Introduction to Cell Biology
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Structure of the Cell: Cell wall and Cell Membrane

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What does the cell now look like? Right and as I said, the complex nature of the structure and the function of the cell is what we are going to discuss from here on. Taking into account the fact that this complexity has now been built in, we are trying to also understand that complexity to some extent, see how that complexity works.

How do things talk to each other, what kind of properties do they have? And this video essentially introduce you to the structure and function of the cell. And we will begin in this class with that perimeter of the cell, which is the cell membrane.

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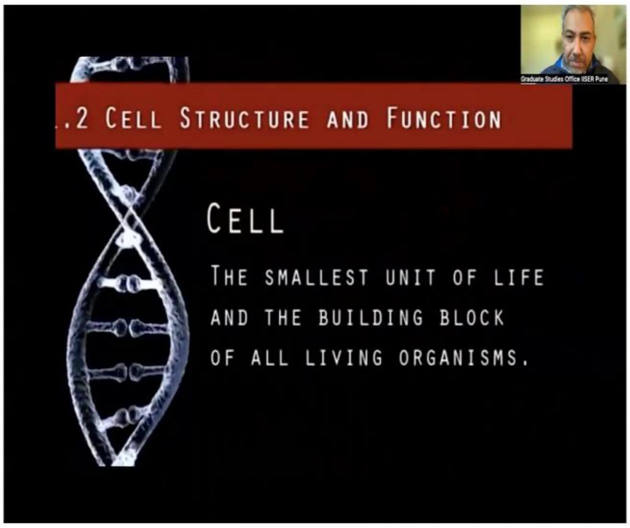
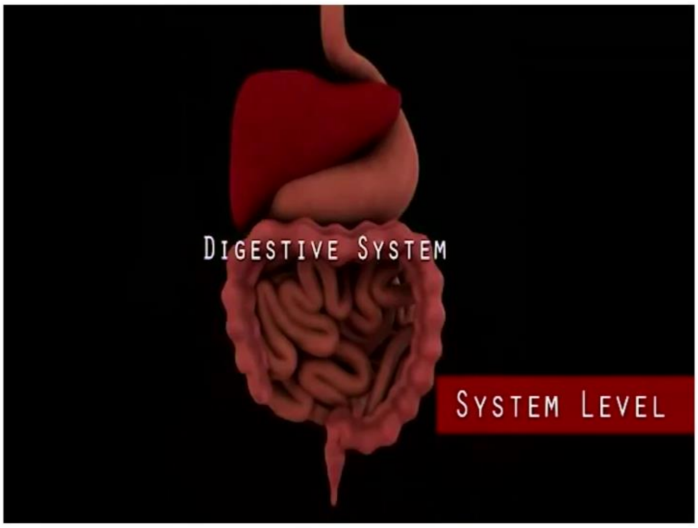
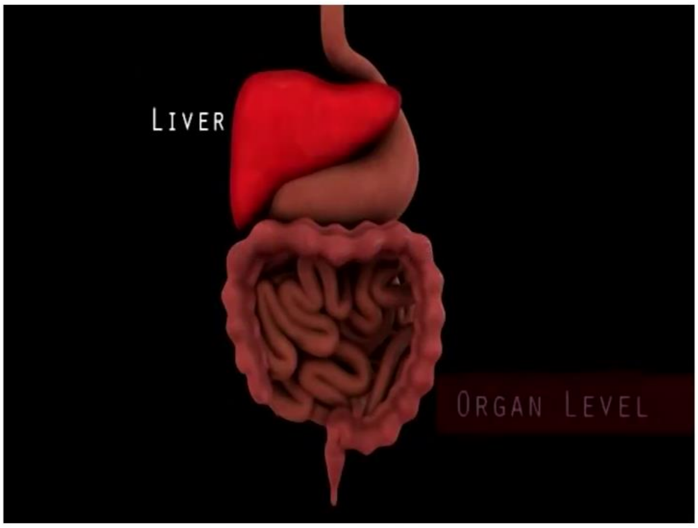
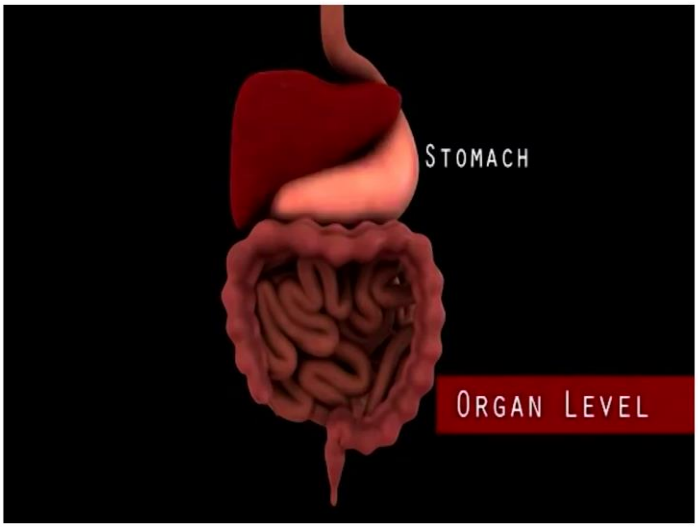


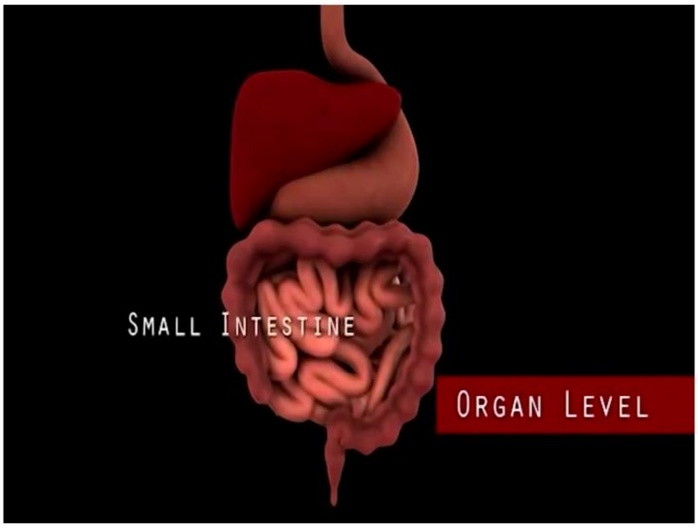

Organism Level

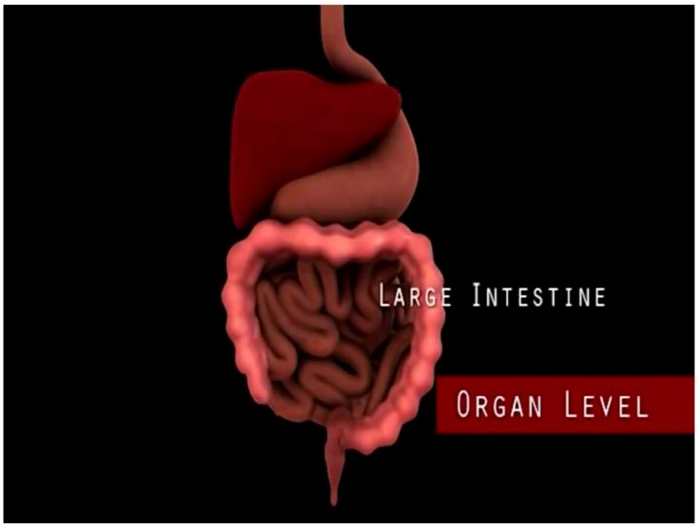

System Level

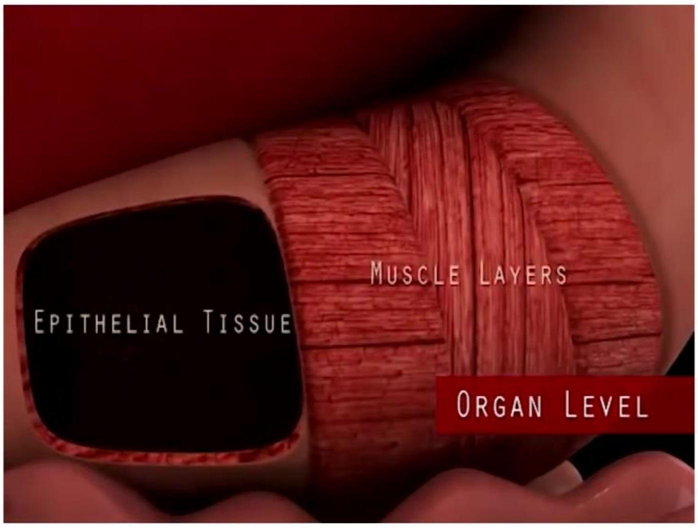

Digestive System
System Level

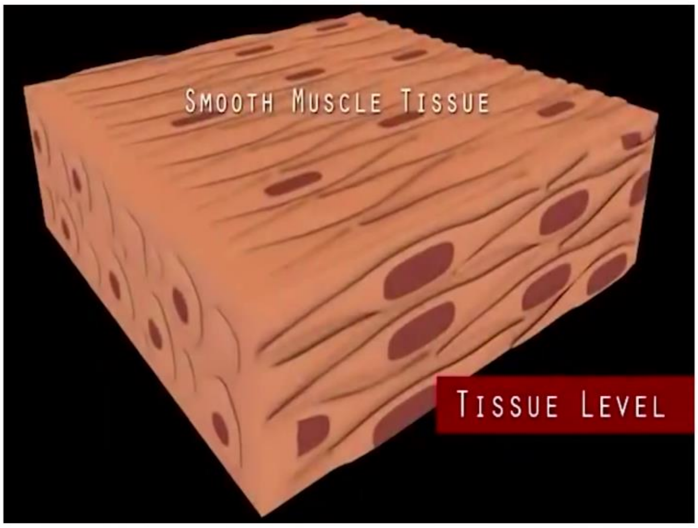

Liver
Organ Level

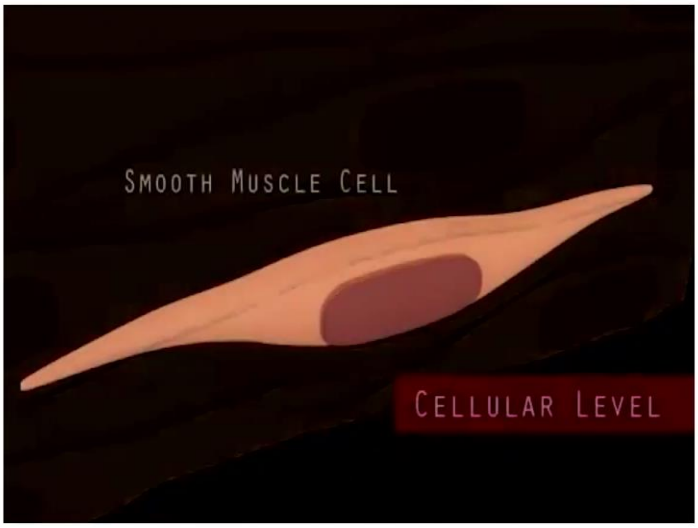

Stomach
Organ Level

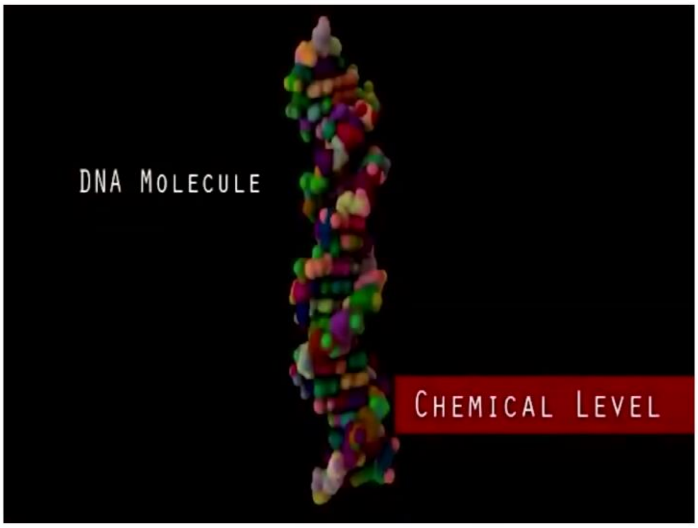

Small Intestine
Organ Level


Large Intestine
Organ Level


Muscle Layers
Epithelial Tissue
Organ Level


Smooth Muscle Tissue
Tissue Level


Smooth Muscle Cell
Cellular Level


DNA Molecule
Chemical Level

So, let us quickly look through this cell is the smallest unit of life. Cell is the smallest unit of life and the building block of all living organisms, appreciating the similarities and differences between cell types within and among organisms is particularly important to the fields of cell biology and molecular biology.

Molecular Biology can be confusing because it is a subject that focuses on things so small, you cannot even see them. So, let us begin with big organisms and work down to the molecular level. Organisms, such as a little girl are made up of organ systems, such as the digestive system pictured here.

Each of these organ systems are comprised of individual organs. As shown in the diagram organs such as the liver, the stomach, and the small and large intestines are part of the digestive system. All of these organs are made up of tissues. Tissues are a group of similar cells that perform the same functions such as the epithelial tissue, and the smooth muscle tissue pictured here.

Tissues are made up of cells, and a cell is the smallest unit of life. Finally, cells contain organelles and molecules such as DNA. Let us examine a cell more closely.

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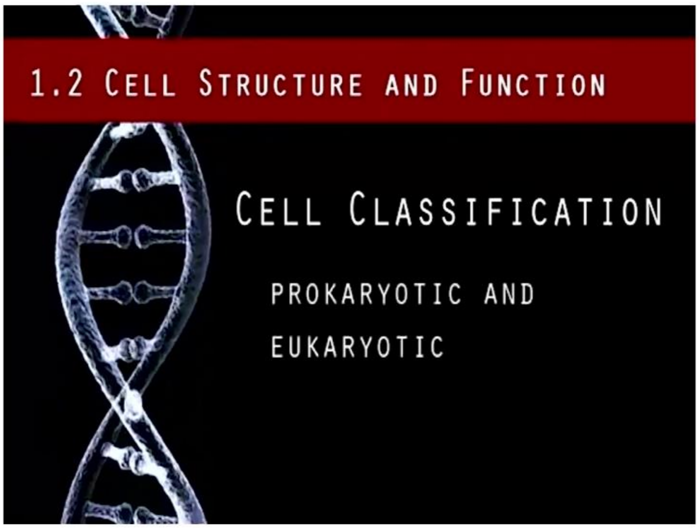
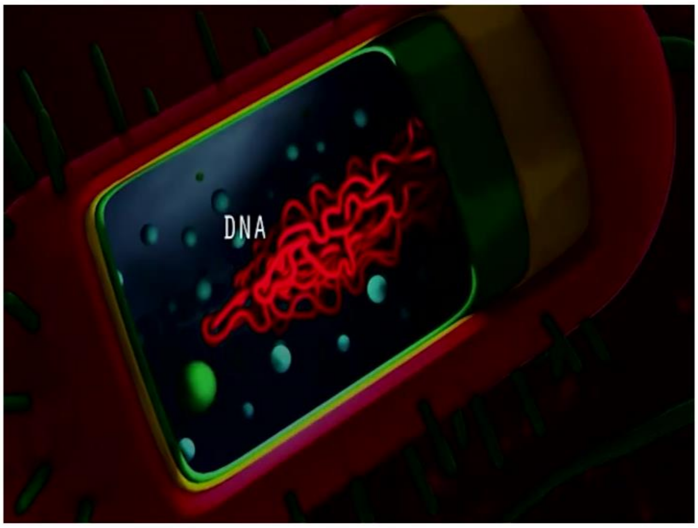


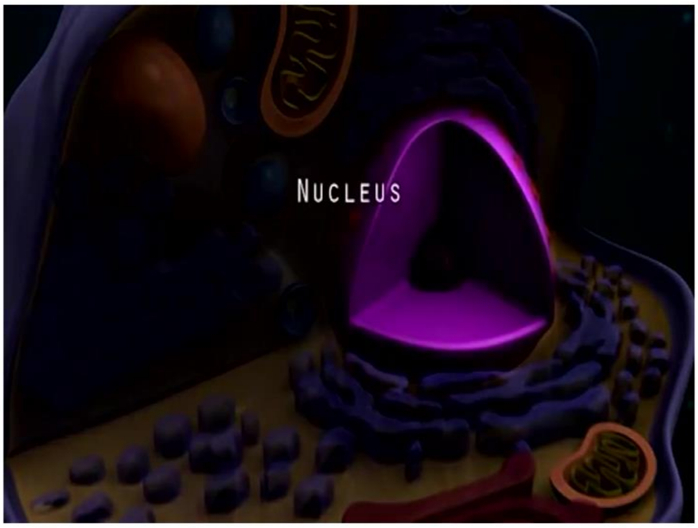

PROKARYOTE

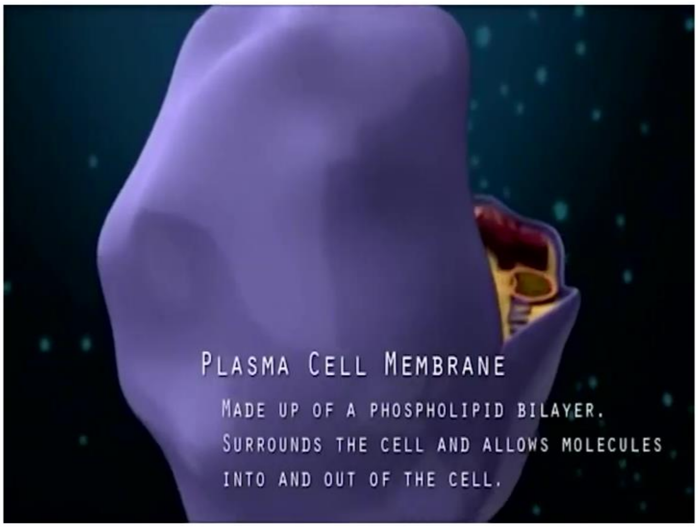

EUKARYOTE

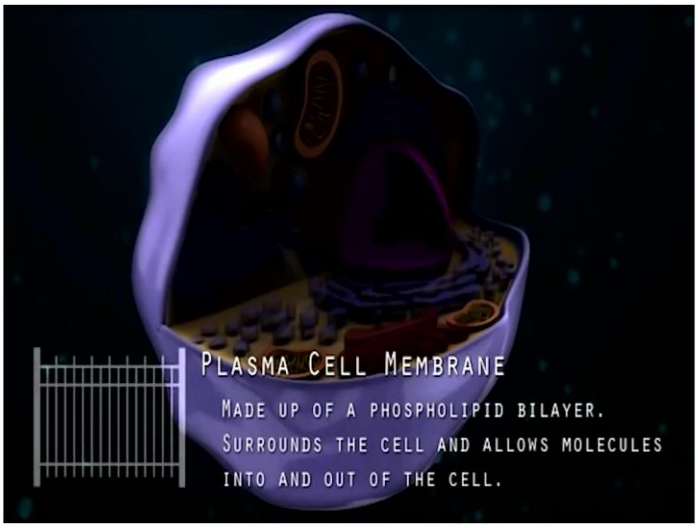

EUKARYOTE


EUKARYOTE


DNA


Nucleus


Plasma Cell Membrane
Made up of a phospholipid bilayer.
Surrounds the cell and allows molecules
into and out of the cell.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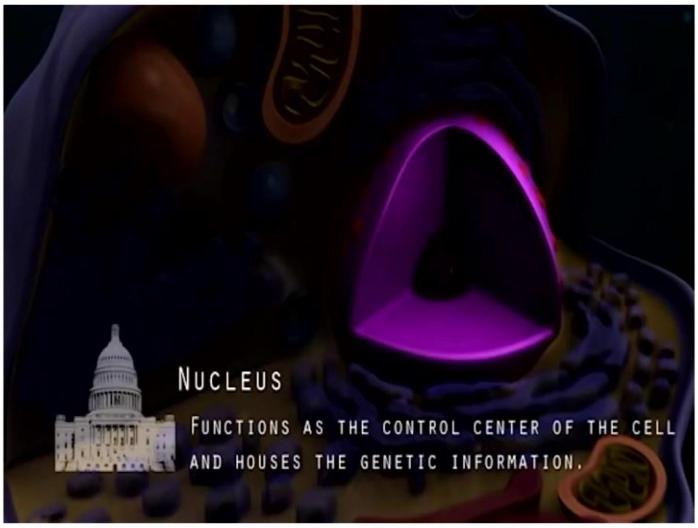
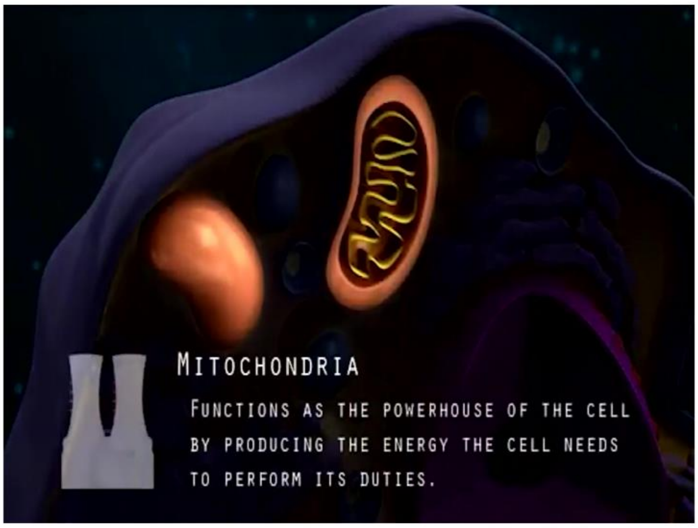

Nucleus
Functions as the control center of the cell
and houses the genetic information.



There are two general classifications of cells, prokaryotic cells and eukaryotic cells. Prokaryotes are single celled organisms and include bacteria and some algae. On the other hand, eukaryotic cells make up more complex organisms, like plants and animals. Prokaryotic cells lack a membrane bound nucleus, so the DNA which is usually a single circular molecule floats in the cytoplasm of the cell.

Eukaryotic cells contain a membrane bound nucleus that holds all of the DNA in one part of the cell, as well as many other organelles. Now let us look at the function of each organelle in a eukaryotic cell. To gain an understanding of the inner workings of the cell, it is helpful to think of the cell as a mini city. Just like in a city, a cell is made up of many parts that have their own functions.

In the cell these parts are called organelles, which are explained next, a plasma cell membrane is made up of a phospholipid bilayer. The bilayer surrounds the cell, protecting it and functions as a gate that allows molecules into and out of the cell. In our city, the cell membrane would be like a large fence surrounding the city that only allows certain molecules to go in and out of the cell.

The nucleus is like the Capitol Building of the city. Because it functions as the control center of the cell and houses the genetic information or instructions for what the cell is supposed to do. The mitochondria functions as the powerhouse of the cell by producing the energy the cell needs to perform its duties. This is just like a power plant providing energy for a city to use.

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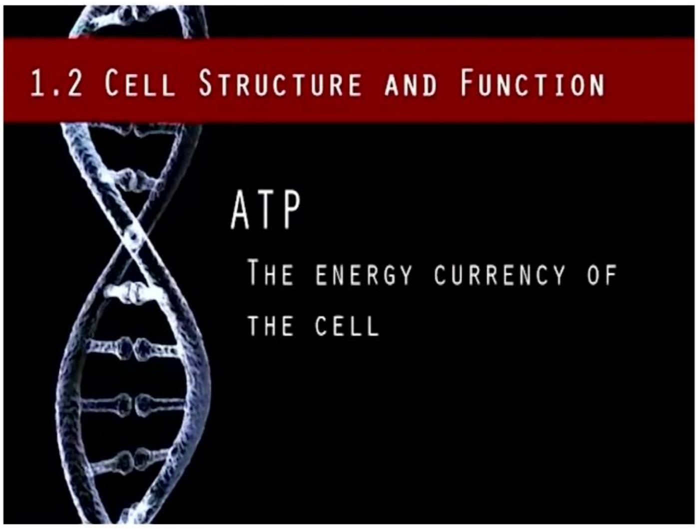

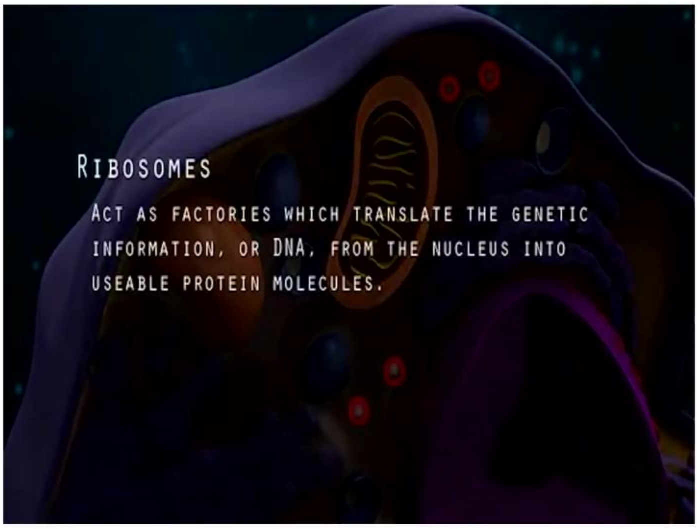

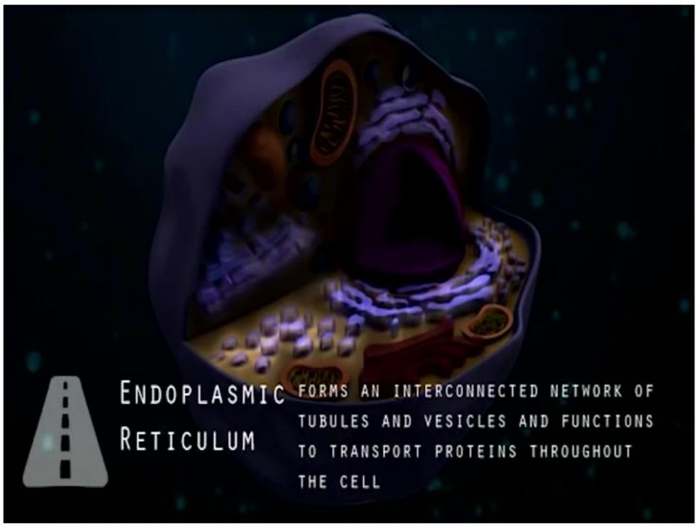

The energy currency of the cell is ATP. The ribosomes act as factories, which translate the genetic information or DNA from the nucleus into usable protein molecules. Proteins do the work in the cell. The Golgi functions as the post office in the cell and packages and modifies the proteins. The endoplasmic reticulum is the Highway of the cell.

It forms an interconnected network of tubules and vesicles and functions to transport proteins throughout the cell. So, those protein containing vesicles would be like the trucks on the highways of our city. Many of the protein producing ribosomes are located on the endoplasmic reticulum. The lysosome is the trash man of the cell because it digests excess or worn-out organelles and proteins by breaking them down and removing them.

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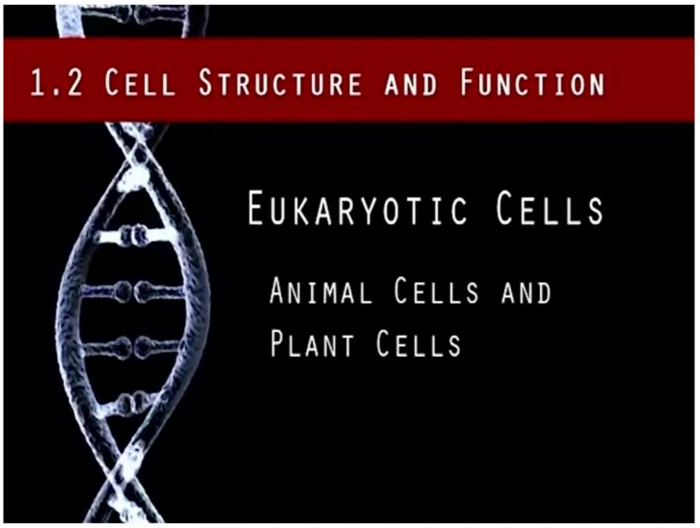
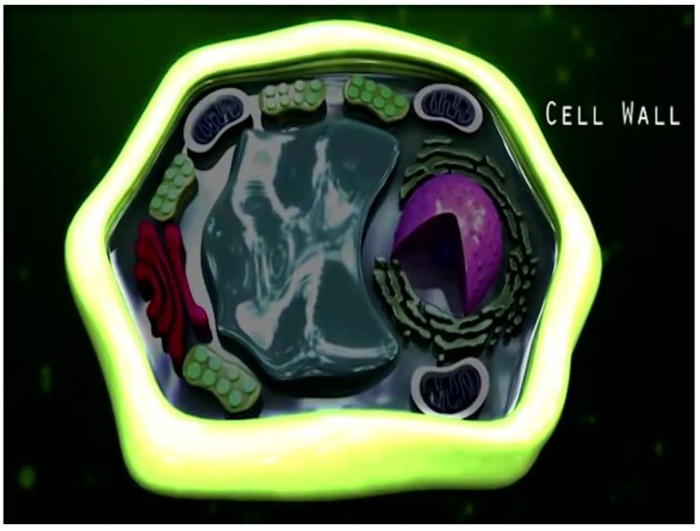
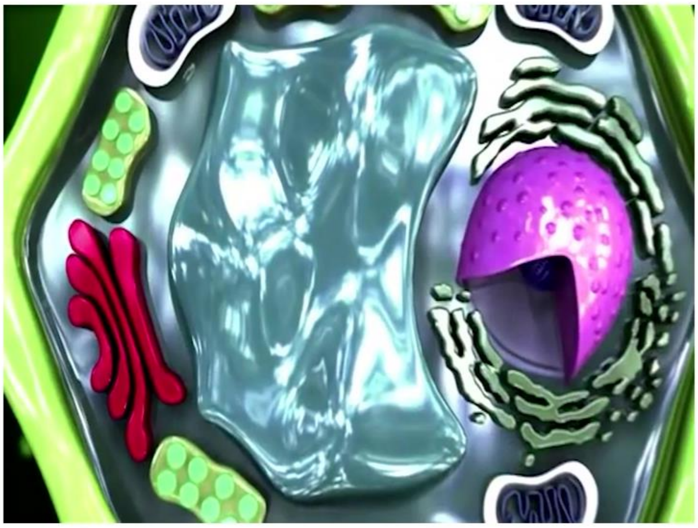
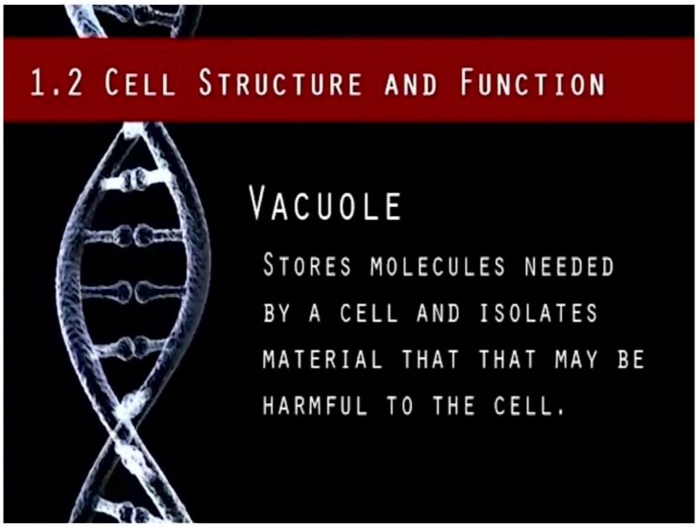


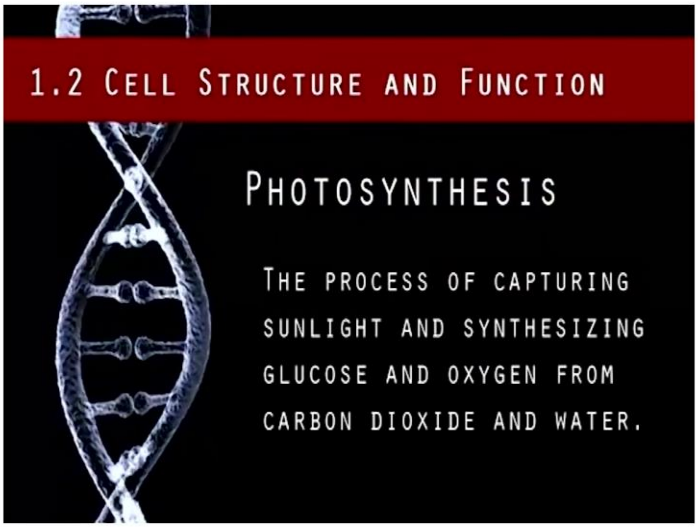


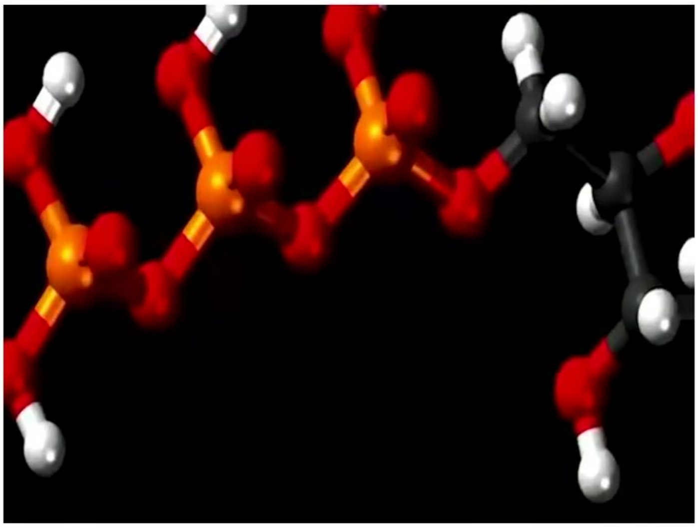


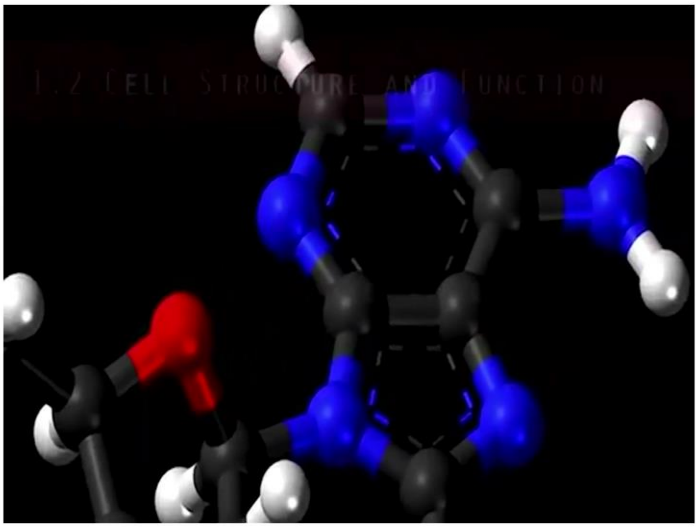

VACUOLE

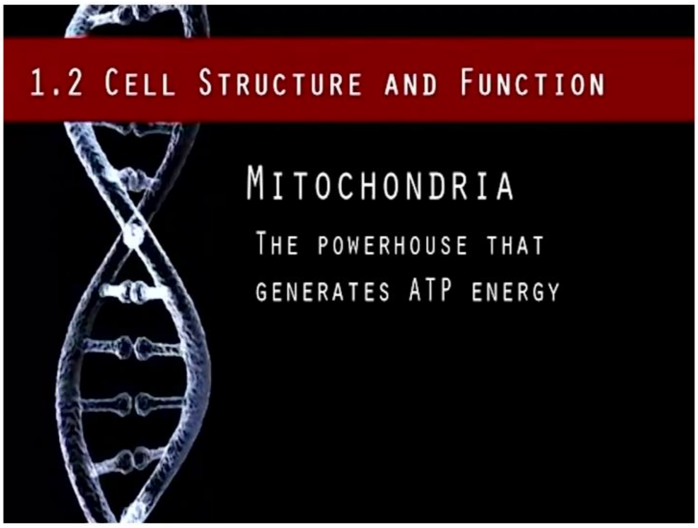

1.2 Cell Structure and Function
Vacuole
Stores molecules needed by a cell and isolates material that that may be harmful to the cell.


CHLOROPLAST


1.2 CELL STRUCTURE AND FUNCTION
PHOTOSYNTHESIS
THE PROCESS OF CAPTURING SUNLIGHT AND SYNTHESIZING GLUCOSE AND OXYGEN FROM CARBON DIOXIDE AND WATER.







There are actually two types of eukaryotic cells, animal cells and plant cells. Both types of cells are very similar, but there are three distinct differences. First, plant cells have a cell wall surrounding the plasma cell membrane. Animal cells just have a cell membrane. Secondly, there is often just one large central vacuole found in plant cells, whereas animal cells have a few small ones.

The vacuole stores molecules needed by a cell, and also isolates material that may be harmful to the cell. The final difference is plant cells have an additional organelle called a chloroplast. The chloroplast is the site of photosynthesis in a plant cell. Photosynthesis is the process of capturing sunlight and synthesizing glucose and oxygen from carbon dioxide and water.

Photosynthesis is one of the most important biochemical pathways since nearly all life on Earth depends on photosynthesis as a source of energy. Animals metabolize the glucose from a plant source to produce ATP, the energy currency of the cell. Recall that all organisms need energy to do cellular processes. Do you remember which organelle is the powerhouse that generates ATP energy? That is right, it is the mitochondria.

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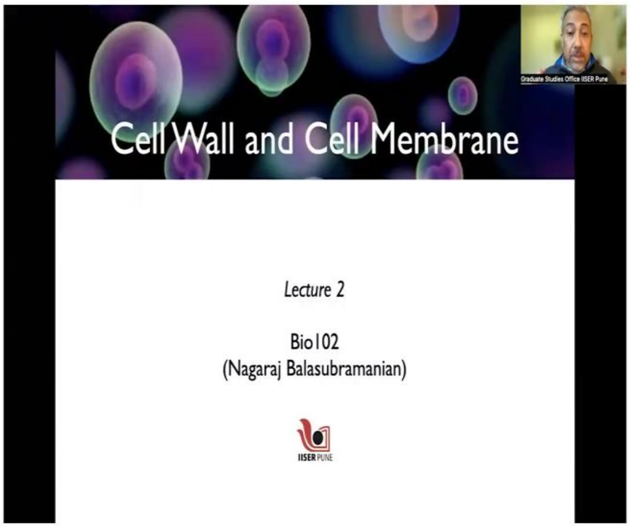

So, that is a brief introduction to all the players. And clearly, there is all the things that we talked about that up to this particular point, the fact that there is, this compartmentalization, distribution of labor, the greater efficiency that you were talking about earlier, all this comes into play when you look at this characteristic of how the cell is put together. And all of this begins with the cell wall or the cell membrane.

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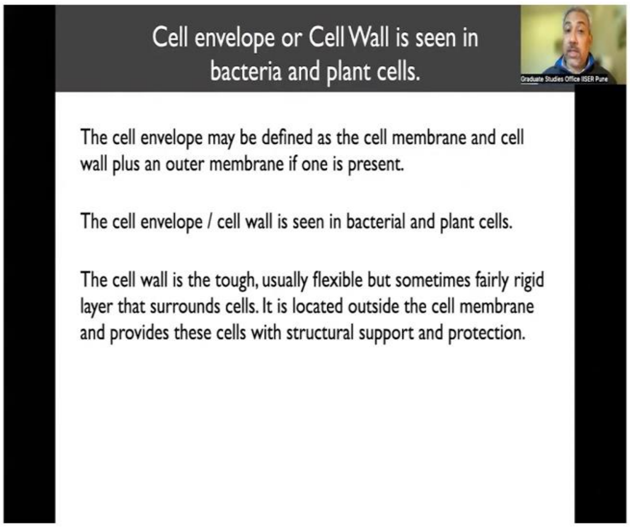

And the cell envelope in particularly, or the cell membrane, and the cell wall, are present both in bacterial and plant cells, mammalian cells have something that is just the plasma membrane, and in that sense, are distinctly different from the fact that there is not really a covering or a protection beyond that plasma membrane.

But both bacteria and plant cells, bacteria have something called a cell envelope, and plant cells have a cell wall, which add additional protection, to the cell membrane and also do other functions in the fact that they exist. The as mentioned, here, the cell wall is in plant cells, particularly is flexible, but a fairly rigid structure.

And it is made up of in both of these cases, the fact that there is that additional boundary, that boundary has very distinct properties, it is made up of very distinct components. And on most of these occasions, the intent is to protect and create a certain amount of barrier, if you want to call that to the entry of things into the cell, and more importantly, guard the cell that way as well.

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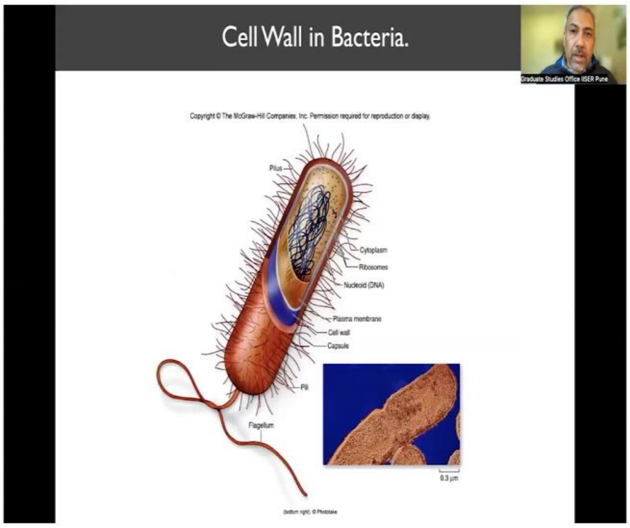

And this is an image that you guys are not familiar with, where you have seen how the early eukaryotic prokaryotic bacterial cell would look like. And, there is a cell wall here, which is the cellular envelope, if you want to call it that, you have the plasma membrane here, you have the nuclei, DNA, the ribosomes that are present the cytoplasm that is present, in many of these bacteria, they have structures like Pillai, which as we heard earlier, among the things they do is increase the surface area of the cell.

And increasing the surface area is kind of important, because remember, these are very tiny creatures. And the kind of contact they have with the environment is largely defining the by this border, by the edge by the plasma membrane of the cell. And the plasma membrane in a small cell is only that much, it covers everything that is, the perimeter of the cell. The fact that there are structures like Pillai means that the plasma membrane essentially goes around and comes back.

So, every time it goes around, and comes back, you have all that area that it is now acquiring, and that allows for greater contact. So, imagine if you took all the Pillai that bacteria had, and took all the membrane that was part of the Pillai and opened it up, just puffed the bacteria, you would effectively increase the size of the bacteria significantly. And that is what having these kinds of structures do.

They also have structures like the flagellum and the flagellum is a very interesting structure, in terms of its architecture, in terms of how it is put together. There is this very interesting documentary, there are theories that were floated based on the architecture of the flagellum and the way it is assembled. If you have not looked at the architecture of the flagellum and the rotor of the flagellum, go Google this.

Because it is one of those remarkable things that almost led people to think that, this could not have been done by evolution, and that documentary is about this, this idea of so called intelligent design, and how that theory was put out. And now is, very clearly debunked as, as not a theory per se, and this documentary will be about it. And this is where the flagellum comes in? So, the flagellum is allowing for bacteria to move.

So, it is highly possible that initially, these structures were singular that did not move around too much. But with time, the having the flagella meant that they could now, go from one place to another as well.

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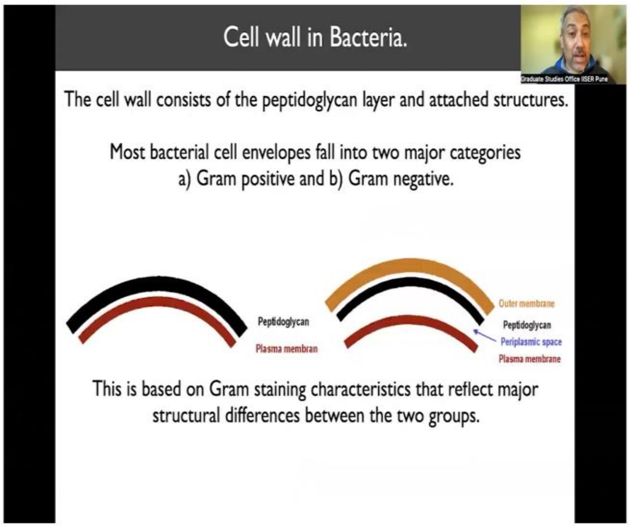

The cell wall, in bacteria, has a peptidoglycan layer. And this is different from the plasma membrane. Now, the plasma membrane is interesting because it is made up of lipids. And one of the thoughts to have here is the idea that almost all plasma membrane in all life that has evolved, seems to be made up of lipids. And that stems from the notion that most of this evolution happened in an aquatic or an in an aqueous environment.

So, to be able to separate anything in an aqueous environment, define something as outside and inside, you want something that is not going to mix with the aqueous environment and lipids were perfect for it. Because they were able to keep out water. And so, they could keep water out from outside as well as keep the water that is inside, on the inside.

And that meant that now you can have changes that are happening on the inside, in a way that allows the insight to be very different from the outside of the cell. In bacteria this envelope that is above the plasma membrane, is the peptidoglycan layer. And the peptidoglycan layer, varies. And in some bacteria, there is also an outer membrane over and above the peptidoglycan layer and depending upon the presence of this outer membrane, bacteria are also classified into gram positive and gram negative bacteria.

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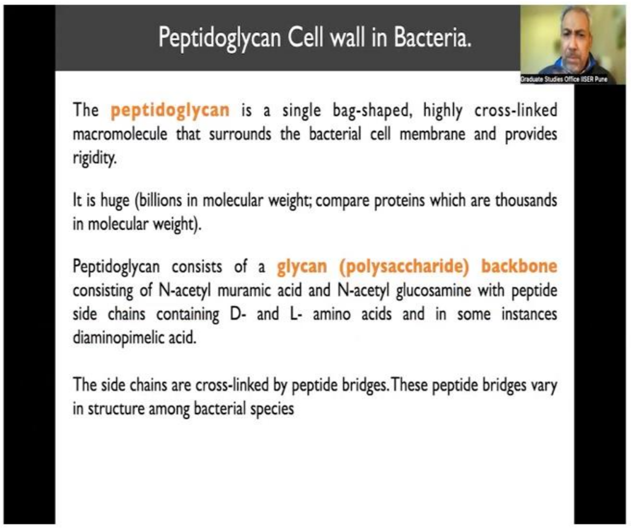

Peptidoglycan is largely made up of sugars, it consists of a glycan backbone, and, peptide side chains, which come together to create an architecture that is distinctly not lipid, remember that. So, the Peptidoglycan, which is sitting outside the plasma membrane, this is made up of lipids, this has this characteristic, sugar based, architecture.

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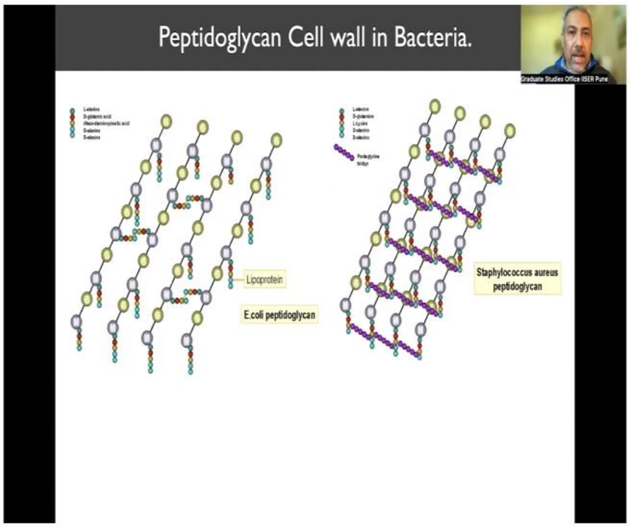

And, that peptidoglycan layer varies depending upon the bacteria that we are looking at. Remember, the bacteria that we now know, and we study in all of these cases, are versions of what may have existed right at the beginning. So, clearly, these are evolved over time, and acquire changes, to begin with the peptidoglycan layer may have been very simple, but some of that basic architecture should have existed long ago for it to be retained and carried forward as well.

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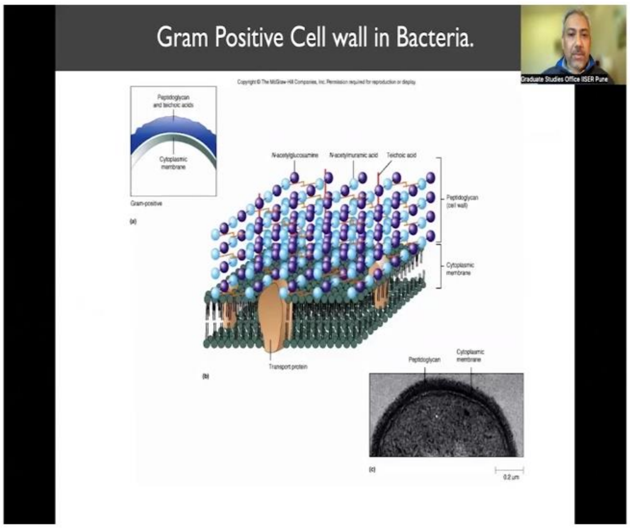

And so, that is the peptidoglycan layer cell wall on the outside, the one in blue and purple. And right below it in green is the cytoplasmic membrane, which is the plasma membrane, and the cytoplasmic membrane is essentially lipids.

And in all of these cases, those lipids make a lipid bilayer, and this is something that we will talk about as well, the fact that these are two layers of lipids, and they have come together largely in a bilayer manner, because the lipids have an architecture that have a head and a tail, and their ability to repel water is variable in the head and the tail.

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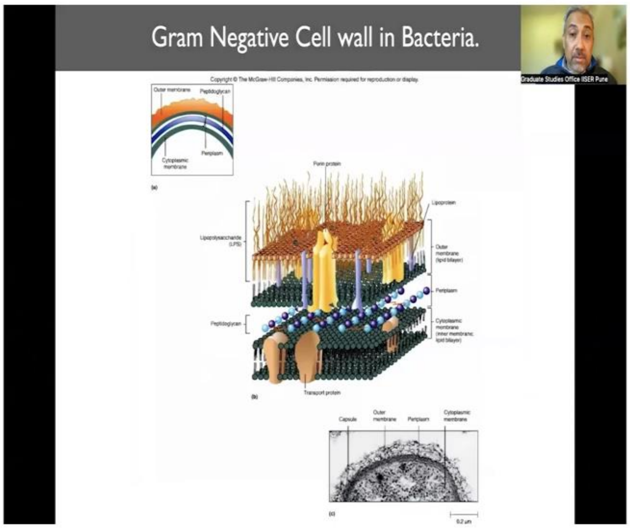

The gram-negative bacteria, on the contrary, also have a lipo-protein layer, which is very different from the just the peptidoglycan layer that we know of, and that is a very distinct architecture. So, even in bacteria, this, the presence or absence of this lipopolysaccharide layer, that is there in, in some bacteria, but not the other, allows for distinction to happen.

And distinction is for us for bacteria, these are ways they have developed and evolved to do what they want to do, which is, thrive, survive, multiply, make new bacteria and continue living. And the fact that they have done this well, is the reason why we are still talking about them.

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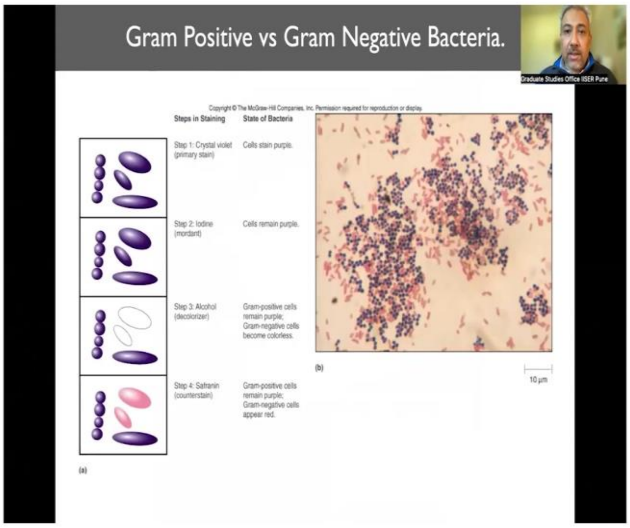

And there could be versions of these that, may have disappeared that do not exist right now. And hence we are not aware of them or we are not discussing them. And this architecture of having a peptidoglycan layer with the lipid polysaccharides or just the peptidoglycan layer is what is used to stain these bacteria differently.

And there is a staining protocol called gram staining, where essentially you stain bacteria and the peptidoglycan layer stains and the lipo polysaccharide the bacteria that have the lipo polysaccharide layer, the stain gets trapped in the lipo polysaccharide you remove that lipo polysaccharide.

And so, now you are left with a layer underneath which has no staining, and then you go and stain that with a different color. So, the bacteria that do not have lipo polysaccharide layer stain in one color, the one which had lipo polysaccharide, that you removed stain in another color. And this staining protocol is what is also referred to as gram staining.

And it is something that is used even today to classify bacteria, one of the primary requirements for you to identify a new species of bacteria is, find out whether they are gram positive or gram negative which means, they have just the peptidoglycan or do they have peptidoglycan and a lipo polysaccharide layer on top.

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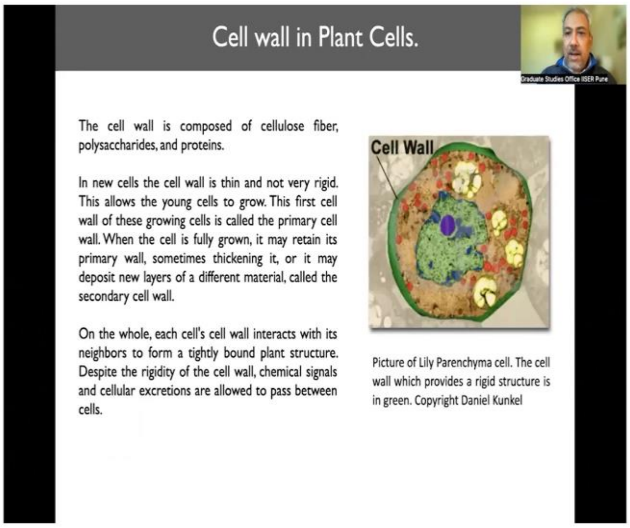

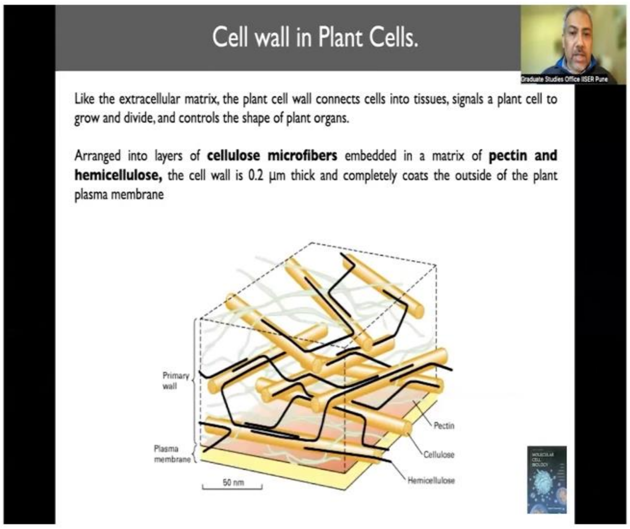

In plants, obviously, this cell wall is distinctly different, because it is much more rigid, it is made up of cellulose and pectin molecules that allow for greater strength in protecting the inner cell, plants have this and, this ability to grow into large, big structures, I do not know how many of you heard of trees like the sequoias, which grow at a specific altitude.

And there are these beautiful Sequoia forests in America, for example, that those sequoias are as old as the pyramids, and, they have, they are as tall as, 14-15 storied buildings, and they have survived for as long as the pyramids have, and a lot of that is possible because of their architecture, and the cell wall is vital to that architecture.

So, the ability of a plant to grow, and compensate for what it cannot do, which is move around, stems from the fact that there is this very strong cell wall that they have, and that cell wall is put together by pectin, cellulose, hemicellulose, all coming together.

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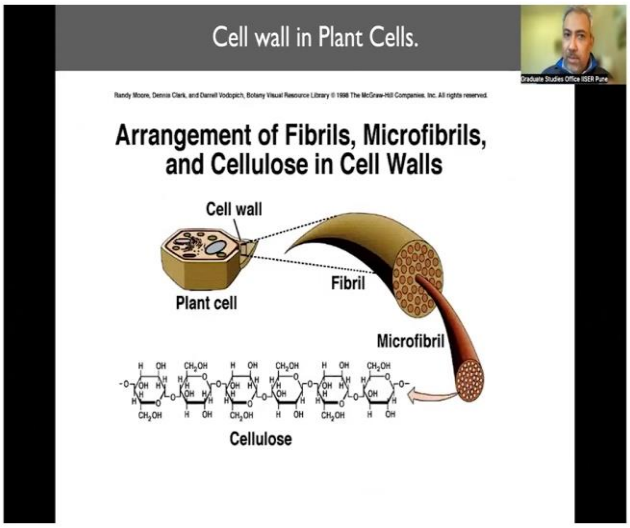

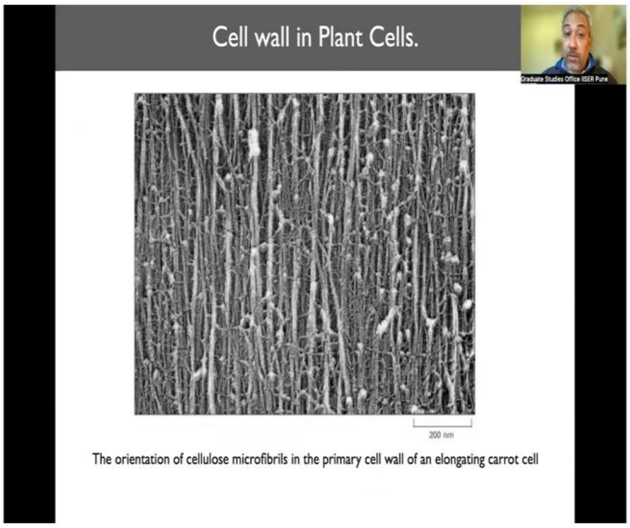

And it is arrangement of these fibrils is that, that drives the making of the cell wall here, this is a picture of the of the cell wall in plants. And as you can see, it is a complex mesh, that now provides this strength that the plant cell needs to grow as a complex structure.

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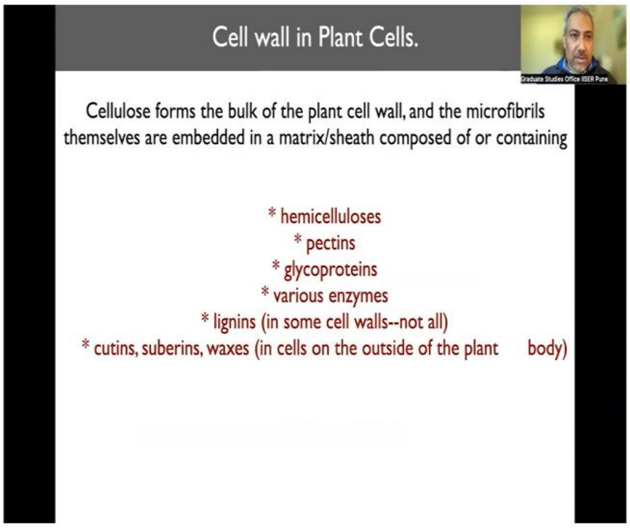

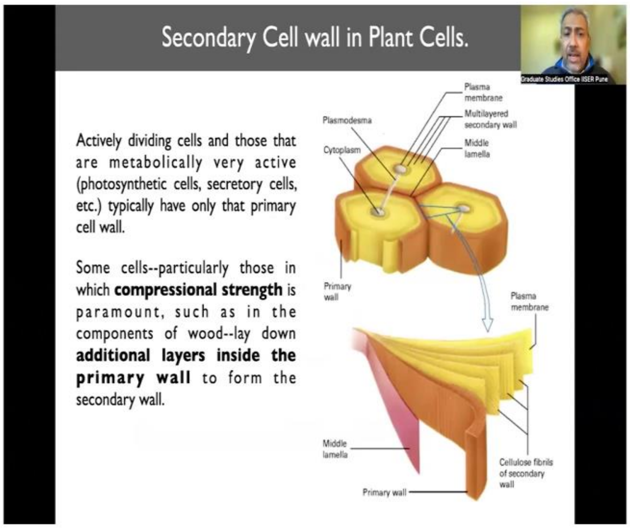

And these are the components that are part of that particular cell wall. And their coming together is what as I mentioned, also, allows for this compressional strength that exists. The other interesting thing about the cell wall implants is along with the primary cell wall, that can be secondary cell walls that are deposited, which allows for the cell wall to grow and for the plant to grow as well in the process.

And that is another interesting adaptation that has happened. The reason I am presenting both of these cell walls, the cell envelope in bacteria and cell wall and plant side by side is because, as an idea, they are doing similar things. Because they are a layer that is outside the plasma membrane and now is trying to protect and they have evolved very differently.

So, the primary concept might be is the same, but the way this architecture is put together, the way it is used, has clearly changed over time. And one happens for a very early cell and the other happens for a more complex evolved cell if you want to call it that.

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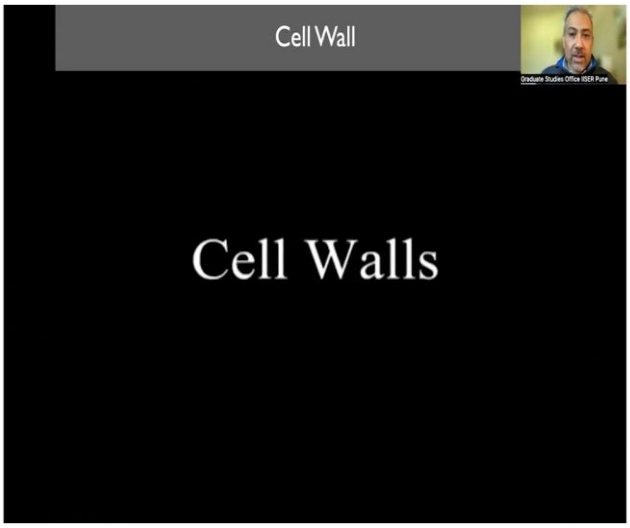

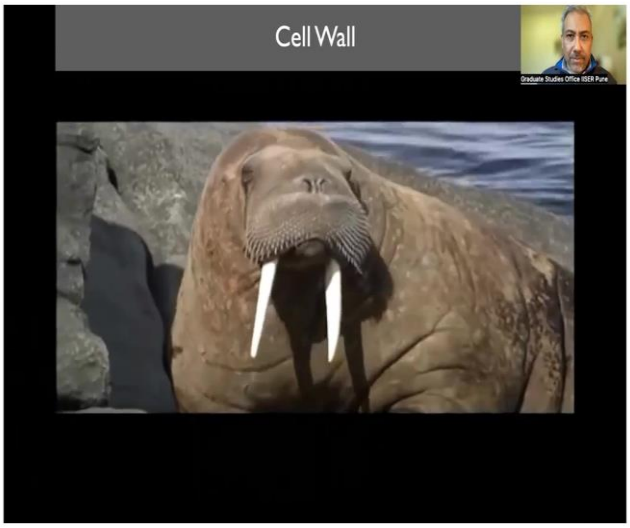


Cell Wall
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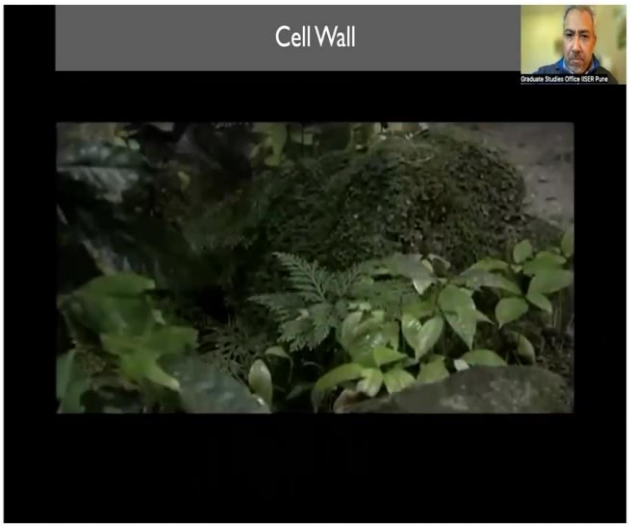
Cell Wall
Graduate Studies Office IISER Pune


Cell Wall
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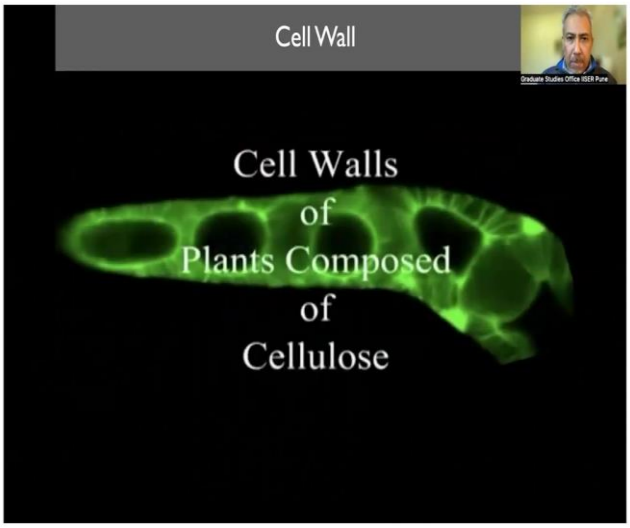
Cell Wall
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Cell Walls
of
Plants Composed
of
Cellulose


Cell Wall
Graduate Studies Office IISER Pune
Cell Walls
of
Fungi Composed
of
Chitin


Cell Wall
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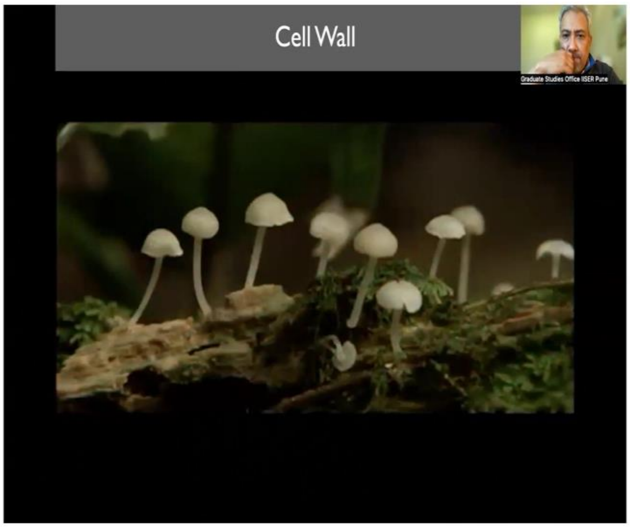
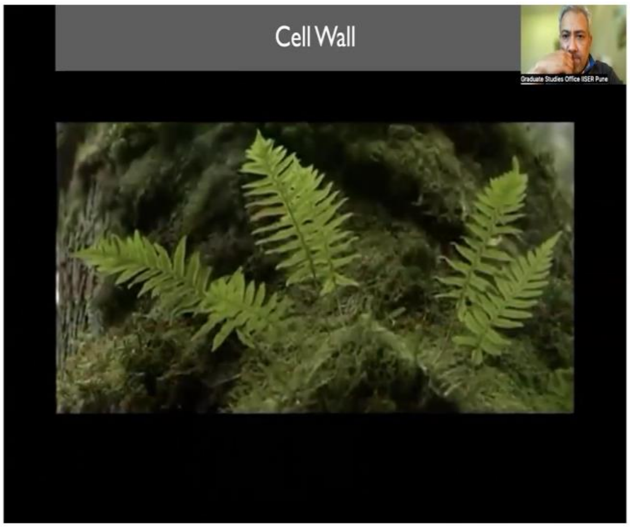

Cell Wall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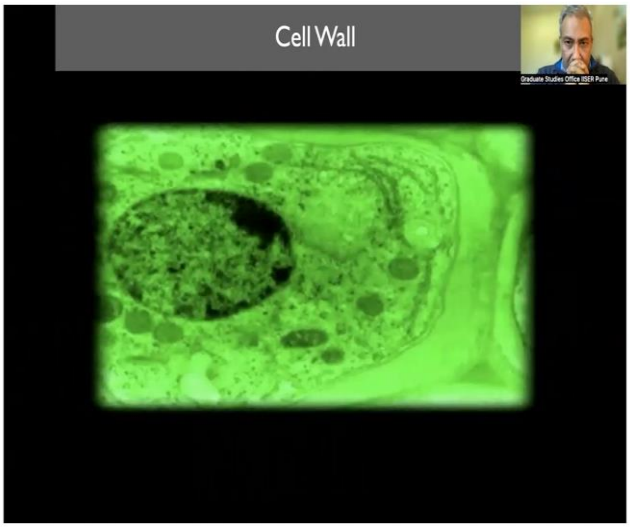
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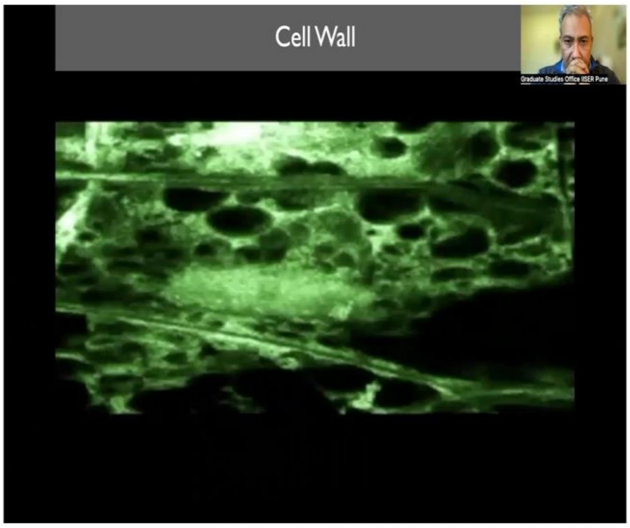
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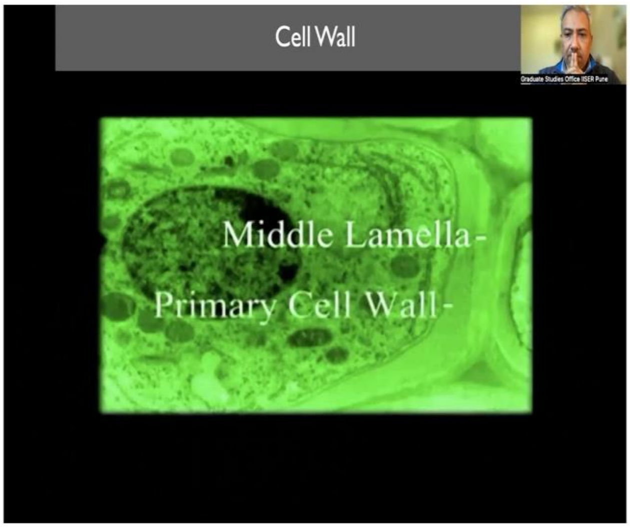
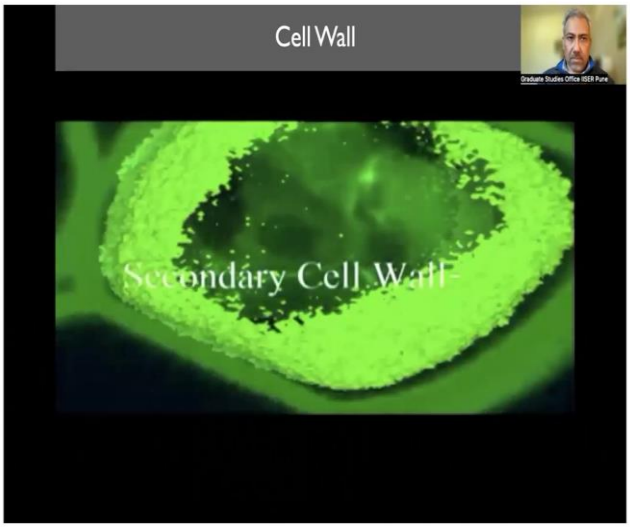
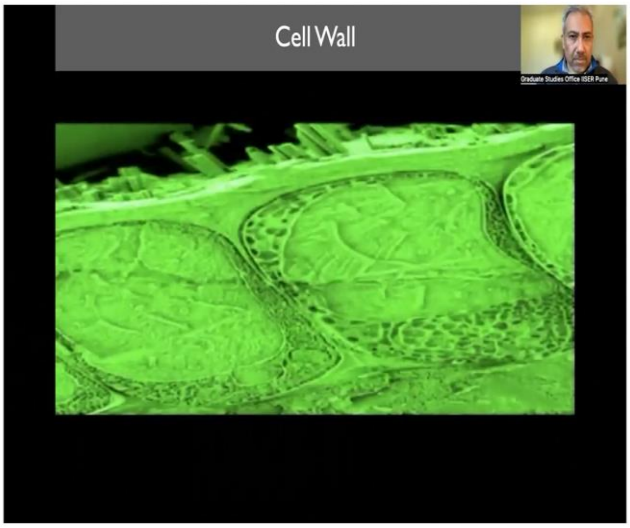

Cell Wall
Middle Lamella-
Primary Cell Wall-


Cell Wall
Secondary Cell Wall-


Cell Wall
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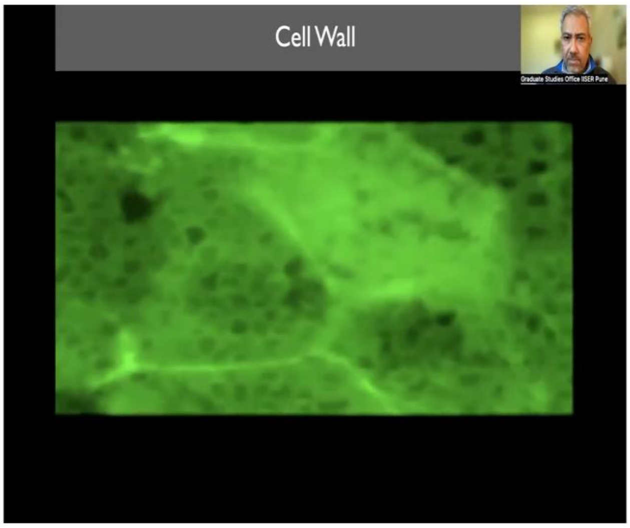

So, we look at this last video of the about the cell walls and stop today here.

While in animals the cell membrane is exposed directly to the external environment. In the cells of certain protests most bacteria and fungi at all plants, the cellular membrane is covered by a stiff non-living cell wall. In plant cells, the cell walls are composed of cellulose and other polysaccharides.

Well in fungal cells, the walls are made up of a modified polysaccharide called chitin. Bacterial cell walls also have a chitin like framework to which amino acids and other molecules are bound. Mushrooms and plants have cell walls because unlike animals, they have neither an external or internal skeletal structure to provide support, and must therefore rely on rigid cell walls in order to stand erect.

Cell walls are produced by the cells they surround. In plants, vessels filled with a sticky polysaccharide, such as pectin line up across the middle of dividing cells, eventually fusing together to form a new plasma membrane that separates the new daughter cells from one another. The pectin glues the two daughter cells together, and forms what is referred to as the middle lamella.

Each daughter cell secretes cellulose through its cellular membrane, underneath the middle of mela, to form the primary cell wall. Many plants then secrete additional cellulose molecules beneath the primary wall to form a thick secondary cell wall. In some plant cells, the secondary cell wall may become thicker than the rest of the cell. The cells that form tree trunks and branches have these very thick cell walls.

These cells are composed almost entirely of cellulose. Without these strong and thick cellulose walls, trees would be incapable of supporting their large loads. Cell walls, in addition to being strong, are also porous to allow the passage of small molecules such as minerals, amino acids and sugars to the cell membrane.

Just as in animals however, it is the cell membrane in plants that actually controls the passage of materials between the cell and its external environment. So, that is a brief introduction to the architecture that we know in cells. And how cell walls are put together.