Transport in plants

Model Answers 1

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Exchange and transport
Topic	Transport in plants
Booklet	Model Answers 1

Time allowed: **80 minutes**

Score: **/59**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

The downy birch tree, *Betula pubescens*, produces varying numbers of leaf hairs.

These hairs are between 200 μm and 500 μm long in response to different environmental conditions.

(a) State the **pattern** of variation shown by leaf hair density. **[1]**

Continuous variation

Continuous variation is controlled by several genes and does not fall into discrete categories, if plotted on a graph it would gibe a normal distribution and the results are quantitative

(b) Leaf hair density can be measured in the laboratory.

Outline a practical method that could be used to determine the density of hairs on the underside of a leaf.

[3]

- Use a microscope
- Use a graticule
- Calibrate the graticule using a stage micrometer
- Count the number of hairs in a given area using the graticule
- Repeat on different areas of the leaf
- Divide the number of hairs by the area
- Calculate a mean

On the face of it a tough question, however in any investigation there are usually marks for repeats and means, so they're always worth a shot. Give the examiner what they want too, in other words tell them how to work out the density, by dividing the number by the area. Using graticules etc may also be a low point in your biology, so if it still is then just do some name dropping. 'Eye piece graticules' and 'stage micrometers' get marks just for being mentioned!

(c) A group of students investigated the relationship between the distance of different trees from a river and the mean leaf hair density.

Table 25 shows the results of their investigation.

Distance from river (m)	Rank of distance	Mean leaf hair density (number mm^{-2})	Rank of hair density	Difference in ranks (d)	Difference squared (d^2)
9.1	4	33.1	2	2	4
13.7	1	34.8	1	0	0
5.5	7	11.3	7	0	0
0.3	10	3.4	10	0	0
5.4	8	27.3	4	4	16
11.5	3	30.3	3	0	0
1.7	9	6.3	8	1	1
6.0	6	22.9	6	0	0
11.9	2	5.7	9	(-)7	49
6.8	5	23.2	5	0	0

Table 25

(i) Complete Table 25 by calculating the difference between the ranks and then squaring the difference.

[Answer on Table 25] **[2]**

- Rank correct

  Squared correctly

It is quite straightforward to rank the mean leaf hair density - start with the greatest density and work sequentially (34.8 mm-2 is the highest and therefore number 1, followed by 33.1 which is number 2, and so on.

To find d, you simply take the rank of hair density from the rank of distance across each row. 9.1m from the river is ranked fourth, with the mean leaf density of 33.1mm-2 ranked second. d = 4 -2 = 2. You then square this value to find the difference squared.

Take your time with this type of question to avoid making a silly error.

(ii) Use the formula below to calculate Spearman's rank correlation coefficient for this data.

$$r_s = 1 - \frac{6Rd^2}{n(n^2 - 1)}$$ **[2]**

Rs = 0.576 or 0.58

(d) The students concluded that there is a positive correlation between distance of the tree from the river and mean leaf hair density.

(i) Suggest reasons for this positive correlation. **[2]**

- Further away from the river there is less water available
- Transpiration by the leaves causes water loss
- Hairs on the leaf trap water vapour and reduce transpiration
- Water vapour potential gradient is reduced from inside to outside the leaf

Hairs on the leaves trap pockets of water vapour known as diffusion shells, these reduce the diffusion gradient of water vapour out of the stomata. Adaptations like these are common in plants adapted to reducing water loss in other words, xerophytes

(ii) For this investigation, the students randomly selected leaves from ten downy birch trees at varying distances from the river.

Suggest **three** ways in which the students could improve the validity of their sampling method.

[3]

- Leaves should be from the same the size or age of trees
- Leaves should be the same the size or age
- Repeats from each tree and a mean calculated
- Leaves should be collected from the same part of each tree
- Samples should be collected systematically at regular intervals

The validity of an investigation is improved by taking control variables into account. In this case the source of the leaves which are sampled. Marks are given for repeats which makes results more reliable but in the context of this question it helps to improve validity

(e) Another group of students repeated this investigation and calculated r_s = 0.589. The critical value of r_s at the 5% level for 9 degrees of freedom is 0.600.

They concluded that their results showed a weak positive correlation between leaf hair density and distance of the tree from the river.

Evaluate the conclusion of this group of students. **[2]**

- The students conclusion is incorrect
- The student's hypothesis should be rejected
- There is no correlation between the two variables
- The difference seen is due to chance

In this case the result is less than the critical value so any difference is probably due to chance. In this case the null hypothesis is accepted.

[Total:15]

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Question 2

(a) A group of students wanted to observe the position of xylem vessels in the leaf stalks (petioles) of celery.

Describe a procedure they could use to do this. **[2]**

- They could stand the stalks in a dye
- Then cut it in cross/transverse section or
- Cut in cross section
- Then stain before putting under a microscope

(b) Water Starwort is a hydrophyte belonging to the genus *Callitriche*. It is an aquatic plant which has its stems fully submerged in water.

Cholla is a cactus belonging to the genus *Cylindropuntia*. It can grow over 4 metres tall.

In the space provided below, give **one** way in which you would expect the walls of the xylem vessels in the stems of Water Starwort and the walls of xylem vessels in the stems of Cholla, to differ from those of a herbaceous dicotyledonous plant growing in a deciduous woodland.

Water Starwort

Cholla

[2]

- Starwort has less lignin than woodland plants
- Cholla has more lignin than woodland plants

The aquatic plant is submerged in water so the pressure inside the xylem will not be very low. However, the cactus is over 4m tall so the pressure in its xylem will be very low so the xylem walls have to be much thicker to prevent collapse.

Remember the pressure in the xylem is LOW and below atmospheric

(c) Xylem and phloem are two vascular tissues found in plants.

State **one** similarity and **two** differences between the structure of xylem and phloem.

[3]

- Both are made up of tubes/cells joined end to end/both are made up of more than one cell type
- Xylem wide lumen, phloem narrow lumen
- Xylem no companion cells, phloem has companion cells
- Xylem has lignin, phloem no lignin
- Xylem no cross walls, phloem has sieve plates/cross walls
- Xylem has pits, phloem has no pits

[Total: 7]

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Question 3

The following statements summarise the results from experiments designed to discover more about the translocation of organic materials in the phloem.

A	Any increase in the sugar content of leaves is followed by a similar change in the sieve tube contents in the stem.
B	The rate of transport increases with increasing temperature, reaching a maximum at 25 °C before decreasing at higher temperatures.
C	Translocation stops when stems are treated with a substance that inhibits respiration.
D	Sugars can be transported both up and down the plant.
E	Aphids can be used to sample phloem sap.
F	Roots, young leaves and growing fruits will import sugars.

(a) State all the letters that provide evidence for the following conclusions: **[4]**

Translocation is an active process.

B and C

B suggests that enzymes are involved in respiration (temperature rise above 25°C), whilst C suggest that stopping respiration stops translocation, so it relies on energy

Sugars are translocated from source to sink.

A, D and F

A suggests that sucrose is produced in the leaves by photosynthesis and loaded into the phloem. D suggests mass flow in either direction. Roots and growing fruits are sinks because they use up sugars.

(b) Explain how mass flow of the phloem sap occurs in plants with a vascular system. **[3]**

- Sucrose accumulates in the sieve elements
- The build up of sucrose and assimilates lowers the water potential in the sieve tube
- Water enters the sieve tube by osmosis and raises the hydrostatic pressure
- At the sink, the sucrose and assimilates leave the phloem and raise the water potential
- Water leaves the sieve tubes by osmosis down the water potential gradient and the hydrostatic pressure goes down
- Assimilates move from source to sink along a hydrostatic pressure gradient

The term, assimilates, refers to all the products made by photosynthesis. Sucrose is the main assimilate along with amino acids.

[Total: 7]

CHEMISTRY ONLINE
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Question 4

Fig. 4.1 shows a potometer, a piece of apparatus used for estimating the rate of transpiration.

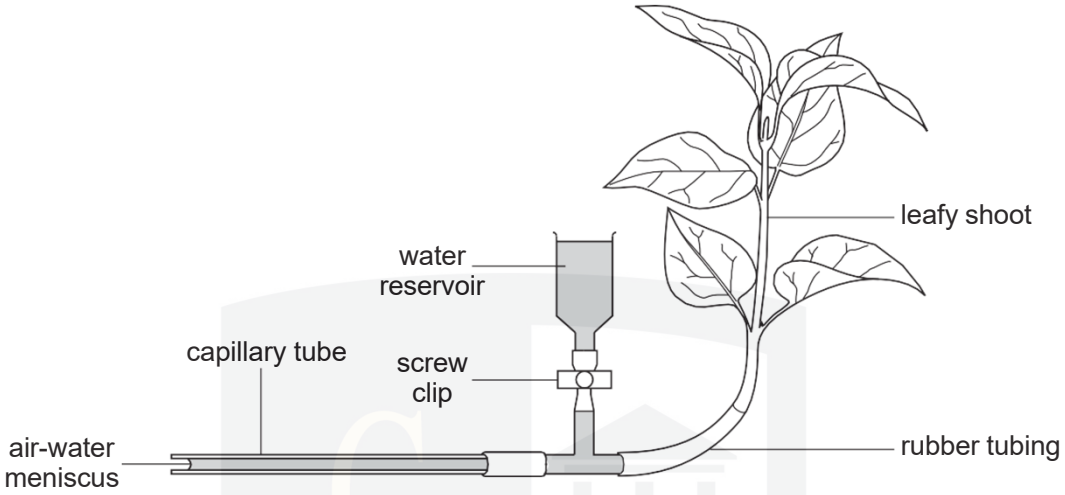


Fig. 4.1

(a) State **one** essential component of the apparatus, not shown in Fig. 4.1, that must be added before any results can be recorded.

[1]

An essential component of the apparatus that must be added is a:

- Timer
- Scale/ ruler

(b) Describe **three** steps a student should take when **setting up** the potometer to ensure that the apparatus works correctly.

[3]

Steps that should be taken when setting up a potometer are (any three from):

- Ensure that the shoot is healthy
- Assemble the apparatus under water
- Check the apparatus is water tight
- Check that there are no air bubbles in the apparatus
- Cut the stem at an angle
- The leaves are dry

A potometer measures the rate of water uptake into the stem of a plant (and thereby giving an idea of the rate of water loss by transpiration). In order for this to be as accurate as possible, a bubble needs to be created in the capillary tube (but only one!), for this to be seen. If water is leaking or there are air bubbles, this will make the results less accurate.

(c) A student used the apparatus shown in Fig. 4.1 to investigate how transpiration rates vary during the day. The student placed the potometer on a window ledge in the laboratory and estimated the rate of transpiration four times during the day.

The results are shown in Table 4.1.

Table 4.1

time of day	rate of transpiration (arbitrary units)			
	replicate 1	replicate 2	replicate 3	mean
10.00	32	29	31	30.7
12.00	37	35	38	36.7
14.00	23	26	25	24.7
16.00	25	27	24	

(i) Calculate the mean value for the rate of transpiration at 16.00 hours.

Give your answer to **one decimal place**. **[1]**

Add the values up: 25 + 27 + 24 = 76

Divide by 3 (total number of values): 76/3 = 25.3

- 25.3

(ii) Explain why, for each time of the day, the student carried out three replicates to calculate a mean. **[2]**

The student carried out replicates:

- to make their results more **reliable**
- to help identify **anomalies**

Replicates improve **reliability** (not accuracy) as it allows the variation in the data to be seen. The more replicates that are taken, the more likely the spread of data around the mean will be less, as anomalies can more easily be identified.

(iii) Suggest **two** possible reasons, other than light and temperature, why the rate of transpiration was **lower** in the afternoon than in the morning. **[2]**

Reasons why the rate of transpiration was lower in the afternoon than in the morning are:

- The plant may have been dying
- The stomata may have been closed
- The air was more humid (so there was a higher water potential in the air)
- There was less air movement

***Exam tip**: this is a 'suggest' question, so you will not have directly been taught why transpiration rates will be lower in the afternoon. However, you will have been taught what factors affect transpiration.*

(iv) Explain why the potometer only gives an **estimate** of the rate of transpiration. **[2]**

The potometer only gives an estimate of transpiration because:

- it measures water **uptake**
- but some water is used in **photosynthesis**
- so not all water taken up is lost in **transpiration**

[Total: 11]

Question 5

(a) Complete the following paragraph about the loss of water from plants. **[4]**

The loss of water from the aerial parts of a plant is known as .....transpiration..... .

The majority of water is lost from the leaves. Water is transported up the stem in the .....Xylem..... and passes into the mesophyll cells of the leaf by .....osmosis..... . Water evaporates from the surface of these cells. The water vapour diffuses out of the air spaces in the leaf through the .....stomata..... .

Transpiration – this is the process by which water moves through the plant and diffuses out of the stomata on the leaves

Xylem – this is the vessel which moves water from the roots to the leaves of the plant – not to be confused with the phloem which transports assimilates from the leaves to the rest of the plant

Osmosis – This is the movement of water molecules from a high concentration to a low concentration across a partially permeable membrane

Stomata – these are small pores on the leaves of plants through which gas exchange can occur

(b) (i) Explain why water loss from the leaves of a plant is unavoidable. **[2]**

Water loss is unavoidable as:

- all leaves have **stomata** which open to allow **gaseous exchange**
- for **photosynthesis**
- which is essential for the plant to make **sugars**
- some water is also lost via the **cuticle**

(ii) Name the **type** of plant adapted to reduce water loss from its leaves. **[1]**

The type of plant adapted to reduce water loss is called a:

- **Xerophyte**

These are plants adapted to environments where water is very scarce and so have many features which reduce water loss.

(iii) State **and** explain **two** adaptations of leaves that reduce evaporation.

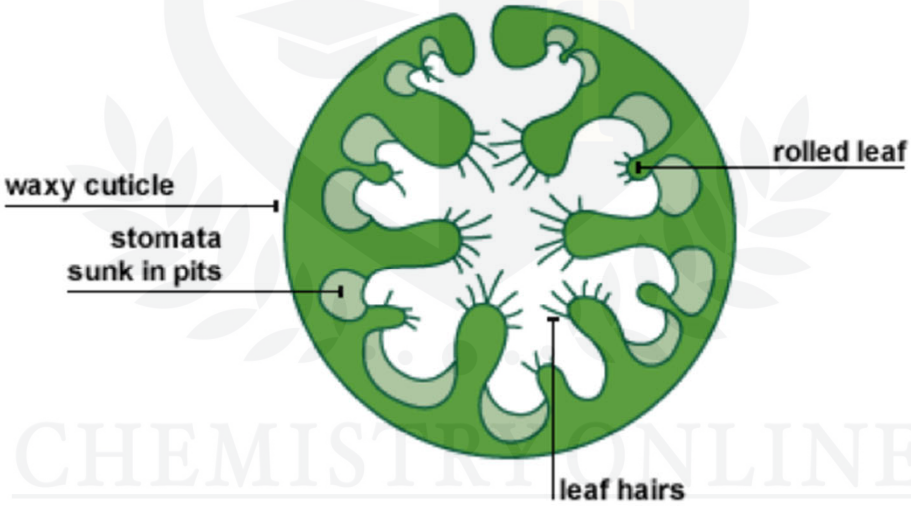
In your answer, you should use appropriate technical terms, spelt correctly. **[5]**

- hairy leaves
  - trap **water vapour**
- stomata found in pits
  - pits trap **water vapour**
- leaves are rolled
  - reduces the **surface area**
- high solute concentration in cells
  - reduces the water **potential** inside leaf cells
- thick **cuticle**
  - which is waterproof
- small, **needle**-like leaves
  - smaller **surface area**
- fewer stomata
  - reduces **diffusion** of **water vapour**

- stomata close during the day
    - reduces **diffusion** of **water vapour**
- most stomata on lower surface
    - less exposure to sun and therefore cooler
- more densely packed spongy mesophyll
    - smaller surface area for evaporation

***Exam tip**: make sure you use your key words, shown here in bold, to gain your QWC mark.*

Diagram to show how marram grass (an example of a xerophyte) is adapted to reduce water loss:



[Total: 12]

Question 6

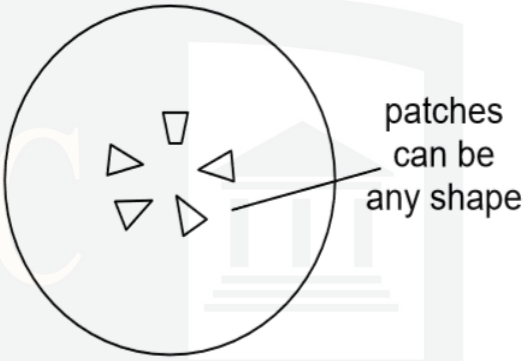
Translocation is the movement of the products of photosynthesis within a plant.

Translocation occurs in the phloem and involves sources and sinks.

(a) Using the outline below, draw in the position of the phloem in the root of a dicotyledonous plant.

[1]

root



The position of the phloem in the root of a dicotyledonous plant can be seen:

In dicotyledonous plants, the vascular tissue can be found in the centre.

(b) Research using carbon dioxide containing a radioactive label, C^{14}, has revealed the following evidence about the mechanism of translocation:

A. labelled carbon can be observed in the phloem soon after being supplied to a well-lit plant;

B. the rate of movement of sugars in the phloem is many times faster than could be achieved by diffusion alone.

Different research has revealed that:

C. an insect such as an aphid feeds by inserting its proboscis (mouth parts) into the phloem;

D. the pH of the phloem companion cells is lower than surrounding cells;

E. the phloem companion cells contain many mitochondria.

Using the letters **A**, **B**, **C**, **D** and **E**, select **two** pieces of evidence from the list above which support the theory that translocation occurs in the phloem.

[2]

Evidence that translocation occurs in the phloem:

- A / labelled carbon can be observed in the phloem soon after being supplied to the plant
- B / the rate of flow of sugars in the phloem is higher than diffusion
- C / an insect such as an aphid feeds by inserting its proboscis (mouth parts) into the phloem

A is evidence as translocation is the movement of assimilates (carbon containing)

B is evidence that it occurs in the phloem as translocation uses active transport to move sugars, so does not rely on concentration gradients for movement, as diffusion does. In the phloem, assimilates also travel down pressure gradients.

C is also evidence, as aphids require sugar for feeding, which can be found in the phloem.

D (the pH of the phloem companion cells is lower than surrounding cells) does not alone serve as evidence for translocation in the phloem.

E (the phloem companion cells contain many mitochondria), again, supports the theory that these cells are active, but does not alone act as evidence for translocation in the phloem.

(c) State what is meant by the terms *source* and *sink*. **[2]**

- Source-Place where sugars are loaded into the phloem
- Sink-Place where sugars are unloaded from the phloem

(d) When the bark is removed from a tree, the phloem is also removed. If a complete ring of bark is removed, the tree trunk can be seen to swell above the cut.

Suggest **two** reasons why the trunk swells above the cut. **[2]**

The trunk swells above the cut because (any two of):

- sugars cannot pass the cut
- this decreases the water potential
- causing water to move into cells
- this damage triggers increased cell division
- to produce cells to store sugars
- The cut also causes infection

***Exam tip**: this is a 'suggest' question. This means you will not have been taught this content directly, but will need to use the information that you have been taught and apply this knowledge to the question.*

[Total: 7]