25. Xylem forms part of a plant's transport system.

Explain why large multicellular plants need a transport system.

--- **[3]**

26(a). Fig. 3.1 shows a bubble alga, *Valonia ventricosa*, which is one of the largest unicellular organisms in the world.

Fig. 3.1

Calculate the surface area to volume ratio of a bubble alga that has a diameter of 2.5 cm.

Assume the bubble alga is spherical. Show your working.

Answer = ………………………………………………………… **[3]**

(b). Multicellular organisms, such as plants, have evolved internal transport systems.

i. Explain the benefit to plants of internal transport systems.

____

____

____

____ **[2]**

ii. The transport systems of plants contain cells that are specialised to perform a particular function.

The table below shows information about three types of specialised plant cell. Three boxes have been completed already.

Complete the rest of the table by placing the correct responses in the empty boxes.

Cell	Location	Example of a substance transported	Contains chloroplasts? (✓ or ✗)
Guard cell		carbon dioxide	
Companion cell			✗
Root hair cell	roots		

[3]

27. *Heliamphora*, shown in Fig. 18.1, is a genus of carnivorous plant. Its leaves are adapted to form water-filled traps for insects. The insects are attracted by nectar, then fall into the traps and drown. The plants digest the insects and absorb the mineral ions produced. This allows *Heliamphora* to survive in soils with low mineral content.

Fig. 18.1

Fig 18.2 shows a transverse section of part of a *Heliamphora* stem, with three tissues labelled.

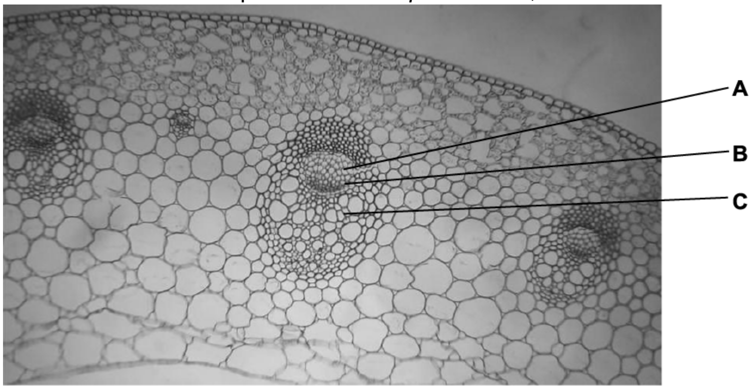


Fig. 18.2

i. Identify the tissues labelled by the following letters:

A ____

C ____

[2]

ii. The tissue labelled **B** is cambium.

What type of cell makes up this tissue?

____ **[1]**

28. This question is about the impact of potentially harmful chemicals and microorganisms.

i. Salts that a plant needs, such as nitrates and phosphates, are taken into root hair cells by active transport.

For which macromolecule does a plant need both nitrogen **and** phosphorus?

____ **[1]**

ii. Flooding of fields by seawater can damage crops. Seawater contains dissolved salts, including sodium chloride.

How would flooding affect soil water potential?

____ **[1]**

iii. Sodium chloride in solution dissociates into Na^+ and Cl^-.

Explain how the Casparian strip prevents these ions from reaching the xylem of the plant by the apoplast pathway.

____

____

____

____ **[2]**

29.

i. Soluble mineral ions are present in soil.

Explain why water molecules can form hydrogen bonds with nitrate (NO_3^-) ions.

--- **[2]**

ii. Fig. 18 shows a process that occurs in the cell surface membrane of the endodermis in the root.

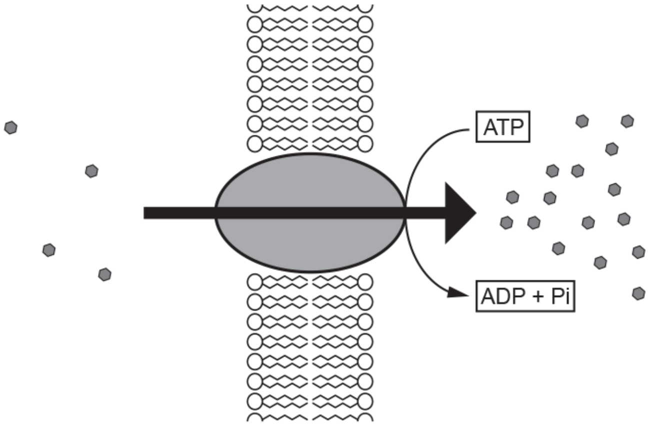


Fig. 18

Explain how the events shown in Fig. 18 cause water to enter the endodermis.

--- **[2]**

30. Fig. 1 shows a cross section of the root of an onion plant.

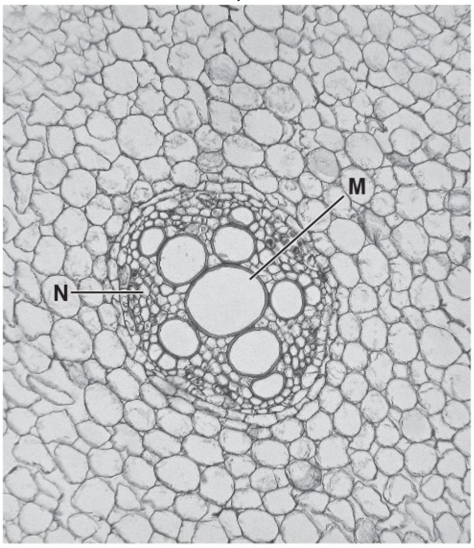


Fig.1

Identify the **tissues** shown at **M** and **N**.

M --

N --

[2]

31(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]**

(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]**

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

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

Similarity 1

____

____

____

Difference 1

____

____

____

Difference 2

____

____

____ **[3]**

32. Plants need water to survive.

Fig. 24 is a section through xylem tissue from a **stem** of a dicotyledonous plant.

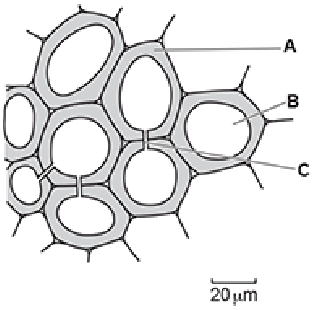


Fig. 24

i. Identify **A**, **B** and **C** on Fig. 24.

A ....

B ....

C ....

[3]

ii. Some plants, such as mosses, do not have xylem. Mosses are small plants that rarely grow more than a few cm in height.

Suggest why mosses do not need structures such as roots or xylem to survive.

____

____

____ **[1]**

33. Fig. 22.1 shows a transverse section of the stem of a typical pondweed viewed using a × 10 objective lens. Part of a graticule is shown below the stem. The markings on the graticule are 0.1 mm apart.

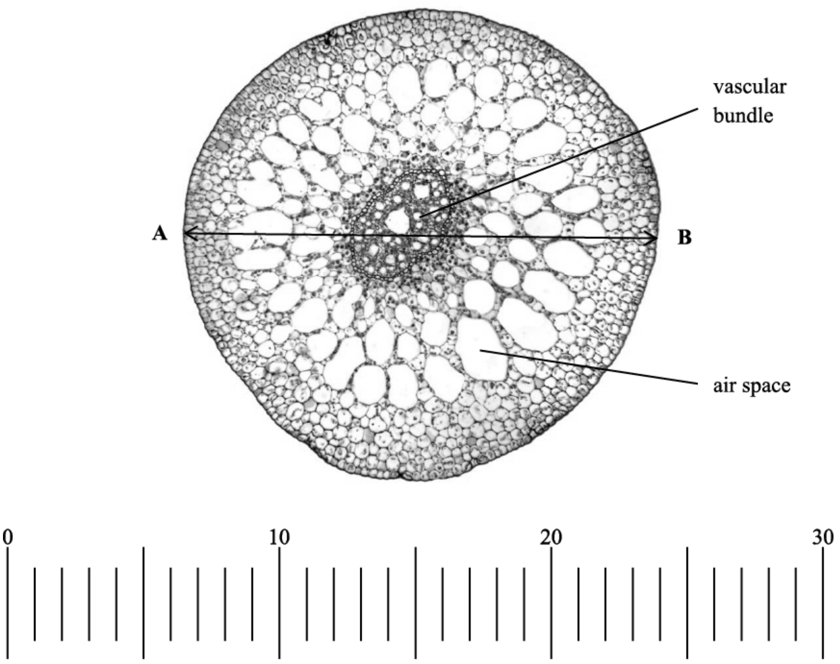


Fig. 22.1

A student was asked to view cells from the phloem in transverse section using a high power objective lens. **Fig. 22.2** shows two diagrams of phloem tissue.

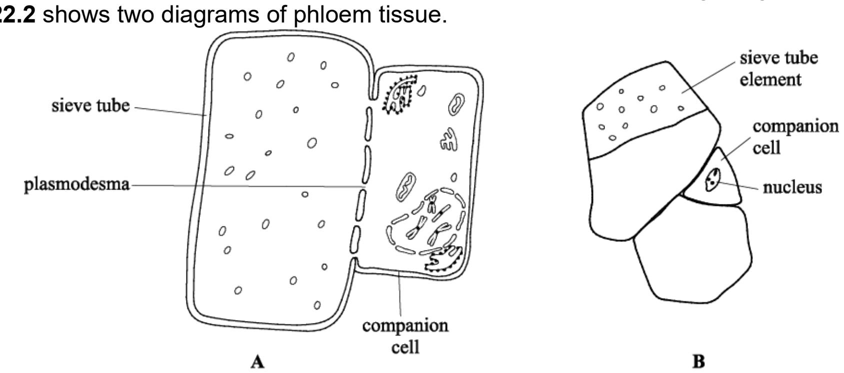


Fig. 22.2

i. Which diagram is the more accurate representation of what the student could see? Justify your decision using **two** separate features of the diagrams.

____

____

____

____ **[2]**

ii. State what is meant by the *resolution* of a microscope.

____

____ **[1]**

iii. The slide viewed to draw the diagrams in **Fig. 22.2** had been stained.

Table 22.1 shows a list of stains and the cell feature that can be stained.

Stain	Cell feature stained
Nile blue	nuclei
eosin	cytoplasm
Sudan red	cell membrane
iodine	starch

Table 22.1

Which stain had the student used? Explain your answer.

____

____

____

____ **[2]**

34. Xylem vessel elements are produced from non-xylem cells in meristematic tissue.

Fig. 23.1 shows an electronmicrograph of xylem tissue.

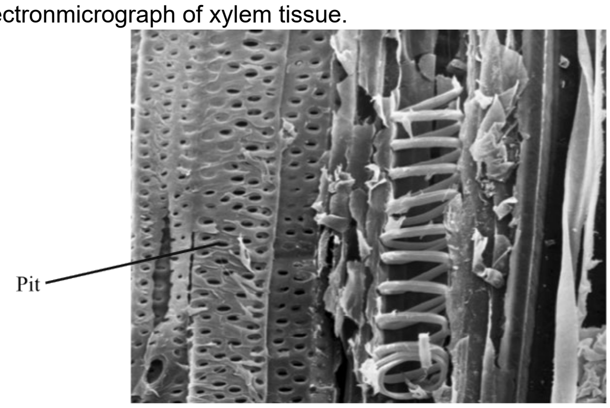
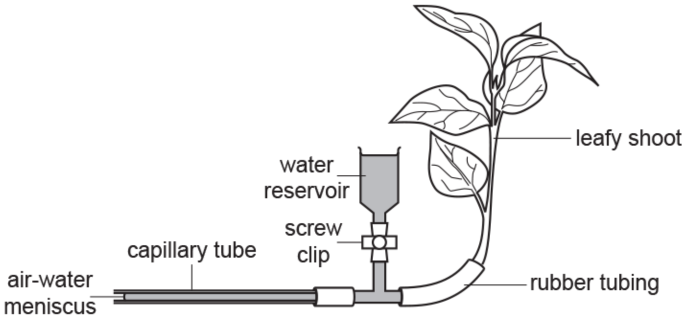


Fig. 23.1

State the function of the pits in xylem tissue.

____ **[1]**

35(a). The figure shows a potometer used to measure the rate of transpiration in a leafy shoot.



Besides safety precautions, explain **one** practical precaution that should be taken when using a potometer.

Precaution ____

Explanation ____

____

____

[2]

(b). A student carried out an investigation to measure the effect of air movement on the rate of transpiration.

The student used the apparatus shown in the figure, adding an electric fan to create air movement. They measured the distance travelled by the air-water meniscus in 5 minutes.

This was replicated five times with the fan switched off and then five times with the fan switched on.

The results are shown in the table.

Replicate number	**Distance travelled by meniscus in 5 minutes (mm)**	
	fan switched off	**fan switched on**
1	87	128
2	89	124
3	91	125
4	98	123
5	99	128
Mean	92.8	125.6
Standard deviation	5.40	

i. Calculate the standard deviation for the distance travelled when the fan was switched on.

$$s = \sqrt{\frac{\Sigma(x - \overline{x})^2}{n - 1}}$$

Use the formula:

Give your answer to **2** significant figures.

Standard deviation = ... **[2]**

ii. What can you conclude from comparing the standard deviations of the two means?

--- **[1]**

(c). The student carried out another investigation to estimate the total leaf surface area of a shoot.

i. The student wanted to estimate the total leaf surface area of the shoot.

At the end of the investigation they removed all the leaves from the shoot.

They placed the leaves on graph paper and then counted squares to obtain an estimate of leaf area.

State **two** things the student would have to do to ensure that the estimate of leaf area was accurate.

1 ---

---

2 ---

---

[2]

ii. In this investigation, the student calculated the rate of transpiration to be 30 $mm^3\ min^{-1}$.

They estimated the total leaf surface area of the shoot to be 37 cm^2.

Calculate the rate of transpiration in $cm^3\ hr^{-1}\ cm^{-2}$.

Give your answer in standard form to **2** significant figures.

Rate = ... $cm^3\ hr^{-1}\ cm^{-2}$ **[2]**

36. * Plants lose water by transpiration.

The rate of transpiration varies between different species of plant.

The rate of transpiration can be measured using a potometer.

Plan an investigation into the rate of transpiration in two species of plant that would allow valid data to be collected.

Details of how to set up a potometer are not required.

____

____

____

____

____

____

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____

____

____

____

____ **[6]**

37(a). A student was comparing transpiration rates in tomato leaves and watermelon leaves. They selected eight separate leaves on different tomato plants and sealed a plastic bag over each leaf. They repeated this process for the watermelon plants. The plastic bags were left for six hours then they used a syringe to collect any water inside the plastic bag. The volume of water was recorded.

An example of their method can be seen in Fig. 24.1.

Fig. 24.1

Identify **two** problems with this method and **for each** problem suggest how the method can be improved.

1 ____

____

____

____

2 ____

____

____

____

[4]

(b). The results of the experiment are shown in Fig. 24.2.

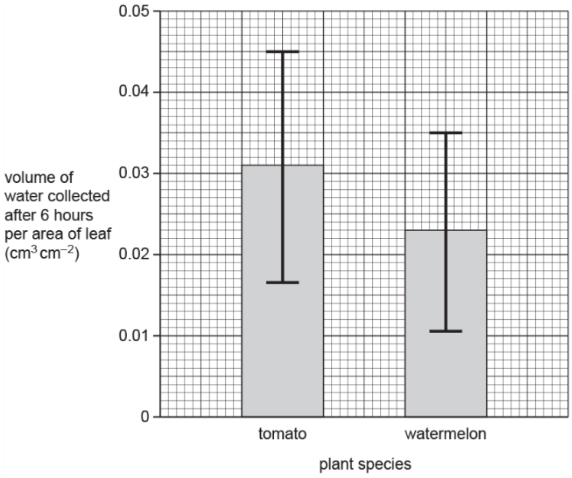


Fig. 24.2

What conclusion can be drawn from this graph? Justify your answer.

____

____

____

____

____ **[2]**

(c). Describe how a potometer can be used to calculate a more accurate rate of transpiration.

___

___

___

___

___

___

___

___ **[4]**

38(a). 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 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			
13.7	1	34.8			
5.5	7	11.3			
0.3	10	3.4			
5.4	8	27.3			
11.5	3	30.3			
1.7	9	6.3			
6.0	6	22.9			
11.9	2	5.7			
6.8	5	23.2			

Table 25

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

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

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

$$r_s = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$$

[2]

(b). 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]**

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.

1 ____

____

2 ____

____

3 ____

____

[3]

(c). 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.

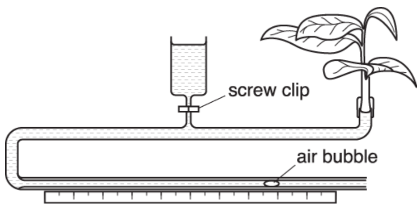
Evaluate the conclusion of this group of students.

____

____

____ **[2]**

39. A diagram of a potometer is shown below.



Which of the following options, **A** to **D**, is a precaution that is **not** needed when setting up a potometer?

A. Remove excess water from the surface of the leaves before readings are taken.
B. The screw clip must be opened while taking the readings.
C. The shoot should be cut whilst under water.
D. There should be no extra air bubbles.

Your answer [ ] **[1]**

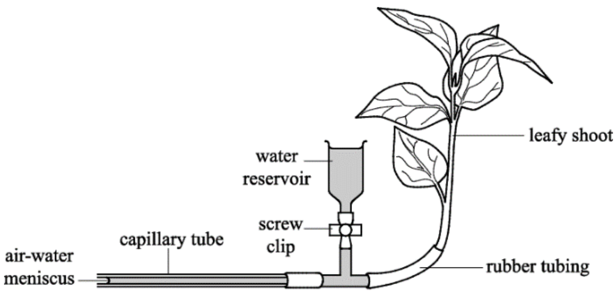


Fig. 25.1

40. Fig. 25.1 shows a potometer.

a. A student used this apparatus to investigate the role of stomata in transpiration. The student noted the position of the air-water meniscus each minute for five minutes.

The student then covered the underside of one of the leaves in petroleum jelly before repeating the measurements. This was continued until the undersides of all the leaves had been covered.

Table 25.1 shows the results.

Number of leaves with undersides covered in petroleum jelly	Position of meniscus (mm) at					
	0 min	**1 min**	**2 min**	**3 min**	**4 min**	**5 min**
0	0	23	44	65	84	102
1	0	20	40	58	77	95
2	0	16	31	47	61	76
3	0	11	23	37	50	62
4	0	9	17	24	32	40
5	0	6	11	16	22	28

Table 25.1

The student presented these results as a graph. **Fig. 25.2** shows the graph.

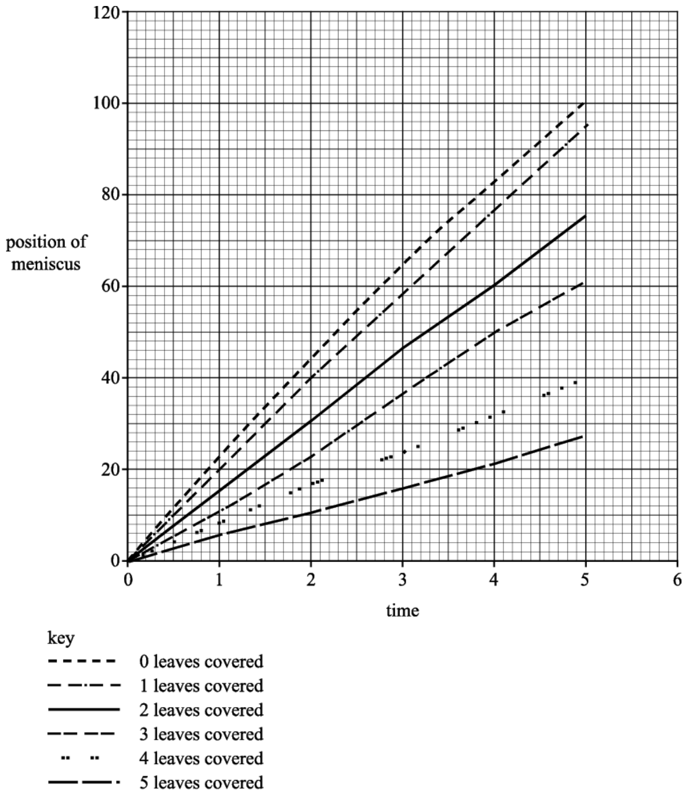


Fig. 25.2

i. State two different types of information the student has missed from the graph.

____

____ **[2]**

ii. Use the graph to calculate the minimum rate of transpiration.

Show your working.

Answer ....mm min^{-1} **[2]**

b. Suggest how water is being lost from the cut stem when all the leaves have been treated with petroleum jelly.

____

____ **[2]**

c. Suggest **two** possible sources of error in this investigation.

____

____ **[2]**

41. Name **and** describe **two** pathways that water takes to reach the xylem vessels at the base of the stem.

____

____

____

____

____

____

____ **[2]**

42(a). The student wanted to compare the rates of transpiration of the two leafy shoots shown in Fig. 4.3.

Fig. 4.3

Describe how the student could ensure that a valid comparison could be made between the two leafy shoots.

____

____

____

____

____ **[2]**

(b). An investigation was carried out into the loss of water from a leafy shoot. The apparatus used is shown in Fig. 4.1.

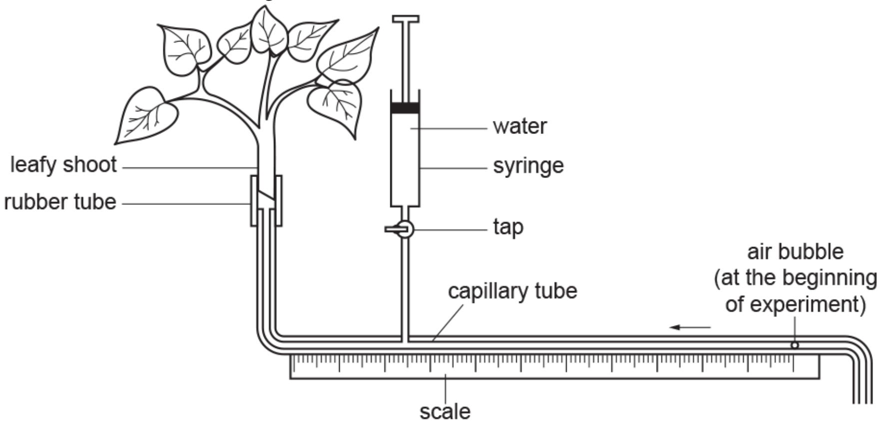


Fig. 4.1

A student obtained replicate readings for the movement of the air bubble during five minutes in three different conditions. The results are shown in Table 4.1.

Condition	Distance moved by bubble in 5 minutes (mm)						
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Trial 6**	**Mean**
In still air	89	84	86	87	85	86	86.2
With an electric fan	142	139	144	138	139	141	140.5
In still air and lower leaf surface covered with petroleum jelly	32	28	31	57	27	29	34.0

Table 4.1

i. Identify an anomalous reading in the data **and** evaluate the extent to which it has affected the mean that has been calculated.

____

____

____

____

____

____

____

____ **[3]**

ii. Suggest a reason for the reading that you identified as anomalous in **(i)**.

____

____ **[1]**

iii. The internal diameter of the capillary tubing was 0.7 mm.

Table 4.2 shows the mean rate of transpiration in each of the experimental conditions.

Condition	**Mean rate of transpiration (mm^3 min^{-1})**
In still air	
With an electric fan	10.81
In still air and lower leaf surface covered with petroleum jelly	2.62

Table 4.2

rate of transpiration = ... mm^3 min^{-1} **[3]**

iv. The control experiment in this investigation was to measure the mean rate of transpiration in still air.

Explain why the control experiment is carried out in this investigation.

____

____

____ **[1]**

(c). Another student suggested using an alternative apparatus for measuring the rate of transpiration of a leafy shoot. Fig. 4.2 shows this apparatus.

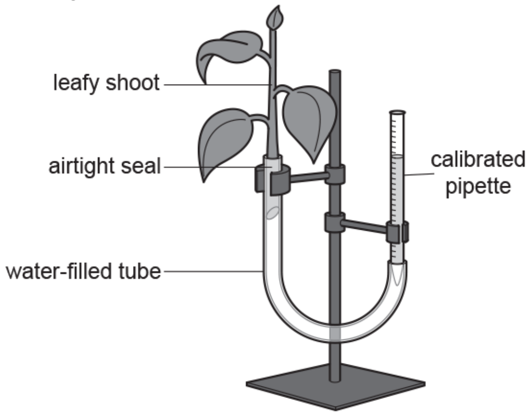


Fig. 4.2

The student stated that this apparatus would be an improvement on the apparatus shown in **Fig. 4.1** because the volume of water taken up could be measured directly.

Suggest why it might be considered better to use a capillary tube rather than a calibrated pipette to measure water uptake.

____

____ **[1]**

(d).

i. State what assumption is made when using this apparatus to measure the rate of transpiration.

____

____

____ **[1]**

ii. * There must be no air in the apparatus in Fig. 4.1 for it to work correctly.

Describe and explain the precautions that need to be taken when setting up and using the apparatus in Fig. 4.1 to ensure that no air is present.

____

____

____

____

____

[6]

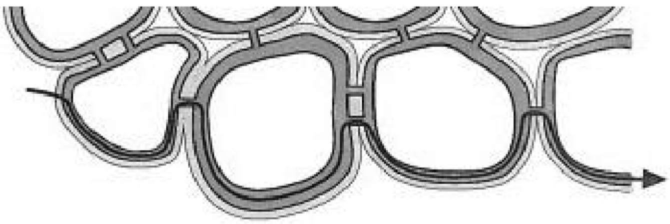
43. The water calthrop, *Trapa natans,* lives in lakes and other water bodies. Its leaves float on the surface of the water. Its stems trail just under the surface of the water.

i. What name is given to plants like *T. natans*, which are adapted to life in water?

____ **[1]**

ii. Fig. 20.1 shows cells from the stem of *T. natans*. Water travels between the cells by two different pathways, **X** and **Y**.

X



Y

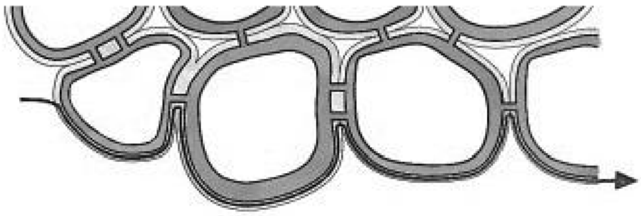


Fig. 20.1

Name the pathways represented by diagrams **X** and **Y**.

X

____

Y

____

[2]

44. Water is transported across the root of a plant by more than one pathway.

Which of the following statements about water molecules moving via the symplast pathway is **not** correct?

A Water molecules can move from cell to cell without crossing a membrane.
B Water molecules can pass through the Casparian strip.
C Water molecules must pass through the endodermis.
D Water molecules travel between cells down a water potential gradient.

Your answer

[1]

45. The water calthrop, *Trapa natans,* lives in lakes and other water bodies. Its leaves float on the surface of the water. Its stems trail just under the surface of the water.

A potometer was used to calculate the rate of transpiration from leaves of *T. natans* with different surface areas.

Table 20.1 shows the data obtained during the investigation.

Surface area of leaf (cm^2)	**Time (min)**	**Distance moved along capillary tubing (mm)**
39.6	0	0
	20	4
	40	8
	60	10
	80	12
69.4	0	0
	20	6
	40	9
	60	13
	80	18
99.2	0	0
	20	7
	40	15
	60	23
	80	38

Table 20.1

i. Give **two** factors that need to be controlled in this investigation in order to obtain valid data.

1 ____

2 ____

[2]

ii. In its natural habitat, *T. natans* has many leaves with a surface area greater than 99.2 cm^2. Explain why this does not affect the rate of transpiration in a way which would be harmful for the plant.

____

____

____ **[1]**

46. Terrariums are popular for growing houseplants.

A terrarium is a glass container containing soil and small plants.

Once established, a terrarium can be sealed and the plants will be able to grow for months or even years despite not being in contact with the outside atmosphere.

The terrarium maintains moist conditions for the plants.

i. Suggest **one** other reason why the plants in a sealed terrarium continue to grow.

____

____

____ **[1]**

ii. Cacti are popular house plants.

Suggest why cacti do **not** grow well in a terrarium.

____

____

____ **[1]**

47. Halophytes are plants that have the ability to live in soils with a very low water potential. In the UK these plants form part of salt marsh communities.

Suggest **and** explain how the root hairs of halophytes are able to absorb water by osmosis from the soil of the salt marsh.

____

____

____

____

____

____ **[2]**

48. Fig. 23.2 shows a cross section of a plant stem. The vascular bundles containing xylem found in most other flowering plants are absent. There are many air spaces in the stem.

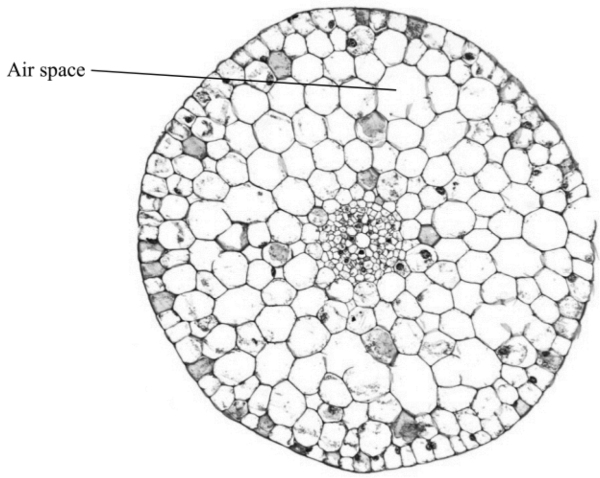


Fig. 23.2

Suggest and explain **two** likely adaptations of the **leaves** of the plant in Fig. 23.2.

1 ____

2 ____

____ **[2]**

49. Explain how glucose produced in photosynthesis is translocated to parts of the plant where glucose is metabolised or stored.

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____ [6]

50(a). Following their formation, assimilates are transported throughout the plant by translocation in phloem.

Phloem sap mainly consists of carbohydrate in the form of sucrose, but also contains other solutes.

i. Suggest why it is beneficial to the plant for the carbohydrate to be transferred throughout the plant in the form of sucrose rather than as an alternative carbohydrate.

____

____

____

____ [2]

ii. How is transport in the phloem similar to and different from transport in the xylem?

Similar

____

Different

____

____

[2]

(b). Assimilates are loaded into the phloem at the 'source' and then transported to the 'sink'.

i. Explain, with a suitable example, how some parts of the plant can act as both a 'source' and a 'sink'.

____

____

____

____ [2]

ii. * **Fig. 19.1** is a diagram that represents the loading of sucrose into the phloem at the 'source'.

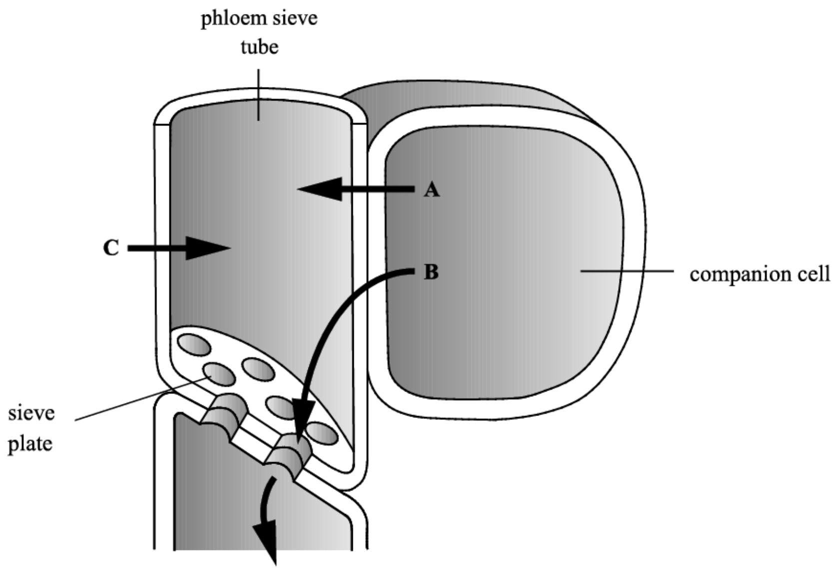


Fig. 19.1

With reference to **Fig. 19.1**, explain the process of the loading of sucrose into the phloem and its movement in the phloem.

____

____

____

____

____

____

____

____

____

____

____ **[6]**

(c). Fig. 19.2 is a diagram of a potato plant. Potatoes are tubers which are underground storage organs.

Fig. 19.2

Actively growing tissues have a high demand for carbohydrates. This means that a lot of phloem sap is directed to these tissues and requires sucrose to be unloaded in large amounts.

In an investigation, potato plants were modified by having a gene for invertase inserted into their DNA so that the gene for invertase would be expressed in the tubers. Invertase is responsible for catalysing the hydrolysis of the disaccharide sucrose.

A trial experiment was carried out to compare the properties of the modified plants with those that had not been modified. After harvesting, the tubers of three of each type of plant were compared. The results are shown in **Table 19.1**.

	Modified	**Not modified**
Mean number of tubers per plant	2.2	5.3
Mean mass per tuber (g)	49.7	16.8
Mean sucrose concentration (mg g^{-1} tuber mass)	1.4	13.7
Mean glucose concentration (mg g^{-1} tuber mass)	36.3 ± 3.5	1.9 ± 0.3
Invertase activity (arbitrary units)	62.1	1

Table 19.1

i. Name the bond that is hydrolysed by invertase.

____ **[1]**

ii. The potato tubers contain monosaccharides.

Compare the concentration of monosaccharides in the modified tubers with those that were not modified.

____

____ **[2]**

iii. In the modified plants, the unloading of sucrose is increased in the tubers compared with those that were not modified.

The transport of sucrose to the tubers was also increased in the modified plants.

Using the data and the information given, deduce a possible mechanism to account for the increased unloading and transport of sucrose in the modified plants.

____

____

____

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____ [4]

iv. The trial experiment compared the properties of modified potato plants with those that were not modified.

Analyse the data and draw conclusions about the yield of the tubers of modified plants compared with those tubers from plants which had not been modified.

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____ [3]

51. Glucose and other carbohydrates are present in respiring cells. The concentrations of carbohydrate molecules vary between tissues.

A student conducted tests on three tissues, **A, B** and **C**. Table 2 shows the results of these tests.

Tissue	Colour after Benedict's test	Colour after treatment with HCl and Benedict's test	Colour after iodine test
A	red	red	yellow
B	yellow	red	black
C	orange	orange	black

Table 2

Two of the tissues were known to be phloem tissue and liver tissue.

Use the evidence in Table 2 to identify which tissue, **A**, **B** or **C**, is phloem and which tissue is liver. Explain your answer.

Tissue .... must be phloem because ....

....

Tissue ....must be liver because ....

....

[3]

52(a). 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.

State all the letters that provide evidence for the following conclusions:

Translocation is an active process.

____

Sugars are translocated from source to sink.

____

[4]

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

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[3]

53(a). Plants need water to survive.

Water enters plants through the roots. Most roots are covered in root hairs.

The number of root hairs per mm^2 of root surface is described as the density of root hairs.
The density of root hairs can vary between and within species.

A scientist examined a plant root. The plant root had a diameter of 2 mm. In 1 mm of root **length** the scientist counted 440 root hairs.

Calculate the density of root hairs on the root the scientist examined.

Use the formula: Surface area of cylinder = $2\pi r(r + l)$

Give your answer to **2** significant figures.

density = ...**[3]**

(b). A scientist investigated the effect of different mineral solutions on root hair density on cress plants.

Cress plants were grown for seven days in two different mineral solutions, **A** and **B**.

The results are shown in the table below.

Cress plant	**Root hair density (hairs mm^{-2})**	
	Mineral solution A	**Mineral solution B**
1	42	25
2	53	41
3	60	32
4	52	34
5	38	58
6	48	27
Mean	48.8	
Standard deviation	8.0	

i. Calculate the standard deviation of root hair density for cress grown in mineral solution **B**.

Use the formula: $s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$

[Write your answer in the table] **[3]**

ii. The scientist thought that mineral solution **B** might cause a reduction in root hair density.

Suggest an appropriate statistical test that the scientist could carry out in order to confirm their hypothesis.

____ **[1]**

54(a). Aphids are small insects that feed on the sap that is translocated through the plant in the phloem. These insects insert their fine mouthparts, stylets, into phloem tissue and allow the sap to flow out of the phloem.

One method of collecting sap is to allow the aphid to feed as shown in Fig. 1.

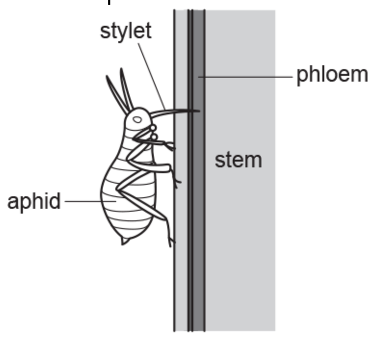

Fig. 1.1

The aphid is then anaesthetised and the stylet is cut off close to the aphid's head. The sap can then be collected and analysed.

A researcher analysed the sap collected and the results are shown in Table 1.

Substance tested for	Conclusion
glucose	negative
starch	negative
sucrose	positive

Table 1

i. Phloem tissue is made up of different cell types.

Identify the type of phloem cell into which the stylet is inserted to obtain the sap.

____ **[1]**

ii. Separate samples of the sap were tested for the presence of glucose, starch and sucrose.

Using Table 1, complete the following passage, using the most appropriate terms.

In order to test for the presence of glucose, ...

.... was added to the sap sample and boiled. The final colour was

.... and so it was possible to arrive at the conclusion shown in Table 1.

When iodine solution was added to the sap sample, the final colour was

.... To test for the presence of sucrose, the sample was

first boiled with .... After the rest of the test had been

completed, the colour of the mixture indicated that sucrose was present in the sample.

[4]

(b). Sucrose is carried in phloem sap from source to sink.

i. Explain why starch is not transported in the sap.

____

____ **[1]**

ii. Suggest why sucrose is a more suitable transport molecule than glucose.

____

____ **[1]**