

Cell and Molecular Biology
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Week 12
Summary and Conclusions
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Hello everyone, this is Dr. Vishal Trivedi from the Department of Biosciences and Bioengineering, IIT Guwahati. And in the course on Cell and Molecular Biology, we have discussed many aspects related to this particular topic. So, we have discussed how the different types of biomolecules interact with each other, and as a result of this interaction, they are actually governing and regulating the different types of outcomes. The course in cell and molecular biology is being divided into 12 modules where we have discussed the different aspects related to this particularly important topic. So, in module 1 we have discussed how the origin of life is happening.

So, we have discussed how the different types of events are happening. So, we initially discussed the different types of hypotheses and how life has originated. And then we have also discussed Stanley Miller's experiment and how the modern theory of chemical evolution explains the different events that are happening and what is responsible for the origin of life on Earth. So, we discussed the Stanley Miller experiment and how the Stanley Miller experiment was a groundbreaking experiment to explain that in primitive Earth, there were biomolecules and inorganic molecules interacting with each other to form simple molecules, and then these simple molecules interacted with each other to form proteins, lipids, and DNA.

And then these small particles, like structures that are being called coacervates, started eating each other, and that is how they formed into a mini cell, which is called a primitive cell. And then the primitive cell has acquired, you know, the features of being a prokaryotic cell as well as those of a eukaryotic cell. Although there is no conclusive evidence regarding how the origin of life has formed or how life originated on Earth, these are the most conclusive and easiest ways of explaining it because they are based on experiments. And then, subsequent to that, we have also discussed the evolution and how the different organisms are evolving from each other. So in that context, we have discussed Lamarck's theory, we have discussed Darwin's theory, and then we also discussed Hugo de Vries's theories and so on.

And the purpose of discussing this theory is that it actually explains the different aspects of how evolution has been happening and how the different types of organisms have

appeared on Earth. While we were discussing all this, we also understood that it is not one theory that is correct and the other theory that is wrong. It is actually the other many theories that are coming together, and that is how they are explaining evolution. And then we moved on to module number two, where we discussed the cell. We have discussed the cellular structures.

So we discussed the prokaryotic structures. We discussed the eukaryotic structures. So within the prokaryotic structures, we discussed the cell wall. So we discussed the gram-positive cell wall and the gram-negative cell wall. And we discussed the differences between the gram-positive and gram-negative cell walls.

We discussed the gram staining and so on. And then we moved on to the eukaryotic cell where we discussed the plasma membrane. So we discussed the composition of the plasma membrane, the fluid mosaic model, and so on. And then we also discuss the nucleus, the mitochondria, chloroplasts, the endoplasmic reticulum, Golgi bodies, lysosomes, ribosomes, and so on. We discuss the organelle structures, we discuss their composition, we discuss their functions, and so on.

After this, we will also discuss how you can monitor cellular growth, how you can have different types of properties that you can actually exploit in various analytical techniques, and we have discussed the simple technique, like the serial dilution method. Enzymatic methods such as the MTT assay are discussed, as well as some of the more complex systems where we have shown you how to count the cells using the cell counter and how that can also be used for monitoring whether the cells are growing or not. In this context, we took you to my lab and showed you a demo of how you can see all these experiments. Subsequent to that, we also discussed what will happen if there is a dysregulation; there will be a disturbance in cell growth and so on. And in that context, we discussed apoptosis as well as autophagy.

Then in module 3, we discussed cell division and said that cell division is the fundamental nature of all cells. The intercellular organelle is a balance between cell death, cell division, and the dynamic number of cells for the tissue antennas. The cell cycle has four stages: we discuss cell growth, chromosome replication, chromosome segregation, and cell division. Prokaryotes reproduce in a short span of time, while higher eukaryotes take hours to reproduce, and the regulatory proteins that regulate the cell cycle in prokaryotes include DNA-A, HAD, CQA-A, PAR system, MIN protein, and FTS proteins. And the eukaryotes have various types of checkpoints to ensure that there is a transfer of stable genetic content.

The progeny is involved in having the DNA development checkpoints like the ATMs,

ATRs, p53, RB, and so on. Different combinations of cyclin-dependent protein kinases and cyclins actually facilitate the progression of cells through the different stages of the cell cycle and so on. The basic nutrition requirements of the cell cycle include the basic building blocks such as amino acids, vitamins, minerals, carbohydrates, and so on. And then we also discuss different types of the various methods of monitoring cell growth, which include direct cell counting methods, turbidimetric methods, spectrophotometric methods, biochemical assays, imaging methods, and so on. And then we also understood the role of the cell cycle and its importance in regulating the different types of events and in its role in not developing abnormal cells and the production of cancer cells.

Then in module 4, we discuss the transport phenomena. Remember that the uptake of cellular material is a very, very important phenomenon for the organism to take up nutrition, right? So in that context, we discuss passive transport, we discuss active transport, we take an example of the prokaryotic system, and we have taken an example of the eukaryotic system. So, cellular transport is a very important and critical process that ensures cellular functions by regulating the movement of molecules across the membrane. And the different membrane and the surface layer form the barrier and regulate the movement of molecules across them. Various transport processes and mechanisms are present in the prokaryotic system, such as bacteria, and they are also present in the eukaryotic system, such as mammalian cells.

The main purpose of these transport phenomena is to provide the essential nutrients. They are being used to regulate the ion balances. So, in some cases, some of the ions are actually going to be thrown out of the cell, and some of the ions are being taken up, right? This happens very often in the different types of cells. So that you can maintain the membrane polarity and a particular type of charge across the plasma membrane. So, transport phenomena play a very crucial role in these kinds of processes, and in this particular module, we discuss the different types of transport phenomena across the membrane.

Then in module 5, we discuss cell signaling. So, cell-to-cell communication is a very important phenomenon, right, where the cell is conveying a message to the other cell. So, these cells could be their own cells, right? So, in that case, it is actually going to do the autocrine signaling. If the cell wants to give the signal to the neighboring cell, then it is going to be paracrine signaling, or if the cell wants to send the signal to a very distant cell, then it is going to be endocrine signaling. Cell-to-cell signaling is very important in terms of regulating many types of events such as growth, development, aging, and so on, and that's why it is important to understand these events.

So we have taken an example from the prokaryotic system. We have taken an example

from the animal system, and we have also taken an example from the plant system, and we discuss different types of signaling molecules. We have taken examples of the animal hormones, we are talking about the plant hormones, and we have also talked about the environmental factors, how they are also responsible for generating cell signaling and how they can also impact the outcomes. For example, we discuss phyto-signaling and how the plant is receiving different wavelengths of light and how it is actually responding. So, in this, we have also discussed the autocrine, paracrine, and endocrine systems; we discuss animal hormones and plant hormones.

And then in module 6 we discuss the genetic rules; we have discussed Mendel's laws of genetics and we discuss how Mendel's laws explain the different types of genetic behavior, what is being observed from generation to generation, and how these laws actually explain the appearances of the different types of genetic diseases. So we first discussed Mendel's law of genetics. Then we also discussed the different types of ways in which sex determination is being established. And lastly, we also discussed the different types of genetic diseases. Then in module 7, we discussed more about Mendel's law, right? So we discussed Mendel's law related to the one allele.

We discussed Mendel's law when the two alleles are involved, and we discussed Mendel's law of dominance, Mendel's law of independent assortment, and then we also discussed the exceptions to Mendel's law, such as incomplete dominance, co-dominance, and so on. And then we also discuss the different types of genetic diseases. Then in module 8, we discuss the application of different types of gene regulations, transgenic animals, plants, antisense technologies, and so on; we also discuss genetically modified organisms and the ethical concerns related to them. Then in module 9, we discuss biomolecules, including the structure of DNA, the structure of RNA, and the structures of proteins. and we discuss how you can isolate the DNA from mammalian cells, how you can characterize the DNA by taking it, how you can determine the accuracy as well as the purity of the DNA by measuring the absorbance at 280 nanometers, and how you can estimate the DNA using the DPA reagents.

And then while we were discussing the RNA molecules, we discussed the general structure of messenger RNA. We discussed how you can purify the messenger RNA using the oligodT columns or the triazole methods. And we have taken you to my lab where the student has shown how you can purify the RNA using the triazole methods. And then we also discuss how you can estimate the RNA, how you can check the purity of the RNA by taking an absorbance at 280 versus 260 nanometers, and so on. And lastly, we also discuss the protein molecules.

Then in module 10, we discuss one of the important phenomena that has been called the

central dogma of molecular biology. So we discuss the genetic material; we discuss the central dogma of molecular biology. So in that context, we discuss the replications, we discuss the transcription, we discuss translations. So when we were discussing the replications, we discussed the replication in the prokaryotic system and the replication in the eukaryotic system. When we discuss the transcriptions, we cover both prokaryotic and eukaryotic transcriptions, as well as post-transcriptional modifications, including messenger RNA capping, polyadenylation, and so on.

Lastly, we discuss the translation, focusing on translation in the prokaryotic system as well as translation in the eukaryotic system, and we also discuss post-translational modifications. Now when we move to module number 11, we discuss immunology. So we discuss the basics of immunology. So initially we discuss the different components of the immune system. So we discuss cell-mediated immunity.

We discuss humoral immunity. We discuss the different components of cell-mediated immunity and humoral-mediated immunity. We discuss the antibody structures, we discuss the production of the antibody, and I have taken you to one of the labs in Cedari where the scientist has shown you how you can develop the antibody in the rabbit. and how you can purify the antibody from the rabbit using affinity chromatography. And then we also discuss the interaction of the antibody and antigen, and how you can use that to develop the different types of assays. So we discuss the hemagglutination assays, we discuss the ELISAs, and we discuss the different types of ELISAs.

So we discuss the indirect ELISA, direct ELISA, and the sandwich ELISA. And we took you to my lab where the student showed you how you can use the sandwich ELISA to measure the level of one of the cytokines called TNF alpha. So then we also discuss the vaccines, how you can understand the different types of vaccines that are being developed, and what their roles are in providing protection. And lastly, in the previous module, we discussed the gene therapy, and we also discussed the cellular factory. So, this is all about the different types of modules and the content that we have discussed in the cellular molecular biology course.

And the purpose of this particular course is to give you a whole-soul experience of how the different types of biomolecules interact with each other and how they are actually responsible for the different types of outcomes. And I have taken full liberty in taking you to my lab where we have shown you not only the theoretical part, but we have also shown you how you can perform the different types of experiments so that you can study these events in your own laboratory or actually understand the events in a much better way. So, with this, I would like to conclude my lecture here, and I hope you will appreciate our efforts and like this course. Thank you.