

# 9.2 Transport in the Phloem of Plants

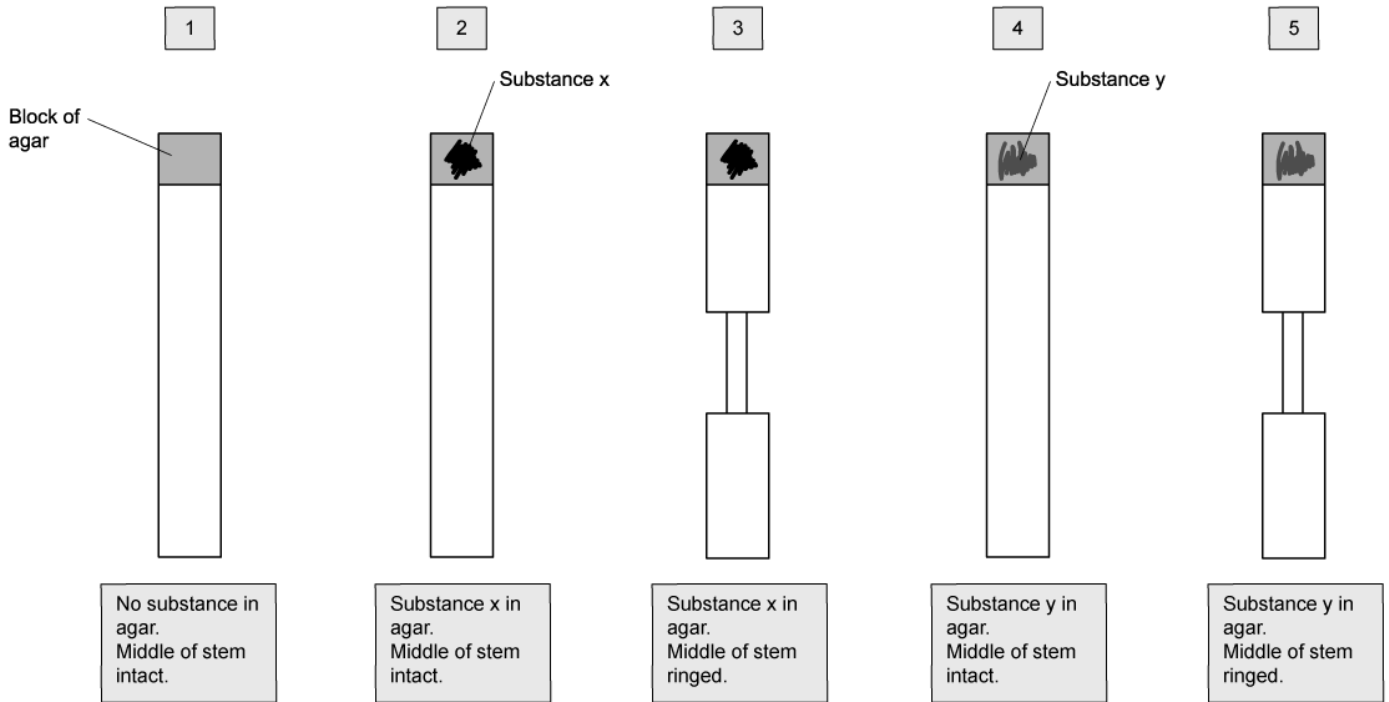
## Question Paper

Course	DP IB Biology
Section	9. Plant Biology (HL Only)
Topic	9.2 Transport in the Phloem of Plants
Difficulty	Hard

**Time allowed:** 70  
**Score:** /57  
**Percentage:** /100

**Question 1a**

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.

[1 mark]

[1 mark]

### Question 1b

b)

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

[2 marks]

[2 marks]

### Question 1c

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.

[4 marks]

[4 marks]

### Question 1d

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]

[3 marks]

### Question 1e

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

[2 marks]

[2 marks]

### Question 2a

a)  
Translocation in the phloem can be regarded as the plant equivalent of the mammalian circulatory system.  
Evaluate this statement.

[6 marks]

[6 marks]

### Question 2b

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  $\Psi$ .

There are two types of water potential, each given the symbols  $\Psi_p$  and  $\Psi_s$ .

Suggest what each symbol relates to.

[2 marks]

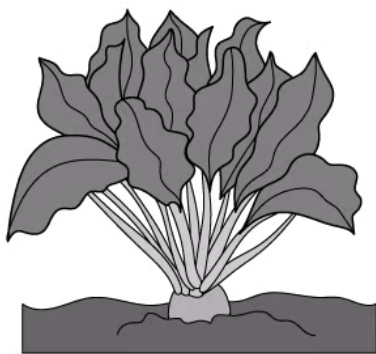
[2 marks]

### Question 2c

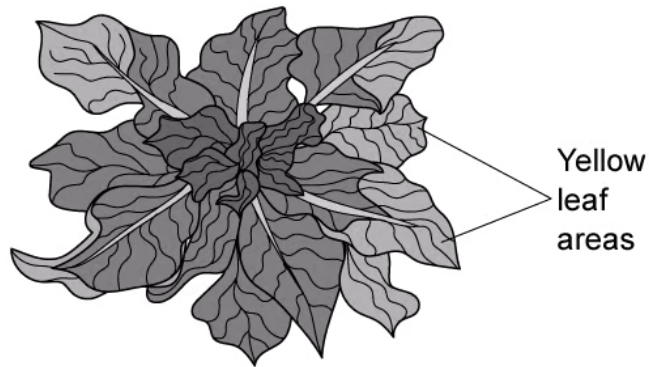
c)

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]

[2 marks]

### Question 3a

a)

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

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

(ii) Sugars are translocated from source to sink.

[2 marks]

[4 marks]

### Question 3b

b)

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

[3 marks]

[3 marks]

### Question 3c

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.

[2 marks]

[2 marks]

### Question 3d

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.

[2 marks]

[2 marks]

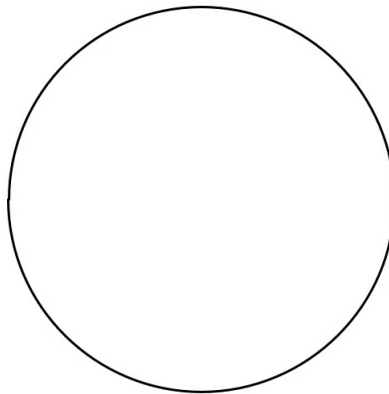
### Question 4a

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]

[1 mark]

### Question 4b

b)

Research using carbon dioxide containing a radioactive label,  $^{14}\text{C}$ , 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.

[2 marks]



[2 marks]

**Question 4c**

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:

<b>Observation 1</b>	isolated companion cells became slightly negatively charged compared with their surroundings
<b>Observation 2</b>	companion cells could decrease the pH of the surrounding solution from 7.0 to 5.6
<b>Observation 3</b>	the pH inside the companion cells rose from 7.0 to 8.2
<b>Observation 4</b>	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.

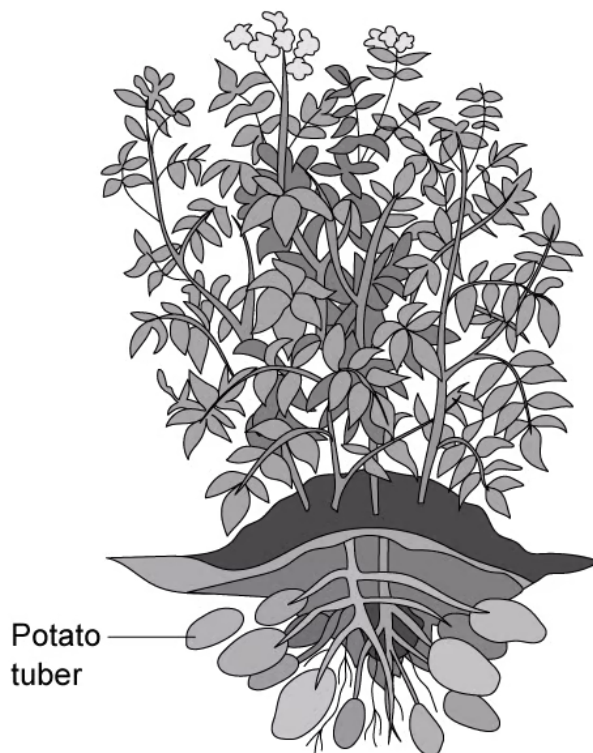
Deduce the conclusions that can be drawn from **Observations 2 and 3** about the mechanism.

[2 marks]

[2 marks]

### Question 4d

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 / $\text{mg g}^{-1}$ of tuber mass	1.4	13.7
Mean glucose concentration / $\text{mg g}^{-1}$ of tuber mass	$36.3 \pm 3.5$	$1.9 \pm 0.3$
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]

[4 marks]

### Question 5a

*One mark is available for clarity of communication throughout this question.*

a)

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

[7 marks]

[7 marks]

## Question 5b

b)

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

**[8 marks]**

**[8 marks]**