Model Answers: Medium

1a

a) The actual length of a palisade mesophyll cell is...

- 20 000 ÷ 250; [1 mark]
- 80 µm; [1 mark]

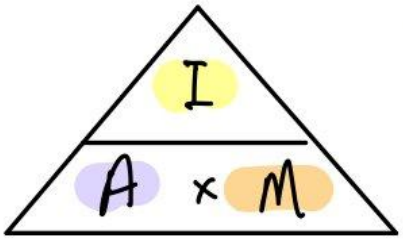
Full marks can be awarded for the correct answer in the absence of other calculations.

[Total: 2 marks]

Remember to convert the measurements into appropriate units; this can be done before the calculation or after, but it is good practice to get into the habit of doing it beforehand to avoid forgetting afterwards!

Once you have done a calculation of this nature it is always worth asking yourself whether the answer you have come out with sounds right; given that we know that plant cells can range in size from around 10 - 100 µm, a size of 80 µm sounds about right, but if you had come out with 8 or 800 then you could assume that you had gone wrong somewhere and go back to check your numbers.

The equation for calculating magnification is



I = Image size
A = Actual size
M = Magnification

Work out which equation is needed:

The Q asks for actual size of a cell → $A = I \div M$

Work out which numbers you need:

$I = 2\,cm = 20\,mm = 20\,000\,\mu m$

appropriate units for cell size

A palisade cell is labelled as 2cm in length

mm x 1000 = μm

$M = \times 250$ — The Q tells us this

Substitute numbers into the equation:

$A = 20\,000 \div 250$ [1 mark]

$= 80\,\mu m$ [1 mark]

b) Structures **P**, **Q**, and **R** are...

- **P** = xylem; [1 mark]
- **Q** = phloem; [1 mark]
- **R** = guard cell; [1 mark]

[Total: 3 marks]

1c

c) i) Features of structure **R** that assist with function include...

Any **two** of the following:

- Thick cell walls facing (the air and) the stoma **and** thin cell walls facing surrounding (epidermal) cells; [1 mark]
- Bands of cellulose microfibrils surrounding the cell; [1 mark]
- Cell walls have no plasmodesmata; [1 mark]
- Cell surface membrane is folded; [1 mark]
- Cell surface membrane contains many channel/carrier proteins; [1 mark]
- Cytoplasm has a high density of/many chloroplasts; [1 mark]
- Cytoplasm has a high density of/many mitochondria / mitochondria have many cristae; [1 mark]
- Several small vacuoles (rather than one large vacuole); [1 mark]

c) ii) The benefits of these features could be...

Any **relevant two** of the following:

- (Differences in cell wall thickness) allow the guard cell to expand/swell outwards in one direction / without blocking the stomata; [1 mark]
- (Cellulose microfibrils) provide the cell wall with strength (to prevent bursting when pressure increases) / allow the guard cells to increase in length but not in width; [1 mark]
- (Lack of plasmodesmata) increases the control over substances leaving and entering the cell; [1 mark]
- (Folded membrane) increases surface area for transport/channel/carrier proteins; [1 mark]
- (Channel/carrier proteins) allow guard cells to adjust their water potential / transport solutes/named solutes into and out of the cell; [1 mark]
- (High density of chloroplasts) allows increased production of ATP during chemiosmosis / production of glucose for respiration; [1 mark]
- (High density of mitochondria / many cristae) allows increased production of ATP / release of energy for active transport; [1 mark]

- (Several small vacuoles) increases the ability/flexibility of the guard cell to increase/decrease in volume / allows the guard cell to take on more water **OR** the small vacuoles fuse to make one large vacuole during guard cell opening and separate into small vacuoles when stomata are closed; [1 mark]

Reject *references to production/creation of energy.*

[Total: 4 marks]

Note that it needs to be possible to make a logical suggestion as to the **benefit** of the given guard cell features. Other features may have been observed (e.g. guard cells have few grana), but if these features don't have an obvious adaptive value then marks will not be awarded.

1d

d) The role of stomata in plant homeostasis is...

- (Stomata) control the diffusion of carbon dioxide into the leaf / control the concentration of carbon dioxide present inside the leaf; [1 mark]

[Total: 1 mark]

2a

a) Two features that help to identify the cells in Fig.1 as guard cells are...

Any **two** of the following:

- The cell walls are thicker between the cells / around the pore than around the outer edge; [1 mark]
- There are several/multiple vacuoles; [1 mark]
- There are several/many/multiple / a high density of chloroplasts; [1 mark]

[Total: 2 marks]

2b

b) The environmental conditions could be...

Any **three** of the following:

- Dark; [1 mark]
- Hot / high temperatures; [1 mark]
- Dry / water stress; [1 mark]
- Low humidity; [1 mark]
- High carbon dioxide concentration; [1 mark]

[Total: 3 marks]

The guard cells in Fig.1 are almost completely closed, so you should consider environmental conditions that will cause stomatal closure.

2c

c) The size of the stomatal pore in Fig. 1 could be increased by...

Any **five** of the following:

- Active transport of / ATP is used to transport hydrogen ions/protons/H^+ out of the guard cell (via a proton pump); [1 mark]
- The inside of the guard cell becomes negative in comparison to the outside; [1 mark]
- Potassium/K^+ channels open **and** potassium ions diffuse into cell; [1 mark]
- (Potassium ions cause) water potential of cells to fall/decrease; [1 mark]
- Water moves into guard cells by osmosis; [1 mark]
- Guard cells swell / volume of guard cells increases / guard cells become turgid; [1 mark]
- Thicker inner walls / bands of cellulose/microfibrils cause cells to bend/curve; [1 mark]

[Total: 5 marks]

3a

(a) The conditions in which abscisic acid (ABA) plays a role in plant physiology are...

- Reduced water availability; [1 mark]
- High temperatures e.g. a heatwave; [1 mark]

[Total: 2 marks]

If you know the topic well, resist the temptation to launch into a detail mechanism of how ABA causes stomatal closure; the command word is 'state' which only requires two brief statements. Any elaboration you write will be a waste of time as it won't earn you any extra marks.

3b

(b) The two inorganic ions that play a role in the action of abscisic acid in leaf function are...

- Calcium/Ca^{2+} **AND** potassium/K^+; [1 mark]

Roles:

- Calcium ions move into the guard cell cytoplasm and cause other ion channel proteins to open; [1 mark]

- Potassium ions diffuse out of the guard cell cytoplasm, increasing its water potential (so water follows and the guard cell becomes flaccid and closes); [1 mark]

[Total: 3 marks]

3c

(c) An estimate of how many stomatal guard cells this leaf will have on its lower surface is calculated as follows:

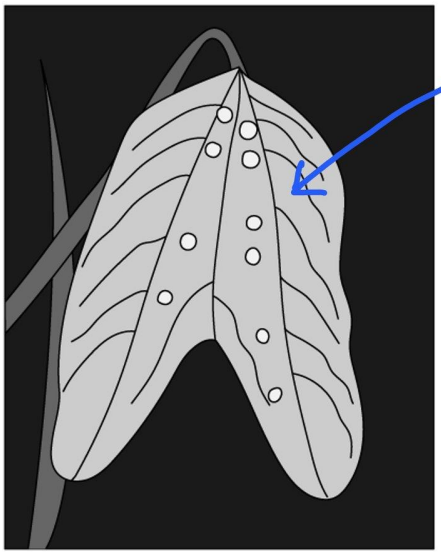
- 112 stomata per mm^2 = 112 × 100 = 11 200 per cm^2; [1 mark]
- 11 200 per cm^2 × 10.5 = 117 600 stomata; [1 mark]
- 117 600 × 2 = 235 200 guard cells per leaf lower surface; [1 mark]

[Total: 3 marks]

A leaf has a surface area of $10.5cm^2$ on its lower side.

Stomata are found at a density of 112 per mm^2 in the species of leaf in question.

Calculate an estimate of how many stomatal guard cells this leaf will have on its lower surface.



Area $10.5\,cm^2$

$1\,cm^2$ is made up of
$10mm \times 10mm$
$= 100\,mm^2$

Leaf area in mm^2 is
Therefore
$10.5 \times 100 = 1050\,mm^2$
[1 mark]

Step 2: stomatal density = $112 / mm^2$

Number of stomata on the underside of the leaf $= 1050 \times 112$

$= 117600$
[1 mark]

There are 2 guard cells surrounding each stoma, so

Number of guard cells $= 117600 \times 2$
$= 235200$ [1 mark]

[Total: 3 marks]

(d) A a role for the chloroplasts found in guard cells on the underside of leaves is...

- As photoreceptors / light receptors / to receive stimuli about lighting conditions; [1 mark]
- (In order to) initiate stomatal opening/closing mechanisms; [1 mark]

[Total: 2 marks]

The role of these chloroplasts is clearly not their usual photosynthetic role, given that the lower epidermis cells do not contain any chloroplasts, presumably because of insufficient light intensity underneath the leaves for photosynthesis to take place at an acceptable rate. As a light-sensing organelle, a chloroplast can absorb light which causes changes in the electronic structure of the various photosynthetic pigments. It is thought that these chloroplasts act as the receptors for light, the stimulus that initiates stomatal opening or closing at different times of the day / night.