Introduction to Cell Biology
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Lecture 57
Cell Division Discussion session

Professor: There are a few hands that are up for today, so, I am going to take questions that some of you have. The first hand that was up is Ajinkya. Ajinkya, please, go ahead.

Student Ajinkya: Sir, you stated that the lamina disintegrates to form the nucleoporin?

Professor: No, the lamina is the lamina, the nuclear protein is the nuclear pore complex. So, that breaks up separately, the lamina obviously breaks up separately, as I said, see some of this mechanism like where does individual components go sit? We are still figuring out, so, the lamina what happens to the lamina as it breaks up? Does it again get just distribute in the cell and at some point of time reassemble? We do not completely know at this point of time, but lamina and nucleoporins are not the same thing that is what.

Student Ajinkya: Yeah, so, my question is that you said you also said that nuclear parents migrate to different parts of the endoplasmic reticulum. So, what is? Is there any significance to that phenomena?

Professor: So, the see the nucleoporins are integrated in the membrane, nuclear membrane is connected to the ER a lot of the distinction between the nuclear membrane and the ER membrane is lost during mitosis. So, it could still be part of a membrane in the pieces of the nuclear pore complex.

And now, it could be in a region that otherwise would have been called the ER. So, a lot of the distinction that exists between many of these structures is kind of altered during cell division and then re-acquired as the cell, reassembles. So, this may just have to do with the fact that the nuclear pore complex is part of the membrane and kind of breaks up and distributes in the membrane and does not fall off entirely from the membrane.

Student Ajinkya: Okay. Sir, thank you.

Professor: Vaishnavi your query.

Student Vaishnavi: Sir, in one of the first slides, where we looked at how the microtubules arranged during the metaphase I saw two microtubules from to the both the centrosomes attached to each other, why was that?

Professor: So, this kind of attachment happens, there are many such interactions that happen in the opening up of the two mitotic spindles, remember, there are strands of microtubules that are connected to them. It is not like they are completely the centrosomes are free floating, because there are microtubules here and there are microtubules and they actually are connected. And so, along with microtubules that are pulling the centrosomes apart, there are microtubules here that are growing that are pushing the centrosomes apart as well.

So, microtubules as long as they have a way to communicate with each other and motor proteins are one of the ways they do it, they will have overlaps in places just as the tip of the microtubules will bind to the centrosome using a very elaborate mechanism, this kind of overlap attached through maybe motor proteins is also likely to take place, and that is happening because of how this all began. So, and then once they are sufficiently apart, the microtubules come apart the center of the chromosomes are arranged and now that same tips have to go bind the centrosomes sorry!! Had to bind the centromeres in the chromosomes per se.

Student Vaishnavi: Okay, Sir.

Professor: Vignesh your query.

Student Vignesh: Sir, so, at the start of the cell cycle, you have an approximately spherical cell at the end of the cell cycle, you have two daughter cells that are half the volume and that are also approximately spherical. So, I did some basic surface area volume calculation and at the end, you have approximately 25 percent more surface area than you had at the beginning. So, there are two explanations for this. One is that there is a large increase in lipid generation during those cell cycle the mitosis that allows the surface area to expand by this much or the density fluctuates throughout the mitosis that allows for this to happen. So, what is happening?

Professor: Both probably happen. And, go look up this review on lipids I will put it up and both scenarios actually could be happening. And, there is a lot more lipid in the cell that now becomes available at the plasma membrane. So, for example, we did not talk about this, but, later on in

advanced cell biology courses, you will probably read about it where there are, invaginations in the membrane like, caveolae like structures, and if you really pull on them, and the membrane is to expand these caveolae like structures actually fall back, they give their membrane to the plasma membrane.

So, there is a way for membrane to be added to the cell membrane. And, at the same time, there could be other mechanisms that of synthesis that are also contributing to the amount of lipid that is there in the in the cells. The two daughter cells may not be as big as the parent cell per se to begin with. And that is something to consider as well, when you think about this.

Student Vignesh: Okay, Sir.

Professor: Anubhuti, your query.

Student Anubhuti: Yes, sir, I had a doubt in mitochondria paper.

Professor: In what? Mitochondria paper.

Student Anubhuti: Yes, sir. Sir, in that slide it was given that when they breakup because of a several protein and all then the rejoin again. So, why do they rejoin?

Professor: See for the functionality of the mitochondria in an active cell, which is not dividing that architecture is vital. So, the mitochondria are not existing as elongated structures, just for fun, so, they that architecture is vital to how they mediate their functions. So hence, a lot of time and effort and energy is put back in not only so when distribution and break up has to happen, those structures are not amenable to that kind of distribution. So, you chop them up and then distribute it. And then you bring them back together to being the structure that they originally were.

Sai Chinmay has query. A how exactly are the organelles distributed among the cells? Is there equal division, or they just statistically get distributed? Stochastically is probably what you mean, also, are the microtubules involved in gathering all these organelles as well?

So, a lot of this happens, both of these happens, where some of it is just stochastic distribution. If you have these big, stirring of the by the actin, then that obviously ensures that everything is getting mixed nice and well, before the division takes place. Some of it is probably also mediated

by direct binding to microtubules and Golgi. For example, there is some speculation that there could be direct binding, so that also could be taking place.

Anand has a query, what does the term sumoylation of DRP1 mean? Sumoylation is a modification that happens on DRP1, as a matter of fact, Girish's lab here at IISER study sumolation of proteins. It is a modification that adds a certain residue, which is called sumo and hence the name sumoylation that affects the functionality of those proteins that are sumoylated, so, DRP function is affected by sumoylation.

And that is one of the changes that is taking place. Why is the kind of mitochondria being moved around in circles? Because it likes going around in circles, so, I think the mitochondria are being moved around in circle because it is trying to distribute the mitochondria, and make sure that they go, they are evenly distributed throughout the cell.

What is particularly interesting, and nobody asked me this, at least up until now, is why does that movement happen in the anti-clockwise direction and not the clockwise direction? Because it moves in one direction so, does it happen the other way too, and if not, why? It happens only in the anti-clockwise direction.

So, go look up the paper and see what they have to say about why that is the case. Abhinav has a query, does every chromosome always get split properly? Actually, does not, sometimes that actually there can be mistakes and separation does not happen polyploidy kind of situations happen where an additional pair of chromosomes end up in a cell, and the cells do not do fine and eventually, in most cases, these cells are gotten rid of but sometimes, they can be problematic as well. Vinu Kumar, you have a query? I do not know how I should pronounce your first name.

Student Gaadha: Sir, Gaadha.

Professor: Gaadha. Go ahead, Gaadha

Student Gaadha: Sir, my doubt was regarding the actin comet tails helping mitochondria does that happen only during mitosis, or do they also help in moving the mitochondria during normal cell movement?

Professor: Yeah, very good question. So, far they have been seen only during mitosis. And that may have to do in part, because of the fact that the architecture of the mitochondria is very different in non-mitotic cells. And so, they are not really trying to be moved around. And, so, that might explain why this happens only during mitosis.

Many of the mechanisms that required, that trigger this formation of these tails are also activated during mitosis which is probably one more reason, why these mitochondria in the (mitosis) mitotic state, only have the states? They are fragmented mitochondria. And now they are, being moved around as well. So, that is my short answer. Goraksh, your query.

Student Goraksh: Sir, I did not get the part where you said it is always anti-clockwise. Like, if you look at it from one side, it is anti-clockwise but, from the other side, it is clockwise right? So how do you say…

Professor: So, this is like saying, it is moving in one direction, as you look at it like this is like saying, if you put a mirror in front of it, it is clockwise. Sure, when I am looking at it from, you are looking at it on the screen, it moves in one direction and it does not matter what that direction is, you can call that direction whatever you want. But there is movement in of the actin ring in one particular direction and not the other. And that is the query, what on earth lets the cell say, this is the direction I am going to move this in? And clockwise, anti-clockwise is our terminology does not really matter.

Couple of questions on chat. Dhayria has a query, why does the cell try to go into a spherical structure before mitosis? Good question, what do you think might be the reason? So, is that, when it comes to separation of two daughter cells having rounded cell ensures that a lot of the heterogeneity that exists, see, when the cell is spread out, deciding where the central plane for division is, may not may be that easy to do, that is a lot more easier to do if the cell is rounded up, because you kind of have a sense of where exactly that middle is going to be like.

This may also obviously the finding of that middle is determined by lipids for example, that could be present and their distribution is again regulated differently when the cell is in this rounded confirmation. So, to allow for this kind of separation to take place, and ensure as close as possible for even distribution of components, because many of these components, have some active mechanisms, but for a most part are using stochastic methods to be distributed.

So, you want that separation to ensure that there is a 50-50 chance of things going this way or that way in part mediated by the or facilitated by the fact that cells round up. So, there is a active mechanism to reduce the adhesion of the cells and allow them to round up before this happens.

Student Dhayria: Thank you.

Professor: Sorry!! You were saying something?

Student Dhayria: No, I was just saying thank you.

Professor: Gautam has a query are mid bodies found in telophase permanent? If they are not, then how do the microtubules and actin fibers within them get distributed? So, there is a mechanism for everything. And as I said, I have not gone to the detail of many of these aspects, simply because the scope of that is just too much. How are these centrosomes duplicated? Again, very detailed mechanism is known about how this is taking place. So, there are mechanisms for these structures to break up just as there are mechanisms for them to be brought together and assembled into very distinct architectures.

And that mechanism, when it comes to the Golgi or the ER we briefly touched upon how phosphorylation dephosphorylation of very specific proteins could do this? So, if you are curious, go back and read a little bit. There is a lot of information on how many of these processes are regulated as well. If the microtubules Nilanshi has a query of the microtubules attached to the kinetopore of the chromosomes are arranged at the metaphase plate, how are the chromosomes arranged in the phase first place? Please go look this up. How is that architecture created?

I am not discussing that here because that is really beyond the preview of this class. There is a lot of information on how this happens? Each and every step, I could teach an entire course on just cell cycle, and all the steps. So, go look this up, and let us see what you find out. Last two questions, Hirak you go first.

Student Hirak: Sir, in continuation to Goraksh's point that if mitochondria move in anti-clockwise since during a cell cycle, but the cell could turn upside down, and then the mitochondria moving in the other.

Professor: It does not matter. This is what I am trying to tell you, it moves in one direction. This way now, if you if you do the cell this way, it is much it is still going the same direction, it is relative to the cell its position may have changed, but it moves in one direction that is the point. So, you can look at it this way, you can look at it this way and the clockwise, anti-clockwise is our view of that, but effectively within the cell, that movement happens in a certain direction.

And, it is not like it goes one round this way, and then goes another round that way, or it does five rounds this way, and then goes back the other way. It does rounds in a certain direction, and keeps doing rounds in that direction. And the question was why that could be happening at all? Go look this up, I mean, they have not they do not have a clear explanation for this. But they have some suggestions on what could be the case. Vaishnavi, last query.

Student Vaishnavi: Sir, during the actin wave does it move around only the mitochondria or other organelles also?

Professor: So, the mitochondria have actin tail like structures that allow it to be moved, but the pieces, the fact that you can see this big wave of actin that is going through suggest that other structures which are pieces that are floating around will obviously be moved around because the (cyto) there is a cytosolic current that is created effectively. And so, that will ensure that a lot of the other broken up structures are also distributed in the cell, so, this could have implications for other structures in the cell and the way they are distributed also.

Student Vaishnavi: Okay.

Professor: So, yeah, so mitochondria could be the place where this was discovered, but it probably (have) has implications for other cellular components being distributed as well.