Plant Cell Bioprocessing
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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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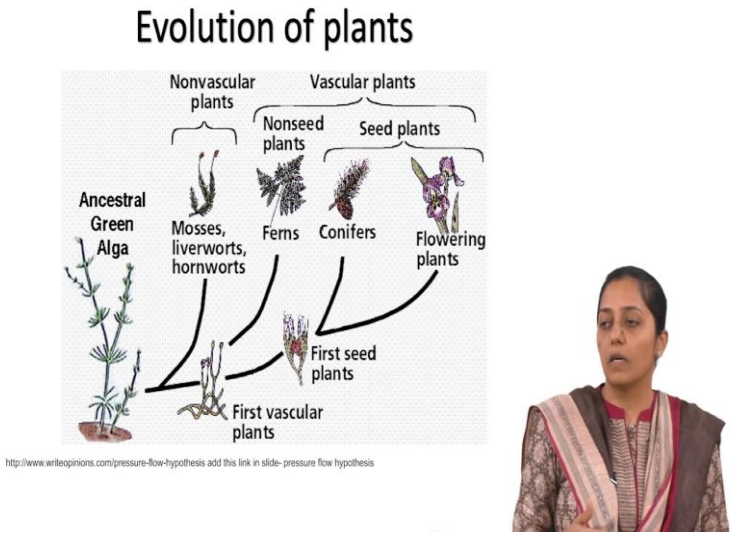

So, now we will briefly go through how plants evolved, what are the different types of plant tissues, and during evolutions how the different types of tissues have evolved. We will also talk about the structure of the leaf and transport in roots and stems through the vascular bundles.

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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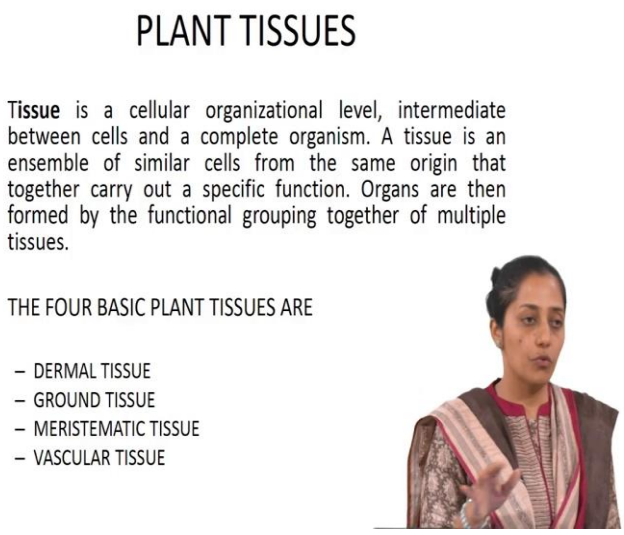

Let us now talk about the different tissues in the plant. First what is a tissue? When similar cells from the same origin come together to perform a specialized function, they form a tissue. When a number of tissues come together having or carrying out different functions in a functional manner then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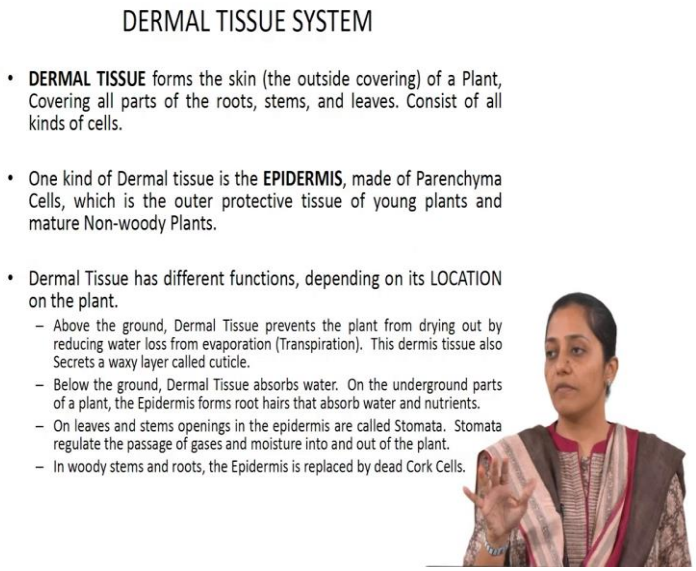

So, now let us talk about all these tissues. Dermal tissue; by the name itself means, the skin of the plant. They are composed of many different types of cells, .We will now talk about the aerial parts and the ground parts. One kind of the dermal tissue is called the epidermis .Epidermis is mainly made 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 them find 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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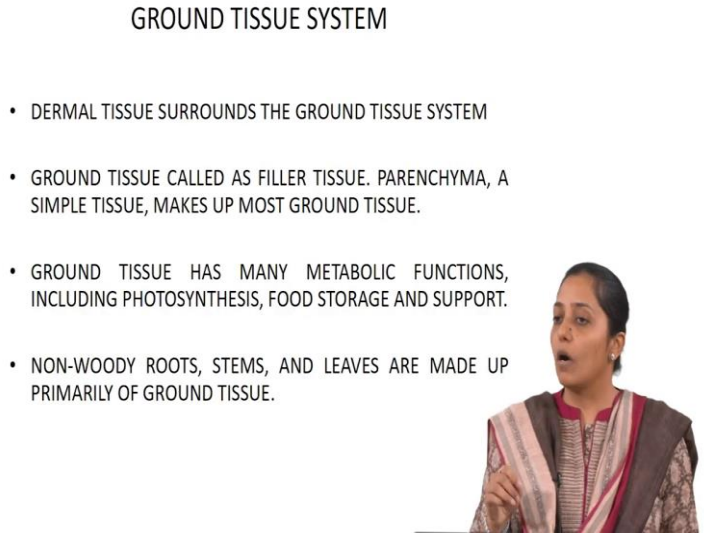

Ground tissue is the mass of the plant; it forms the major flesh of the plant in the stem. Majority of the cells in the ground tissues are parenchyma cells. They carry out many different kinds of functions. These parenchyma cells, because they can differentiate into different types of cells, can take 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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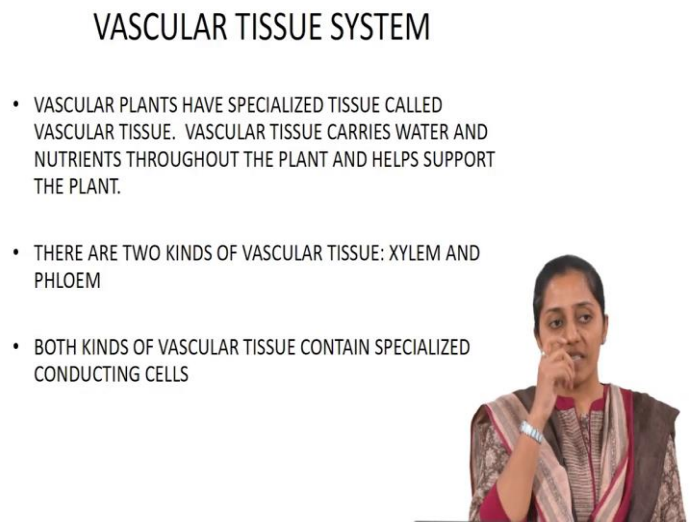

Vascular tissue system – This is the system through which evolution came into the plant cells. There are two kinds of vascular tissues; one is the xylem and the phloem.

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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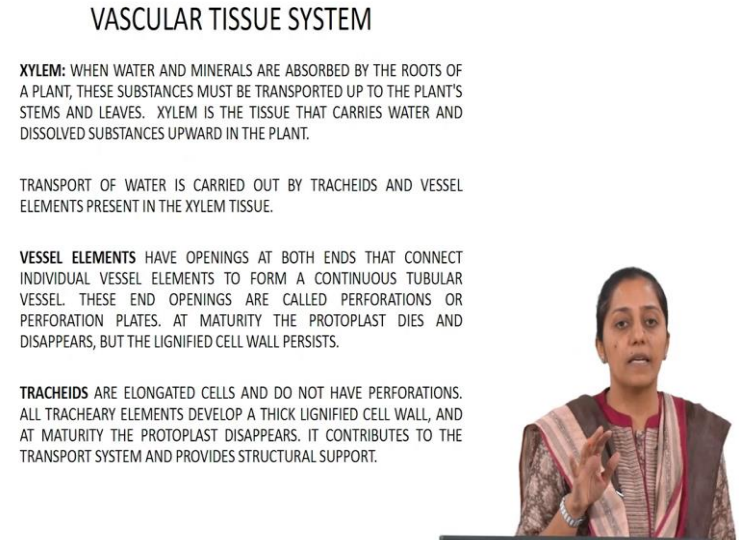

Let us talk about the xylem. Now, when the water gets absorbed onto the roots, how do you think the water is able to get transported through the xylem against gravity till the leaves. It has to travel to the leaves where the photosynthesis is happening right?

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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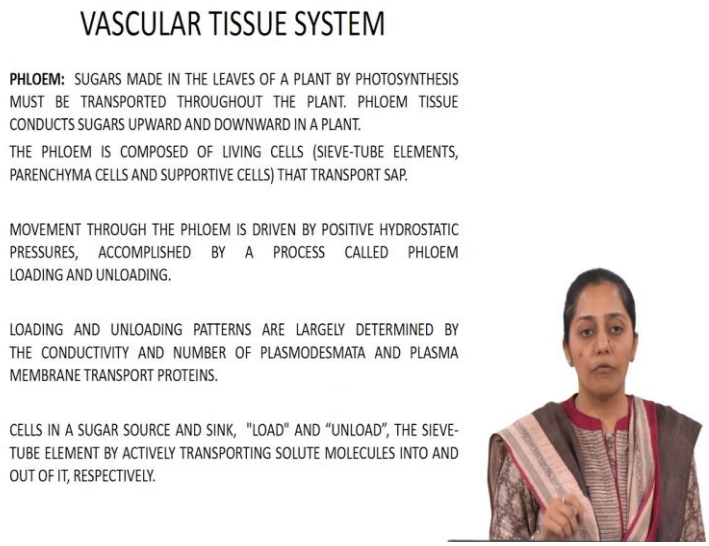

So, then talking about phloem, the purpose of phloem is to transport sugar to different parts of the plants. The type of cells which are responsible, are called as sieve tube elements, which are again long cells.

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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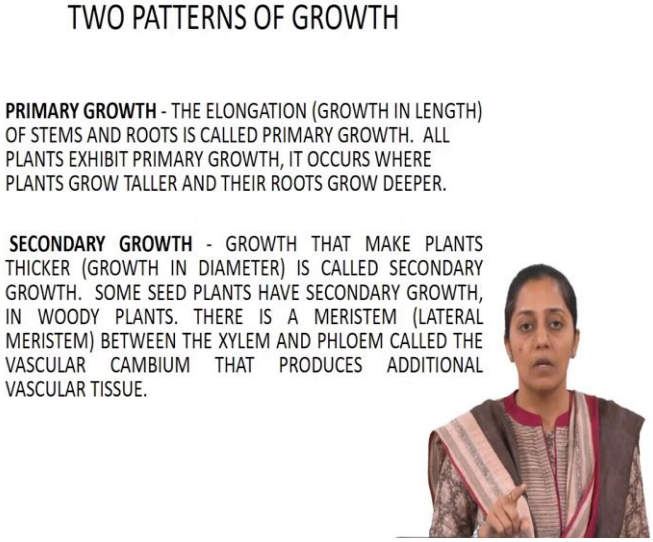

There are two patterns of growth; one is primary growth and the second is secondary growth. Primary growth is where elongation or the lengthening of the aerial parts or underground parts happens, so that is primarily meristematic tissue. This growth is not throughout life like animals or mammals where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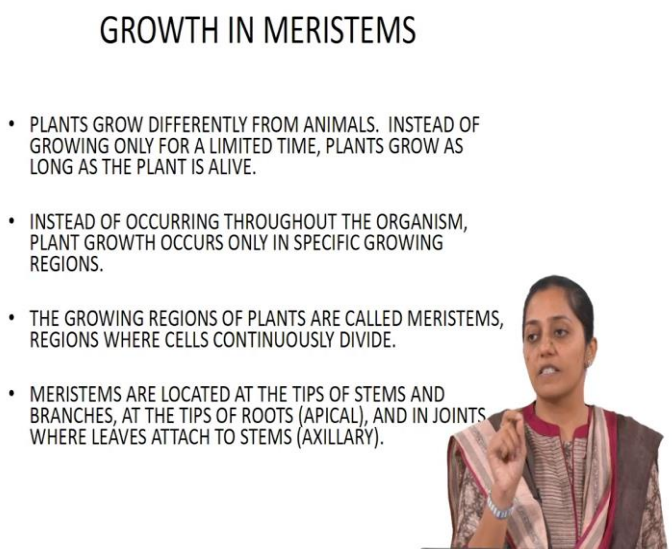

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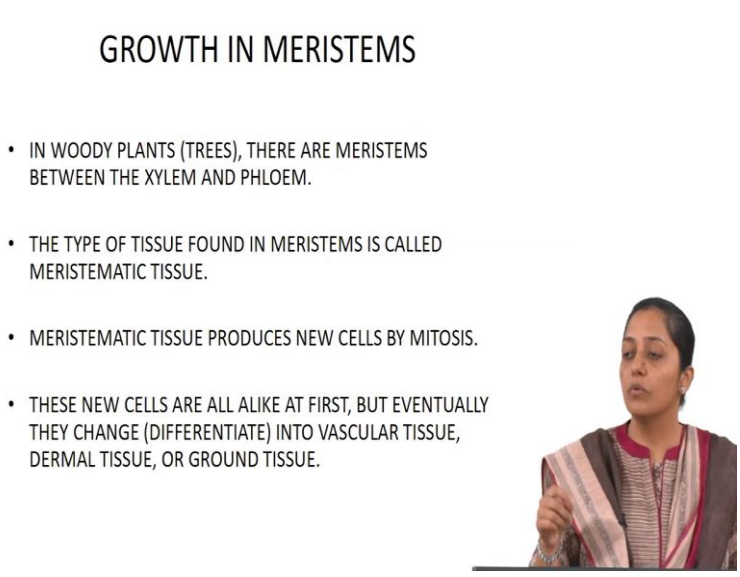

These meristematic tissues or meristems divide, through mitosis that is through simple cell division.

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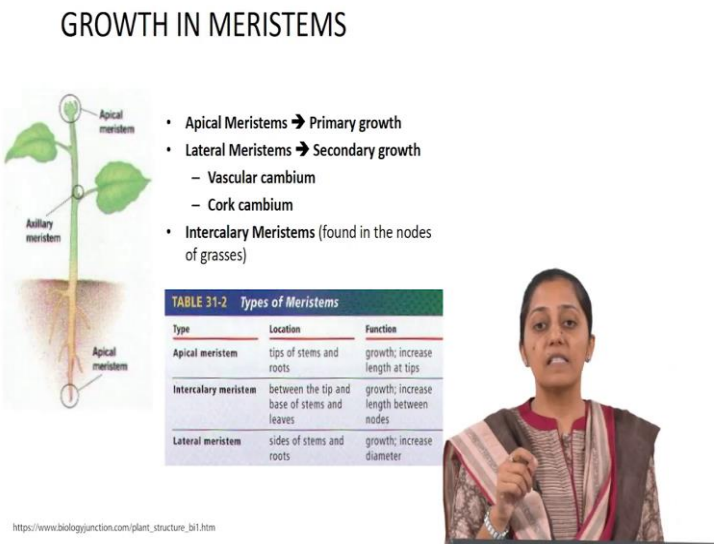

These meristematic cells, have the ability to continuously divide and then differentiate into different types of tissues or different types of cells. Growth in meristems can be apical meristem or the lateral meristem at the inter nodes or nodal regions. There are rapidly dividing meristematic regions 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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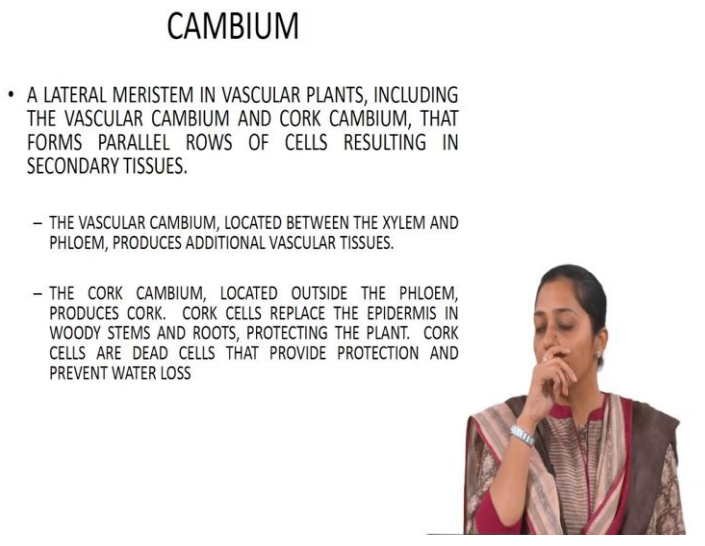

Vascular cambium: This is a lateral meristem in the vascular plants through which the xylem and the phloem of the cell keeps rejuvenating. This happens because of the vascular meristem which is present between xylem and the phloem and it increases the size of the vascular cambium.

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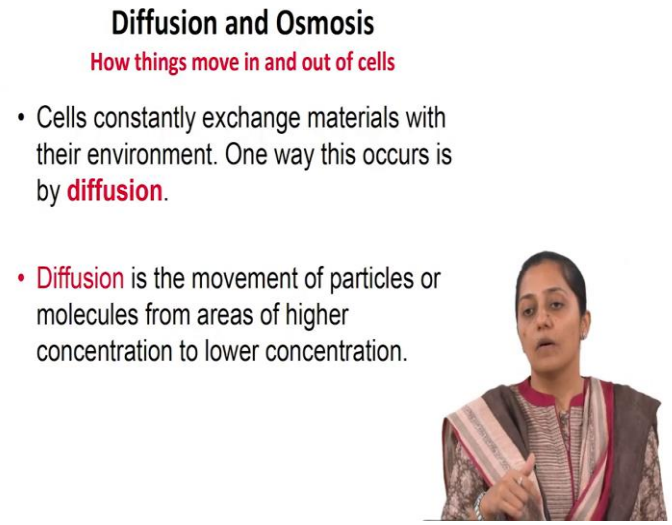

Diffusion is the process which helps in the transport of water from the roots till the upper regions of the plant. The driving force for diffusion is concentration.

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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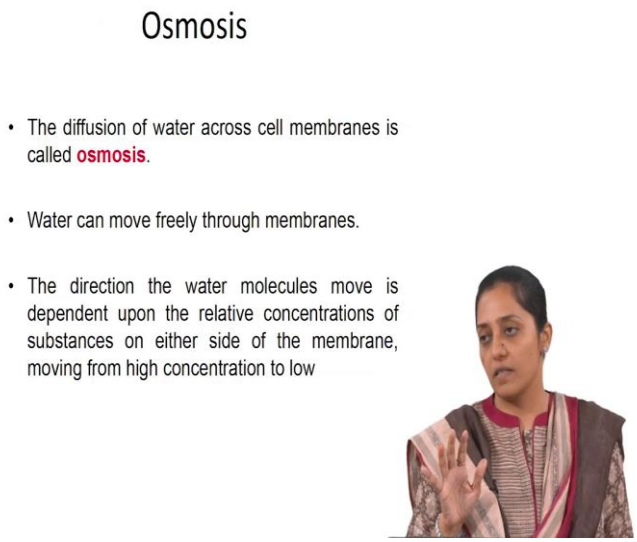

Plasmolysis is seen in wilted leaves. Because of transpiration, water is lost, the plasma membrane withdraws itself, and thus they shrink. And if you put it in a hypertonic solution, these leaves will become turgid because of the movement of water molecules from outside to the inside.

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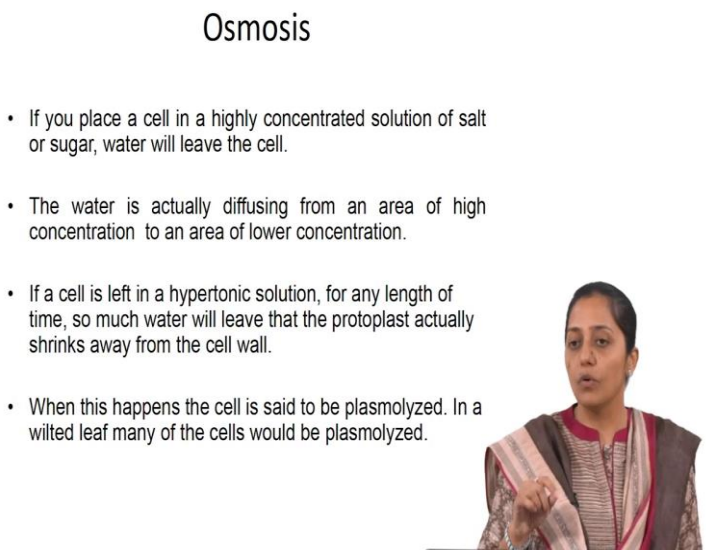

We know that cellular membranes, are semipermeable membranes and water can easily move in through these membranes. Once the water moves through the roots to reach the xylem, it has to cross the root hairs, cortex region, then it has to cross the phloem, then

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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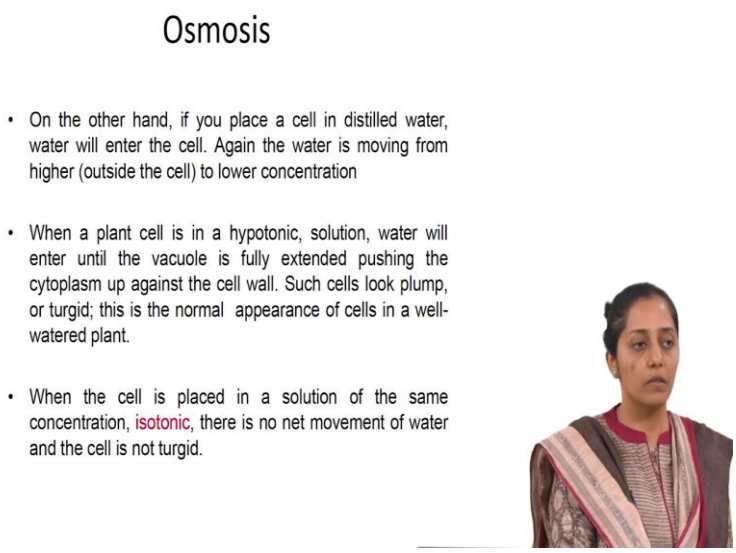

In an isotonic solution there will be no change, because there is no concentration gradient. The concentration of the solutes is same both inside and outside.

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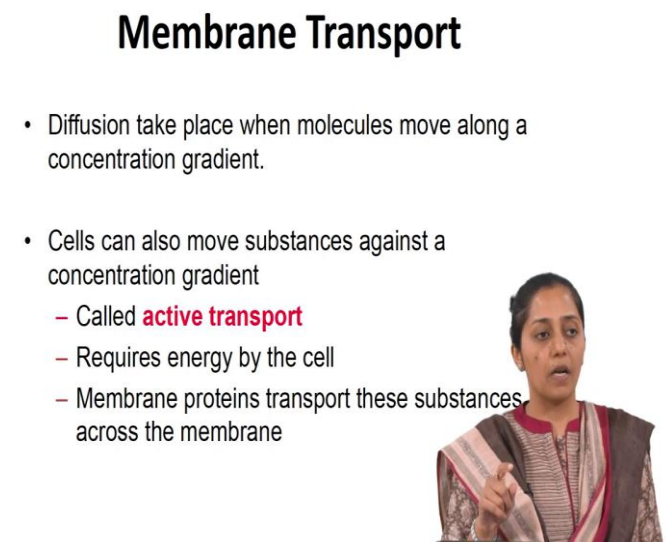

So, now, for water, the transport is mainly diffusion. For minerals and salts and for phloem - movement of sugars, active transport is required.

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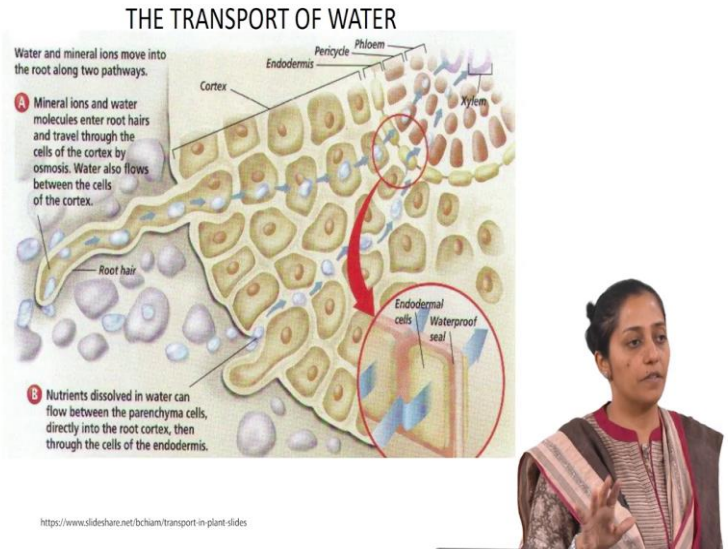

In roots, once the water has been absorbed, the movement can be through two ways, one is that the water can pass through the cells; and reach the xylem; another way is the gaps between the cells which is utilized to reach till the xylem.

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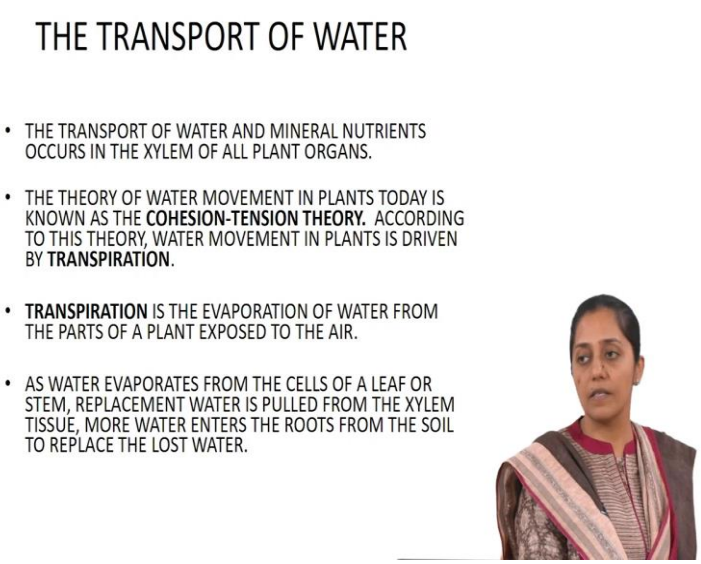

So, as we had already discussed, transpiration is one of the ways by which the water is able to flow through the xylem. It creates negative pressure in the xylem for water movement to happen. 98 percentage of water which is absorbed every day is lost because of transpiration. Water is needed for photosynthesis. 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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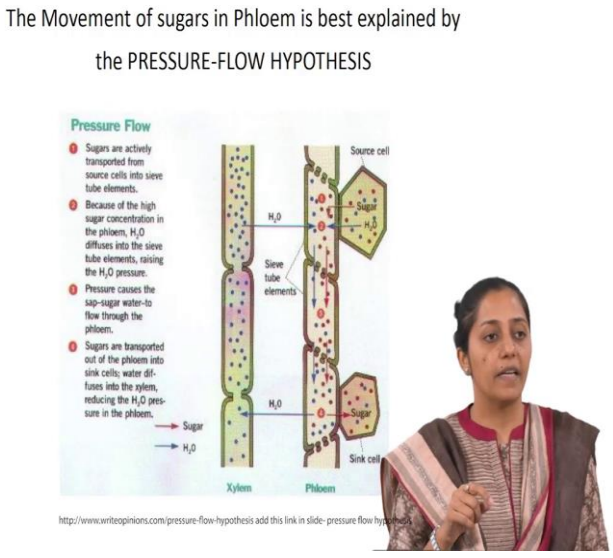

The hypothesis which is used to explain the flow of sugar molecules in the sieve tube elements is pressure flow hypothesis. Because the xylem is adjacent to phloem, the water molecules diffuse in from the xylem to the phloem at the site of source, It is the source where the sugar is being prepared. So, 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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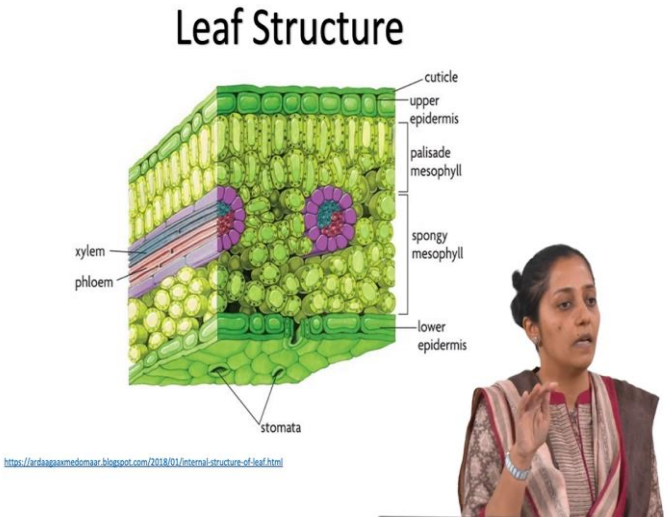

Leaves: The photosynthesis takes place at leaves. The upper surface of the epidermis is very thin and transparent. Below is the, modified parenchyma cells which is the site for photosynthesis.

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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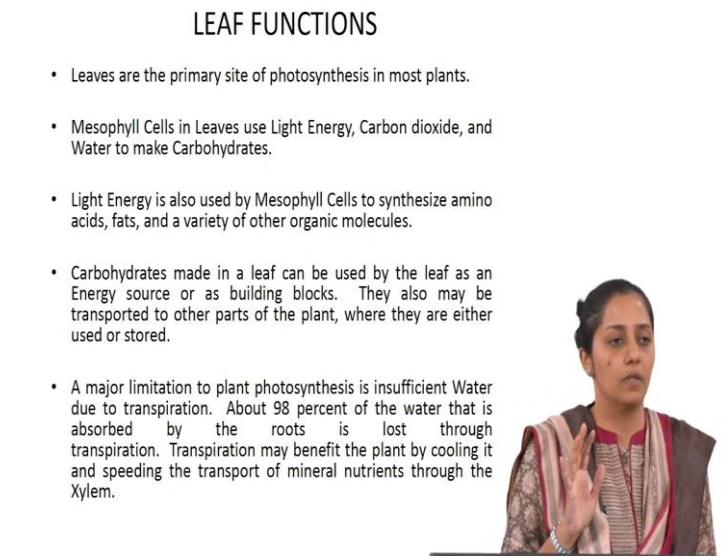

Plants cannot move. There are variations such as more sunlight or no sunlight. How do the plants adapt themselves to cater to their needs of photosynthesis? Too much of sunlight may result into lot of loss of water and also, and damage can happen. What would the plant do to survive? It will close the 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 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 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 C3 class of plants. The plants in arid regions are called as C4 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.