Course Name: I Think Biology

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W12L63_Course Wrap-Up

Hello and welcome to the I Think Biology NPTEL course. If you are watching this lecture, then first let me congratulate you because that means you have been through 12 weeks of lecture as this is the course wrap up, in this lecture, I won't be doing a week by week summary of what we have covered through the course, but instead I will highlight certain ideas and concepts that we wanted to bring out when we were planning this course. I will also be talking about certain specifics that I think are important for you to know. So perhaps after watching this lecture, you could revisit some of those other lectures which I talk about in the light of what I said in this one. So let's go.

The first idea that I would like to highlight is that we have viewed biology as an integrated science throughout this course and I will explain what that means. The other idea that we again highlight throughout the course is that of the scientific process. So let me come to the first one.

We can no longer view biology in the old ways of dividing it into botany, zoology or microbiology because we now know that the same processes are at work in plants, animals or microorganisms. Whether it is at the genetic and molecular level, at the cellular or say structures inside the cell and their processes or even certain higher order levels, whether it's in ecosystems or things that we may not normally associate with like group behavior and group dynamics.

For instance, you can study group dynamics in bacteria in a plate or in slime molds or in cells in culture, in schools of fish and even in animal herds. And amazingly enough, some of the same physical principles or equations can be applied to explain how these group dynamics work. So in that sense, we are all interconnected and several times we undergo the same processes. And so when we look at biology, especially at the college level, we should have this broader lens and then depending on the space or the time scale that we are looking at, we can make use of a particular tool.

So rather than being driven by the discipline or saying that, oh, I'm a botanist or a zoologist, we

should indeed be question driven. In order to illustrate this fact, let me look at one of the first topics that we covered in week one, which was what is life? Now this is a standard topic which is covered in many biology textbooks, but this is again a topic which has led to a lot of debate as you can see here. Even now there are books being written on this and we also covered this and said, okay, what are the characteristics of life? So we can think about movement, we can think about growth, we can think about reproduction, response to stimulus, and we try to categorize life in those ways. But then we went one step further and asked, can we attribute these characteristics to something that we normally don't think of as living? And here we asked the question whether we can think of a city as a living organism. And when we do this, we immediately change the way in which we look at a city.

And we went into some detail in trying to examining what is known as the urban metabolism of a city. So how does the city eat? How does it breathe? How does it excrete? Whether some of the inputs and outputs are linear or whether they can be circular so that the city starts to work more as an organism, which is in homeostasis or equilibrium, such that all inhabitants and constituents of the city continue to live and thrive within it. So when we apply the lens of a living organism to the city, we change the way we think about it.

The next big idea that I would like to talk about is the scientific process or the scientific method. We talked about what is science and how people go about doing science. And the simplest way that we can define science would be that it is a particular way of looking at the world, which uses a very particular method. And we used a case study of windmills in the Western Ghats to try and kind of break down the steps in this scientific method. But we also highlighted that there is no one single method and people use a variety of tools and methods in order to answer questions, but in a scientific manner. Beyond that, we also spoke to practitioners of science or scientists.

So again, in week two, I would like to highlight this discussion we had with Dr. Shashi, where he spoke about the differences between experiment versus theory. He also spoke about the meanings of the word theory when it is used in science, which is very different from the casual use of this word, where it can mean just an opinion or a guess. But in science, when we use the word theory, it means it's an explanation for a particular phenomena which is supported by scientific evidence. So it's backed up by fact.

So when we say the theory of evolution by natural selection, we mean that we now know that this is the way it works because we have an overwhelming body of evidence for it. Continuing on with our discussion of the scientific process, we looked at other aspects. For instance, we had a discussion with Dr. Suhel Quader on science and society and how it is sometimes dangerous to apply scientific concepts to larger human questions and how even scientists can have several biases. And here we discussed things like survival of the fittest and applying that phrase to human society, which is illustrated in this image where America is being shown as very fit and Spain, which is the person who has been captured, is somehow less fit.

And so America will be the survivor because of certain ideas of progress and enlightenment, whereas Spain, which is less fit because of its medieval ideas, will not survive. We also looked at an interesting aspect, which is that of art and science and their interrelationship. And here we had a discussion with a practitioner, Dr. Ipsa Jain, and then she spoke about how art can serve as a vehicle for telling stories about science, not just to lay people, but in fact, art can even provide insights to scientists about their own work. So moving on from there to some of the nuts and bolts of the course, where we covered different topics within biology.

And here I would like to highlight for you what we call the pillars of biology, which are evolution, genetics, and cells. So evolution explains the great diversity of life that we see out there, how it came about and the changes that it has undergone over a long period of time. Genetics explains to us how evolution actually happens through mutation and heredity. And cells, you could say, are the site of all this action because genes are contained within cells and then cells can undergo changes during meiosis or different kinds of horizontal gene transfer events and then cause them to change. And so this change can be at the individual level and then it can propagate into a population and then give rise to various evolutionary processes. So we can look at all these topics, keeping this in mind.

So in week three, we looked at the parts of the cell. So what is the cell comprised of? And here I would like to highlight the lecture on central dogma, which explains the transmission of information amongst these various molecules that we have in the cell. And one thing that I would like to highlight as part of these biomolecules lectures is the very tight relationship between the structure of the molecule and its function. And then that has effects on the cell as a whole.

So you must keep this in mind when you are viewing or when you're discussing biomolecules. We then looked at cells where we had the standard lecture on kind of animal cells and plant cells, but we also did this kind of fun lecture on what our favorite cells are. So you should also think about what your favorite cell might be and why do you like it? Moving on then, we looked at the life cycle of a cell and asked what are some of its checkpoints, what happens when these checkpoints go awry, which can then lead to cancer. And so we did a lecture on cancer biology by Dr. Ramray Bhat, and we also had a discussion with him about it where he spoke about his work and some of the tools and techniques that he uses to study cancer.

Looking then at genetics, we did the Mendelian genetics, which is something that you would have known from your school textbooks. But we also looked at modern genetics, where we said, okay, how do people study some of these topics now? And we introduced the concepts of forward genetics and reverse genetics. So in forward genetics, you know what is the phenotype and you're trying to figure out what is the genotype. So where is the mutation happened, which chromosome and does it spread throughout the genome. In reverse genetics, you know the

genotype and you're trying to figure out what is the phenotype. And we also explained some of the methods that scientists use to do that, whether it is whole animal screens to look at developmental mutants in embryos, or it is doing site-directed mutagenesis to then produce different kinds of phenotypes.

So here again, I would like to highlight that whenever you're studying a topic, you must always keep this question in mind. How did people come to know this? What were some of the tools and techniques that they used? How were these data generated? Finally, we looked at the topic of evolution. And here we looked at evidences for evolution, whether it is biogeography or homology. We studied the mechanism of evolution, which is a cause for confusion for many students. So things like mutations, genetic drift, gene flow, and natural selection.

And then we did a discussion on the misconceptions of evolution. So after having watched this lecture, you should then try and figure out whether you still have these misconceptions and discuss this with some of your peers and other people, perhaps in your family and larger friends. We did a more in-depth discussion of certain topics in evolution, especially the species concept and what is biodiversity and how again, to use the tools and techniques to estimate biodiversity.

And then continuing on with the nuts and bolts concepts, we also asked what are some skills and capacities that students of biology must know? And here I would like to highlight three of them. One is quantitative skills. The other is critical reading. And the third one is finding information reliably. So biology is now a heavily quantitative science. And so students of biology must know basic math skills. These can be very simple ones, things like estimation or knowing orders of magnitude. So your exponents or how to read a graph, how to make sense of a linear graph versus a logarithmic graph. And so I urge you to revisit these lectures in order to brush up on these skills.

Then we did a lecture on how to read a scientific paper, how to look at its various parts and figure out what they say and how to highlight certain important things and enhance your own understanding and also how to read the figures within a paper. Last but not least, we did a lecture on how to find information reliably. We know that especially during COVID times, we got information in various forms from like WhatsApp forwards to scientists coming on TV and explaining what the COVID pandemic is all about.

So here again, we must use our judgment in order to find out what is a reliable information source and how to go deeper into a particular topic. So these are very general skills. They're not particular to biology, but as students of biology, it is indeed important for you to know all these three skills.

Continuing with the capacities themes, we did a week on tools and techniques used in biology. So we studied microscopy. We looked at molecular biology techniques. We did a demonstration video on how to isolate DNA and do PCR. And then finally, we did a lecture on BT cotton,

where most of these molecular techniques are now used. So we didn't just stop at the science of BT cotton, but we also did discussion on how to assess the technology of BT cotton and the impact it has had on farmers. So as again, students of biology, we must ask when a certain discovery is going to happen. Or when a technology is developed, what the way it will get used defines, what is the impact it will have. So who are some of the stakeholders? What is the role that they play in making sure that the technology is properly used?

Again, continuing with this capacities theme, we did a week on applications where we looked at disease and public health in biology. In the malaria case study, we looked at a range of topics from how malaria is caused by the parasite, what is the life cycle of the parasite to its treatment and what can be done in order to treat malaria. We then did looked at rotavirus and especially at vaccine development in rotavirus to highlight the fact that people with various skills and capacities have to come together to solve a complex problem like vaccine development.

Finally, we did a lecture on public health and a discussion with Dr. Abha Rao on certain aspects of public health. So here again, I would like to highlight the interconnectedness of biology because biodiversity and public health are connected. And this is, again, we know this through the corona pandemic because human beings are increasingly coming into contact with wild animal species, which is causing the transmission of viruses from animals to humans and again from humans to animals. And this is happening because more and more habitats are getting fragmented because of human activity and hence animals are now coming into closer and closer contact with human beings. We know this happened in the corona pandemic and is probably likely to happen again.

So here is a connection of two topics which you would have thought are completely separate. And then last but not least, we looked at the topic of biology and climate change. So the climate crisis is basically affecting every aspect of human society and it is also affecting every other non-human living species on earth. So again, as students of biology, no matter what topic or concept you are studying, you now have to look at it in the light of the climate crisis because we highlighted the fact that organisms are undergoing physiological changes. They are undergoing changes in their habitat.

Plants and animals are showing range shifts because they're trying to move to whatever is their optimum climate niche. We know that body size is changing in animals and birds. And again, there are large-scale ecosystem level changes which are happening because of the climate crisis. So whatever that you study in the textbook, you have to look at it in the light of this climate crisis. And finally, we looked at another aspect of the climate crisis, which is nature-relatedness, where we asked the question, what is the reason for this disconnection with nature that we had, that we have, and how might we go about repairing it, which will mean a change in the way we think about who we are and our place in the world.

So with that, I'm ending this course wrap-up and I can only hope that you will stay curious and stay engaged with all the issues that I have spoken about. Thank you.