Introduction to Cell Biology
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Endosymbiont Theory

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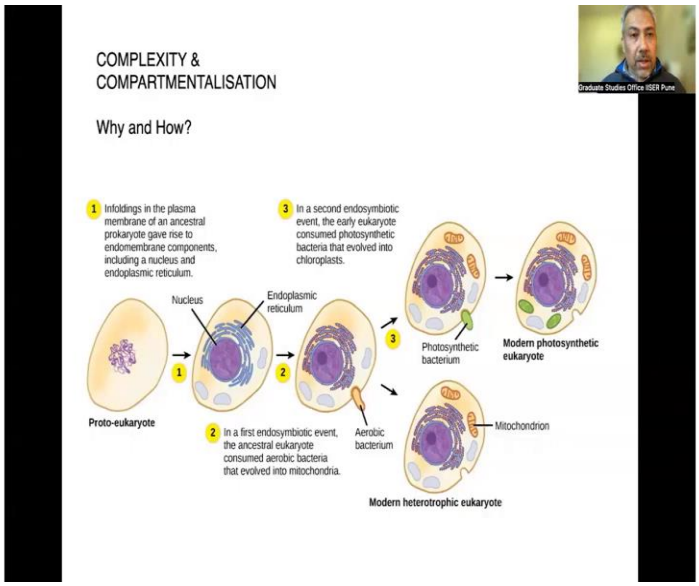

So, last time we were talking about complexity and compartmentalization as being one of the more defining elements of a complex eukaryotic cell as we know it today and the fact that it evolved from something that is more primal, more minimal in the eukaryotic cell. And one of the ideas was this hypothesis that there could be the uptake of one cell by the other, which could have been the beginning of this complexity.

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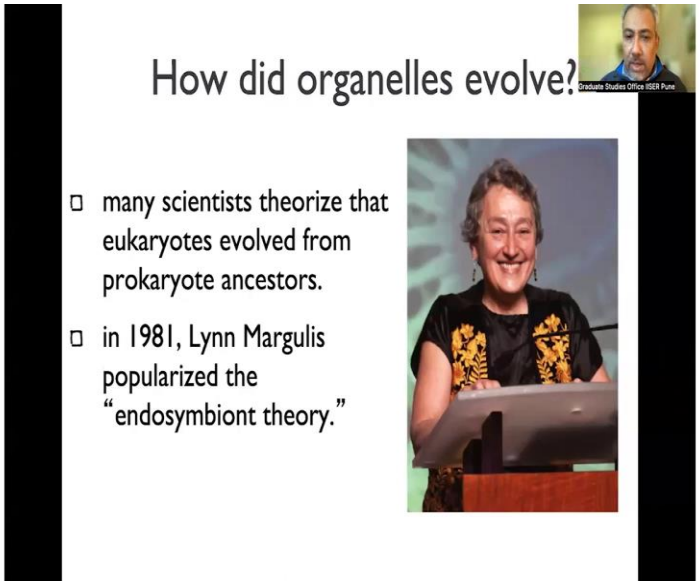

And it is a remarkable thing that there are these leaps that happen every once in a while. And in all fairness, during evolution, at least as we know it, these leaps have happened only very seldomly or at least have happened in a way that allows you to see the leap in the sense that the leap has stayed and existed long enough for us to discover the leap. That kind of scenario has existed only a few times.

And both in context of mitochondria or chloroplasts, such a leap could have happened. And these could have happened independently. They could have happened few million years apart. We do not necessarily know whether they all happened at around the same time. And those details still elude us. It is probably very difficult to know that as well. And there could be a leap like that waiting to happen. It may happen in the next 10 years. It could happen in the next million years, which could change the course of how we live and cells live. And so that possibility is always there.

And a lot of this is attributed to quite remarkable scientists whose theory is the endosymbiont theory proposed in 1981, Lynn Margulis came up with this hypothesis, that this could have happened. And there is now increasing evidence to suggest that we have organelles or remnants of these organisms in the form of these organelles that effectively suggest that they could have come together this way. And as I said, the mitochondria is a good example of this.

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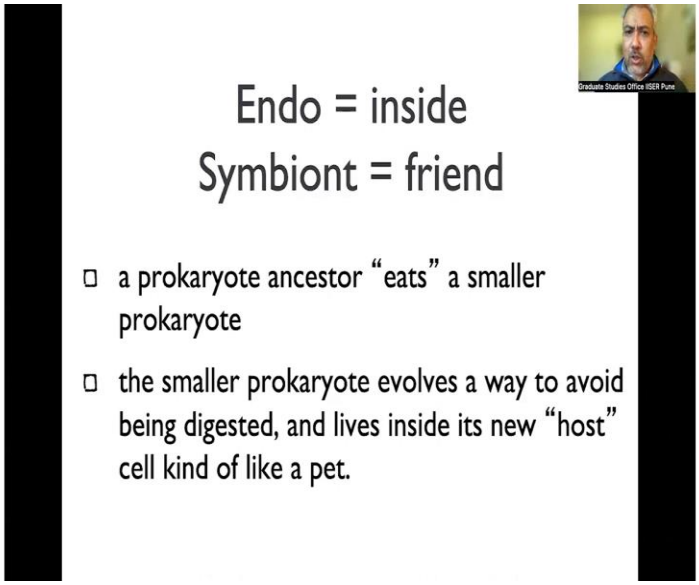

The whole idea of the endosymbiont theory, of course, is that it is endo which is inside and symbiont which is a friend and the fact that these two symbionts came together and increasingly became dependent on each other allowed for this complexity to evolve. Now, one of the rate limiting steps here or one of the reasons why is such an endosymbiont being taken in led to the complexity of eukaryotic cells may have also to do with the fact as to what was that symbiotic relationship and also the fact that this endosymbiont that was taken in was able to add significantly to the energy availability to this other cell.

It is possible that more than one endosymbiont was taken in at some point of time and that further made it possible to have more energy in this now symbiont cell, the cell where these two or three or more prokaryotic cells were now together. And that may have allowed for other changes to happen. It may have allowed these this cell now, this cell that is a coming together of cells, to be able to invest in things that cells earlier may not have been able to.

So, it is highly possible that this coming together kept happening many times till the right kind of combination came together and that now allowed for that particular kind of cell to thrive and do well. And we do not necessarily know, if, how many times this happened before we got a cell that actually could grow further and divide and kind of keep some of that complexity.

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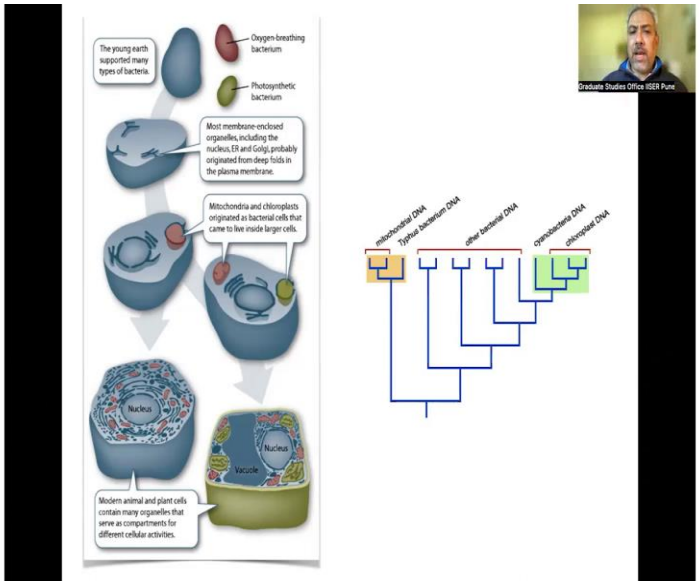

The mitochondria, obviously, is a very striking example of this. And many of you probably read already about it and you know what the mitochondria is capable of. And there are some very striking aspects about the mitochondria. And one among them is the fact that the mitochondria has a double membrane. Now, we will come to the membrane next when we discuss both prokaryotes and eukaryotes. And, but the thing to remember is that that boundary of a cell or a boundary that a structure that eventually became a cell is very, very vital to the evolution of these structures.

The fact that those boundaries could be formed is what effectively defined the origin of a cellular structure even before complexity evolved, the primary cellular structure. And in the mitochondria there is an outer membrane and an inner membrane. And the outer and inner membrane have both existed or both exist now in the mitochondria that is present in our cells. And it is unique in that sense as compared to other organelles. There are very few things in the eukaryotic cell that have these two membranes. And it is thought to be a remnant of the fact that this mitochondria when it came in, came with its membrane, and as it went into this cell was covered by the membrane of this cell as well. So, it now has these two membranes that exists there.

The presence of these two membranes makes, has a very important role in how the electron transport chain that works in the mitochondria works and how energy or ATP is generated in the

mitochondria. So, if you are interested, go look up what that bilayer membrane, that membrane, having two membranes means to the mitochondria.

The other interesting thing about the mitochondria is the genetic code in the mitochondria is very interesting. And let me get to that first.

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And it has its own DNA. And the mitochondrial genome is very distinctly different from the nucleus. And it is interesting that the genetic material of this endosymbiont has existed after so many millions or billions of years in a form that allows us to tell that this is distinctly different from the genetic material of this parent cell that lies in the nucleus. Among the things is the way the genetic code is read is distinctly different.

And there are many other similarities goes to talk about structure, genome, the base repair system, how to correct errors in the DNA, for example, is very distinctly different in the mitochondria. All of this suggesting that it is a structure that could not have come in any other way other than it having existed independently and possibly being taken in. So, all of this supports the idea of the endosymbiont.

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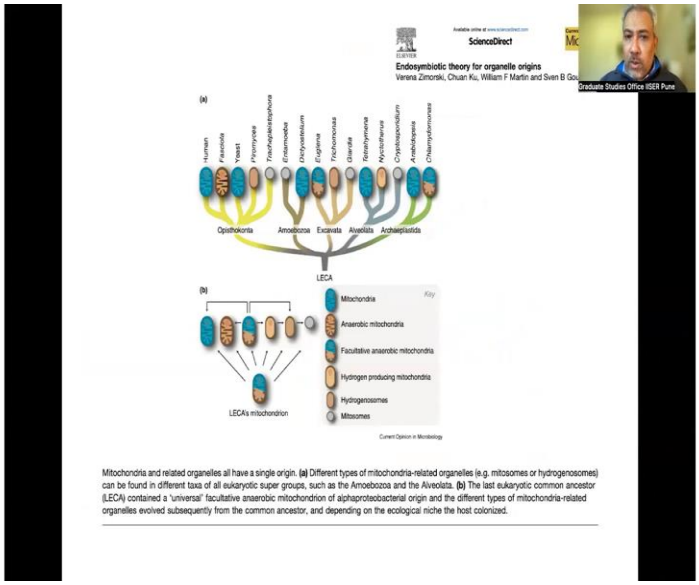

The other interesting aspect is also that there are versions of this mitochondria or versions of such an endosymbiont that are present in varying species. And that is also interesting, because they are all not the same thing. And the mitochondria, as we know it in a mammalian cell, there is a slightly different version that exists in some other organisms, which leads us to think that it is highly possible that this kind of uptake of something being taken up by the other, may have happened in more than one place, in more than one form, may be happening even now as we speak and the fact that the coming together of what two things come together could have had a significant impact in the outcome of that coming together. And so there are many coming

togethers that may have happened that eventually may have given rise to the mammalian cell and to all these other variants that exists.

So, clearly, this is evolution working in ways that allows for certain properties or traits to be selected. But the important point is that the idea that such an intake can happen seems to be fairly, there is no convincing evidence to suggest that that is likely to have happened. And both these organisms the up taker and the endosymbiont have benefited from this. That is the only way this could have sustained and existed for as long as it has.

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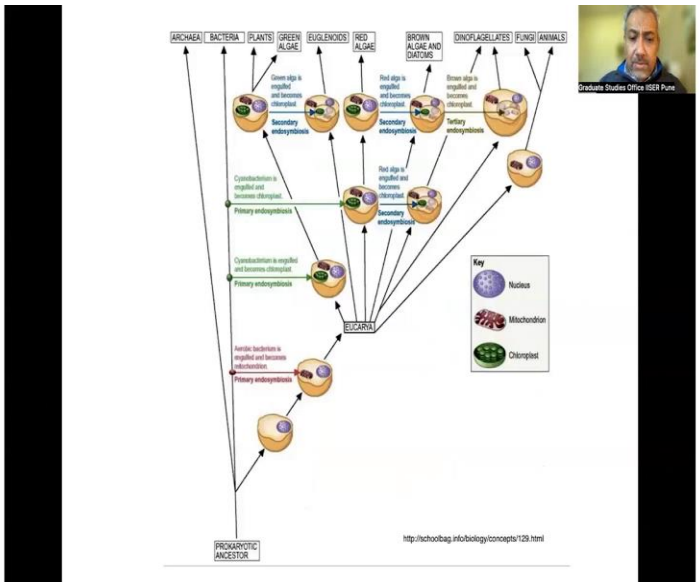

And this now, as I showed earlier as well, there are varying improvements that could happen in the cell. And this is seen across the evolutionary bandwidth that you could see all these modifications, enhancements that are happening in cells as they acquire one or more of these endosymbionts. So, it is highly possible that the coming together of these or this uptake could have been the early event, and not just one endosymbiont, there could have been more than one endosymbiont that was taken up, that now allows for complexity to evolve.

And this has then led to all the other little organelles that we know of. But the beginning of it all, the beginning of all this complexity may have originated from the fact that there is this ability of endosymbionts to exist and thrive and do well as well. So, that is the understanding of the endosymbiont theory.