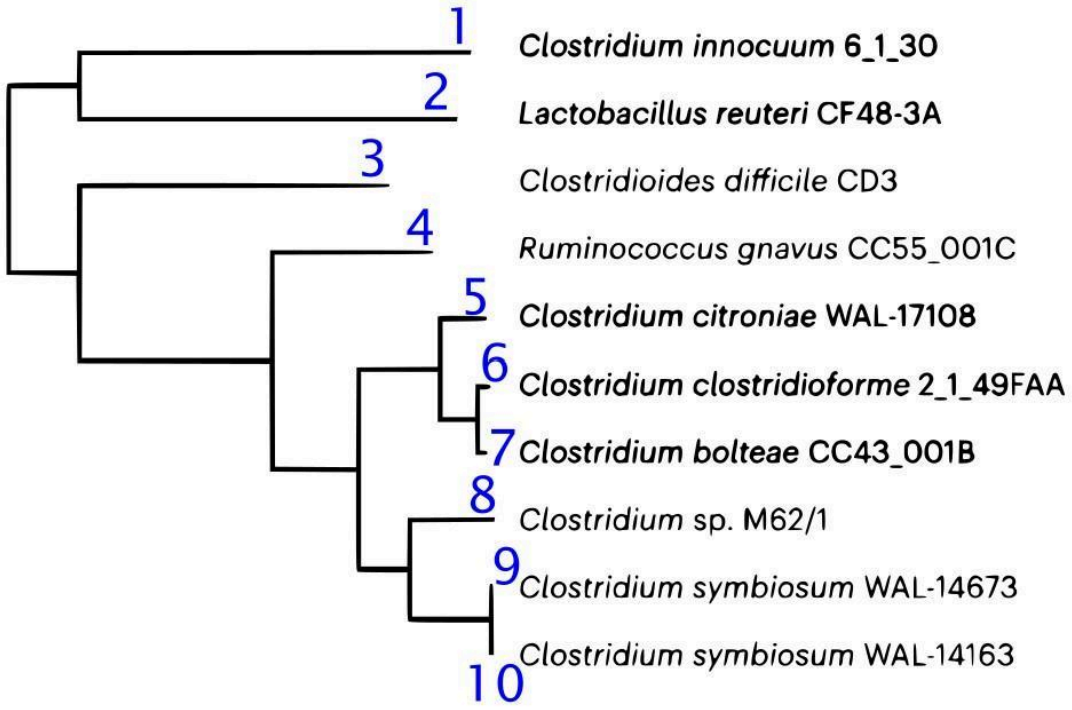
TRUE FALSE

d) The sensitivity of the fluorescence camera should be determined by plating dilutions of *Clostridioides difficile CD3*

TRUE FALSE

Part 6 of 8

The phylogeny of the *Clostridium* family below shows how closely species are related according to their entire genome sequence.



4 marks

Mark the following as TRUE or FALSE

a) The gene encoding the unknown enzyme exhibits an ancestry pattern consistent with the rest of the genome.

TRUE FALSE

b) The gene for the unknown enzyme probably evolved multiple times.

TRUE FALSE

c) The gene for the unknown enzyme probably spread by horizontal gene transfer.

TRUE FALSE

d) The gene for the unknown enzyme probably has an identical sequence in all of the species.

TRUE FALSE

e) This phylogeny shows very few genes, except the unknown enzyme, are present **only** in the species which can convert bilirubin to urobilinogen. Therefore, scientists can find the enzyme easily.

TRUE FALSE

f) To confirm the identify of the gene encoding the unknown enzyme, scientists could transfect it into *E. coli* and grow them on the fluorescent plates.

TRUE FALSE

Part 7 of 8

After identifying the unknown gene, scientists found that, like most bacterial genes, it was an 'operon' which encoded 3 different enzymes.How can they find which enzyme is responsible for converting bilirubin to urobilinogen?

3 marks

Mark the following as TRUE or FALSE

a) Look for the amino acid sequence most similar to *The Old Yellow Enzyme* family (which is known to carry out a similar class of reaction).

TRUE FALSE

b) Use artificial intelligence (AlphaFold) to model the tertiary structure of the enzyme and how bilirubin could bind.

TRUE FALSE

c) Determine that **no** bacteria which are **not** known to convert bilirubin to urobilinogen contain the suspect enzyme.

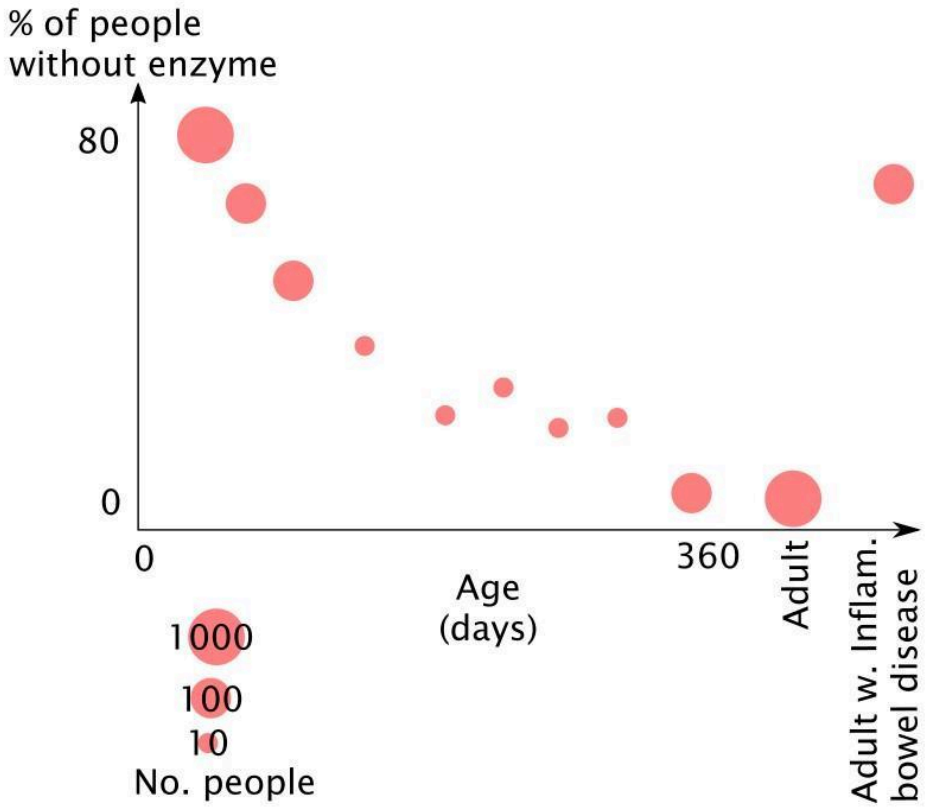
TRUE FALSE

d) Determine that **all** bacteria which are known to convert bilirubin to urobilinogen contain the suspect enzyme.

TRUE FALSE

Part 8 of 8

Scientists tested for the gene in samples from many people to determine what proportion were unable to safely detoxify haeme.



3 marks

Mark the following as TRUE or FALSE

a) The youngest babies may be most at risk of jaundice.

TRUE FALSE

b) Sample sizes are insufficient to be confident in the trend.

TRUE FALSE

c) People with inflammatory bowel diseases may be at risk of jaundice.

TRUE FALSE

d) We can conclude that lack of the enzyme is a causal factor of jaundice.

TRUE FALSE

e) We can conclude that lack of the enzyme is a causal factor of inflammatory bowel diseases.

TRUE FALSE