

This paper is the Intermediate Biology Olympiad 2022.

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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.**

***Answers are not provided.***

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.

# Intermediate Biology Olympiad 2022

This was one 60 minute paper.

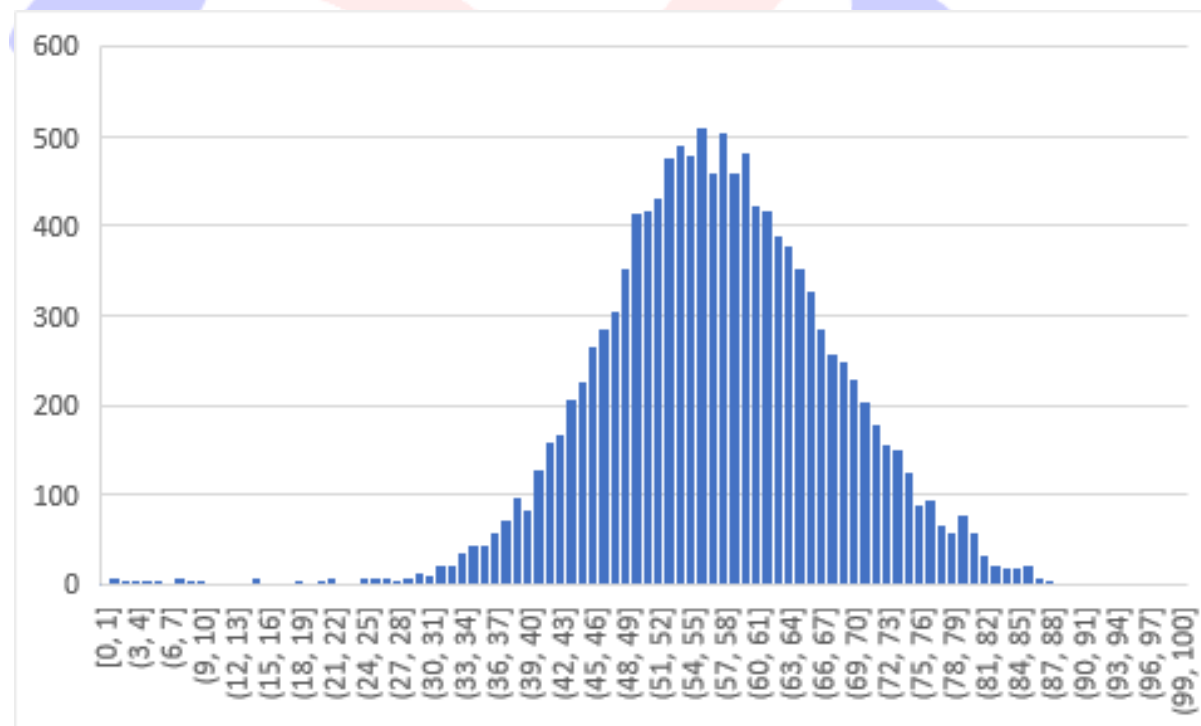
You may use a calculator.

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 in the British Biology Olympiad 2023
Gold	74.39%	5%
Silver	67.88%	10%
Bronze	62.23%	15%
Highly Commended	58.05%	15%
Commended	54.29%	15%



# Intermediate Biology Olympiad 2022

Duration: 60 minutes

Total marks: 100

## Question 1

### Part 1 of 7

What percentage of nucleotides in double-stranded DNA would contain thymine, if 32% contain guanine?\*Type a number (with or without the % sign is fine)\*

**2 marks**

*Write something below*

-----

### Part 2 of 7

What are the possible blood types of the children of a man with blood type A and a woman also with blood type A?

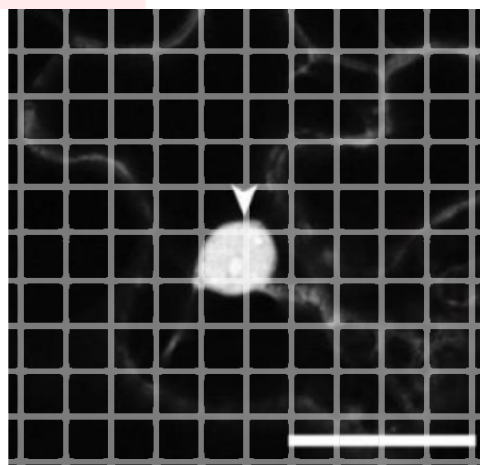
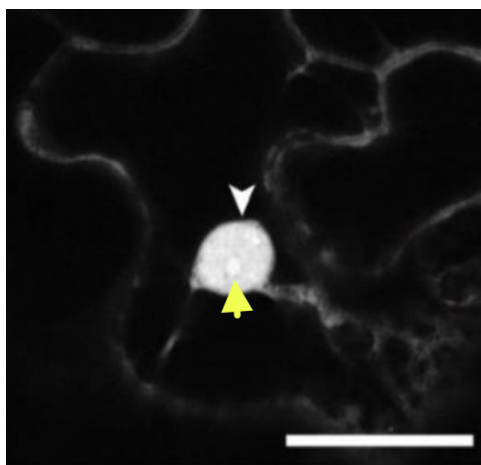
**1 mark**

*Choose as many as appropriate*

- a) A
- b) B
- c) AB
- d) O

### Part 3 of 7

This is a micrograph of a fluorescent protein which is found mainly in the nucleus (labelled with a white arrowhead) of the plant *Nicotiana benthamiana*. The scale bar is 25  $\mu\text{m}$ . How wide is the nucleus, to the nearest  $\mu\text{m}$ , at the widest point?\*Both images are identical but a grid line has been overlaid on the right\*Type a number in terms of  $\mu\text{m}$  (you don't need to type the unit)\*



Nuclear-labelled *Nicotiana benthamiana*, Johnston et al., 2022, 10.1101/2022.06.01.494363, CC BY 4.0

**2 marks**

*Write something below*

-----

**Part 4 of 7**

Which organelle is labelled with the **\*\*yellow\*\*** arrowhead?

**1 mark**

*Choose ONE*

- a) Mitochondria
- b) Chloroplast
- c) Ribosome
- d) Amyloplast
- e) Nucleolus
- f) Endoplasmic Reticulum

**Part 5 of 7**

Which of the following are products of respiration?

**3 marks**

*Choose as many as appropriate*

- a) ATP
- b) Water
- c) Glucose
- d) Oxygen
- e) Lactic acid
- f) Carbon Dioxide
- g) Heat
- h) Light

**Part 6 of 7**

DNA is a huge double-stranded macromolecule in the cell. What type of bonds hold together bases on **\*\*the same strand\*\***?

**1 mark**

*Choose ONE*

- a) Ionic bonds
- b) Covalent bonds
- c) Disulphide bonds
- d) Hydrogen bonds
- e) Peptide bonds

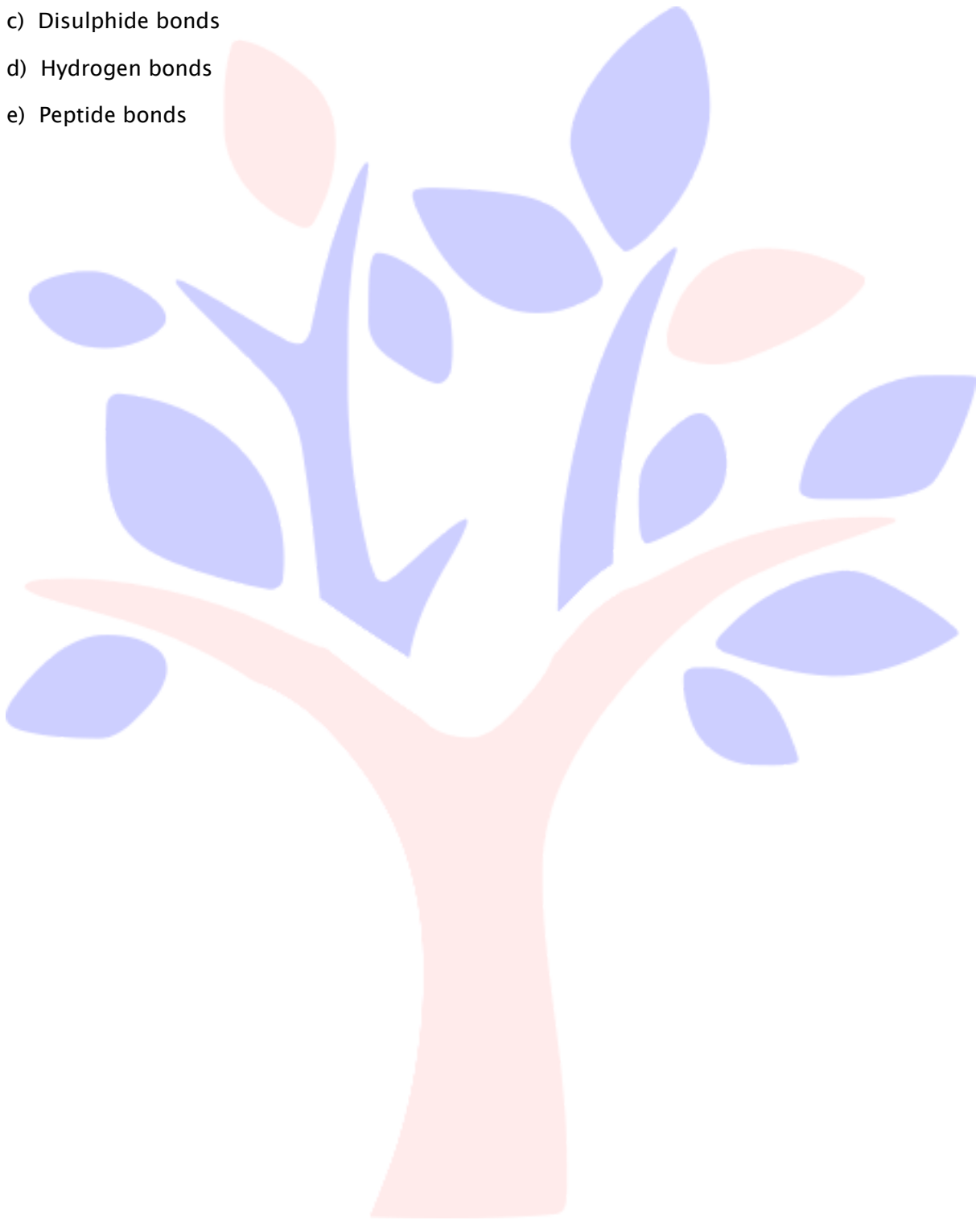
**Part 7 of 7**

What type of bonds hold together bases on **\*\*different\*\*** strands?

**1 mark**

*Choose ONE*

- a) Ionic bonds
- b) Covalent bonds
- c) Disulphide bonds
- d) Hydrogen bonds
- e) Peptide bonds



## Question 2

### Part 1 of 8

An alien organism uses 37 amino acids while its DNA is made up of 7 types of nitrogenous bases. What is the *minimum* number of bases in each of its codons? Codons are the number of bases encoding an amino acid i.e. humans have codons of 3 bases

**3 marks**

*Write something below*

-----

### Part 2 of 8

An adult human has a cardiac output of 5 **L/min**. The kidneys receive 25% of cardiac output. Of the blood they receive, the kidneys filter 10% of its volume into the uppermost part of the urinary system. The person excretes 1 **L** of urine per **day**. What is the volume of urine which the kidneys reabsorb into the blood? Give your answer in **mL/min** to the nearest whole number. *You don't need to type the unit*

**3 marks**

*Write something below*

-----

### Part 3 of 8

On average, a beech tree fixes gross 360  $\mu\text{mol/min/m}^2$  of  $\text{CO}_2$  by photosynthesis. The same tree absorbs gross 60  $\mu\text{mol/min/m}^2$  of  $\text{O}_2$  by respiration. How many net molecules of glucose does it produce? Give your answer in  $\mu\text{mol/min/m}^2$ . *You do not need to type the unit*



By Malene Thyssen - Own work, CC BY-SA 3.0,  
<https://commons.wikimedia.org/w/index.php?curid=752225>

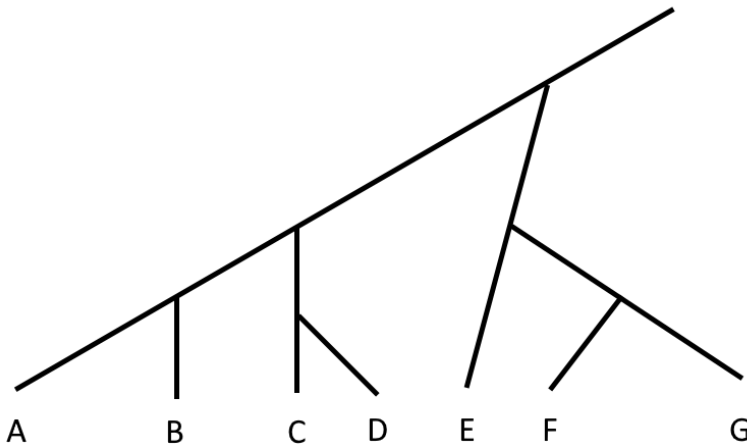
**2 marks**

*Write something below*

-----

### Part 4 of 8

A monophyletic clade is one which contains a common ancestor and *all* of its descendants. Using the tree, which of the following are monophyletic clades?



A phylogenetic tree

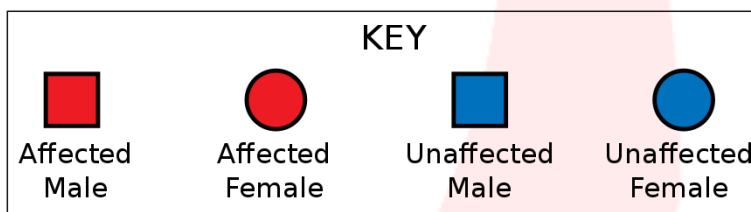
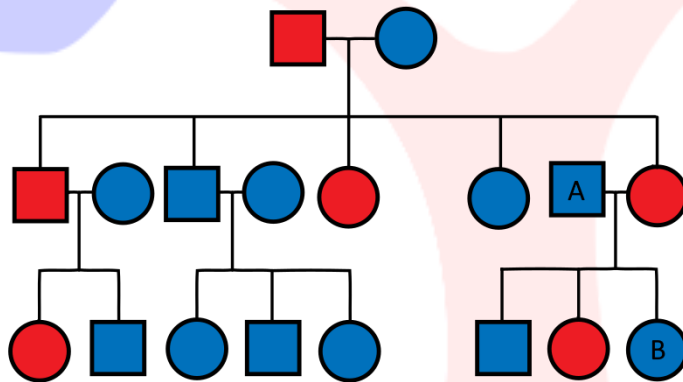
**2 marks**

Choose as many as appropriate

- a) C D
- b) C D E F
- c) C D E F G
- d) E F
- e) E F G
- f) F G

### Part 5 of 8

Below is a pedigree showing three generations of a family affected by a disease.



edited from Jerome Walker, GNU Free Documentation License

### Part 6 of 8

What type of mutation caused this disease?

**1 mark**

*Choose ONE*

- a) Dominant
- b) Recessive
- c) Cannot tell

**Part 7 of 8**

Assuming the mutation is recessive, what genotype does person A have?

**1 mark**

*Choose ONE*

- a) Homozygous healthy
- b) Heterozygous
- c) Homozygous disease
- d) Cannot tell

**Part 8 of 8**

Assuming the mutation is recessive, what is the chance that B is heterozygous for the disease causing allele? \*You can give your answer as a percentage or a frequency\*

**2 marks**

*Write something below*

-----



### Question 3

#### Part 1 of 4

The first land plants were short and flat.



Public Domain, <https://commons.wikimedia.org/w/index.php?curid=85253>

#### Part 2 of 4

Over millions of years, plants evolved to include extremely tall trees.



By Matteo De Stefano/MUSE This file was uploaded by MUSE - Science Museum of Trento in cooperation with Wikimedia Italia., CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=48201759>

#### Part 3 of 4

What is the **\*\*main\*\*** reason natural selection has favoured height?

**1 mark**

*Choose ONE*

- a) Tall plants can spread their seeds further
- b) Tall plants can spread their pollen further
- c) Competition for light favours tall plants
- d) Competition for water favours tall plants
- e) Tall plants are protected from herbivores

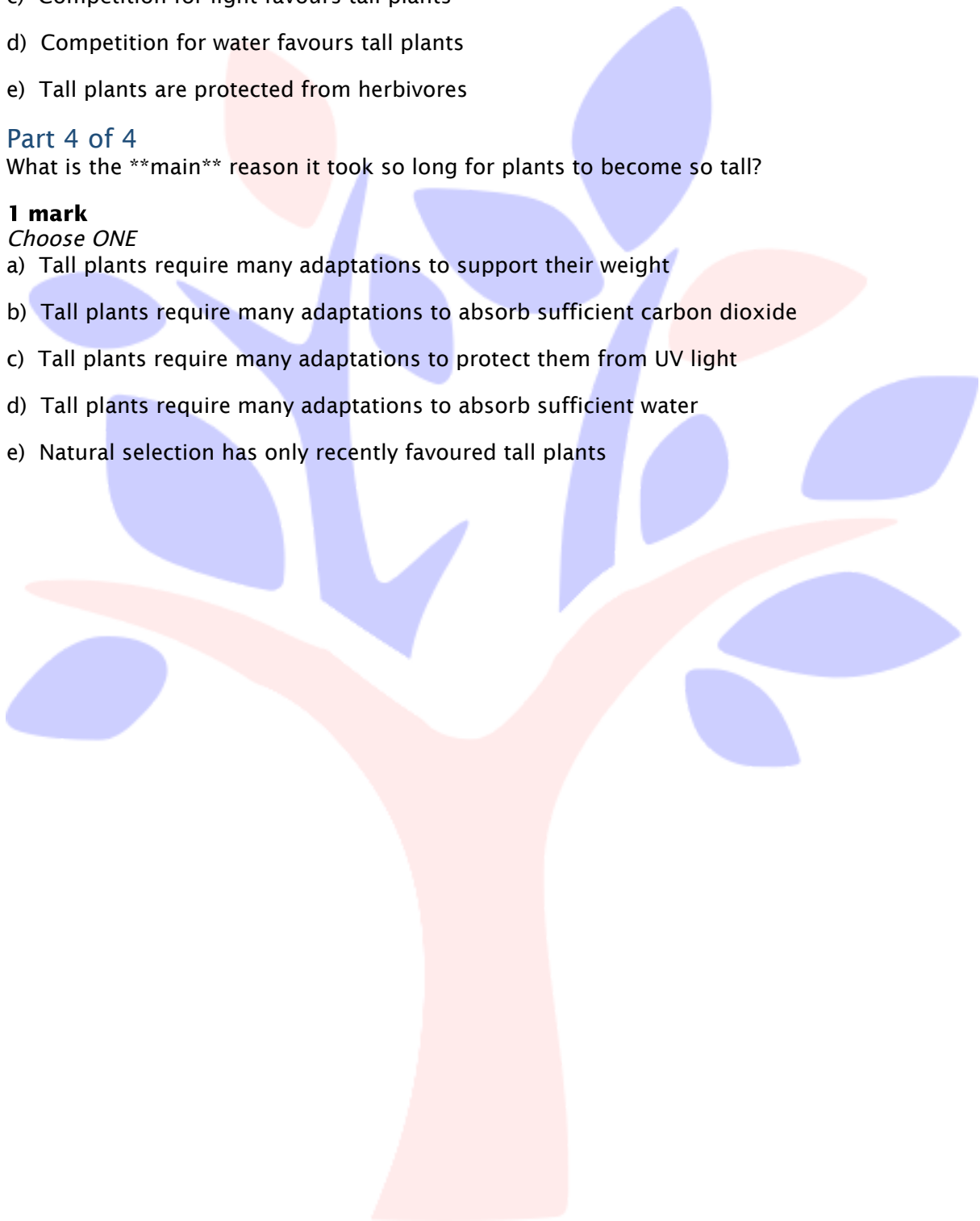
**Part 4 of 4**

What is the **\*\*main\*\*** reason it took so long for plants to become so tall?

**1 mark**

*Choose ONE*

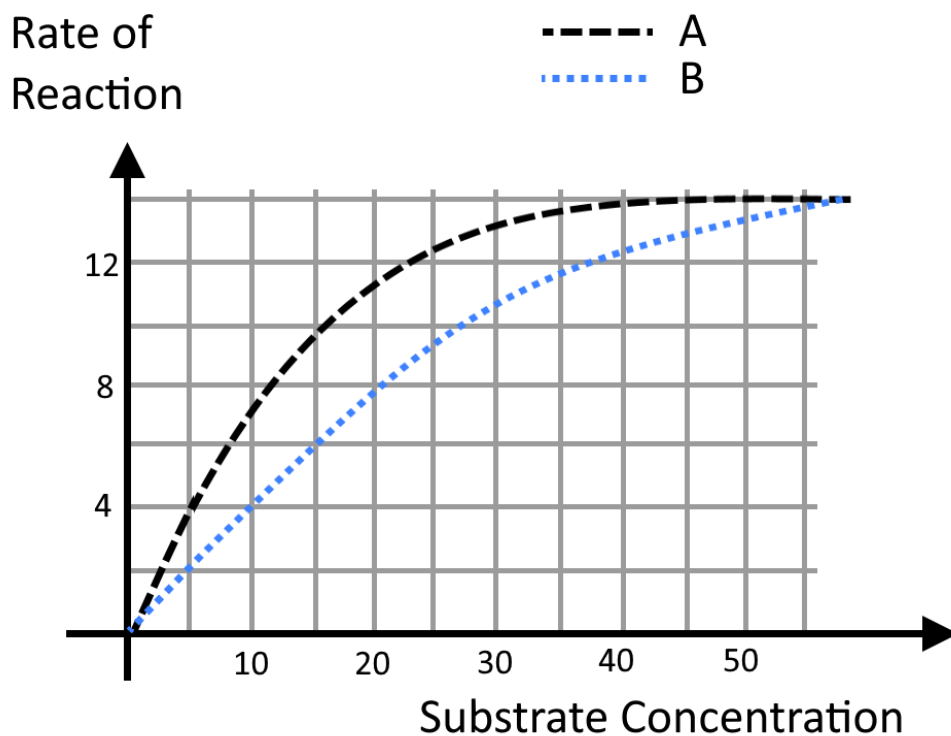
- a) Tall plants require many adaptations to support their weight
- b) Tall plants require many adaptations to absorb sufficient carbon dioxide
- c) Tall plants require many adaptations to protect them from UV light
- d) Tall plants require many adaptations to absorb sufficient water
- e) Natural selection has only recently favoured tall plants



## Question 4

### Part 1 of 9

A scientist measures the rate of an enzymatic reaction with and without an inhibitor at different substrate concentrations.



### Part 2 of 9

Which of the lines show the reaction **\*\*without\*\*** an inhibitor?

**1 mark**

Choose ONE

- a) A
- b) B

### Part 3 of 9

What type of inhibitor has been tested?

**1 mark**

Choose ONE

- a) Competitive
- b) Non-competitive
- c) Suicide inhibitor

### Part 4 of 9

Which part of the enzyme does the inhibitor likely bind?

**1 mark**

Choose ONE

- a) The right-hand side
- b) Anywhere
- c) The active site
- d) A site of sub-unit polymerisation

#### Part 5 of 9

What is the max speed ( $V_{\text{max}}$ ) of the uninhibited reaction? \*Type a number without units\*

**2 marks**

*Write something below*

-----

#### Part 6 of 9

What is the Michaelis constant ( $K_m$ ) of the reaction of line A? \*The Michaelis constant is the substrate concentration at which the speed of the reaction is half its maximum.\*Type a number without units\*

**2 marks**

*Write something below*

-----

#### Part 7 of 9

What is the percentage increase in the Michaelis constant ( $K_m$ ) of line A to line B? \*A number with or without the % sign is fine\*

**2 marks**

*Write something below*

-----

#### Part 8 of 9

Which of these could speed up  $V_{\text{max}}$  of the reaction?

**3 marks**

*Choose as many as appropriate*

- a) Adding more enzyme
- b) Gently heating the reaction
- c) Vigorously heating the reaction
- d) Adding more substrate
- e) Adding more product
- f) Stirring the mixture

#### Part 9 of 9

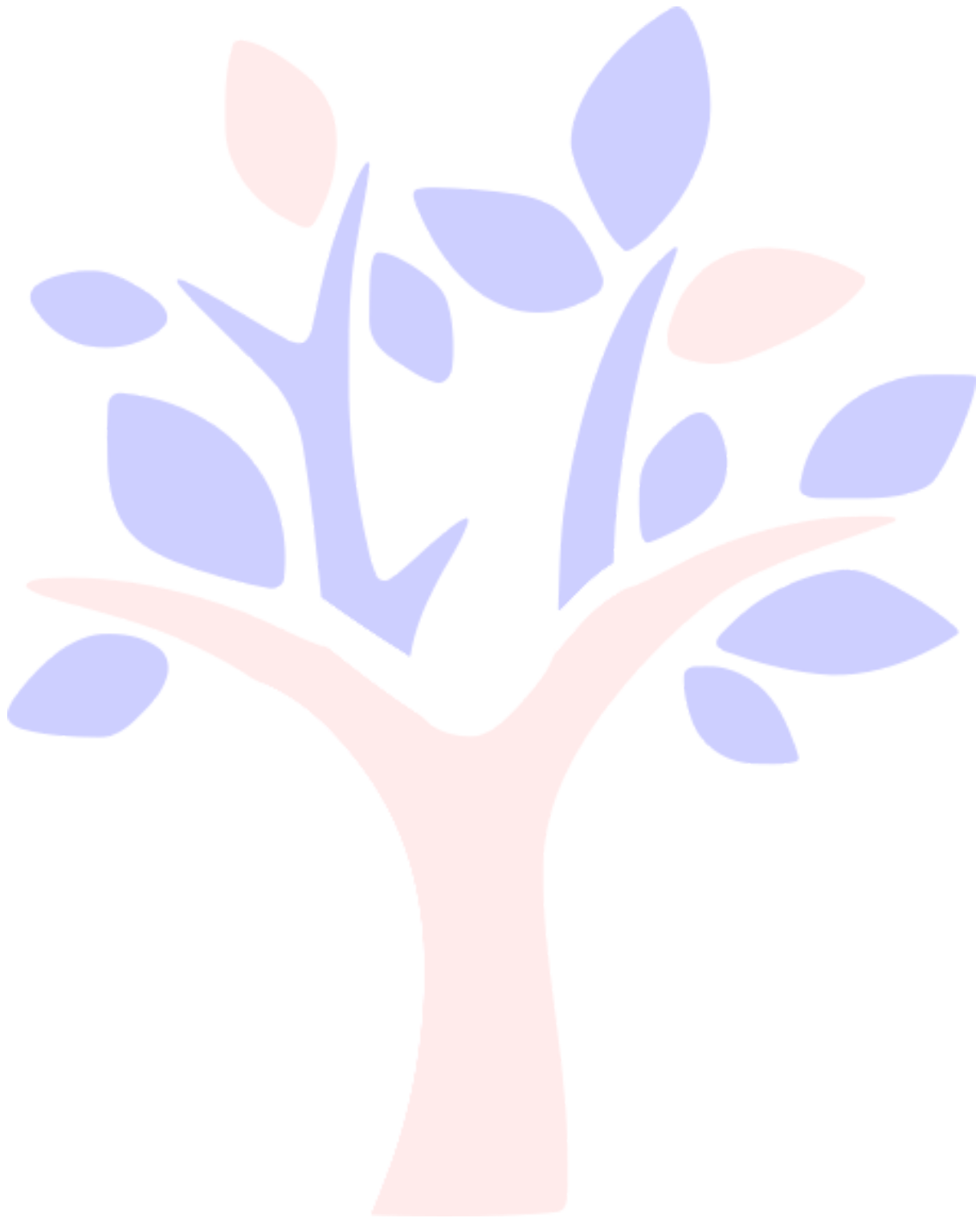
Which of these could change the equilibrium point of the reaction?

**3 marks**

*Choose as many as appropriate*

- a) Adding more enzyme
- b) Gently heating the reaction
- c) Vigorously heating the reaction

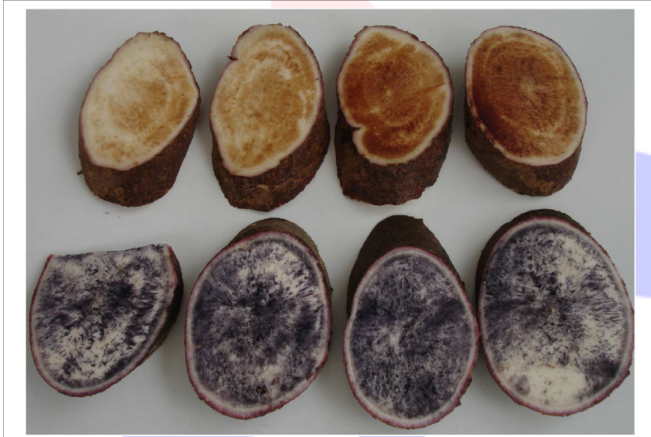
- d) Adding more substrate
- e) Adding more product
- f) Stirring the mixture



## Question 5

### Part 1 of 6

Rank these plant tissues in order of which would show the darkest staining with iodine solution.\* The phloem transports products of photosynthesis in sap down from the leaves.\* The xylem transports things absorbed by the roots into the leaves.\*Put the darkest at the top, faintest at the bottom\*



Karlström, Amanda & Calle, F. & Salazar, Sandra & Morante, Nelson & Dominique, Dufour & Ceballos, Hernan. (2016). Biological Implications in Cassava for the Production of Amylose-Free Starch: Impact on Root Yield and Related Traits. *Frontiers in Plant Science*. 7. 10.3389/fpls.2016.00604.

#### 3 marks

*Put into the correct order*

- a) Xylem
- b) Bulb/tuber
- c) Phloem
- d) Leaves

### Part 2 of 6

Rank these plant tissues in order of which has the greatest osmolarity.\* Osmolarity is a measure of the concentration of substances dissolved in water\*Put the greatest at the top, lowest at the bottom\*

#### 2 marks

*Put into the correct order*

- a) Phloem
- b) Bulb / Tuber
- c) Xylem

### Part 3 of 6

Some insects, such as aphids, feed off the phloem **\*\*(group A)\*\***.





By Kent Loeffler - <http://www.ars.usda.gov/is/graphics/photos/apr12/d2459-1.htm>, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=66276712>

#### Part 4 of 6

Some insects, such as spittlebugs, feed off the xylem **\*\*(group B)\*\***.



By Diliff - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=40494161>

### Part 5 of 6

Sort these statements into insect group A or group B.

#### 4 marks

*Groups*

Group A

Group B

*Put into the groups above*

- a) Draw out plantfluid easily
- b) Can cause a plant to quickly wilt
- c) Must have strong sucking mouths
- d) May secrete nutritious waste for 'farmer ants'
- e) Must draw out larger volumes of plant fluid

### Part 6 of 6

How could you distinguish whether fluid comes from the xylem or phloem? \*Mark each as true or false\*

#### 4 marks

*Mark the following as TRUE or FALSE*

f) Tasting sweet

TRUE FALSE

g) Tasting salty

TRUE FALSE

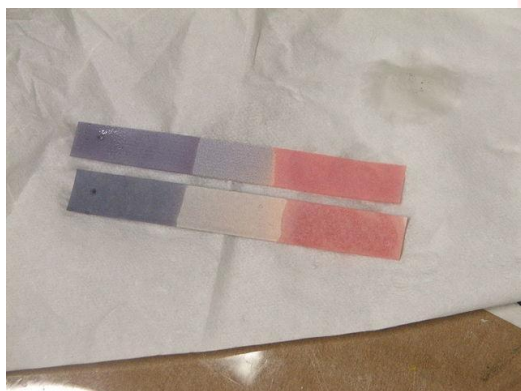
a) Benedict's test



By Kubawlo - Own work, CC BY-SA 4.0,  
<https://commons.wikimedia.org/w/index.php?curid=19455438>

TRUE FALSE

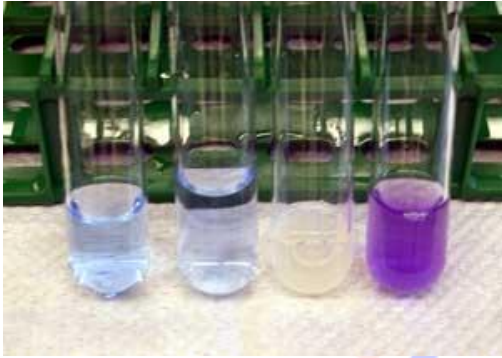
d) Litmus test



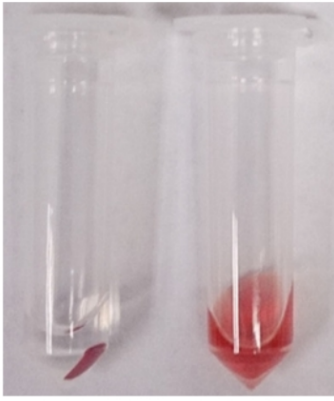
By Chemicalinterest - Own work, Public Domain,  
<https://commons.wikimedia.org/w/index.php?curid=12524809>



TRUE FALSE  
b) Biuret test



TRUE FALSE  
e) Animal red blood cell lysis (whether or not they burst when placed in the fluid)



TRUE FALSE  
c) Emulsion test



TRUE FALSE

## Question 6

### Part 1 of 10

Some organisms can generate their own warmth (endotherms) and others cannot (ectotherms).

### Part 2 of 10

Split the following organisms into endotherms and ectotherms

#### 2 marks

*Groups*

Endotherm

Ectotherm

*Put into the groups above*

- a) Mackerel
- b) Frog
- c) Blue tit
- d) Dolphin
- e) Oak tree

### Part 3 of 10

A dog is an endotherm and a lizard is an ectotherm.



A dog licking a lizard

### Part 4 of 10

Early in the morning, which animal will be the most metabolically active?

#### 1 mark

*Choose ONE*

- a) Dog
- b) Lizard
- c) Both

### Part 5 of 10

On a particularly hot day, which animal will be hiding from the sun?

**1 mark**

*Choose ONE*

- a) Dog
- b) Lizard
- c) Both

**Part 6 of 10**

Why can getting too hot kill dogs?

**3 marks**

*Choose as many as appropriate*

- a) Some enzymes start working too fast compared to others
- b) Some enzymes may denature
- c) The dog's cells will dry out
- d) Cell membrane properties begin to change
- e) The dog runs out of circulating fluid

**Part 7 of 10**

Plants, like animals, have to avoid getting too hot, however, plants cannot simply move into shade. Which are adaptations plants employ to keep cool?

**2 marks**

*Choose as many as appropriate*

- a) Small leaves
- b) Reflective leaves
- c) Changing leaf angle out of the sun

**Part 8 of 10**

Once too hot organisms must remove excess heat.

**Part 9 of 10**

Which plant would cool down quicker when the weather improves: a leafy tree or a barrel cactus? Assume they have the same mass\*

**1 mark**

*Choose ONE*

- a) Leafy Tree



Araucaria sp  
b) Barrel cactus



Barrel cactus

### Part 10 of 10

Dogs pant to cool down. If a dog was afflicted with emphysema, would it cool down quicker or slower than a healthy dog?

**1 mark**

*Choose ONE*

- a) Cool quicker with emphysema
- b) Cool slower with emphysema

## Question 7

### Part 1 of 9

Locusts are flying herbivorous insects which form swarms. The largest locust swarms show \*plague behaviour\*, when individuals from huge areas condense into a thick cloud, then begin moving very fast across continents, eating all plants in their path. Locust plagues have caused famines throughout history.



Ancient Egyptian Locust painting. By Maler der Grabkammer des Horemhab - The Yorck Project (2002) 10.000 Meisterwerke der Malerei (DVD-ROM), distributed by DIRECTMEDIA Publishing GmbH. ISBN: 3936122202., Public Domain, <https://commons.wikimedia.org/w/index.php?curid=154302>

### Part 2 of 9

Locusts were thought to be a distinct species. However, scientists have discovered that locusts are simply grasshoppers which change their appearance and behaviour suddenly (as shown in the image below). Species of grasshoppers everywhere in the world can turn into locusts if they are put in stressful conditions.



Solitary



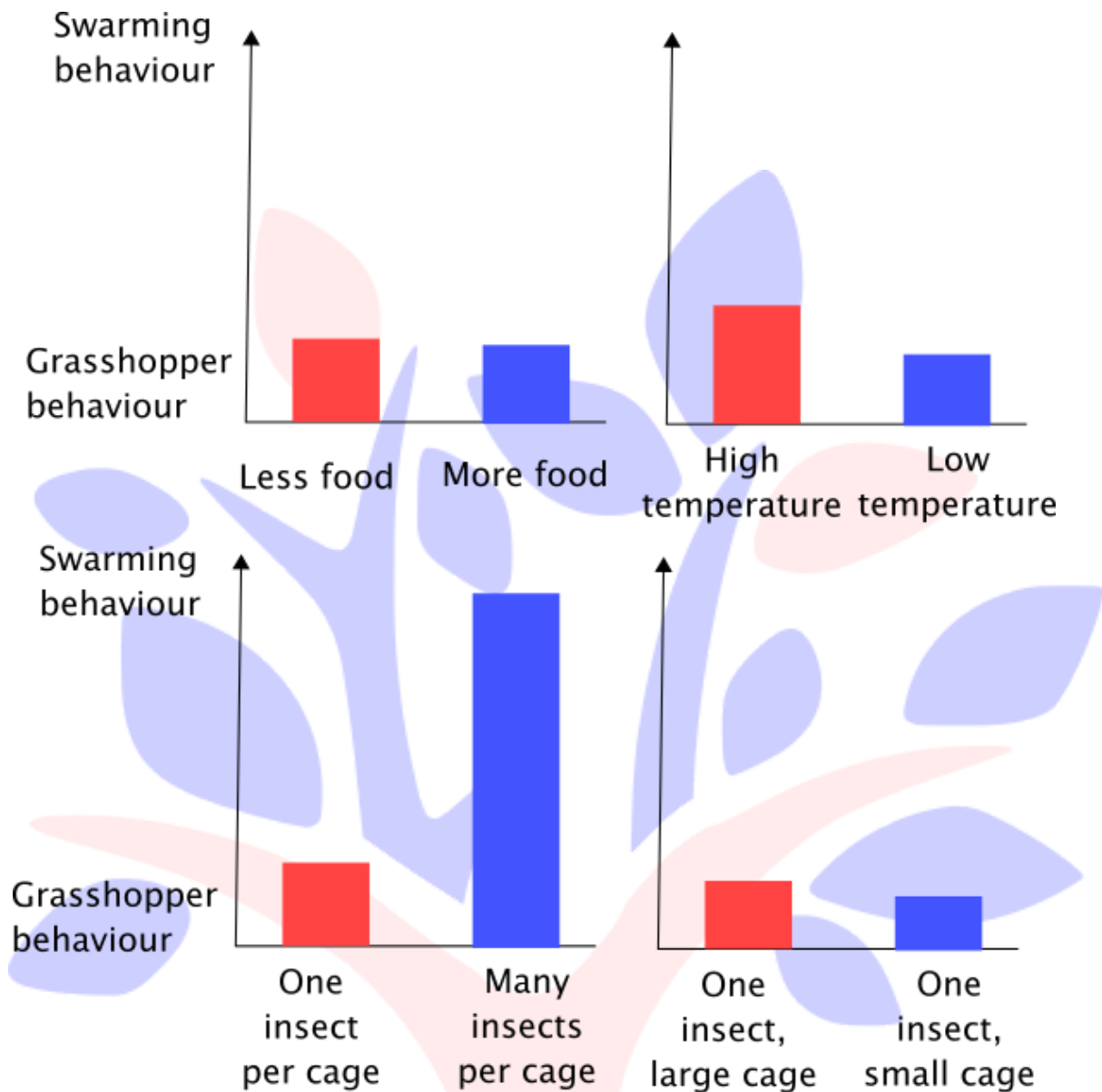
Gregarious



Grasshopper and Locust of same species By Compton Tucker, NASA GSFC - An Insect's Alter Ego, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=526037>

### Part 3 of 9

Grasshoppers normally prefer to live alone, move slowly and are harmless. Grasshoppers were put in cages in different conditions, and their preference for living alone or in swarms was measured.



#### Part 4 of 9

How should this experiment be designed?

#### 4 marks

Mark the following as TRUE or FALSE

a) Only one variable should be different between each cage

TRUE FALSE

b) Grasshoppers in each cage should be allowed to reproduce until each cage is full

TRUE FALSE

c) Several cages of each condition should be measured

TRUE FALSE

d) Each cage should contain a different species of grasshopper

TRUE FALSE

e) The same grasshoppers should be moved into each condition sequentially

TRUE FALSE

### Part 5 of 9

Which factor appears to cause grasshoppers to start becoming locusts?

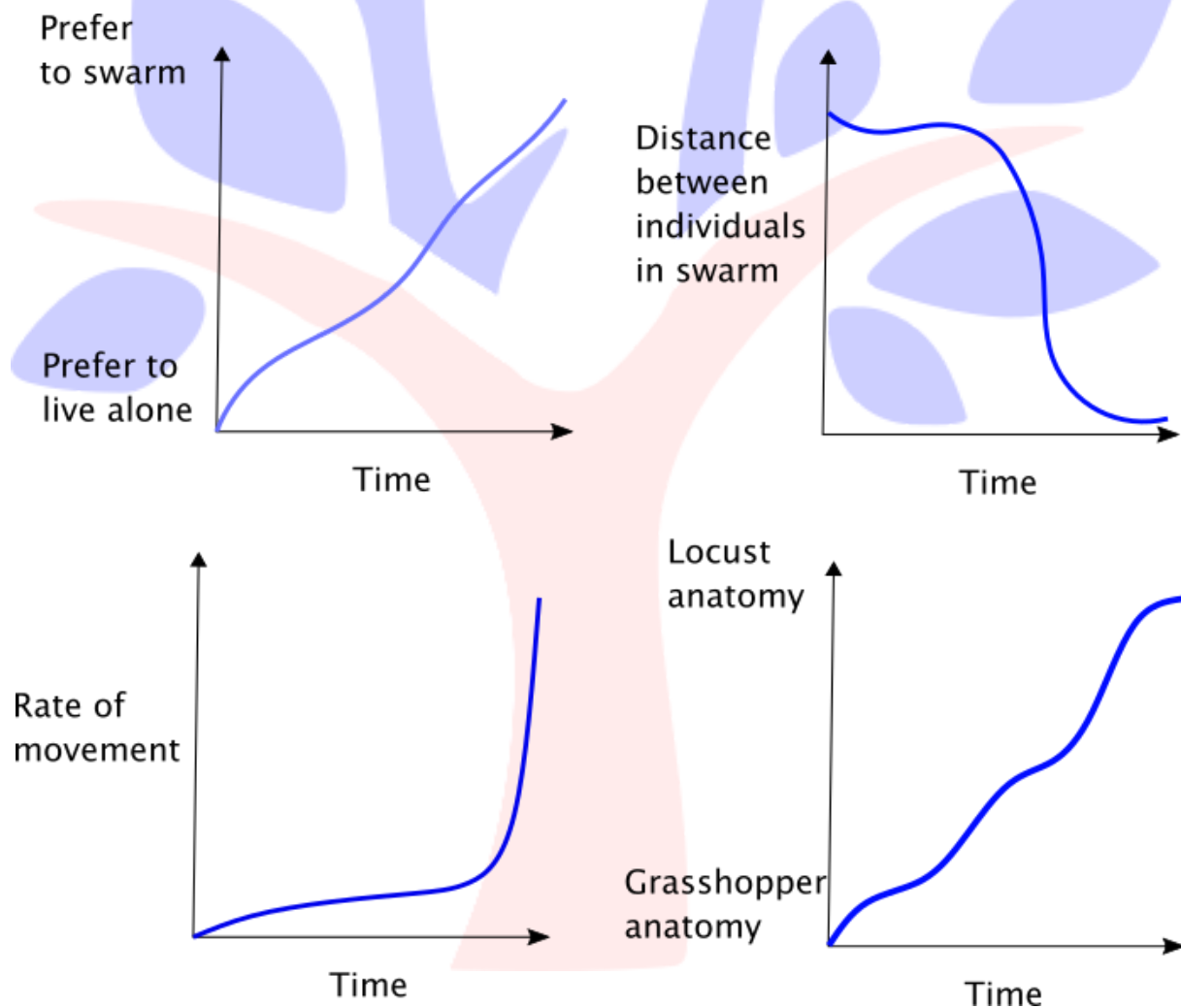
**1 mark**

Choose ONE

- a) Lack of food
- b) Heat stress
- c) Lack of space
- d) Too much contact with other grasshoppers
- e) All of the above
- f) None of the above

### Part 6 of 9

Grasshoppers were forced to live in the condition which makes them start to swarm for several weeks (a few generations). Their anatomy and behaviour were measured.



### Part 7 of 9



Using all the information, put in order the steps that cause normal grasshoppers to transition into a locust plague.\*Put the first step at the top, and the final step at the bottom\*

**4 marks**

*Put into the correct order*

- a) A thick plague of locusts travels large distances together
- b) Food runs out and individuals move very quickly to find more
- c) Individuals live more closely together than normal
- d) Swarms become denser and faster
- e) Swarms merge together and full locusts are produced
- f) Individuals prefer to gather in swarms

**Part 8 of 9**

Different ecological incidents have created locust plagues which lead to famine. These incidents can create \* \*\*A\*\* Excess food for grasshoppers\* \*\*B\*\* Reduced predation of grasshoppers\* \*\*C\*\* Increased grassland and bare soil for grasshopper mating and egg-laying

**Part 9 of 9**

Match the historical events, i-iii, with A-C.\* \*\*i\*\* Extreme rain in the horn of Africa / Arabia, after drought, in 2018\* \*\*ii\*\* Excessive cattle farming in Australia from 1870\* \*\*iii\*\* China eradicating Starlings (insectivore birds) in 1958

**3 marks**

*Groups*

A

B

C

*Put into the groups above*

- a) i
- b) iii
- c) ii

## Question 8

### Part 1 of 13

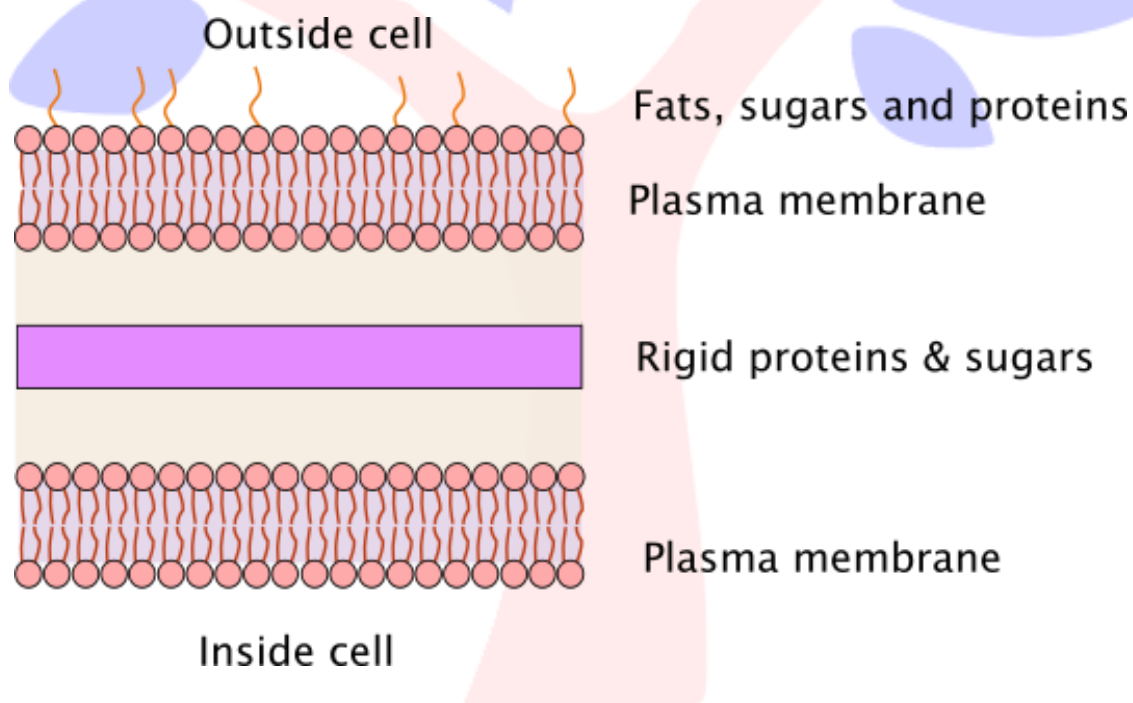
\*Beggiatoa\* are chemolithotrophic (rock eating) bacteria. They are found at the bottom of lakes or seas, forming a white carpet due to the sulphur stored in them. \*Beggiatoa\* bacteria use hydrogen sulphide ( $\text{H}_2\text{S}$ ) as an energy source to fix  $\text{CO}_2$ .



By Fabio Russo - Own work, CC BY-SA 4.0,  
<https://commons.wikimedia.org/w/index.php?curid=97201775>

### Part 2 of 13

\*Beggiatoa\* are typical Gram-negative bacteria, which means their cell-wall looks like the diagram below.



### Part 3 of 13

Compare \*Beggiatoa\* to human cells.

**5 marks**

Mark the following as TRUE or FALSE

a) Humans and \*Beggiatoa\* both have two phospholipid bilayers

TRUE FALSE

b) Humans and \*Beggiatoa\* both have polysaccharide (carbohydrate) layers

TRUE FALSE

c) Humans and \*Beggiatoa\* both have proteins sticking out from their outer layer

TRUE FALSE

d) Small molecules, such as oxygen, can diffuse through the walls/membranes of both humans and \*Beggiatoa\*

TRUE FALSE

e) Human and \*Beggiatoa\* cells both swell if they are put in pure fresh water, and shrink in salty water

TRUE FALSE

#### Part 4 of 13

\*Beggiatoa\* can metabolise  $\text{H}_2\text{S}$  to elemental sulphur (S).  $4\text{H}_2\text{S} + \text{NO}_3^- + 2\text{H}^+ \rightarrow 4\text{S} + \text{NH}_4^+ + 3\text{H}_2\text{O}$

#### Part 5 of 13

If the bacteria metabolise 2836 molecules of  $\text{H}_2\text{S}$ , how many molecules of sulphur do they make? \*Type a number\*

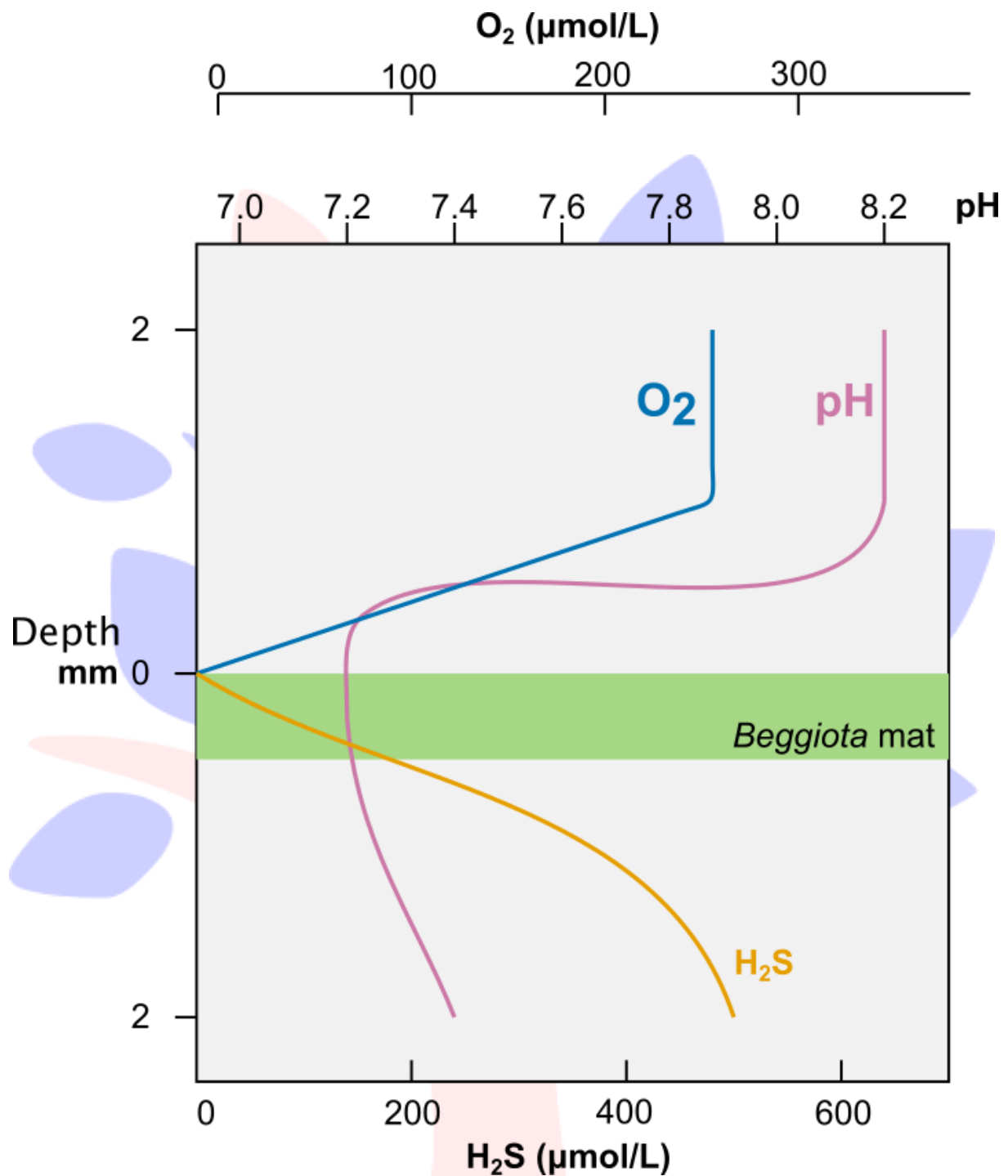
**1 mark**

Write something below

-----

#### Part 6 of 13

You take interest in the local \*Beggiatoa\* patch and take samples at different depths above and below the bacterial mat. You measure the oxygen content, pH and amount of  $\text{H}_2\text{S}$  in each sample.



#### Part 7 of 13

You want to grow these bacteria in a test tube, but also recreate the mud environment as closely as possible.

#### Part 8 of 13

What pH should your test tube have?

**1 mark**

Choose **ONE**

a) 7.0

- b) 7.2
- c) 7.4
- d) 7.8
- e) 8.2

### Part 9 of 13

#### 3 marks

Mark the following as *TRUE* or *FALSE*

a) There should be equal amounts of  $\text{H}_2\text{S}$  and  $\text{O}_2$  in your tube

TRUE FALSE

b) The mud in your tube should be left undisturbed (not stirred)

TRUE FALSE

c) The bacteria in your tube consume  $\text{O}_2$  if it is available

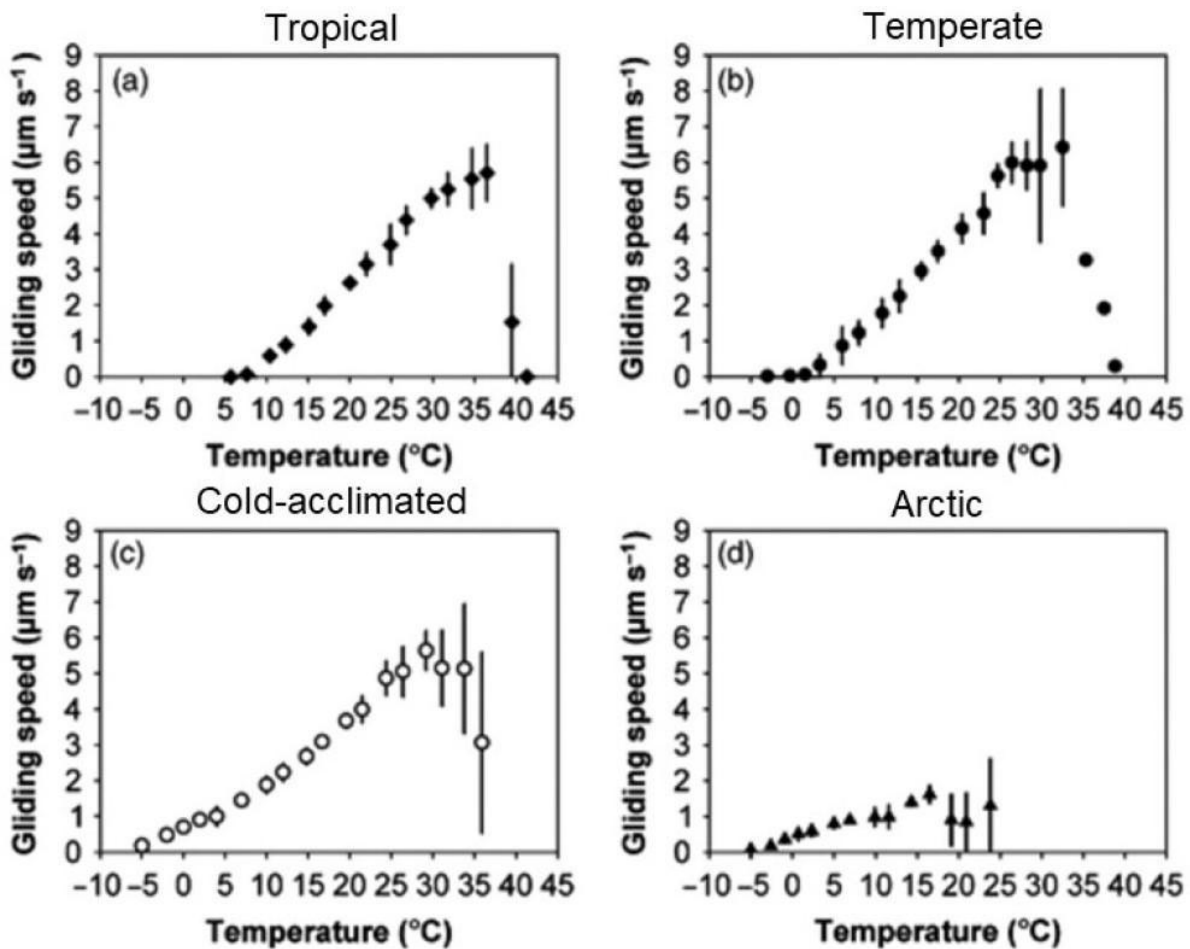
TRUE FALSE

### Part 10 of 13

You notice that your \*Beggiatoa\* move and glide and their movement speed changes with temperature.

### Part 11 of 13

You collect \*Beggiatoa\* from Mexico, Denmark and Greenland, which are tropical, cold-acclimated and arctic strains, respectively. You measure the gliding speed of each strain while slowly heating them from  $-10^\circ\text{C}$  to  $45^\circ\text{C}$ .



<https://academic.oup.com/femsec/article/73/2/234/541568>

### Part 12 of 13

After cooling down filaments heated 45°C, they still did not move.

### Part 13 of 13

#### 4 marks

Mark the following as TRUE or FALSE

a) The bacteria do not move below  $-10^{\circ}\text{C}$

TRUE FALSE

b) The decrease in gliding speed at  $45^{\circ}\text{C}$  is due to heat damage

TRUE FALSE

c) The optimum temperature for the temperate strain is  $35^{\circ}\text{C}$

TRUE FALSE

d) Cold-acclimated bacteria cannot withstand the water around them being frozen

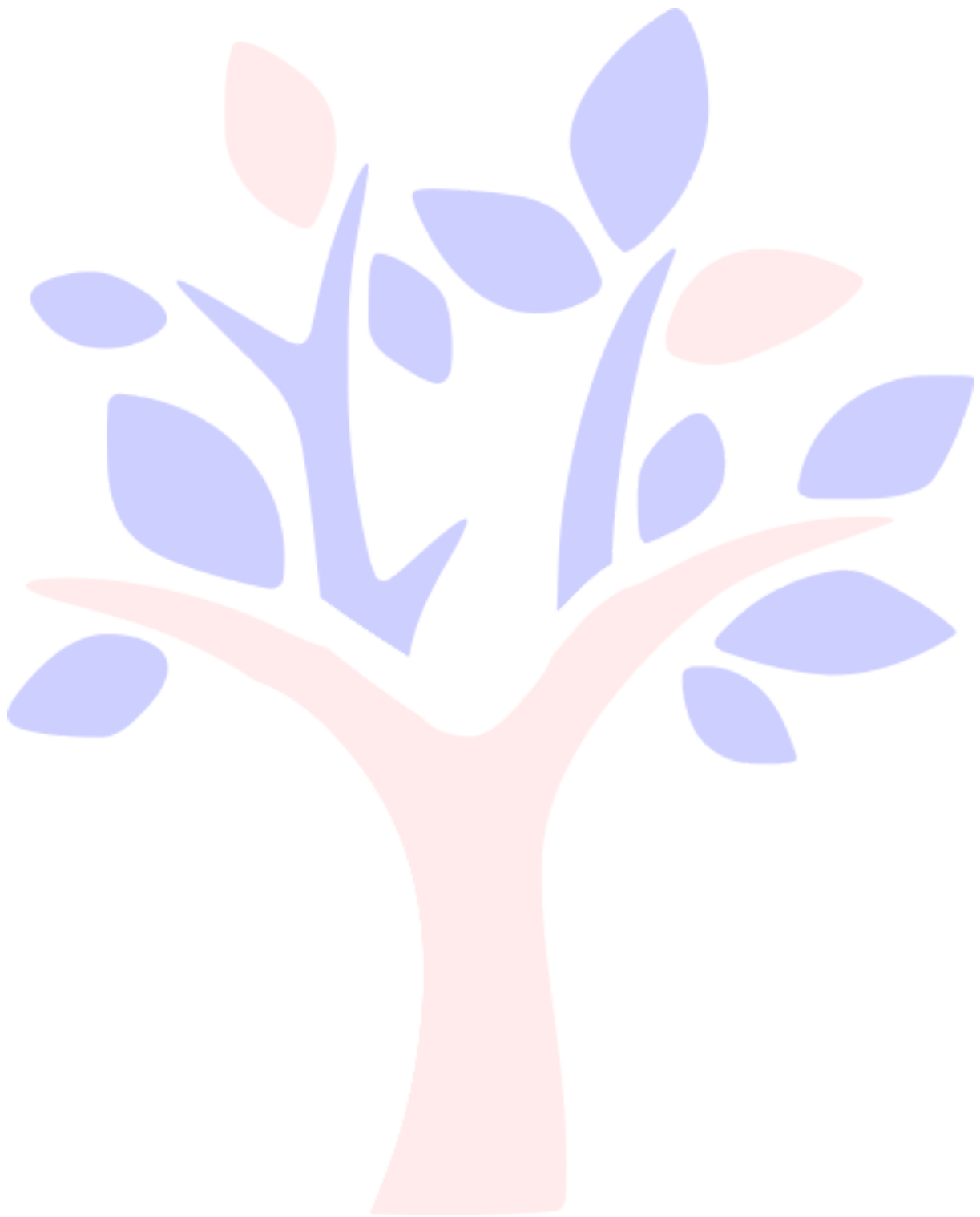
TRUE FALSE

e) \*Beggiatoa\* from different locations have adapted to the temperature of their ecological niche

TRUE FALSE

f) You'll find it easier to identify where an unknown strain is from if you grow it at  $10^{\circ}\text{C}$  compared to  $30^{\circ}\text{C}$

TRUE FALSE



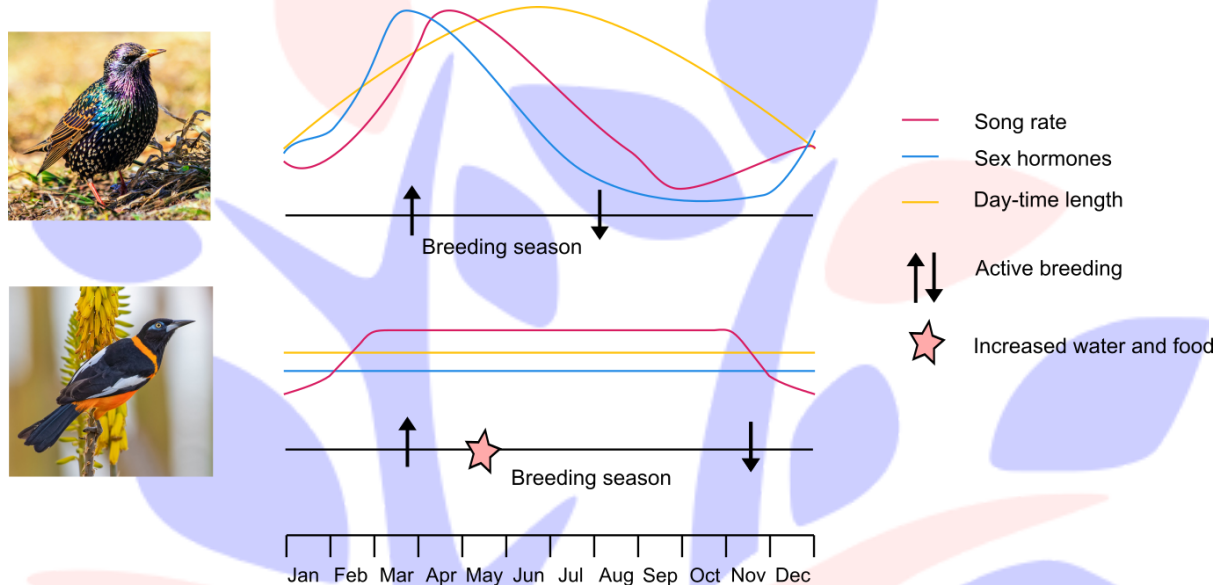
## Question 9

### Part 1 of 6

Not all birds sing at the same time. Hormonal changes, weather and resources can affect when they sing.

### Part 2 of 6

The song rate of the European starling (top, temperate climate) and Venezuelan troupial (bottom, tropical climate) were measured throughout the year.



### Part 3 of 6

4 marks

Mark the following as TRUE or FALSE

a) The breeding season of the troupial lasts longer than the starling's

TRUE FALSE

b) Sex hormone levels probably cause changes in the song rate of starlings

TRUE FALSE

c) Day-time length does **\*\*not\*\*** change with season in tropical climates

TRUE FALSE

d) Day-time length probably causes changes in song rate in troupials

TRUE FALSE

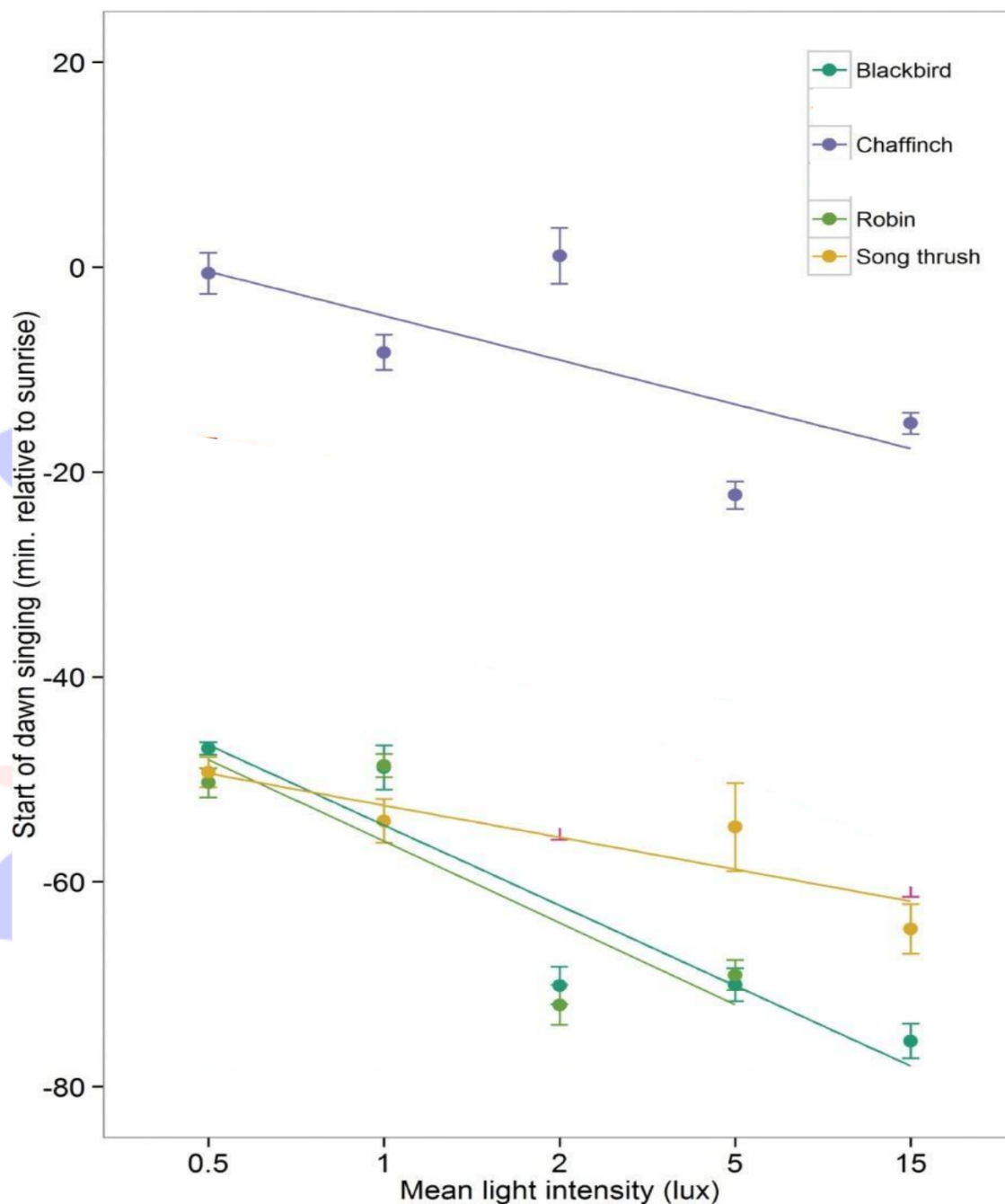
e) Starlings have a higher song rate than troupials in July

TRUE FALSE

### Part 4 of 6

The intensity of light also has an impact on the start of morning bird song.





#### Part 5 of 6

\* On the y axis, the more negative the value is, the earlier the start of the bird song is, compared to sunrise.\* On the x axis, light intensity is measured in lux.

#### Part 6 of 6

##### 4 marks

Mark the following as TRUE or FALSE

a) Robins start singing earlier in the morning than chaffinches

TRUE FALSE

b) Increased light intensity makes song thrushes start singing noticeably earlier

TRUE FALSE

c) Increased light intensity makes robins start singing noticeably earlier

TRUE FALSE

d) If robins and song thrushes start singing at the same time, the light intensity is probably 0.5-1 lux

TRUE FALSE

e) The time chaffinches start singing is less affected by weather than the time robins start singing

TRUE FALSE



