RA 2

Translocation

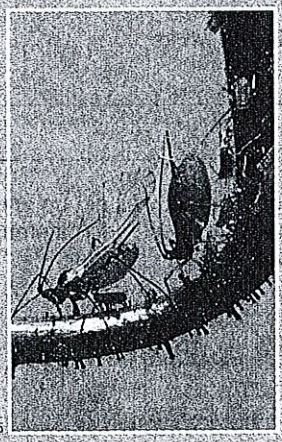
Answer Key

Phloem transports the organic products of photosynthesis (sugars) through the plant in a process called **translocation**. In angiosperms, the sugar moves through the sieve elements, which are arranged end-to-end and perforated with sieve plates. Apart from water, phloem sap comprises mainly sucrose (up to 30%). It may also contain minerals, hormones, and amino acids, in transit around the plant. Movement of sap in the phloem is from a **source** (a plant organ where sugar is made or mobilized) to a **sink** (a plant organ where sugar is stored or used). Loading sucrose into the phloem at a source involves energy expenditure; it is slowed or stopped by high temperatures or respiratory inhibitors. In some plants, unloading the sucrose at the sinks also requires energy, although in others, diffusion alone is sufficient to move sucrose from the phloem into the cells of the sink organ.

Transport in the phloem by pressure-flow

Phloem sap moves from source (region where sugar is produced or mobilized) to sink (region where sugar is used or stored) at rates as great as 100 m h^{-1}: too fast to be accounted for by cytoplasmic streaming. The most acceptable model for phloem movement is the **pressure-flow** (bulk flow) hypothesis. Phloem sap moves by bulk flow, which creates a pressure (hence the term "pressure-flow"). The key elements in this model are outlined below and in steps 1-4 right. For simplicity, the cells that lie between the source (and sink) cells and the phloem sieve-tube have been omitted.

1. Loading sugar into the phloem from a source (e.g. leaf cell) increases the solute concentration inside the sieve-tube cells. This causes the sieve-tubes to take up water from the surrounding tissues by osmosis.
2. The water absorption creates a hydrostatic pressure that forces the sap to move along the tube (bulk flow), just as pressure pushes water through a hose.
3. The gradient of pressure in the sieve tube is reinforced by the active unloading of sugar and consequent loss of water by osmosis at the sink (e.g. root cell).
4. Xylem recycles the water from sink to source.



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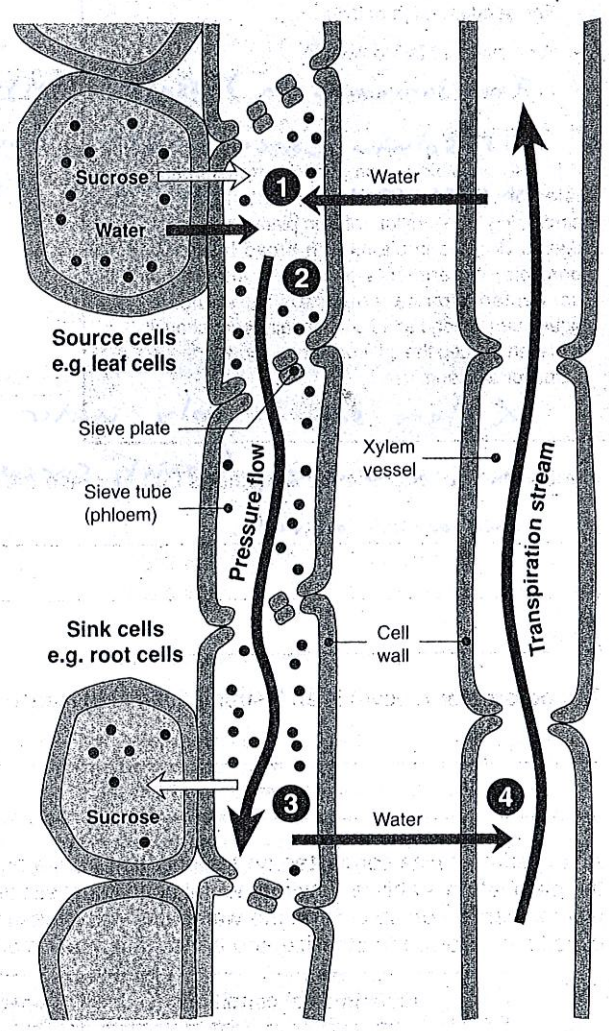
Measuring phloem flow

Experiments investigating flow of phloem often use aphids. Aphids feed on phloem sap (left) and act as natural **phloem probes**. When the mouthparts (stylet) of an aphid penetrate a sieve-tube cell, the pressure in the sieve-tube force-feeds the aphid. While the aphid feeds, it can be severed from its stylet, which remains in place in the phloem. The stylet serves as a tiny tap that exudes sap. Using different aphids, the rate of flow of this sap can be measured at different locations on the plant.



Modified after Campbell *Biology* 1993

1. (a) Explain what is meant by *source to sink* flow in phloem transport: Sugars flow from where they are produced / stored to where they are needed.

   (b) Name the usual **source** and **sink** in a growing plant:

   Source: Leaves Sink: Growing tissues, fruits, flowers, roots, etc.

   (c) Name another possible **source** region in the plant and state when it might be important: Tubers (like a potato) where sugars are stored and then used when photosynthesis is not occurring.

   (d) Name another possible **sink** region in the plant and state when it might be important: Growing tissues, fruits, flowers, roots, nuts, seeds, etc.

2. Explain why energy is required for translocation and where it is used: Loading and unloading of sugars into and out of the phloem usually requires active transport.

3. In your own words, describe what is meant by the following:

(a) Translocation: The transport of sugars from where they are made or stored to where they are needed throughout the plant.

(b) Pressure-flow movement of phloem: The movement of sugary phloem sap from where osmotic pressure is high at the source to where osmotic pressure is low at the sink.

4. Briefly explain why water follows the sucrose as the sucrose is loaded into the phloem sieve-tube cell:

The increase in dissolved sugars in the phloem at the source increases its solute concentration. Because of this, water moves in by osmosis. Water moves to regions of higher solute concentration.

6. Contrast the composition of phloem sap and xylem sap (see the activities on xylem and phloem if you need help):

Xylem sap is only water and dissolved minerals. Phloem is mainly a sugary sap (mainly sucrose), but also contains some minerals, hormones, and amino acids.