Means of Transport

Transportation is an important phenomenon which will take place in all the higher organisms. In plants, materials of transport mainly include gases, water, hormones, minerals, organic material etc. through diffusion, active transport etc. Let us take a look.

Transport in Plants

1. Transport of Water

Water gets absorbed by the root hair and gets transported inwards by different pathways till it reaches the xylem vessels. This continuous uptake of water creates a *root pressure* which pushes the water upwards. The pull created due to transpiration of water through the leaves causes the rising of water in the tall trees.

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- Phloem Transport
- Transpiration

2. Transport of Minerals

Minerals are also absorbed by the roots and transported upwards poet through the xylem along with water.

3. Translocation of Organic Solutes

Organic compounds synthesized during the process of photosynthesis gets transported through the phloem sieve tubes. Such a transport of organic solute is called translocation.

Means of Transport

1. Diffusion

Movement of molecules and ions in solid, liquid and gaseous state from a region of their higher concentration region of lower concentration is called diffusion. This happens because, in a region of high concentration, partial pressure is higher as compared to the region where the concentration is low as the particles have inner and kinetic energy.

This process will continue till the concentration of molecules become same. Also, different substances can diffuse at the same time. The direction and rate of diffusion of one substance will be independent of the direction and rate of diffusion of another substance

Diffusion Pressure

The molecules while moving hit each other which creates a diffusion pressure. It can be defined as the potential ability of molecules to diffuse from an area of higher concentration to an area of lower concentration.

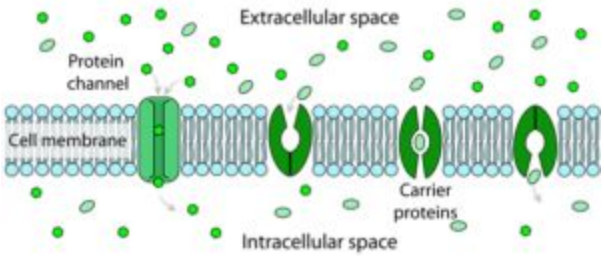
Factors affecting diffusion

- Temperature: More temperature causes increased kinetic energy, hence the rate of diffusion is more.
- The density of diffusing substance: Rate of diffusing substances is inversely proportional to the density of diffusing substance.
- Medium in which diffusion occurs: Gas diffuses more rapidly through a vacuum than air.

2. Facilitated Diffusion

It is a spontaneous passage of molecules and ions across a membrane through specific carrier proteins without involving energy. Hence facilitated diffusion is also a type of passive transport. This also

occurs from an area of more concentration gradient to an area of less concentration gradient.



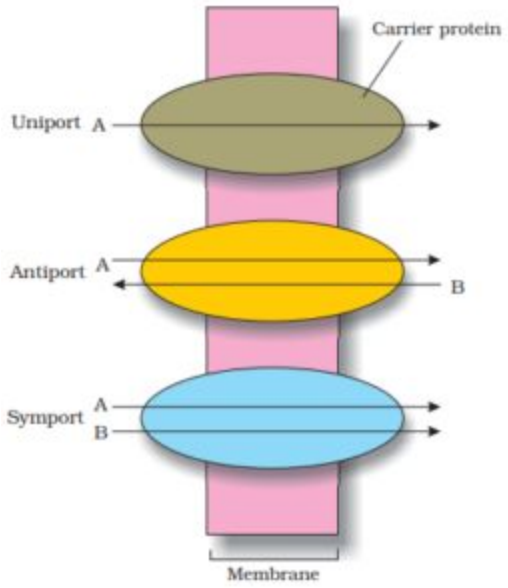
Importance of facilitated diffusion

Biological membranes basically are hydrophobic in nature. Water soluble molecules like glucose, sodium ions and chloride ions cannot pass through the membrane as the lipids make it hydrophobic in nature. Transport of such substances is facilitated by transport proteins. These proteins are embedded in the bilipid layer. They provide the binding site for molecules to be transported.

After binding the transport proteins to change their shape and the molecule is carried to the other side of the membrane where it is released. There are some large transport proteins which form huge pores in the membranes.

These are called *porins*. They provide passage to large molecules and ions.

Sometimes two different types of molecules move across the membrane simultaneously by the process of facilitated diffusion. When both kinds of molecules move in the same direction outside to inside or inside to outside, it is called *symport*.



When they move in opposite direction it is called *antiport*. And when a particular kind of molecules moves across the membrane independent to other molecules, the type of diffusion is called *uniport.*

3. Active Transport

When the transport of materials are not spontaneous but involves an expenditure of energy, the type of transport is called active transport. This transport generally takes place against the concentration gradient. Active transport always leads to accumulation of molecules are ions towards one side of the membrane.

Active transport is carried out by membrane proteins. The protein uses the energy to carry the substance across the membrane. Certain pumps are generated which can transport the substance uphill from lower concentration to higher concentration. The transport rate is maximum when all the protein transporters are saturated. The carrier proteins are generally specific in action. They are also sensitive to an inhibitor.

Comparison of Different Types of Transport

Diffusion	Facilitated diffusion	Active transport
Occurs along the concentration gradient	It occurs along the concentration gradient	Occurs against the concentration gradient

Does not require carrier molecules	Require special transport proteins	Require special transport proteins
Process is not sensitive to Inhibitors.	This process is sensitive to Inhibitors	Process is sensitive to Inhibitors
Energy is not required	The energy is not required	Energy is required
Saturation of transport does not occur	Transportation saturates when all the carrier proteins are being used	Transportation saturates when all the carrier proteins are being used

Solved Questions for You

Question: Identify a type of molecular movement which is highly selective and requires special membrane proteins but does not require energy.

Answer: The type of transport is facilitated transport.

Question: How is it that the intracellular levels of K+ are higher than extracellular levels in animal cells?

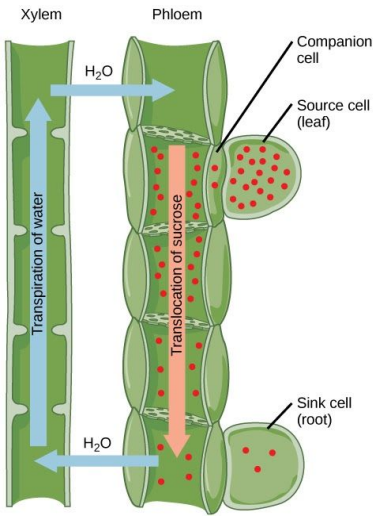
Answer: This will happen through active transport. Active transport occurs from lower concentration to higher concentration and leads to accumulation of materials on one side of the membrane.

Phloem Transport

Food is synthesized in the green parts of a plant. The non-green parts are depended on the photosynthetic cells for nourishment. The food in the form of sucrose is transported by the vascular tissue phloem. Let us learn a bit more about phloem transport. The transportation occurs in the direction of the source to sink. Transport of organic solutes from one part of the plant to the other through phloem sieve tubes is called translocation of organic solvents.

Source and Sink- The Bi-directional flow

The photosynthetic part usually acts as the source and the part in which the food is stored acts as the sink. But in Early Spring when the leaves are shed, the sugar stored in roots mobilize the organic material towards the growing Buds. Here we can see that the direction of the source and sink is reversed. Hence we can say that bidirectional flow of food occurs in the phloem.



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- Means of Transport
- Transpiration

Evidence to Support that Translocation occurs through the Phloem

1. Ringing or Girdling Experiment

In a healthy potted plant, all the tissue outer to the xylem including bark, cortex, and phloem is removed from a small portion of the woody stem (girdling). The upper and lower part of the plant is now attached only through the xylem.

After a few days, it is observed that the food material is accumulated just above the girdling. Also, the roots die first in the girdled plant. This may happen because the food is not transported to the roots. This experiment proves that phloem is responsible for translocation of organic material.

2. Mechanism of Phloem Transportation

Sieve tubes in the phloem form long columns with holes in the end walls. Cytoplasmic strands pass through these holes forming a continuous channel.

3. Pressure flow or Mass flow Hypothesis

This theory was proposed by Munch and elaborated by Mars and others. It is the most accepted mechanism for translocation of Sugars in higher plants. It occurs in the following steps.

- The glucose prepared in the leaves is converted into sugar.
- The sugar in the form of sucrose is moved into the companion cells and then into the living phloem sieve tube cells by active transport.
- This creates a hypertonic condition in the phloem.

- Water in xylem vessels adjacent to phloem moves through endosmosis.
- Osmotic pressure rises and phloem SAP moves from an area of higher osmotic pressure to the area of low pressure.
- Osmotic pressure is maintained low at the sink.
- At the sink again active transport is required to move the sugar out of the phloem SAP into the cell where the sugar is used to release energy by the process of respiration.

Solved Questions for You

Question 1: Movement of substances in xylem is unidirectional while in phloem it is bidirectional. Explain.

Answer: Xylem transports water. Since transportation of water always takes place from roots to leaves, the direction of transport always remains in the upward direction. Translocation of organic material occurs from source to sink. Since the source and the sink may change their position, the movement is bidirectional.

Question 2: Differentiate between diffusion and translocation in plants.

Answer Diffusion is the passage of substances from the region of their higher concentration to the region of lower concentration due to the kinetic energy of the particles. It usually occurs in all directions. Translocation is a bulk transport of materials in solutions from inside the plant channels in a particular direction caused by forces other than the kinetic energy of the particles.

Transpiration and Structure of Stomata

Transpiration is the process in which plants release the water inside it in the form of moisture or water vapor. Parts of plants like stems, small pores on leaves, flowers evaporates the water to the atmosphere. Basically, Transpiration is the process in which water is evaporated in the atmosphere from plant leaves and other parts. Some amount of water is consumed by roots and rest is evaporated in the atmosphere. Let us study more about types of Transpiration and Stomata of leaves.

Types of Transpiration

Transpiration can be of different types depending upon the specialized organ from where it is occurring.

- *Stomatal transpiration*: It is the loss of water through specialized pores in the leaves. It accounts for around 80 to 90% of the total water loss from the plants.
- *Cuticular transpiration*: Cuticle is an impermeable covering present on the leaves and stem. It causes only around 20% transpiration in plants.It is further reduced due to a thicker cuticle in xerophytes.
- *Lenticular Transpiration*: Lenticels are the tiny openings present on the woody bark through which transpiration occurs.
- *Mechanism of water loss*: Leaves also absorb visible and invisible radiations of the Sun and gets heated up. The water vaporizers and is given out in the atmosphere. This results in cooling down of the temperature of the leaves. Transpiration is basically regulated by the opening and closing of stomata.

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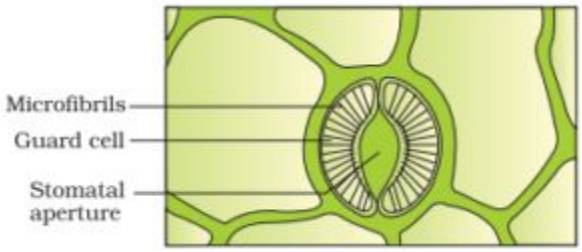
- Means of Transport

- Phloem Transport

Structure of Stomata

Stomata are the tiny pores present in the epidermal surface of leaves. The pores are guarded by two kidney-shaped cells known as guard cells. The inner wall of guard cell towards the stomata is thicker as compared to the outer walls. Also, the peculiar arrangement of the microfibrils of the guard cells also aids in opening and closing of the stomatal aperture.



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The microfibrils are oriented radially rather than longitudinal. This help stomata to open easily. In a dorsiventral dicotyledonous leaf, the number of stomata is a greater on the lower surface as compared to the upper surface. This adaptation helps in reducing the loss of water. In

isobilateral leaf in a monocotyledonous plant, the number of stomata is equal on both the surfaces.

Factors affecting Transpiration

- Climatic factors like temperature, humidity, wind speed etc.
- Plant factors like number and distribution of stomata.
- Percent of open stomata.
- Water status of the plant.
- The structure of canopy of the tree.

Mechanism of Stomatal Movement

The factors which affect stomatal movement are-

- Amount of light
- The concentration of carbon dioxide
- Water supply

The opening and closing of stomata operate as a result of Turgidity changes in the guard cells. During daytime, guard cells photosynthesis due to which osmotic pressure increases. The guard cells absorb water

from the neighboring cells. Guard cells become turgid. As a result, the outer thin walls of guard cells are pushed out and the inner thicker walls are pulled inwards resulting in stomata to open.

During night or in a condition of water scarcity, guard cells are in a flaccid state and remain closed. Transpiration is the main driving force for the ascent of sap (rising of water in the tall trees through xylem vessels) which depends upon the following physical properties of water.

- Cohesion-It is the attraction between water molecules.
- Adhesion– The water molecules get attached to the surface of the tracheary elements of xylem.
- Surface tension– the ability of water surface to behave like a stretched membrane

These properties give water high tensile strength and high capillarity. Because of this, the water is able to rise in vessels and tracheids of xylem of tall trees. As the water is lost from the leaves during transpiration, a pulling action is generated due to which the water rises

high in the tall trees. The force generated by transpiration can create pressure sufficient to lift what over 130 M high.

Transpiration and Photosynthesis – a Compromise

Transpiration is an essential phenomenon.

- It's pulling action helps in absorption and transportation of water in the plant.
- It supplies water for photosynthesis.
- Transpiration cools the leaf surface.
- It maintains turgidity of the cells.

Water and Carbon dioxide are essential for photosynthesis. Stomata are kept open for exchange of gases during the day but it leads to a lot of loss of water and plants get depleted of water due to continuous transpiration. C4 plants might have evolved to reduce the loss of water due to transpiration as they can maintain a constant supply of CO_2 even after the closing of stomata.

Solved Questions for You

Q1. Transpiration is a necessary evil in plants. Explain.

Ans: Transpiration causes huge loss of water. Reduces photosynthesis, lowers growth and may cause wilting of the plan. In spite of all these disadvantages, it is necessary as it provides the pulling action for a\water to rise in the trees. It also maintains the temperature.

Q2. The C4 plants are twice as efficient as C 3 plants in terms of fixing CO 2 but lose only half as much water as C3 plants for the same amount of CO 2 fixed. Explain.

Ans: This is because C4 plants regulate a constant supply of CO2 and keep their stomata closed for some period of time. Due to this loss of water is reduced.