IB · DP · Biology

2 hours 15 questions

Structured Questions: Paper 2

9.2 Transport in the Phloem of Plants

9.2.1 Translocation in Plants / 9.2.2 Sucrose Loading / 9.2.3 Hydrostatic Pressure Gradients / 9.2.4 Skills: Identifying Xylem & Phloem / 9.2.5 Skills: Measuring Phloem Transport Rates

Easy (5 questions)	/45
Medium (5 questions)	/44
Hard (5 questions)	/57
Total Marks	**/146**

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Easy Questions

1 (a) Glucose is the main product of photosynthesis in plant sources, whereas sucrose is the main sugar that is translocated around the plant.

Suggest why.

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(2 marks)

(b) The statements **A - F** below are incorrectly ordered.

A. High pressure forces contents along the phloem

B. Active transport takes sucrose into the sinks

C. Sucrose is actively loaded into phloem

D. Water flows into the phloem by osmosis

E. Glucose and fructose are condensed together

F. Phloem contents reaches the sinks

Identify the correct chronological order of statements **A - F**.

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(3 marks)

(c) When sucrose reaches its sink, it is converted to an oligosaccharide.

Describe the possible structure of an oligosaccharide.

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(2 marks)

(d) Once water in the translocation stream reaches a sink, such as a root tuber, changes in osmolarity cause the water to take a different path.

State what that path is and the eventual destination of the water molecules.

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(3 marks)

2 (a) Name the two main assimilates (products of plants' metabolism) that are carried in the phloem.

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(2 marks)

(b) Define the term 'source' when used in the context of plant biology.

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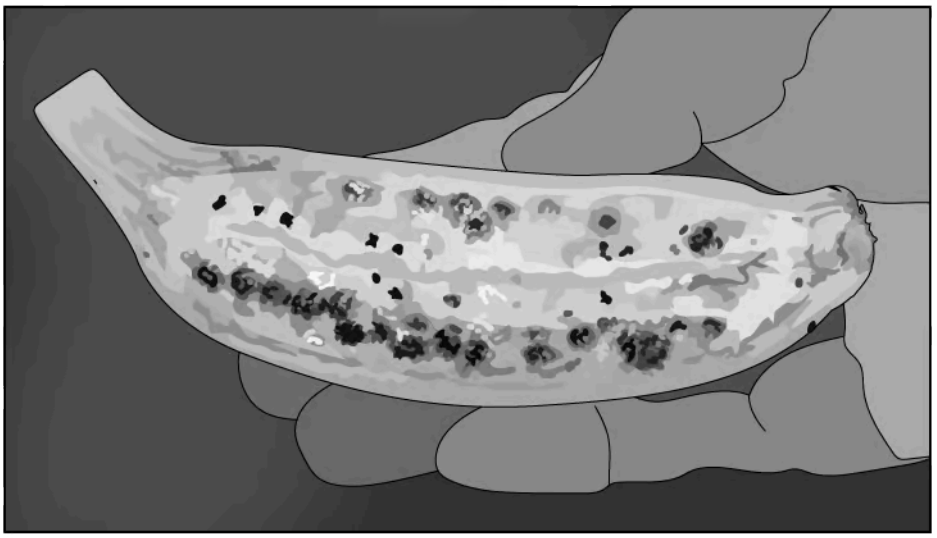
(2 marks)

(c) The image shows a wild banana, cut lengthways. Inside the banana, its seeds are clearly visible. Seeds are usually regarded as sinks.

Give an example of when seeds such as these act as a source.



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(1 mark)

(d) Name the features of the symplast pathway of sucrose translocation that are not present in the apoplast pathway.

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(2 marks)

3 (a) Plasmodesmata found in phloem cells tend to have a wider diameter than those found in cells of the xylem.

Suggest a reason for this.

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(1 mark)

(b) Phloem sieve tubes are adapted to minimise the frictional resistance to the flow of fluid within them.

List **two** ways by which friction is minimised within a phloem sieve tube.

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(2 marks)

(c) A traditional practice used in forestry to manage tree growth is called girdling. This involves removing a complete ring of bark, as shown in the image below. The tree dies over a period of time, allowing forests to be thinned out as required.

State how girdling may kill a tree over time.

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(2 marks)

(d) State the role of the parenchyma in phloem tissue.

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(2 marks)

4 (a) Sucrose enters the phloem companion cells via a co-transporter protein.

Explain how this co-transporter protein works.

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(2 marks)

(b) The processes referred to in part a) take place in a specialised type of companion cell called a transfer cell.

State **two** adaptations of a transfer cell that allow it to carry out sucrose co-transport effectively.

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(2 marks)

(c) The same hydrostatic pressure gradient exists within two different phloem tubes (1. and 2.) in a terrestrial plant.

These phloem tubes are located in the following parts of the plant:

1. Root tuber to growing shoot tip
2. Mature leaf on lower branch to the root tip

Suggest with a reason, whether 1. or 2. will result in a higher rate of translocation.

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(2 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Phloem sieve tubes, similar to many other specialised cells, have features that allow them to carry out their function. Some of these are listed in the table below:

Feature	How the feature assists the function of phloem
Elements lined up end-to-end	
	Aids loading/unloading of assimilates and contains nucleus
	Possess functional membranes for active transport, osmosis etc
	To allow room for flow / symplast pathway without obstruction/resistance etc
Rigid cellulose cell walls	
	To release energy for active transport into / out of the phloem sieve tube

Outline these features and how they assist the function of phloem by completing the missing information in the table above.

(6 marks)

(b) List **five** contrasts between xylem and phloem vessels.

(5 marks)

(c) A plant was given radio-labelled CO_2 containing the ^{14}C isotope of carbon.

(i) Explain how this radio-labelled CO_2 is administered to the plant.

[2]

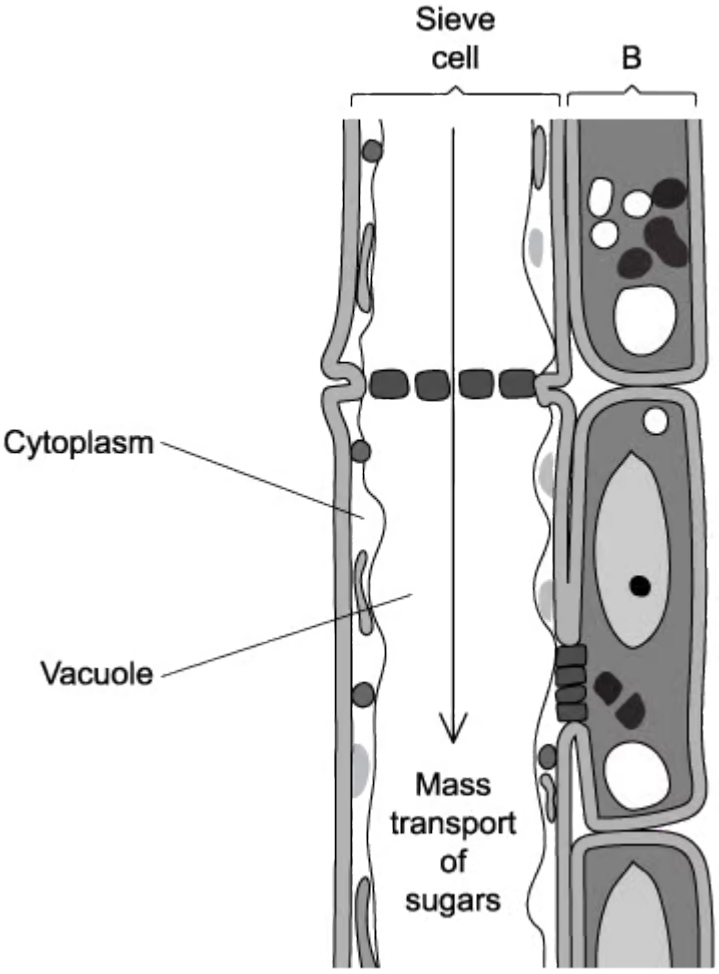
(ii) An aphid stylet placed 18.9cm underneath the leaf first leaked radioactive assimilates after a period of 159 minutes. Calculate the rate of flow of assimilates in the phloem.
State your answer in mm hr^{-1}.

[2]

(4 marks)

Medium Questions

1 (a) The diagram below shows a longitudinal section (LS) of phloem tissue in a plant. Cell type **B** is characterised by a large number of mitochondria.



Suggest why this is advantageous.

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(2 marks)

(b) Using the diagram in part a), suggest and explain a way in which the intracellular spaces of the sieve cells are adapted for mass transport.

(2 marks)

(c) Suggest and explain a way in which the cell walls of sieve cells are adapted for mass transport.

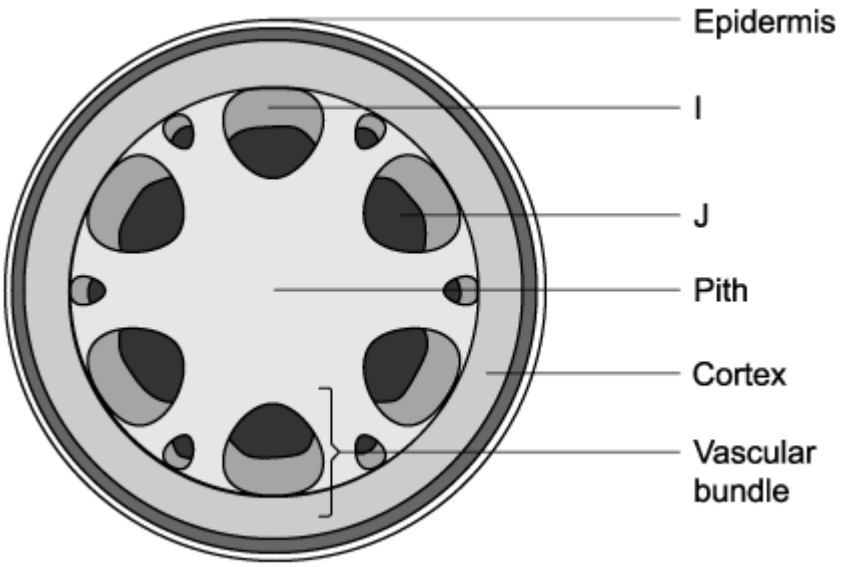
(2 marks)

(d) Most of the sugars produced by plants are used up rapidly in respiration. However, sometimes plants can overproduce sugars during photosynthesis.

Describe what happens to excess sugars in plants

(1 mark)

2 (a) The diagram below shows a transverse section (TS) of a plant stem.



Identify the structure found at **I** and state its function.

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(2 marks)

(b) A scientist used radioactive carbon dioxide to investigate the direction and rate of sucrose transport in a plant. Their results showed that during periods of plant growth, sucrose was mainly transported upwards.

Explain why this occurs.

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(3 marks)

(c) Although most of the sugars produced by plants are used up rapidly in respiration, plants can sometimes overproduce sugars during photosynthesis. Excess sucrose in sink tissues can be converted to starch.

Suggest the benefits of this for maintaining translocation in the plant.

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(2 marks)

3 (a) Translocation occurs from regions known as 'sources' to regions known as 'sinks'.

Describe what the term 'sink' refers to and state two examples of 'sinks'.

(3 marks)

(b) Plasmodesmata are present in the cell walls of companion cells.

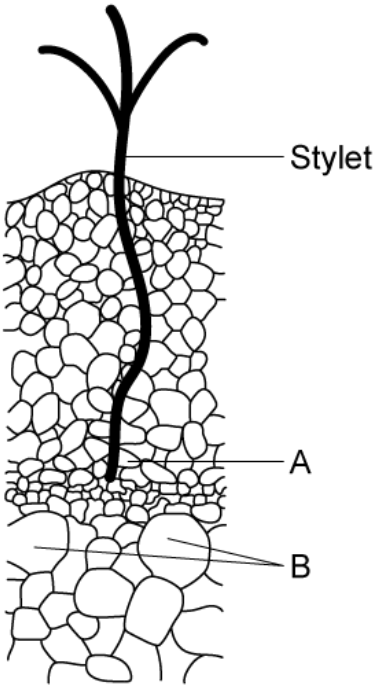
Explain what these plasmodesmata are and their function in companion cells.

(3 marks)

(c) Referring to the movement of sucrose in your answer, explain how a high hydrostatic pressure is generated at 'source' sites in plants.

(3 marks)

4 (a) An aphid was allowed to feed on a plant stem. The aphid was anaesthetised and its head and body were then removed, leaving the stylet (mouthparts) still in place. The severed stylet of the aphid, still embedded in the plant tissue, is shown in the diagram below.



Identify tissue **B**.

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(1 mark)

(b) Identify tissue **A** in the diagram above and state one piece of evidence to support your identification.

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(2 marks)

(c) Describe how the movement of solutes through plant tissues can be studied and measured using aphid stylets.

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(3 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Outline the symplast pathway for the loading of sucrose into sieve tubes.

(3 marks)

(b) Describe how sugar is transported from the lower leaves of a plant to the growing leaf buds at the top of a plant.

(5 marks)

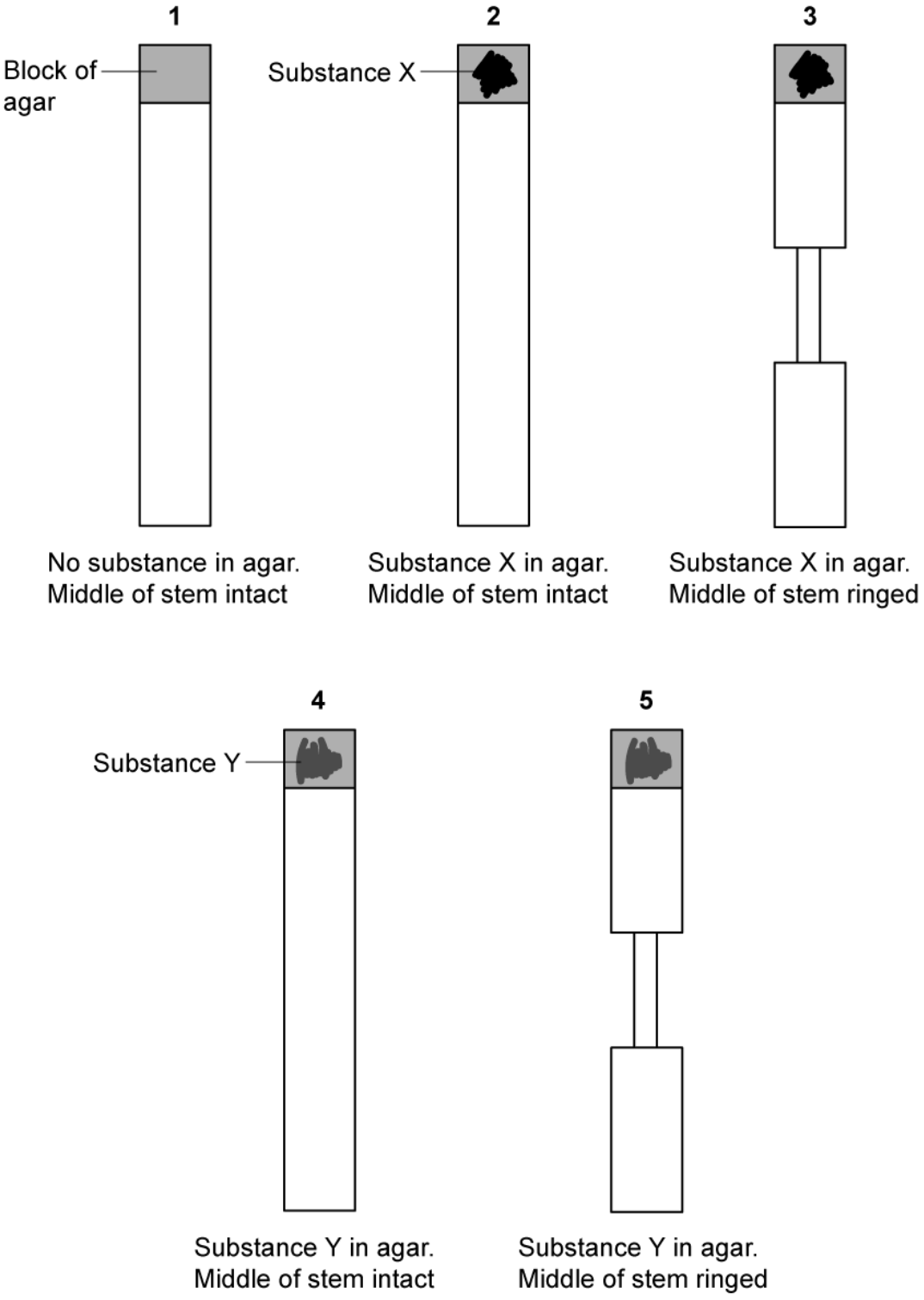
(c) Photosynthesis produces glucose, which is then transported and stored in plants.

Outline how this glucose is transported and stored.

(7 marks)

Hard Questions

1 (a) A scientist is investigating two substances, **X** and **Y**, which may affect the growth of new roots from a cut plant stem. They used a ringing experiment to investigate the transport of substances **X** and **Y** through the stems taken from a grapefruit plant. A length of the stem was cut from each grapefruit plant and a small block of agar was placed at the top of each stem. Substance **X** or **Y** was added to some of the agar blocks.



The stems were grown in the same environmental conditions for 5 weeks and then the number of roots per stem was recorded. The roots grew at the opposite end to where the agar block was located. The table shows the results of the experiment.

Treatment	Mean number of roots per stem
1	6
2	13
3	6
4	2
5	6

Agar delivers substances **X** and **Y** in treatments 2 - 5. Suggest **one** other reason why agar is present in all of the treatments.

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(1 mark)

(b) Suggest a conclusion that can be drawn about the action of substance **Y**, using the information from the diagram at part a).

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(2 marks)

(c) The movement of substances through the phloem can be explained using the mass flow hypothesis.

Evaluate whether the data from this experiment supports the mass flow hypothesis. Note that no statistical analysis is required.

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(4 marks)

(d) Upon further research, it was discovered that substance **Y** could be sprayed onto the leaves of a plant and it would be absorbed into the phloem sap.

Using this information, outline the mechanism by which substance **Y** could act as weed control.

(3 marks)

(e) Suggest, with a reason, a better measure of the dependent variable in the investigation in part a) of this question.

(2 marks)

2 (a) Translocation in the phloem can be regarded as the plant equivalent of the mammalian circulatory system.

Evaluate this statement.

(6 marks)

(b) Two parameters of the contents of the phloem have an influence on the rate of translocation within that phloem. These are collectively called water potential and given the symbol Ψ.

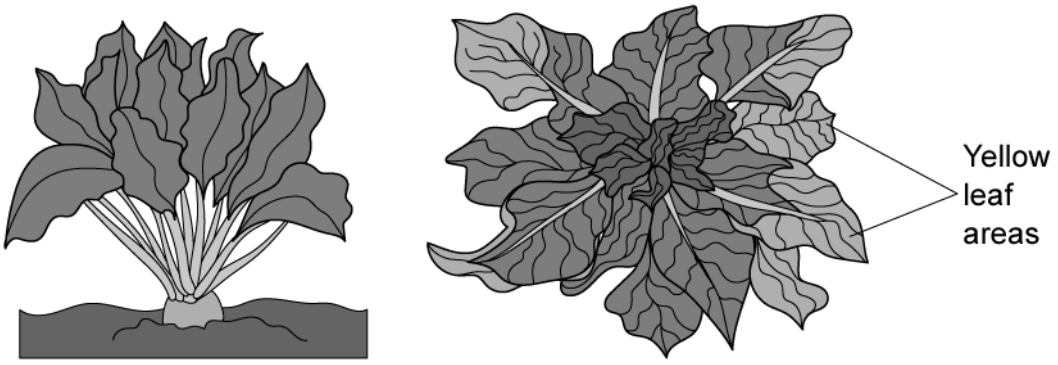
There are two types of water potential, each given the symbols Ψ_p and Ψ_s.

Suggest what each symbol relates to.

(2 marks)

(c) Sugar beet (*Beta vulgaris* subsp *vulgaris*) is the second most important crop grown for table sugar (behind sugar cane), accounting for around 30% of worldwide production. The roots are harvested and processed for their high sugar content.

Yields of sugar beet can be affected by Beet Jaundice Virus, which is spread by aphids and turn crops yellow (see image below).



Healthy sugar beet crop

Sugar beet crop affected by Beet Jaundice Virus

Suggest how Beet Jaundice Virus decreases yields for commercial beet farmers.

(2 marks)

3 (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.

(i) Translocation is an active process.

[2]

(ii) Sugars are translocated from source to sink.

[2]

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(4 marks)

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

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(3 marks)

(c) The use of aphid stylets to measure translocation is well documented. This exploits the aphid's behaviour of penetrating the plant stem with its stylet in order to extract sugars and nutrients from the phloem.

Scientists observing this behaviour were initially puzzled by the fact that an aphid appears to excrete a large proportion of the sugar it ingests via its stylet; it clearly ingests a lot more sucrose than it needs for its own metabolism.

Suggest **one** explanation for this behaviour.

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(2 marks)

(d) Phloem sieve plates have an adaptation whereby a sieve plate closes when the phloem is damaged mechanically eg. by a chewing animal. A polysaccharide called callose builds up in sieve plate pores and can seal the pores within as little as 20 minutes.

Suggest a reason for this adaptation.

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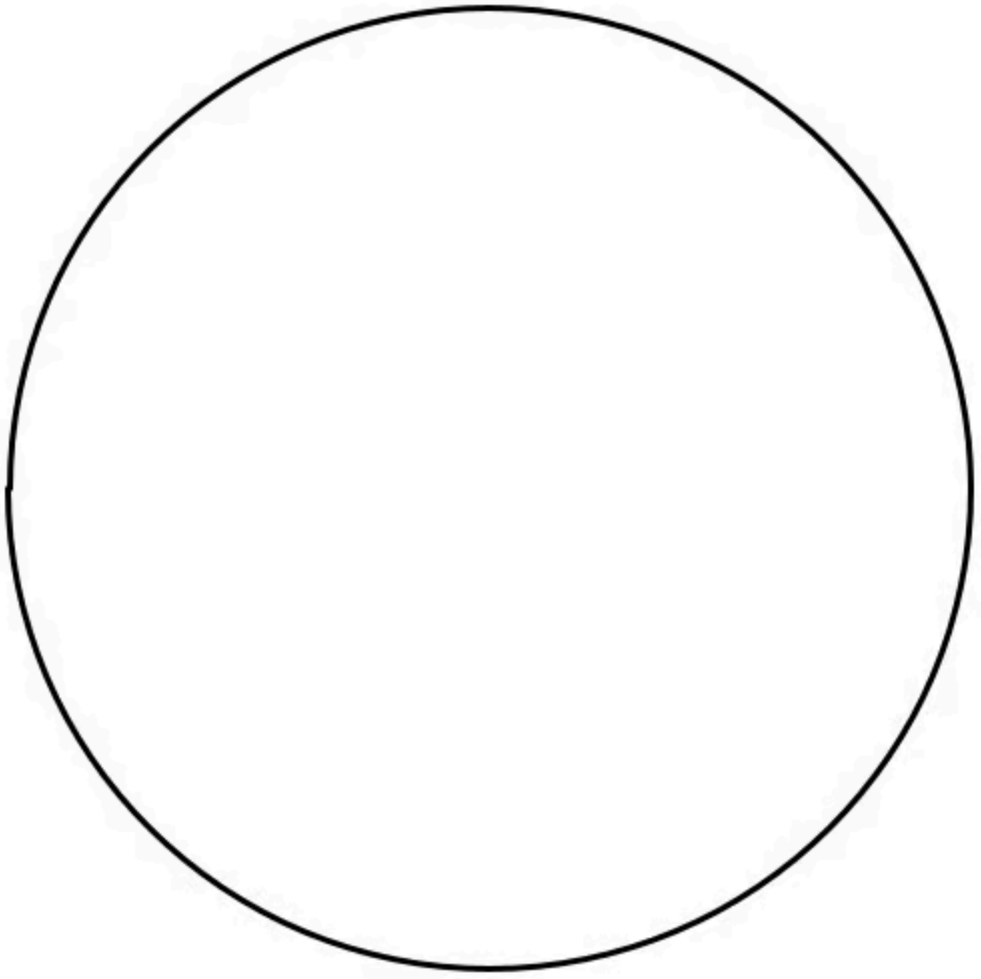
(2 marks)

4 (a) Translocation is the movement of the products of photosynthesis within a plant.

Translocation occurs in the phloem and involves sources and sinks.

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



(1 mark)

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

A. Radio-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

Other research has revealed that:

C. An insect such as an aphid feeds by inserting its stylet (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.

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(2 marks)

(c) The majority of cells in phloem tissue are either companion cells or sieve tube elements. A scientist isolated companion cells and conducted some experiments to investigate the mechanism involved in loading sucrose into the sieve tubes. He recorded the following observations:

Observation 1	isolated companion cells became slightly negatively charged compared with their surroundings
Observation 2	companion cells could decrease the pH of the surrounding solution from 7.0 to 5.6
Observation 3	the pH inside the companion cells rose from 7.0 to 8.2
Observation 4	treatment with cyanide (which stops aerobic respiration) prevents the change in pH occurring

From **Observation 1**, the scientist concluded that the mechanism involved a transfer of

charged particles (ions) between the companion cells and their surroundings.

Deduce the conclusions that can be drawn from **Observations 2 and 3** about the mechanism.

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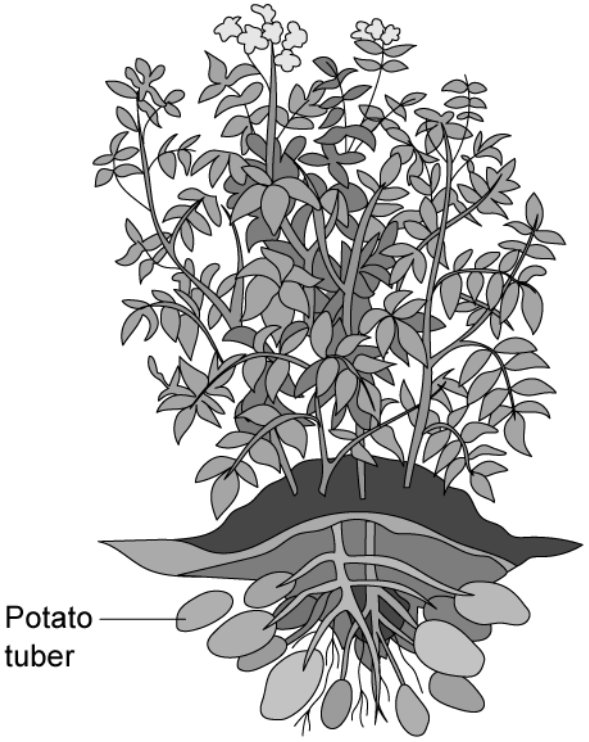
(2 marks)

(d) The image below shows a potato plant. Potatoes grow tubers, which are underground storage organs.



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 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 the table below.

	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} of tuber mass	1.4	13.7
Mean glucose concentration / mg g^{-1} of tuber mass	36.3 ± 3.5	1.9 ± 0.3
Invertase activity / arbitrary units	62	1

In the modified plants, the unloading of sucrose is increased in the tubers compared to 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.

(4 marks)

5 (a) *One mark is available for clarity of communication throughout this question.*

Compare and contrast the apoplast and symplast pathways of translocation in plants.

(7 marks)

(b) Outline the method by which aphid stylets can be used to measure the rate of translocation in the stems of plants.

(8 marks)