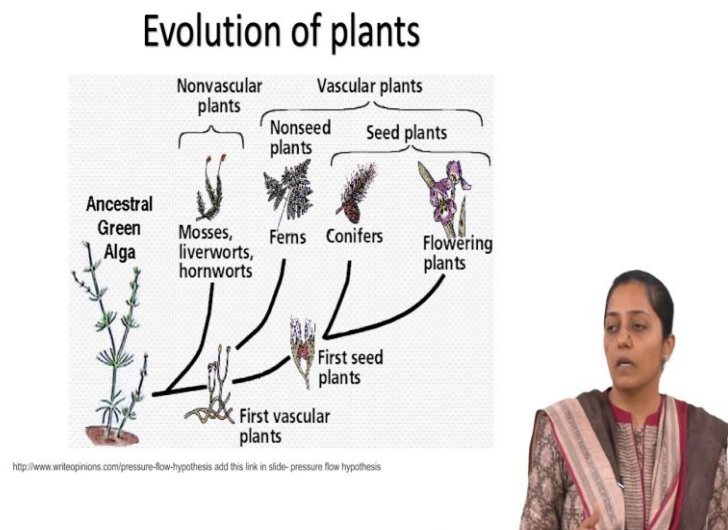


**Plant Cell Bioprocessing**  
**Dr. Smita Srivastava**  
**Department of Biotechnology**  
**Indian Institute of Technology, Madras**

**Lecture - 04**  
**Plant tissues and functions**

We studied the basic structure of plant cells, the different organelles in plant cells, the distinct features of plant cells, and the ways in which plant cells are different in terms of organelles and their functions in the last video.

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So, now we will briefly go through how plants evolved, what are the different types of plant tissues, and during evolutions how the different types of tissues have evolved. We will also talk about the structure of the leaf and transport in roots and stems through the vascular bundles.

To begin with, they plants were non-vascular. When they came from aquatic environments to the land, the terrestrial plants were non-vascular in nature.

It means, the vascular bundle (the vascular tissues xylem and phloem) were missing. Now, because the vascular bundle is missing, the mechanism to transport the water and minerals to long distances against a gravity were missing. So, they have to grow crawling through the level of the ground to long distances, and the transport of minerals

and water should be of a longer distance. So, therefore, they were found very close to water bodies.

Plants like mosses, algae, liverworts which are non-vascular in nature are found to grow near the food source or the water source. Then with evolution, in order to survive, vascular bundles xylem and phloem were formed. Conduction of water and minerals was now possible. They were non seed bearing plants and they propagate their progenies through spores. Example, ferns.

Then further evolution happened and came the seed bearing plants. The seed bearing plants are of two types – angiosperms and gymnosperms. Angiosperms are the non-flowering plants, which have naked seeds like for example, conifers and pine trees. The ovule does not have an ovary around it and there are no fruits. The seeds are open.

In further evolution, the seeds were dispersed through wind. Through pollination, we could get genetically improved varieties. Thus the next evolution was to the seed bearing plants or the flowering plants where the seeds could be encapsulated in fruits.

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## PLANT TISSUES

**Tissue** is a cellular organizational level, intermediate between cells and a complete organism. A tissue is an ensemble of similar cells from the same origin that together carry out a specific function. Organs are then formed by the functional grouping together of multiple tissues.

THE FOUR BASIC PLANT TISSUES ARE

- DERMAL TISSUE
- GROUND TISSUE
- MERISTEMATIC TISSUE
- VASCULAR TISSUE



Let us now talk about the different tissues in the plant. First what is a tissue? When similar cells from the same origin come together to perform a specialized function, they form a tissue. When a number of tissues come together having or carrying out different functions in a functional manner then they become an organ. So, in plants, there are

different kinds of tissues. What are the different kinds of tissues? Dermal tissue, ground tissue, meristematic tissue and vascular tissue.

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### DERMAL TISSUE SYSTEM

- **DERMAL TISSUE** forms the skin (the outside covering) of a Plant, Covering all parts of the roots, stems, and leaves. Consist of all kinds of cells.
- One kind of Dermal tissue is the **EPIDERMIS**, made of Parenchyma Cells, which is the outer protective tissue of young plants and mature Non-woody Plants.
- Dermal Tissue has different functions, depending on its **LOCATION** on the plant.
  - Above the ground, Dermal Tissue prevents the plant from drying out by reducing water loss from evaporation (Transpiration). This dermis tissue also Secretes a waxy layer called cuticle.
  - Below the ground, Dermal Tissue absorbs water. On the underground parts of a plant, the Epidermis forms root hairs that absorb water and nutrients.
  - On leaves and stems openings in the epidermis are called Stomata. Stomata regulate the passage of gases and moisture into and out of the plant.
  - In woody stems and roots, the Epidermis is replaced by dead Cork Cells.



So, now let us talk about all these tissues. Dermal tissue; by the name itself means, the skin of the plant. They are composed of many different types of cells, .We will now talk about the aerial parts and the ground parts. One kind of the dermal tissue is called the epidermis .Epidermis is mainly made up of parenchymatous cells. For example, in leaves they form the thin skin or the transparent layer. Sometimes these kind of cells secrete a waxy layer which is called as the cuticle. It serves the purpose of protecting or preventing the loss of water from the surface of the leaf or the stem. Especially we will find them in non woody plants or young plants. These are in ground level.

In underground level, they are modified as root hairs. The purpose of epidermis here is to increase the absorption capacity of the root, that is to enhance the uptake of water and minerals through these extensions. Thus these epidermis plays an extra role.

The function and structure of epidermis varies according to the location it is present. For example, the cuticle or the waxy layer or waxy compound generation layer is on the surface. Below the surface of the leaf, you will find the epidermis will have large amount of pores or spaces which are called as stomata. And you will find guard cells which make these openings. Now, these openings are used for gas exchange and for the water. So, transpiration happens from here.

In woody plants, epidermis is replaced by the dead cork cells where thin skin gets modified into cork cells. Cork cells are nothing but mature cells which are no longer growing and they become dead at maturity. The cytoplasm is lost, so they are only used for structural and protection purpose. Then the epidermis is modified into cork cells region.

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### GROUND TISSUE SYSTEM

- DERMAL TISSUE SURROUNDS THE GROUND TISSUE SYSTEM
- GROUND TISSUE CALLED AS FILLER TISSUE. PARENCHYMA, A SIMPLE TISSUE, MAKES UP MOST GROUND TISSUE.
- GROUND TISSUE HAS MANY METABOLIC FUNCTIONS, INCLUDING PHOTOSYNTHESIS, FOOD STORAGE AND SUPPORT.
- NON-WOODY ROOTS, STEMS, AND LEAVES ARE MADE UP PRIMARILY OF GROUND TISSUE.



Ground tissue is the mass of the plant; it forms the major flesh of the plant in the stem. Majority of the cells in the ground tissues are parenchyma cells. They carry out many different kinds of functions. These parenchyma cells, because they can differentiate into different types of cells, can take part in various metabolic activities, like in food storage, in synthesis, in photosynthesis which means preparing food and in support which means making the flesh supporting the stem or the leaf.

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## VASCULAR TISSUE SYSTEM

- VASCULAR PLANTS HAVE SPECIALIZED TISSUE CALLED VASCULAR TISSUE. VASCULAR TISSUE CARRIES WATER AND NUTRIENTS THROUGHOUT THE PLANT AND HELPS SUPPORT THE PLANT.
- THERE ARE TWO KINDS OF VASCULAR TISSUE: XYLEM AND PHLOEM
- BOTH KINDS OF VASCULAR TISSUE CONTAIN SPECIALIZED CONDUCTING CELLS



Vascular tissue system – This is the system through which evolution came into the plant cells. There are two kinds of vascular tissues; one is the xylem and the phloem.

Xylem is responsible for water conduction and phloem is responsible for Sugar conduction. The food which is prepared as carbohydrates or sugars in the leaves or the stem is then transported through different parts of the plant. How does that happen? Xylem and phloem contains different kinds of cells which have specific structures to facilitate this process.

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## VASCULAR TISSUE SYSTEM

**XYLEM:** WHEN WATER AND MINERALS ARE ABSORBED BY THE ROOTS OF A PLANT, THESE SUBSTANCES MUST BE TRANSPORTED UP TO THE PLANT'S STEMS AND LEAVES. XYLEM IS THE TISSUE THAT CARRIES WATER AND DISSOLVED SUBSTANCES UPWARD IN THE PLANT.

TRANSPORT OF WATER IS CARRIED OUT BY TRACHEIDS AND VESSEL ELEMENTS PRESENT IN THE XYLEM TISSUE.

**VESSEL ELEMENTS** HAVE OPENINGS AT BOTH ENDS THAT CONNECT INDIVIDUAL VESSEL ELEMENTS TO FORM A CONTINUOUS TUBULAR VESSEL. THESE END OPENINGS ARE CALLED PERFORATIONS OR PERFORATION PLATES. AT MATURITY THE PROTOPLAST DIES AND DISAPPEARS, BUT THE LIGNIFIED CELL WALL PERSISTS.

**TRACHEIDS** ARE ELONGATED CELLS AND DO NOT HAVE PERFORATIONS. ALL TRACHEARY ELEMENTS DEVELOP A THICK LIGNIFIED CELL WALL, AND AT MATURITY THE PROTOPLAST DISAPPEARS. IT CONTRIBUTES TO THE TRANSPORT SYSTEM AND PROVIDES STRUCTURAL SUPPORT.



Let us talk about the xylem. Now, when the water gets absorbed onto the roots, how do you think the water is able to get transported through the xylem against gravity till the leaves. It has to travel to the leaves where the photosynthesis is happening right?

Capillary action alone creates a negative pressure in the xylem as once the water gets evaporated because of transpiration, there is a pull for more water till the leaves.

So, there is a negative pressure in the xylem, and then the water is sucked up from the xylem for the photosynthesis in the leaves. To fill up the roots again, the adsorption takes place. Now, one is that. What other force do you think, what determines capillary action?

Student: Cohesive forces.

Cohesive and what else? Cohesive and?

Student: Adhesive forces.

So, now, how do you think cohesive force and adhesive force helps in facilitating the water movement in the xylem? This is called as cohesive tension theory. So, I will come onto that in the next slide.

Let us talk about the different types of cells in xylem. There are two different types; one is called the vessel elements and the others are tracheids.

Vessel elements, are nothing but columnar cells which have perforations at the top and the bottom. They become like pipe lines with no cytoplasm and empty chambers with lignified thick secondary cell walls and allows the travel of water easily. These perforations are called as perforated plates. These are found at the top and the bottom of the cells.

Tracheids: Tracheids are very long cells which are close to each other along lengths, but because of the length, the water can diffuse through these cells. These are dead cells upon maturity. So, they become empty chambers and therefore they have stronger secondary walls similar to vessel elements.

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## VASCULAR TISSUE SYSTEM

**PHLOEM:** SUGARS MADE IN THE LEAVES OF A PLANT BY PHOTOSYNTHESIS MUST BE TRANSPORTED THROUGHOUT THE PLANT. PHLOEM TISSUE CONDUCTS SUGARS UPWARD AND DOWNWARD IN A PLANT.

THE PHLOEM IS COMPOSED OF LIVING CELLS (SIEVE-TUBE ELEMENTS, PARENCHYMA CELLS AND SUPPORTIVE CELLS) THAT TRANSPORT SAP.

MOVEMENT THROUGH THE PHLOEM IS DRIVEN BY POSITIVE HYDROSTATIC PRESSURES, ACCOMPLISHED BY A PROCESS CALLED PHLOEM LOADING AND UNLOADING.

LOADING AND UNLOADING PATTERNS ARE LARGELY DETERMINED BY THE CONDUCTIVITY AND NUMBER OF PLASMODESMATA AND PLASMA MEMBRANE TRANSPORT PROTEINS.

CELLS IN A SUGAR SOURCE AND SINK, "LOAD" AND "UNLOAD", THE SIEVE-TUBE ELEMENT BY ACTIVELY TRANSPORTING SOLUTE MOLECULES INTO AND OUT OF IT, RESPECTIVELY.



So, then talking about phloem, the purpose of phloem is to transport sugar to different parts of the plants. The type of cells which are responsible, are called as sieve tube elements, which are again long cells.

The sugar sap will be so thick, once it is prepared. How does the flow happen through these cells? First the sugar from some site of synthesis (the cells which are preparing sugar where photosynthesis is taking place) has to be dropped into sieve cells. And then from there it has to be dropped back to the sink wherever sugar is needed.

So, how do you think this is happening? Sugar is not present in the sieve tube elements to begin with. Active transport happens from sink to high concentration. Passive, happens from the source to the sieve tube elements. But then how is the flow happening in the sieve tube elements? A hint, you will always find these vascular bundles together.

Why do you think it is so? Nature does everything for a purpose, it beautifully designs the structure. The flow of the sugar in these sieve tube elements is through hydrostatic pressure. So, what happens is that when sugar is loaded onto the sieve tube elements, the water is close as xylem is close.

The water will flow from the xylem to the phloem. Once the water flows, there will be hydrostatic pressure, and then the sugar starts flowing. Now, it is poured into a sink, through active transport. This is facilitated by removal of water at the site. The water



again diffuses back from those cells at the site to the xylem, so that the hydrostatic pressure can be reduced. Then the active transport can take place to put the sugars into the source cells. It depends on the sieve tube elements which has a lot of plasmodesmata, those connecting channels between xylem and phloem through which this transport happens.

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## TWO PATTERNS OF GROWTH

**PRIMARY GROWTH** - THE ELONGATION (GROWTH IN LENGTH) OF STEMS AND ROOTS IS CALLED PRIMARY GROWTH. ALL PLANTS EXHIBIT PRIMARY GROWTH, IT OCCURS WHERE PLANTS GROW TALLER AND THEIR ROOTS GROW DEEPER.

**SECONDARY GROWTH** - GROWTH THAT MAKE PLANTS THICKER (GROWTH IN DIAMETER) IS CALLED SECONDARY GROWTH. SOME SEED PLANTS HAVE SECONDARY GROWTH, IN WOODY PLANTS. THERE IS A MERISTEM (LATERAL MERISTEM) BETWEEN THE XYLEM AND PHLOEM CALLED THE VASCULAR CAMBIUM THAT PRODUCES ADDITIONAL VASCULAR TISSUE.



There are two patterns of growth; one is primary growth and the second is secondary growth. Primary growth is where elongation or the lengthening of the aerial parts or underground parts happens, so that is primarily meristematic tissue. This growth is not throughout life like animals or mammals where once the growth has happened, they do not keep growing continuously.

But in plants growth can happen till the plant is alive. It does not happen throughout the plant, it only happens in certain regions which are called as meristems, these are meristematic tissue regions which are composed of cells which are continuously dividing. So, it is the function of these tissues to increase the thickness or the length. Even between the phloem and the xylem there is a meristematic tissue which is called as vascular meristem which is rapidly dividing and then differentiates into either phloem or xylem and causes thickness there.



Secondary growth refers to increase in the thickness. You will find it in woody plants. The thick trunks which you see in the plants is because of secondary growth that has happened because of lateral meristems or vascular meristem.

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## GROWTH IN MERISTEMS

- PLANTS GROW DIFFERENTLY FROM ANIMALS. INSTEAD OF GROWING ONLY FOR A LIMITED TIME, PLANTS GROW AS LONG AS THE PLANT IS ALIVE.
- INSTEAD OF OCCURRING THROUGHOUT THE ORGANISM, PLANT GROWTH OCCURS ONLY IN SPECIFIC GROWING REGIONS.
- THE GROWING REGIONS OF PLANTS ARE CALLED MERISTEMS, REGIONS WHERE CELLS CONTINUOUSLY DIVIDE.
- MERISTEMS ARE LOCATED AT THE TIPS OF STEMS AND BRANCHES, AT THE TIPS OF ROOTS (APICAL), AND IN JOINTS WHERE LEAVES ATTACH TO STEMS (AXILLARY).



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## GROWTH IN MERISTEMS

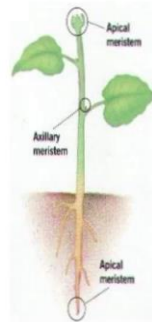
- IN WOODY PLANTS (TREES), THERE ARE MERISTEMS BETWEEN THE XYLEM AND PHLOEM.
- THE TYPE OF TISSUE FOUND IN MERISTEMS IS CALLED MERISTEMATIC TISSUE.
- MERISTEMATIC TISSUE PRODUCES NEW CELLS BY MITOSIS.
- THESE NEW CELLS ARE ALL ALIKE AT FIRST, BUT EVENTUALLY THEY CHANGE (DIFFERENTIATE) INTO VASCULAR TISSUE, DERMAL TISSUE, OR GROUND TISSUE.



These meristematic tissues or meristems divide, through mitosis that is through simple cell division.

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## GROWTH IN MERISTEMS



- Apical Meristems → Primary growth
- Lateral Meristems → Secondary growth
  - Vascular cambium
  - Cork cambium
- Intercalary Meristems (found in the nodes of grasses)

Type	Location	Function
Apical meristem	tips of stems and roots	growth; increase length at tips
Intercalary meristem	between the tip and base of stems and leaves	growth; increase length between nodes
Lateral meristem	sides of stems and roots	growth; increase diameter

[https://www.biologyjunction.com/plant\\_structure\\_b17.htm](https://www.biologyjunction.com/plant_structure_b17.htm)



These meristematic cells, have the ability to continuously divide and then differentiate into different types of tissues or different types of cells. Growth in meristems can be apical meristem or the lateral meristem at the inter nodes or nodal regions. There are rapidly dividing meristematic regions even between the nodes which will help in lengthening the inter node. So, there are different kinds of meristems depending on wherever this meristem region is present. They support either the elongation of the plant or the increase in the secondary growth.

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## CAMBIUM

- A LATERAL MERISTEM IN VASCULAR PLANTS, INCLUDING THE VASCULAR CAMBIUM AND CORK CAMBIUM, THAT FORMS PARALLEL ROWS OF CELLS RESULTING IN SECONDARY TISSUES.
  - THE VASCULAR CAMBIUM, LOCATED BETWEEN THE XYLEM AND PHLOEM, PRODUCES ADDITIONAL VASCULAR TISSUES.
  - THE CORK CAMBIUM, LOCATED OUTSIDE THE PHLOEM, PRODUCES CORK. CORK CELLS REPLACE THE EPIDERMIS IN WOODY STEMS AND ROOTS, PROTECTING THE PLANT. CORK CELLS ARE DEAD CELLS THAT PROVIDE PROTECTION AND PREVENT WATER LOSS



Vascular cambium: This is a lateral meristem in the vascular plants through which the xylem and the phloem of the cell keeps rejuvenating. This happens because of the vascular meristem which is present between xylem and the phloem and it increases the size of the vascular cambium.

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### Diffusion and Osmosis

How things move in and out of cells

- Cells constantly exchange materials with their environment. One way this occurs is by **diffusion**.
- **Diffusion** is the movement of particles or molecules from areas of higher concentration to lower concentration.



Diffusion is the process which helps in the transport of water from the roots till the upper regions of the plant. The driving force for diffusion is concentration.

It is the concentration of solute molecules or other substances present around which will cause the water movement from the root to the upper region which we call as osmosis.

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## Osmosis

- The diffusion of water across cell membranes is called **osmosis**.
- Water can move freely through membranes.
- The direction the water molecules move is dependent upon the relative concentrations of substances on either side of the membrane, moving from high concentration to low



Plasmolysis is seen in wilted leaves. Because of transpiration, water is lost, the plasma membrane withdraws itself, and thus they shrink. And if you put it in a hypertonic solution, these leaves will become turgid because of the movement of water molecules from outside to the inside.

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## Osmosis

- If you place a cell in a highly concentrated solution of salt or sugar, water will leave the cell.
- The water is actually diffusing from an area of high concentration to an area of lower concentration.
- If a cell is left in a hypertonic solution, for any length of time, so much water will leave that the protoplast actually shrinks away from the cell wall.
- When this happens the cell is said to be plasmolyzed. In a wilted leaf many of the cells would be plasmolyzed.



We know that cellular membranes, are semipermeable membranes and water can easily move in through these membranes. Once the water moves through the roots to reach the xylem, it has to cross the root hairs, cortex region, then it has to cross the phloem, then

the xylem. Now, the water after entering the xylem can even come out the same way it is entering. So a mechanism is required to prevent it. Before the phloem, there is another layer of cells which have waterproofing mechanism. These are sealants which has to be crossed before going to the xylem. The water hence passes through a differentially permeable layer. So, the mechanism is a selective one way transport, and it will not allow the water to leak out once it has reached the xylem.

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## Osmosis

- On the other hand, if you place a cell in distilled water, water will enter the cell. Again the water is moving from higher (outside the cell) to lower concentration
- When a plant cell is in a hypotonic, solution, water will enter until the vacuole is fully extended pushing the cytoplasm up against the cell wall. Such cells look plump, or turgid; this is the normal appearance of cells in a well-watered plant.
- When the cell is placed in a solution of the same concentration, **isotonic**, there is no net movement of water and the cell is not turgid.



In an isotonic solution there will be no change, because there is no concentration gradient. The concentration of the solutes is same both inside and outside.

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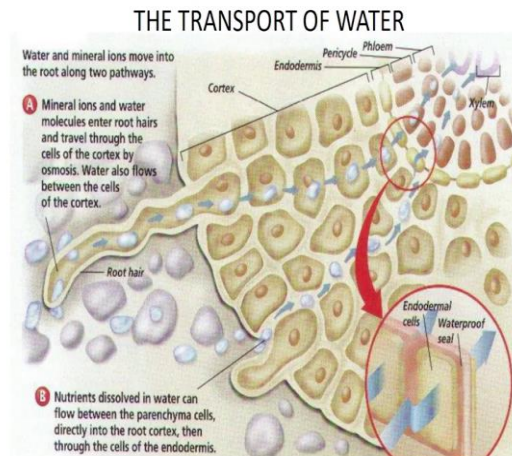
## Membrane Transport

- Diffusion take place when molecules move along a concentration gradient.
- Cells can also move substances against a concentration gradient
  - Called **active transport**
  - Requires energy by the cell
  - Membrane proteins transport these substances across the membrane



So, now, for water, the transport is mainly diffusion. For minerals and salts and for phloem - movement of sugars, active transport is required.

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<https://www.slideshare.net/bchiam/transport-in-plant-slides>



In roots, once the water has been absorbed, the movement can be through two ways, one is that the water can pass through the cells; and reach the xylem; another way is the gaps between the cells which is utilized to reach till the xylem.



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## THE TRANSPORT OF WATER

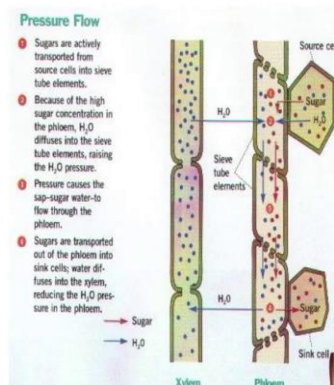
- THE TRANSPORT OF WATER AND MINERAL NUTRIENTS OCCURS IN THE XYLEM OF ALL PLANT ORGANS.
- THE THEORY OF WATER MOVEMENT IN PLANTS TODAY IS KNOWN AS THE **COHESION-TENSION THEORY**. ACCORDING TO THIS THEORY, WATER MOVEMENT IN PLANTS IS DRIVEN BY **TRANSPIRATION**.
- **TRANSPIRATION** IS THE EVAPORATION OF WATER FROM THE PARTS OF A PLANT EXPOSED TO THE AIR.
- AS WATER EVAPORATES FROM THE CELLS OF A LEAF OR STEM, REPLACEMENT WATER IS PULLED FROM THE XYLEM TISSUE, MORE WATER ENTERS THE ROOTS FROM THE SOIL TO REPLACE THE LOST WATER.



So, as we had already discussed, transpiration is one of the ways by which the water is able to flow through the xylem. It creates negative pressure in the xylem for water movement to happen. 98 percentage of water which is absorbed every day is lost because of transpiration. Water is needed for photosynthesis. It becomes the bottleneck or the rate limiting step in the photosynthesis, knowing that 98 percent of the water is getting lost. The other advantage which is balancing out this loss is the mineral transport along with water. The minerals which are coming along with water will be pulled up because of transpiration. Hence, there is an advantage in losing water.

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The Movement of sugars in Phloem is best explained by  
the **PRESSURE-FLOW HYPOTHESIS**



<http://www.writeopinions.com/pressure-flow-hypothesis-add-this-link-in-slide-pressure-flow-hypothesis>





The hypothesis which is used to explain the flow of sugar molecules in the sieve tube elements is pressure flow hypothesis. Because the xylem is adjacent to phloem, the water molecules diffuse in from the xylem to the phloem at the site of source, It is the source where the sugar is being prepared. So, in order for the sugar to move now towards the sink, hydrostatic pressure is needed. So, to achieve the same, water is driven in into the sieve tube elements.

Now, through the sieve tube elements, it will pass and as soon as it reaches the side where it has to be downloaded, the hydrostatic pressure has to be reduced. So, the water is again diffused back into the xylem.

It actively transports the sugar molecules into the sink through membrane proteins. The cell membrane as I said is permeable to water. So, once the sugar is downloaded, then the water is able to diffuse back. These things happen in parallel. There are membrane proteins, transport proteins which help in movement of molecules against the concentration gradient that is called as pressure flow hypothesis.

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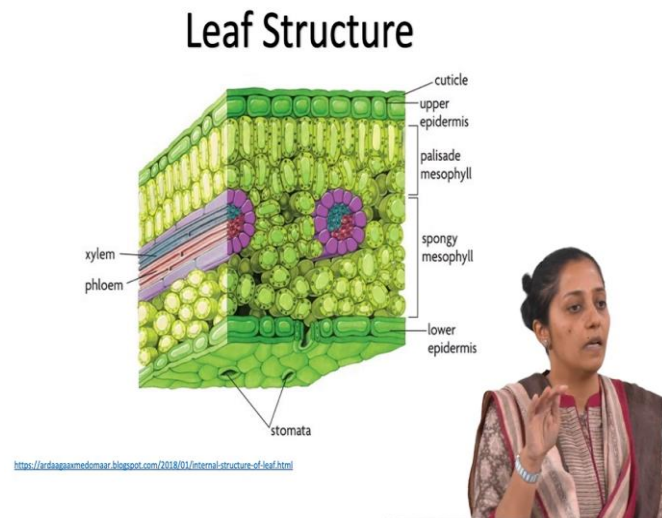
## LEAVES

Most leaves are thin and flat, an adaptation that helps them capture sunlight for photosynthesis.

Like roots and stems, leaves are extremely variable. This variability represents adaptations to environmental conditions.



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Leaves: The photosynthesis takes place at leaves. The upper surface of the epidermis is very thin and transparent. Below is the, modified parenchyma cells which is the site for photosynthesis.

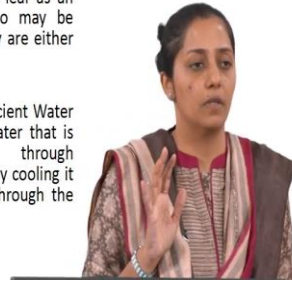
The palisade mesophyll and spongy mesophyll: Spongy mesophylls are randomly arranged. So, there are spaces and it is more flexible. The upper layer which are palisade mesophylls, are parenchyma cells, where light reactions take place, and light gets captured. In this spongy mesophyll, there are veins. Now, these veins are made up of vascular tissue - xylem and the phloem.

The adjacent regions of xylem and the phloem, is called bundle sheath cells. They are modified parenchyma cells. These bundle sheath cells are the site for dark reactions or the spongy mesophyll, where the carbohydrates gets formed. The site for carbohydrates or sugars synthesis has been made close to the vascular bundle, so that it can be transported. That is the source and it has to be transported into the phloem for the movement to different parts of the plant. The lower epidermis will have openings called stomata.

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## LEAF FUNCTIONS

- Leaves are the primary site of photosynthesis in most plants.
- Mesophyll Cells in Leaves use Light Energy, Carbon dioxide, and Water to make Carbohydrates.
- Light Energy is also used by Mesophyll Cells to synthesize amino acids, fats, and a variety of other organic molecules.
- Carbohydrates made in a leaf can be used by the leaf as an Energy source or as building blocks. They also may be transported to other parts of the plant, where they are either used or stored.
- A major limitation to plant photosynthesis is insufficient Water due to transpiration. About 98 percent of the water that is absorbed by the roots is lost through transpiration. Transpiration may benefit the plant by cooling it and speeding the transport of mineral nutrients through the Xylem.



Plants cannot move. There are variations such as more sunlight or no sunlight. How do the plants adapt themselves to cater to their needs of photosynthesis? Too much of sunlight may result into lot of loss of water and also, and damage can happen. What would the plant do to survive? It will close the stomata. But if it closes the stomata, what will happen?

There is no water loss, but now what is the demerit now?

Now, once the stomata is closed, what will happen, no  $\text{CO}_2$  will come inside. So, inside the cells, where these light reactions are happening, the oxygen concentration will rise. Once the oxygen concentration rises, the enzyme which is responsible for photosynthesis- Rubisco can get activated both ways.

But we will see later that once the oxygen concentration increases, rather than doing photosynthesis, because of higher concentration of oxygen, rubisco starts preferring oxygen rather than  $\text{CO}_2$  and some other kinds of undesirable reactions start happening which is not what the plant or the rubisco is meant to do.

So, there are different types of plants depending on the regions where they grow, and they need to adapt to these situations. These are classed as follows: whatever plants we see around us are  $\text{C}_3$  class of plants. The plants in arid regions are called as  $\text{C}_4$  plants.

So, now in the next class we will see we will talk about photosynthesis and photorespiration. Then we will talk about the adaptations into C3 and C4 classes. There is even a third type from C4, and let us see why it happens and how the plant adapt itself to these situations.