Introduction to Cell Biology
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Biology of Cells – Part 2

So, what we will do is, I will take questions. And we will come, try and address the questions that are first on the chat box, and then I will, people who have put their hands up, I will come to them as well.

The command center of the cell somebody wanted to know. As I said, we will come to that. At this point of time, all you need to know is that there is a command center. Some have said the nucleus. The nucleus could indeed be a command center. But what will be interesting to see if, it is the only command center. And there is a tendency for us to think that there is one thing that does all the controlling and that may or may not necessarily be the case.

Let me see if there are any more queries. Let us go to the, those of you who put your hand up, and we will take questions from you. So, we begin with Heerak. Heerak, you put your hand up, can you go ahead and ask your query?

Heerak: Sir, is there a very sharp distinction between prokaryotes and eukaryotes that so many organelles are absent in prokaryotes and suddenly appeared in eukaryotes.

Professor Nagaraj: So, when we discuss organelles, we will introduce this idea of how possibly prokaryotes may have evolved from eukaryotes, sorry, eukaryotes may have evolved from prokaryotes. But the complexity of that exists in eukaryotic cells is what is clearly missing in prokaryotic cells. When you come to the advanced cell biology class, see this is meant to be an introduction, and so everything will not be covered in this particular class.

But when you come to the advanced cell biology class, we actually discuss using very specific proteins, like cytoskeleton proteins, which are really good examples of proteins that have evolved over time, and you will notice how, for example, motor proteins, which are these, you saw these big vesicles that are being walked around with legs, those legs are actually the motor proteins. The motor proteins actually suddenly appear in evolution at one particular point of time. They are not there in prokaryotes. And in eukaryotes, bang, they suddenly begin.

And this is something that we will discuss a little later on how this switch to this degree of complexity may have happened. It may have happened gradually for certain things and it may have happened very suddenly for certain things. But the distinction here is very clear that there is this level of compartmentalization, which comes with an energy cost. So, remember, when we talk about the eukaryotic cells being really big as compared to the prokaryotes that size comes at a cost. And so energy requirements and availability may have changed, which allows for cells to kind of grow and move from being small prokaryotes to more complex eukaryotes.

I will take the next question. Neha Verma, can you go?

Neha: Sir, what is the difference between cell membrane and plasma membrane? Is not the cell membrane derived from the plasma membrane itself?

Professor Nagaraj: So, the cell membrane is the plasma membrane. And this is used very interchangeably in some cases. There is a cell wall, which is distinctly different, and that is unique to plant cells. But in, for all practical purposes, cell membrane and plasma membrane are essentially the same lipid bilayer structure that forms the boundary of the cell. It is the perimeter that defines what is outside versus inside the cell. Vaishnavi, your query.

Vaishnavi: Sir, how are prokaryotic cells able to survive without a lot of these cell organelles? What performs the functions of endoplasmic reticulum, Golgi bodies?

Professor Nagaraj: So, see there is a need and requirement balance here. Now, what it essentially says that is that with prokaryotes the basic structures that are present there are enough to keep the cell alive. The functionality of the cell is also limited. Do not forget that. So, eukaryotic cells do very complex functions and are capable of very complex functions in ways that prokaryotic cells will not be.

So, the lack of compartmentalization, the lack of cellular organelles is limiting what a prokaryote does. But the prokaryote chances are evolved at a time where the intent was to exist if I can put it that way. It was trying to keep, form a cell or form a structure that we now call the cell, which can divide and replicate and its investment is in being able to do that. The energy availability, as I said, is also a rate limiting step here, which means that when the cells, prokaryotic cells existed,

it is likely that the energy availability was limited. And so the compartmentalization, the complexity, the increase in size could all have been limited because of that.

So, the prokaryotic cell is not trying to be the eukaryotic cell. It does what it does, and it does it well enough for those cells to have survived, replicated and lived long enough, because you have to remember there is a few million years before prokaryotes come in, so prokaryotes, eukaryotes come in. Prokaryotes are not thinking at some point of time I want to be eukaryotes. They have no clue that these are coming. They have no clue that the changes in the availability of energy and other factors will allow them to develop this complexity. So, do not compare the two.

Now, when you study them, obviously, you have these two comparisons, and you are thinking, well, the complex cells are so much more capable, and so why did not these cells think that we want to be like them. No, there is a huge gap and time between the two. And that is important when you are thinking about this. So, the next person, I am not sure, Deep Shah. Deep, can you go ahead and ask your query?

Deep: Yes, sir. My question was that these prokaryotes like, these prokaryotes cannot be multi-cellular or just prefer not to be?

Professor Nagaraj: No, so they can be under special circumstances. And things like a biofilm of bacteria, actually, now, there are studies to say that they actually, they have complex interactions that exist between them, things like quorum sensing are important for that complexity to exist. So, even though they are made up of individual organisms, they have certain complex characteristics when they are in the form of a group.

So, now, that has taken, been taken to another level when it comes to tissues. There is this idea or notion of the sum being greater than the parts. I do not know if you have heard of this and there is this, okay, you have heard of this, so there is this idea that which is the basis of the Ship of Theseus, which is that the individual parts that come together create something that is more complex in such a way and is able to do something that the individual parts cannot. And that degree of complexity and that level of interaction that is far more sophisticated when it comes to tissues. And that also stems from the fact that the organ, sorry, the cells that are making up those tissues are themselves also fairly complicated or complex in eukaryotes.

So, prokaryotes can make complex structures, can make multi-cellular structures that actually in the classical definition work as something bigger than what these individual cells can be. And in that sense, there is complexity there, in that sense, there is multi-cellularity there. But if you compare that to a tissue like the brain that does far more advanced things, obviously, the complexity varies.

So, the short answer here is they can create complex structures. They do it within the limited capabilities they have. But still coming together to create something bigger or more comprehensive than the parts that make it, by that definition they are, they can be multi-cellular is the answer.

Deep: Sir, so like, do eukaryotes have something special that they can do it even in nature and do create something special?

Professor Nagaraj: No, prokaryotes also do it in nature only, where else are they coming together as well.

Deep: No, like, as you said, like they become tissue and tissue is some...

Professor Nagaraj: So, that is what I am saying. The thing is the inherent complexity that exists in eukaryotes means that the nature of the tissue that they create, the nature of this multi-cellularity that they create is very different from the multi-cellularity that prokaryotes make. But conceptually the fact that individual cells can come together and create something bigger, which does things differently or does more complex things than the individual cells can. By that account, both are comparable. The multi-cellular prokaryotes are in that sense comparable to the multi-cellular eukaryotes. But they are different because of the inherent difference that exists in these cells as well. Harsh, over to you.

Harsh: Sir, in the video we talked about the motor cells. So, are these the train we talked about earlier, which transfer...

Professor Nagaraj: So, this we will come to. Hold your horses, be patient. The idea was to kind of get you interested and hooked. Now, that you know, you want to know about motor proteins you will be waiting for when motor proteins will come and we will talk about it when we come to that.

Harsh: Also, sir, I could not understand the metaphor of different compartments.

Professor Nagaraj: The metaphor of multiple compartments. So, the metaphor is essentially that individual compartments which have very distinct capabilities, organizations exist. And so this segregation that happens by the fact that, it is not one train that runs from one end to the other, that these are individual trains, which means that a train moving in one direction, its direction can be changed and moved in another way, a train can take a different track and move somewhere else. All these capabilities come because there is this compartmentalization.

And the, it is a loose metaphor, but the idea here is to communicate the fact that this kind of compartmentalization is true in many cellular organelles. So, when we come to the Golgi, for example, you will see how compartmentalization means that different compartments carry different properties. And that allows these organelles to actually work in the ways that they do. So, that is the basis of saying compartmentalization. And when we go further, hopefully this will get clearer as to how compartmentalization matters in this context.

Koka, can you ask me? Your query?

Koka: My question is about, like, to run these simulations, like what equations are they using, like, as far as I know, like there are models…

Professor Nagaraj: You meant for recreating what they have done in these videos and I said it is…

Koka: Is it like an actual simulation or a lot of it?

Professor Nagaraj: So, see, this is, this movie was made somewhere around 10 years ago, and it was a fairly elaborate project which used a lot of information that had been collected over many years. Now, you have to remember that all information that is put together there did not come together, did not come from one particular cell type and we were essentially trying to put all of these together in one form.