Plant Cell Bioprocessing
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Lecture - 03
Anatomy of plant cells

In this introduction to Anatomy of plant cells, different organelles of plant cells, the functions of those organelles will be discussed. The different plant cell types which you can come across in a whole plant, and the different functions of those plant cell types or plant tissue types will also be discussed.

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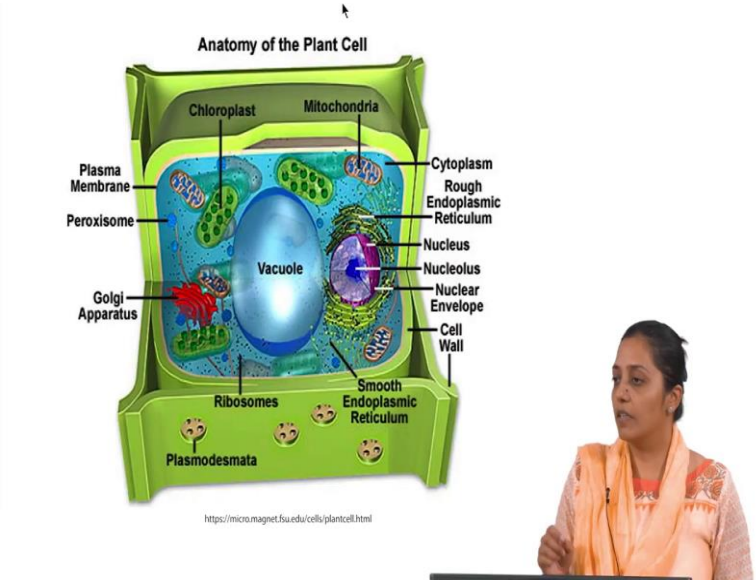

The different kind of major organelles which can be found in different eukaryotic organisms are mitochondria, plastids, endoplasmic reticulum, Golgi apparatus, nucleus, ribosomes, microbodies and vesicles. Exclusive to plant cells, there are peroxisomes and vacuoles. .

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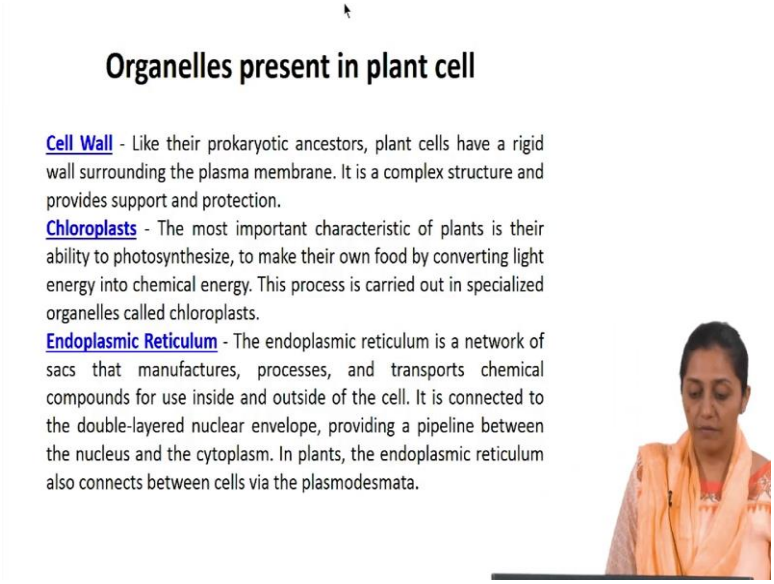

The different functions of these organelles are as follows. Cell wall is found in plants as well as in bacteria and fungi. The cell wall composition in bacteria and fungi are different from the plant cell wall. The plant cell wall contains cellulose which is present only in plant cells.

Further, other components of plant cell wall are hemicelluloses, lignin and pectin. Plant cell wall is divided into primary cell wall and secondary cell wall. Every cell wall will have the primary cell wall, but not all plant cells will have secondary cell wall structure. So, we will be talking in details giving some idea about how primary cell wall is different from secondary cell wall.

Cell wall is a component layer surrounding the cytoplasm or protoplasm. Now, protoplasm is composed of cytoplasm and the nucleus which is everything of the cell apart from the cell wall.

The function of the cell wall is to protect the plant cell. Now, depending on the various stages of the plant development, the cell wall composition is modified. Now, let us talk about the chloroplast. Chloroplast is a distinctive feature in plant cells, which can also be found in many microalgaes as well, but in majority all the plant cells have chloroplast.

The function of chloroplast:

These are organelles originating from plastids. Proplastids, on further differentiation, forms different kinds of plastids with specialized function called plastids. Now, there are many different types of plastids namely chromoplast, amyloplast, leucoplast, elaioplast, proteinoplast. They are named on the basis of their specialised function, in development and growth of the plant. For example, chromoplast is the most common plastid which you must have heard. Chromo, is where the coloured pigments are stored. Chloroplast are the most abundant plastids found in plants. Now, their purpose primarily is to carry out photosynthesis. In photosynthesis, there are light reactions and dark reactions. So, we will discuss about dark and light reactions when we come to photosynthesis. These chloroplasts, are responsible for capturing sunlight and helping the plant in manufacturing the food which is synthesis of carbohydrates.

Then endoplasmic reticulum, we all know the function it plays in the cell. Endoplasmic reticulum is a connection between the nucleus and the cytoplasm. And it helps in manufacturing, processing, transportation of various proteins, fats and other molecules. Now, there are smooth endoplasmic reticulum and rough endoplasmic reticulum. Rough endoplasmic reticulum is differentiated from smooth in terms of ribosomes, sites for protein synthesis; so, it acts like a bridge between double layered nuclear envelope and the cytoplasm. So, it is a connection between the two.

Now, what are peroxisomes? Peroxisomes play a role in photorespiration.

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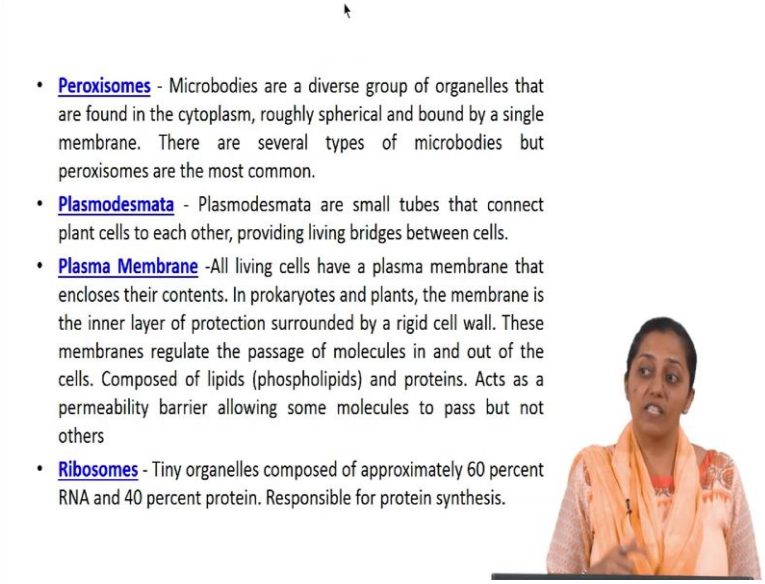

“Peroxy”- because of photorespiration there is a generation of a lot of peroxy radicals. So, plant has to have a mechanism of getting rid of these highly reactive species that can cause damage to cellular membranes and cellular components. So, continuously the plant cell is working on to counter this damage.

Plasmodesmata: Plant cells have a tendency to grow as aggregates, they are almost always found in clumps. Plant cells are found to be attached to each other. There are holes in the cell wall which you can clearly see through light microscope and these holes are called pits. They are formed as the result of thinning of the cell wall during the plant cell division.

The cell wall, while dividing if does not get divided completely, gets compressed. Now, these thinner regions then therefore become the continuity between the two daughter plant cells or the plant cells in connection.

This continuity is not only just a simple gap, but it causes a live bridge between the two plant cells. So, there is a cross talk between the cells and this is how the plant cells are found to be connected to each other. This is called as plasmodesmata or plasmalemma, - the continuity, the live bridge between the adjacent plant cells.

The plasma membrane, acts like a semi permeable membrane.

It means that there is regulation of movement of molecules inside and outside the cell. This regulation can be active where these transport proteins, at the cellular membrane helps in the to-and-fro movement. During metabolism, during plant growth or during survival, cell may need to secrete out certain molecules, and may need to take up certain molecules. So, plasma membranes helps and it also forms a barrier. Ribosomes are the site of protein synthesis, 60 percent is RNA and 40 percent is protein.

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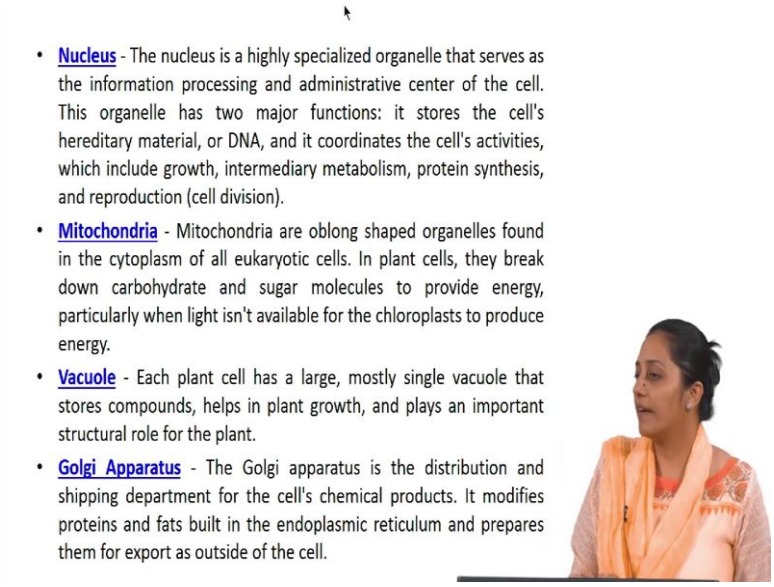

Nucleus is a double layered organelle, and it is the brain centre of the cell. It regulates all the different functions - cell division, cell metabolism, growth, and protein synthesis. Nucleus is the site for genetic material storage.

Mitochondria is the energy centre of the cell. Now, in plant cells when light energy is not available, mitochondria is the organelle which caters to energy generation. In the presence of light, majority of energy generation comes from chloroplast. Photosynthesis, and ATP generation are carried out, which is then utilized for synthesis of carbohydrates in dark reactions.

Then, vacuole is a distinctive feature in plant cells. Vacuoles in younger plant cells are small in size and many in numbers. But as the plant cell matures, it grows in size. The matured plant cells generally have single vacuole- all clubbed together, and they can occupy as far as 80 percent of the cell volume. The turgor pressure causes the cell to maintain the cell turgor and the vacuole when it extends, will prevent plasmolysis. The

other added advantage would be if there is good turgor pressure then all the cell organelles will be extended and pushed towards the cell membrane.Hence, the chloroplast is exposed on the surface, and they can capture as much sunlight as possible.

Vacuole can degrade toxic molecules, waste products or can even act as a site of storage for intermediate molecules like higher secondary metabolites or even toxic secondary metabolites which can be toxic to the plant cell itself. In case of herbivore attack or a pathogen attack they rupture and the secondary metabolite which is toxic, is released, because the vacuoles are extended big in size. It is done to prevent the neighbouring cells from further damage.

Golgi apparatus is also generally present in all eukaryotic cells. It is used for processing and shipping. Processing, means transport conjugated with certain molecules. Transport proteins are conjugated and that will help it to cross the cytoplasm and be transported outside the cell membrane.

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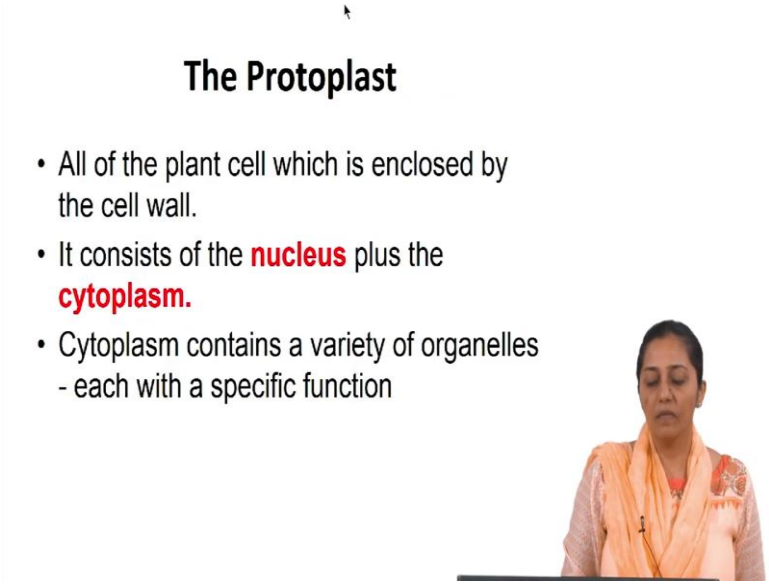

What is protoplast? Protoplast is nothing but nucleus plus the cytoplasm .

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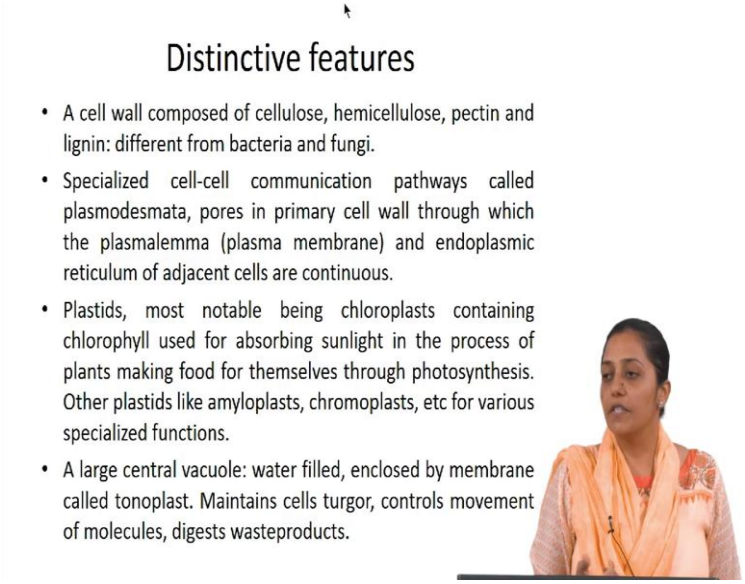

Now, distinctive features, one is that the cell wall is composed of cellulose, hemicelluloses, pectin and lignin. Cellulose is a polysaccharide made up of simple chains of D-glucose. There are many kind of linkages. One such linkage is beta linkages of D-glucose units. But if you see SEM images of these cellulose, you will find it as fine thread like structures, highly complex matrix and very multi layered. Each of those fibrils themselves are composed of thousands of chains of D-glucose. So, this is the reason why cellulose is crystalline and hard in nature.

Hemicellulose, is a heteropolymer; it is amorphous in nature and weaker. It is made up of many different kinds of sugar units such as xylose, galactose, etc.

Pectin is again a heteropolymer which glues the plant cells and plant cell wall components together. The middle lamella which is above the primary cell wall is rich in pectins

Plastids are not only for photosynthesis or storage, but sometimes in secondary metabolism you will find that they are site of synthesis of certain intermediates of biosynthetic pathway. If you see certain biosynthetic pathways like alpha tocopherol or vitamin E biosynthetic pathway, you will find some part of the secondary metabolic pathway is carried out in plastids. So, plastids are not only for storage, but also for site of synthesis.

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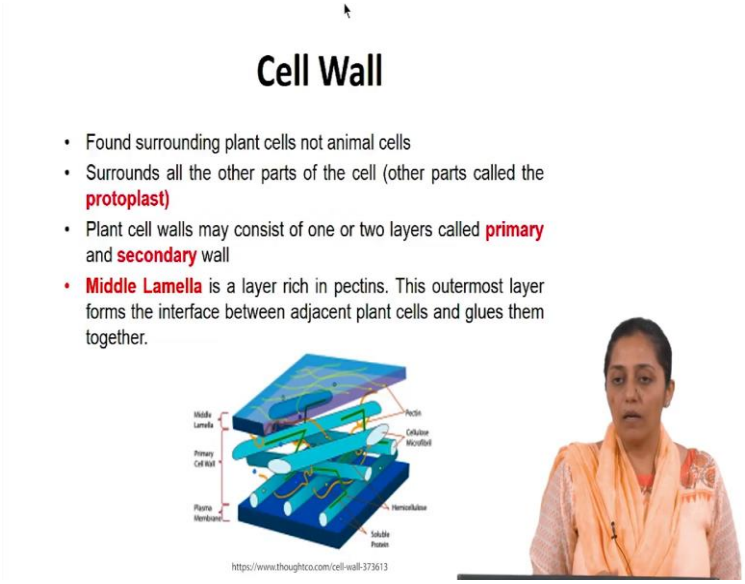

The cell wall middle lamella that is above the primary cell wall is rich in pectins. Those yellow threads that are shown in the picture are pectins.

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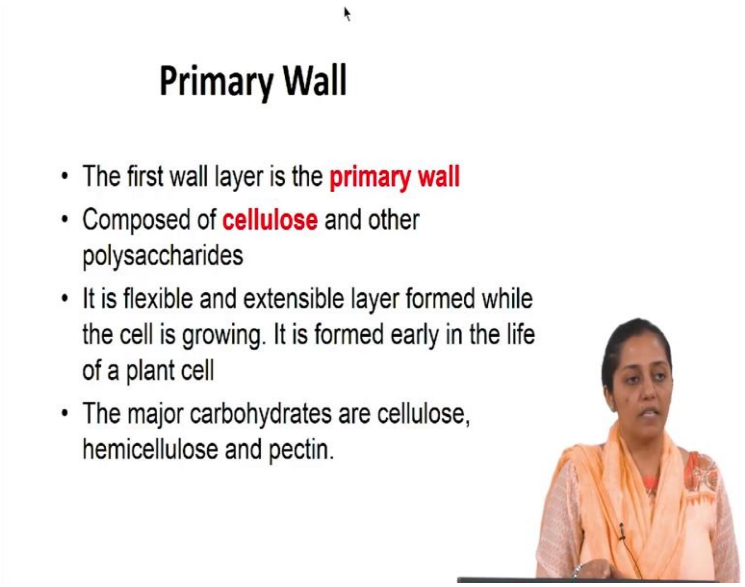

All the plant cells will have primary cell walls, not all plant cells will have secondary cell wall. The function of the primary cell wall is to provide protection and support to the plant cells, but it is still flexible in nature. They are flexible because the cells still need to grow and the cell walls are flexible to allow for increase in size, stretch, and become elongated.

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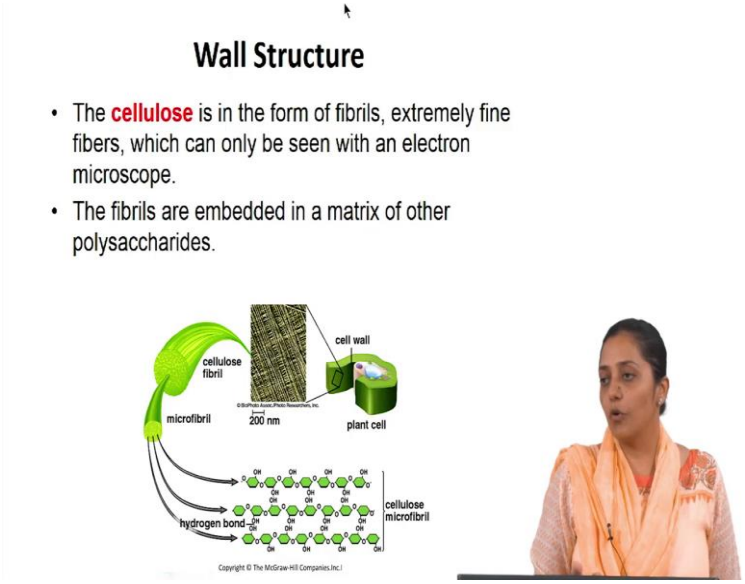

So, I have already spoken about the major carbohydrates in the primary cell wall. Cellulose under SEM looks like this.

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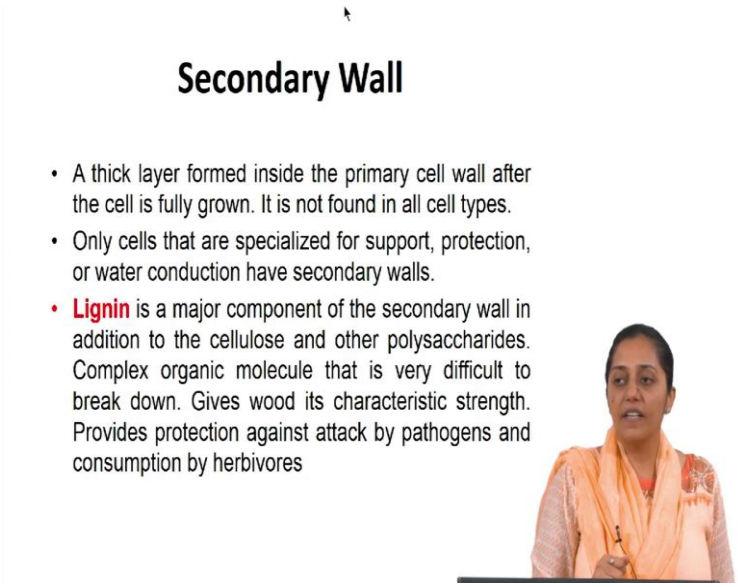

Now, secondary cell wall is under the primary cell wall. Its major function is to prevent the attack from herbivore and to give rigid support to the well grown plant organelles. So, secondary walls are richer in lignin. Lignin is very hard to degrade, which means that its purpose in nature must have been to protect and support the full grown plant. So, this

secondary wall structure appears in cells which are already matured, and now higher specialised function is not the growth, but to protect the cell.

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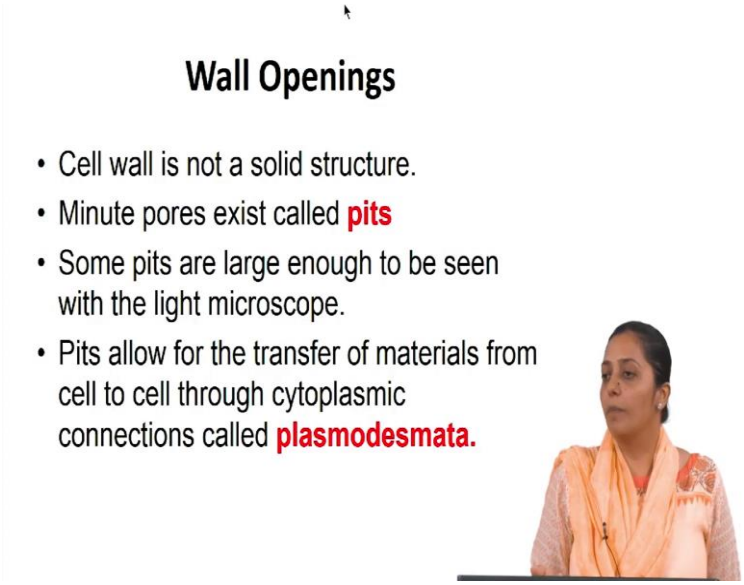

Now, cell wall openings - these are pits, which are holes in the primary cell wall and through which the plasmalemma or the plasmodesmata passes. So, these are live bridges.

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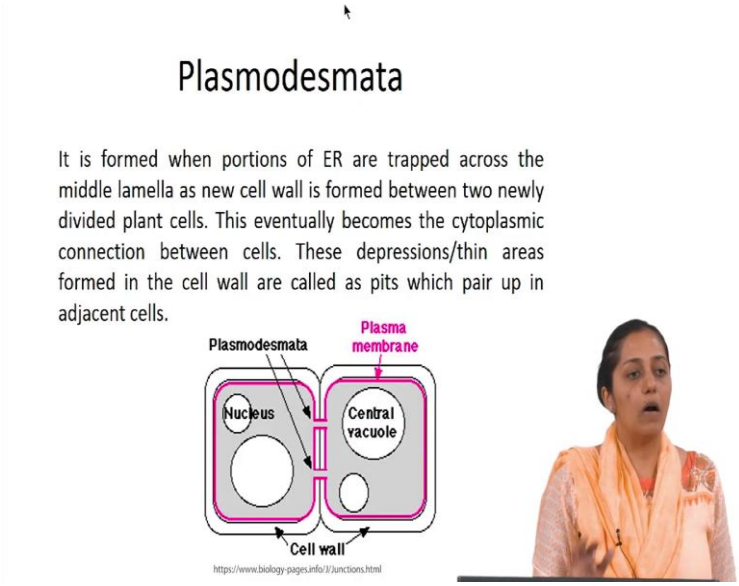

So, this is how plasmodesmata is formed, it is formed when the portions of endoplasmic reticulum, get trapped across the middle lamella. You remember the middle lamella which forms above the primary cell wall as the cell is dividing. The plant cell wall is

made in continuity with the adjacent cells through plasmodesmata. Those compressed regions of endoplasmic reticulum then become the continuity or we can call them as holes among the adjacent plant cells.

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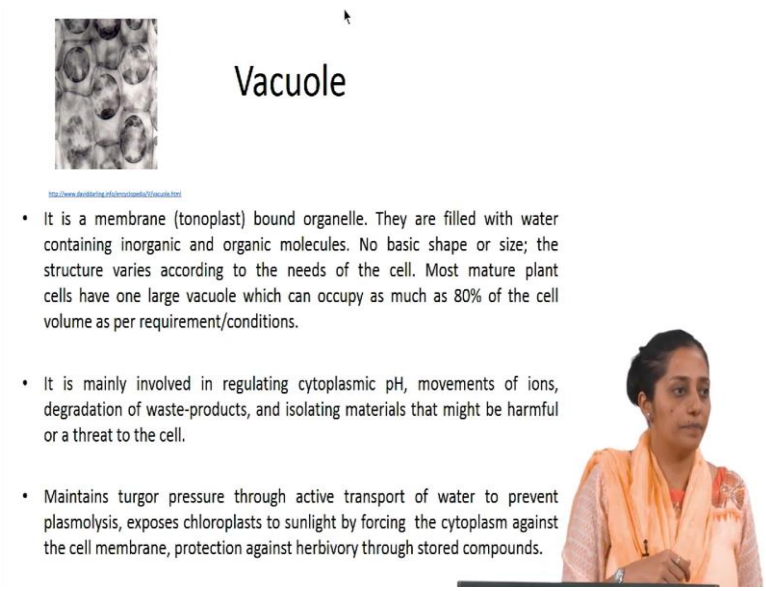
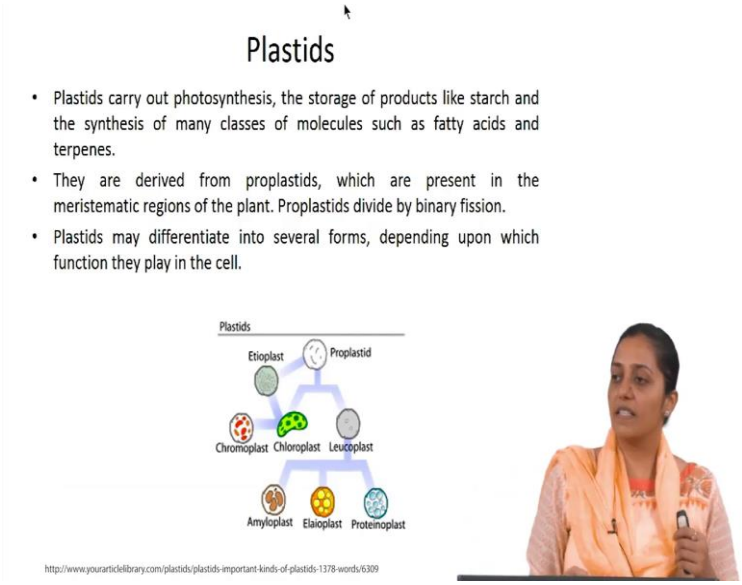


Now, vacuoles are very interesting organelles in plant cells. They help in maintaining cell turgor. Then it helps in storage; it also helps in maintaining the cytoplasmic pH. So, how do you think it can do all these functions selectively based on the molecules stored in? It has some degrading enzymes stored in which will be useful in degrading the waste-products, degrading the toxic molecules.

What is helping the vacuole in carrying out all this function?

It has a membrane called as tonoplast. So, tonoplast is rich in a number of diverse proteins. Now, these proteins are transport proteins, through which active transport can can take place. So, there are many different kinds of proteins in this tonoplast which is a single layer around the vacuole which helps in the selective movement of the molecules from the cytoplasm to inner. The tonoplast also helps in the maintenance of a electrochemical gradient and helps in maintaining the pH of the cytoplasm. And you will find that the vacuole pH is acidic in nature. Why do you think it is acidic in nature?

Many of these enzymes things which are present inside are active at acidic field. (Refer Slide Time: 21:45)



Now, plastids, there are many different kinds of plastids. Chromoplasts are the kind of plastids which can store coloured molecules. Chloroplast for photo synthesis, leucoplast is for storage of many different kinds of molecules where they are further divided into amyloplast. Amyloplast is for starch, Elaioplast for oils, granules, and proteinoplast for proteins.

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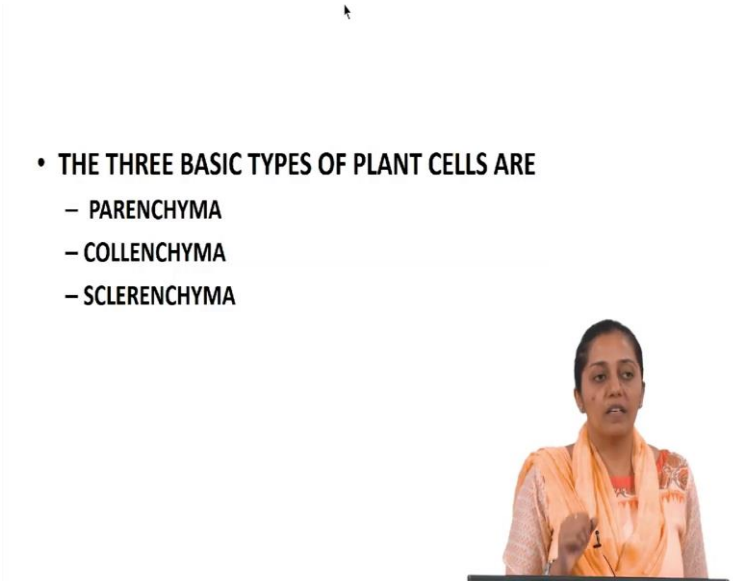

Now, there are three different kinds of plant cells, parenchyma, sclerenchyma and collenchyma. Parenchyma cells are the majority of cells present in the plant. They form the mass of the cells the plant.

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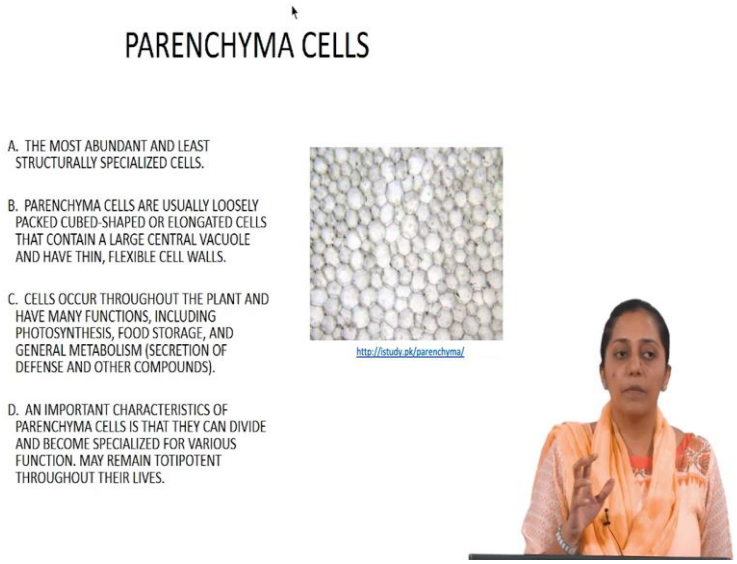

Now, parenchyma cells are those totipotent cells which we keep referring to. They form the mass of the plant and they remain totipotent for entire lifetime. Totipotent means they have the ability to organize themselves into a specialized function, and again redivide and come back to totipotent stage, and again redirect their metabolism to carry out another specialised function. Generally, you will find them in all growing parts in photosynthetic cells, spongy cells, mesophyll cells which are involved in photosynthetic process in leaves. They have primary cell wall as they are present in the young cells which are growing. So, the cell wall needs to be flexible. So, in all parenchyma type of cells you will find there is only primary cell wall. You will find them square shaped generally, but the shape can change to some extent.

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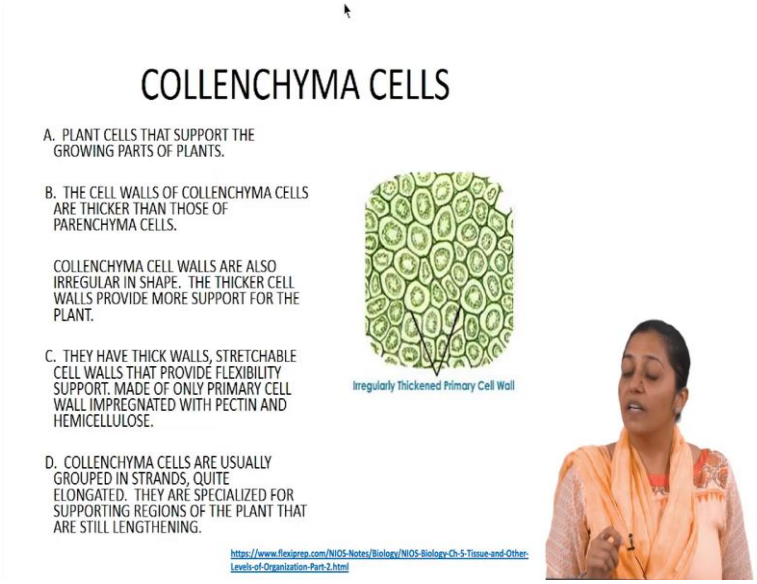

Collenchyma cells have thickened cell wall. Collenchyma cells are layered cells. The role of these cells is a little more specialized which is to support. So, we will find them in regions where the growth is still happening such as the root which is still elongating or the stem which is still growing. Although they are flexible, they are less flexible than parenchyma.

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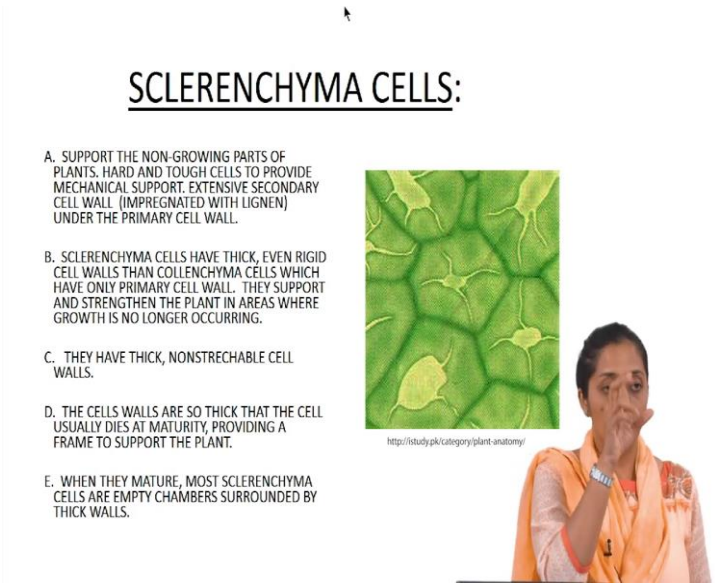

Now, sclerenchyma cells. Sclerenchyma cells, you must have seen a hard coat present in walnut and peach. They are also present in flax or linen which are very difficult to tear

apart. Sclerenchyma cells appear when the plant cell has completely matured, and there is no more growth happening. At maturity, the secondary wall develops and in the secondary wall there is large amount of lignin in it. So, because of the thickness of the plant cell wall and gradual loss of cytoplasm they will become vacuumed empty cells. So, most of these cells if you observe, they will be empty chambers with only cell wall. Generally their purpose is to provide structure, and to provide protection against the external environment.

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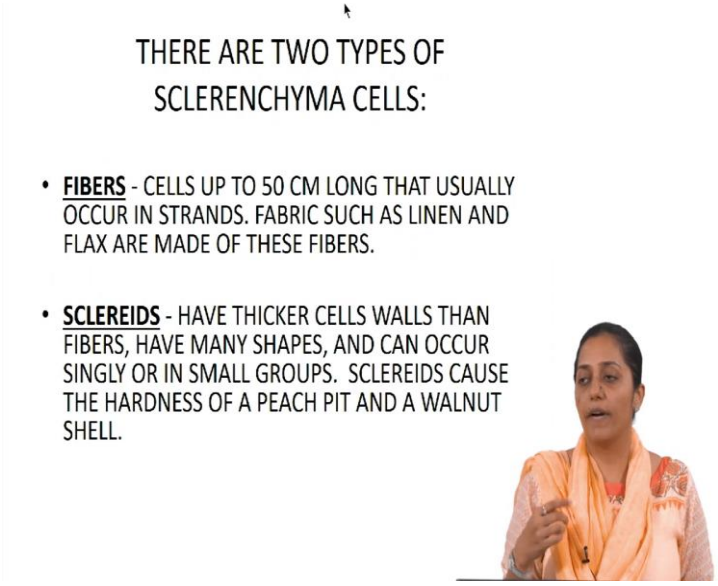

We will find them only in matured parts of the plants where there is no more growth required. There are two types, fibres and sclereids. Fibres are long cells with even upto 50 centimetres length. Eg in fabrics like linen and flax.

Sclereids have much thicker cell wall, even more than fibres.