Phloem translocation

The movements of organic solutes in the phloem is called **translocation**.

Sources and sinks

A source is a part of a plant that is a net producer of organic solutes. For example, during photosynthesis mature leaves are making more organic material than they are breaking down in respiration. Such leaves are the sources or exporters of organic compounds. A sink is a part of a plant that is a net importer of organic solutes. Generally speaking, non-photosynthetic and growing parts of a plant are sinks.

A sink is not always a sink nor a source always a source.

A leaf may, in its young, growing phase be a net importer of organic materials (i.e. a sink). A mature potato tuber turns from a sink to a source when it starts to sprout.

Experimental Evidence

1. Analysis of phloem contents: Sucrose is the form in which organic material is most commonly translocated in plants.

2. Aphid experiments

3. Using radioactive isotopes: Translocation of organic solutes occurs in phloem sieve tubes.

4. The effect of girdling: Girdling experiments, especially when used in conjunction with radioactive tracers, lead to the following conclusions:

Transport up the plant of water and mineral salts continues in the absence of phloem tissue and are therefore, in the xylem. The translocation of organic solutes occurs in phloem.

Loading and unloading of the phloem

The sucrose concentration inside the phloem sieve tubes of the minor veins of a leaf is generally two or three times as high as in the surrounding mesophyll cells. This suggests that sucrose is actively pumped into the sieve tubes against the concentration gradient, a phenomenon known as phloem loading.

Phloem loading requires metabolic energy. Movement against a concentration gradient is one indicator of this. Another is the fact that loading is selective.

Unloading is the reverse of loading and occurs at the sinks. Sucrose and other solutes are actively removed from the phloem and passed to surrounding cells for metabolic activity or storage.

To a large extent the regulation of transport in the phloem is due to sink demand.

Whenever and whenever solute is unloaded from the phloem a sink is created and sap flows in that direction. This explains why the direction of movement in the phloem can change and why it can be in two directions simultaneously.

Diffusion Hypothesis

According to this hypothesis translocation of food from a place of higher concentration, where food is manufactured or stored (supply end) to a place of lower concentration, where the food is consumed or converted to insoluble form (consumption end) occurs by the simple process of diffusion. But it is not accepted because rate is some 40,000 times greater than what could be achieved by simple diffusion. Secondly, unlike diffusion, phloem transport is dependent on metabolism and ceases if the phloem tissue is deprived of oxygen or is poisoned.

Activated Diffusion Hypothesis

This theory, given by Mason and Phillis (1936), assumes that the protoplasm of the sieve tubes accelerate the diffusion of solutes either by activating the diffusing molecules, or by reducing the resistance of the protoplasm to their diffusion. The theory lacks experimental evidence.

Electro Osmotic theory

Fensom (1957) and Spanner (1958) proposed an electro osmotic theory. According to them an electric potential across the sieve plate causes the movement of water along with the solutes.

The hypothesis, however, does not provide answers to several problems of solute translocation.

Interfacial Flow Hypothesis

It was proposed by Van den Honert (1932). According to transported molecules might move along interfaces of membranes, such as the tonoplast. The solute molecules are believed to be absorbed and dispersed at the interface due to the reduction of surface tension. The hypothesis, however, does not have any experimental evidence to show the existence of such a phenomenon in plants.

Munch Mass flow (Pressure flow) Hypothesis

According to the hypothesis when food is manufactured in the leaf, the osmotic potential of the mesophyll cell is very much decreased. This causes absorption of water from the xylem elements of the leaf, resulting in an increase in their turgor pressure. This succeeds in forcing some of the cell solution into the sieve tubes because of which the osmotic potential of the phloem decreases. On the other hand, in the cells of the root or the storage organs, the food is either consumed or is converted into insoluble forms resulting in increase in their osmotic potential and decrease in their turgor pressure. Under the conditions mentioned above, a turgor pressure gradient is established between the supply end in the leaf and the consumption end in the root and, therefore a mass flow of water (containing dissolved solutes) takes place in the phlegm from the upper end to the lower end of the plant.

At the consumption end, water diffuses out into the xylem elements of the root due to the lowering of the osmotic pressure. This water along with the absorbed water is translocated to the leaf through the xylem elements. A sort of cyclic circulatory system is formed.

It should be noted that the movement of solutes is actually due to pressure gradient and not due to water potential gradient. Though the pressure flow hypothesis is a passive but there is role of energy in phloem loading and unloading.