Course Name: I Think Biology

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W12L59_Discussion on Biology and Society

Hello, welcome to the iThink Biology NPTEL course. This week we are exploring biology and society. And so today with me I have Dr. Suhel Quader, an ecologist from the Nature Conservation Foundation and we will be having a discussion with him on various aspects of biology and education. Welcome Suhel. Thanks, Kaustubh.

So I thought we could start with biology teaching in schools and colleges. So what do you think about the way biology is taught in schools right now, typically we seem to learn a lot of information, or children have to draw a lot of intricate diagrams. So what should be the changes we make to school education in biology? Yeah, that's an interesting question. I think that biology in general, you know, people think of as a large collection of facts.

You learn lots of organs and organelles and cells and things like that or names of different kinds of species. But I think what gets less attention is that biology can be also a heavily conceptual discipline. So some concepts tie together all of biology, evolution being one overarching concept, but there are concepts in ecology and other ways in which biological entities interact with each other. I think those get less attention than the factual parts of biology and of course, it's important in any discipline to know some facts. But unless you can tie those facts together in some coherent manner, the facts don't make sense by themselves.

And I think this contributes to the sense among school students that biology is about memorizing lots of facts, which I think is unfortunate and we think we need to pay more attention to the conceptual underpinnings as well. Apart from that, to my mind, school education, since everybody undergoes or ought to undergo school education, school education should be focused on what any citizen of the country or the world needs to know to understand, to prepare themselves for life on their own, adult life, life as a citizen, as a voter. And when we think about biology or any other subject for that matter, we need to ask what is it that everybody needs to know about this subject that will enable them to make sensible decisions about both themselves and their families, but also about society through their actions, for example, as voters. And biology, this century is supposed to be the century of biology and that's because biology has

and is expected to continue to affect our society greatly in several ways. And just two ways, one is the tremendous space at which biotechnology is progressing and the ability of technology to alter biology to suit human needs and interests.

So whether that alteration is of, let's say, crops through genetic engineering of crops, higher-yielding or pesticide-resistant crops, or genetic engineering now increasing a possibility ourselves. Or our children. And all of these technologies, like AI, which is in all the buzz now, come with positives and they come with some costs, they come with some benefits. And for us to be able, as citizens, to be able to evaluate what those advantages and disadvantages or the risks might be, we need to have some basic understanding. And I think when educators are setting the curriculum for schools, they need to think about what are these emerging things, and the decisions we need to make as a society, where everybody needs to have an informed opinion on this.

And to have an informed opinion, what is it that they need to be taught in school because, as I say, school is what everybody goes through. And so I think understanding not just the details of how genes can be altered and manipulated, but what downstream effects there might be, wanted or unwanted, how complex systems work. Biology is about complex systems, that it's not reducible. Although we study them bit by bit, very often we see there are unintended consequences of the things that we do. So what are these kinds of consequences, how severe, how welcome or unwelcome might they be? These are parts of the risk assessment part.

So that has to do with biotechnology. But there's another aspect that comes from climate change, the climate crisis that we see now, which affects every living thing, ourselves but also everything else. And again, climate itself is a complex system and its effects on ecosystems, which are also complex systems, are going to be complex. And when we think about the causes and consequences of climate change, and when we think about solutions, we also need to keep in mind the complexity of the world. And this is where we transcend disciplinary boundaries a little bit because we say that, OK, renewable energy is the solution to climate change, but renewable energy also comes at some kind of cost, borne by either ecosystem in which solar panels or wind farms are being put, or this is borne very often by local people.

Now this is outside the traditional realm of biology and into what we might call sociology, but it raises the question about who pays the costs, which humans pay the costs of technological change or climate change, and often it's the people who can afford to pay those costs the least. And so that brings about questions about social justice and fairness and so on, which is not a biology question, but these kinds of ideas and discussions need to permeate school education because it's unlikely that all children will ever, in their future education and life, be exposed to those kinds of ideas. So when we start with what children need to know out in the real world and use that to inform biology and other education at the school level, that to my mind would be the

starting point. Okay. I mean it seems like you're making a plea for a generalized skill of trying to be informed and develop skills of critical thinking and analysis in school teaching.

Yeah, well critical thinking analysis is crucial obviously, but there is an argument to be made for these disciplinary boundaries. We have the sciences and we have the non-sciences, so that's one broad level boundary. And then within the sciences, we have biology, physics, chemistry, and so on. Very often the disciplines help us to structure our focus and our thinking, but at the same time, we need to blur those boundaries because a lot of biology at the cellular level for example is chemistry. And even further at a smaller scale is physics.

And then when you go at higher levels, talk about planetary levels, then we're talking about geophysics, climate is an entirely different thing. All these things are interrelated. So in the real world in practice when scientists study these, increasingly it turns out that the boundaries are unhelpful. So they're helpful in some sense to kind of help focus our thinking, but they also need to be complicated in that the teaching needs to blur that. Similarly, with the sciences and the non-sciences, we tend to unfortunately, later on after school, we tend to either do sciences or we do non-sciences.

But that seems a little absurd to me. Society as a whole is affected by science tremendously, by science and technology. And so anybody who goes into the humanities or the social sciences needs to understand the natural sciences as well. Maybe not in the depth in which they understand their discipline, but they need to. And the converse is true as well.

I think engineers need to engage with the humanities and the social sciences. Because what engineers do has huge consequences for society as a whole. And to be a thoughtful, sensible engineer or any kind of technology person, you need to think about those aspects as well. Not just the pieces of code that you're writing or the dams that you're going to build or the bridges that you're going to build. So it's a complex thing.

I don't know how to achieve this, but this is at least how I would think about it. I mean, you sort of made a prelude to my next question, which is about college teaching. So typically in India, we've had in biology teaching in college these hard distinctions between botany, zoology, and microbiology. And then in the last maybe 15 or 20 years, we've had newer courses like biotechnology come in. Some colleges teach a course on genomics.

But how do we kind of envision biology education at the college level going forward? Is it related to the kind of thing you were speaking about, where you try and blur the boundaries? Or is there some basic core understanding that every biologist who goes out of college must have? Surely. I mean, we need to have a core. I mean, I would say I think that we specialize too soon and too early in our education system. I'm not a fan of doing a bachelor's in biotechnology, for

example. It seems to me a stupendously narrow way of thinking about education.

At the college level, still I feel that one needs to have a… one begins to specialize perhaps and delve deeper into subjects that weren't able to go into depth in school. But without sacrificing still, you know, for example, I think that I didn't bring up philosophy. I think all biologists, all scientists for that matter, should study philosophy. You can do so at a very rudimentary level in school, but you need to do so in more detail in college. And there are vanishingly few undergraduate programs that allow you to take philosophy classes alongside your science, biology, or whatever other science classes.

Is there an example you can bring in? I mean, if you're talking about what might be the purpose of philosophy in a course in biology? Well, philosophy, for example, asks… there's a branch of philosophy called epistemology which investigates the question, how do we know what we know? For students who are steeped in the sciences, the answer is self-evident, right? They're taught facts in school, they've got some experimental methods, they've learned about experiments, and they know how to do a double-blind randomized controlled trial. And the answer seems to be self-evident, that this is how we generate knowledge. But there's a lot more to explore about the nature of reality, what is the nature of reality? How do we know that some piece of knowledge we're generating is reliable or closer to the truth, so to speak? And other pieces of knowledge are less reliable or less close to the truth. What are the… and this is in the realm of philosophy, logic, and philosophy, the underpinnings of that. And the more we engage with that actually, the more… the thing that I like is that the more we engage with that thinking, the less sure we become of ourselves, the less certain we are.

And I think people in sciences and technology and engineering could do with a healthy dose of skepticism about their work and the underpinnings of their discipline. And because we need to think from first principles for ourselves and not just accept facts or arguments from authority, right? That's the fundamental thing about science, no arguments from authority. And you can only examine those arguments if you have the tools, the intellectual and conceptual tools to be able to… Epistemology, for example, is one of those tools. And other aspects of philosophy are interesting as well, that are useful in this sense as well. So you are arguing for a broader vision of biology, even at the college level.

Absolutely. Yeah, yeah, yeah. Absolutely. Rather than these narrow kind of disciplinary boundaries of botany, zoology. And we have ways to do that. No, we have ways, for example, to do an undergraduate degree in biology more broadly with, let's say, a major in some particular aspect of biology, maybe zoology if you want to call it that, or ecology potentially. And potentially a minor in ethics or philosophy.

Or for that matter in music or something else. I didn't undergo this kind of liberal broad

education because I went through the conventional system. But having seen both abroad and India how some of these things can work, I have become a big fan of this. Then it brings me to a question about the practice of science. Say somebody has finished college or maybe they have done a post-grad degree.

They are out there in the world. They are practicing science. And what can we say about the practice of science in India? Like who is practicing science in India? Who makes decisions about some of the topics that you spoke about? Like gene editing or AI for the benefit of society. Could you say something about that? I think that in any society, any country, decisions about science get made at different levels. So you have, for example, at the country level, there will be a sort of a science strategy for science and research and development of science as a whole. That is developed by the government of the day based on priorities that they have developed or have evolved.

And that's well and good. It's useful to have some sense of direction, and some sense of priority. Otherwise, there are infinite things that one can try and investigate in science. But that's not the be-all and end-all. However because the government, let's say, of any particular country says this is our priority, that funding follows through on that and various kinds of efforts at that level. And we live in a day where an age where governments are the primary funders of science.

And since science, a lot of science is expensive, it has to be governments that support it. So these priorities are supposed to fill some broad societal mandate. But that's a bit abstract because the actual decisions are made by individual people in these committees and so on. They are also made by individual people on the ground, the scientists who are applying for this funding or deciding what to do, what to do in their labs. And so at both of those, the individuals in the committees, the high part committees, and the individual scientists, a lot depends on who these people are.

What their training has been, what is their worldview, and what is their conception of a good society or a society we should work towards? How sensitive or blind are they to a non-scientific consideration of, for example, justice and equity when they are deciding for us all in those committees or when they are deciding for themselves in their labs what science is important? And I think that's something worth asking and considering because we know that science as a set of ways to answer questions about the world is fairly cut and dry. It's fairly logical. It follows a certain series of steps, not just one series but there are a family of ways in which we can do science.

And there's not much argument and doubt about that. But because science is done by people, it is influenced tremendously by who those people are. And I'll give you an example from a field that I've studied closely which is behavioral ecology, animal behavior. And until the 1970s or

80s even, the behavioral ecology textbooks and the papers that were published that looked at mating and breeding systems focused entirely on males. Because males are the colorful active ones in many species.

Females seem to be passive entities that just follow along. Not of very much interest of their own, in their own right. But in the 80s and 90s, this was mostly male animal behavior scientists who were studying these things. As more and more women got into the field of animal behavior, they started saying, wait a minute, maybe females are doing something interesting.

Maybe not be very obvious. But let's start studying those, studying females. As more female behavior started getting studied, it became very clear that we had been missing an entire dimension of the relationship between males and females in animals. And females were sometimes doing very interesting things, very subtly. Sometimes actually they're doing things very obviously, but the male scientists that preceded it just put it aside as an aberration or something like that. So for example, we're used to the idea of male antelope fighting for access to females.

But female antelope fight each other as well for access to males. And it's female scientists who observe this. Surely male scientists had observed it earlier but just dismissed it. So this is just an example to say that that's in the case where men and women scientists might, because of their upbringing, because of their priorities, because of their world views, see the same phenomena and interpret them differently.

They may ask different kinds of questions that are along gender. But in society, we have many divisions. We have divisions among, let's say, socio-economic divisions. Perhaps it's mostly wealthy people and their children who get into science.

We'll have a particular kind of worldview. Perhaps that's true already. And people from different backgrounds will not. Or we think about in India, of course, along caste lines. And that may be very different. So the reason we need diversity in science, in the practice of science, but also diversity in these decision-making bodies at a high level, because they can bring in different perspectives about what society needs, and what are the important questions to be asked.

They're not going to decide that a different method of science is needed, I don't think, because the methods are not that diverse. They are, but they're not a matter of preference. But it's fundamentally the questions that are being asked. And perhaps we're missing important directions and questions in science if we don't have a sufficiently diverse set of scientists.

People practicing science. People practicing science. And making decisions about science more broadly. Then here I have a question about, maybe I'll just stick to biology, about the practice of

biology in India. And should we be asking different kinds of questions as, say, compared to Europe or North America? Because oftentimes it seems to me that the kinds of questions that are being asked are similar. But is there a case to be made for asking different kinds of questions? So, you know, broadly, the caricature is there are two kinds of science, you know.

There's applied science, and then basic science. Applied science is meant to give answers to practical problems in the world that we need to solve. How do we increase the crop yield, how do we conserve this particular species, or how do we prevent people from falling ill? And there, surely, there are going to be differences. Our concerns as a tropical developing country will be different from temperate, industrialized, highly industrialized countries in terms of a number of our circumstances. So they can and should be different, in those priorities. From a basic science, which is, let's say, a more fundamental or curiosity-driven science, I'm not entirely sure.

You could argue that science is a product of where it happens. And so, therefore, some scientists in India, for example, take the view that although in the West, the more wealthy nations where there is a lot of money for science, it's all about what's the latest technology I can bring to answer this question. Can I buy the multi-crore rupee machine that I can use? Can I fly drones? Because there is money to be spent, and there is money to be spent specifically on technology to answer even questions in biology and ecology and so on. And I know some scientists personally who, in India, take the opposite track. They sort of challenge themselves to say, what innovative and exciting science can I do with the least amount of money? Without the latest technology.

Where the innovation is an innovation in creativity and thinking rather than technology innovation and the money I have to spend on that. And you could argue that a country like India perhaps should be tilting towards this side. But that's a matter of taste and preference. I don't know.

I have tried to do research which doesn't cost much. The major cost is the people who do the research rather than the machines and the technology. But I also know that there are important questions that require DNA sequencing and require expensive machines and so on. I don't want to make a judgment on that. I'm just describing what different approaches people have. We have thousands of undergraduate teaching colleges across the nation.

In my view, that's a huge untapped pool of potential. Where if we infuse research into these programs, no amount of innovative questioning could go on in these places if the students were taught how to do that. And certainly, certain low-cost ways of doing things or creativity in questions could come about. And I think that can start in school. It should start in school. Because I think that science generally in school and college is taught as knowledge.

Science is a process. It's a way of generating knowledge. It's not the knowledge itself. The

knowledge is scientific. It's risen out of science. It's the process that to my mind is crucial and interesting.

And it needs to be started in school. What are some of these basic principles? How do we say there is evidence for or against climate change? Because that's in the news all the time. How do we say there is evidence that this food supplement will help you lose weight or gain muscle? Or that fat, whether it's saturated or unsaturated is good for you or not. What is the basic evidentiary nature that we are bringing forward to make those claims? And unless you have engaged to some degree in the mud with this, it's all too theoretical. But I think in school one can. One can begin to do simple studies whether observational or experimental.

In college one can do more. There is this entire universe of practice now which is called citizen science which is to engage the larger public into scientific research. And that can happen at any age. There are so many citizen science projects for children in school which may provide a window into this.

And in college for sure. And colleges I know are under-resourced. But the resource is the human resource. And once students are adequately prepared conceptually, absolutely there is so much that can be done that doesn't require… You don't have to wait to get the big labs and expensive machines before you can do lots of interesting things. And then begin to critique and understand some of the other things we talk about. What is the nature of the evidence? What is the nature of knowledge? How do we know what we know? And so on. Moving on from education, I want to ask a more general question which is about how we look at nature or biology in particular.

Sometimes it seems to me that we almost look at nature or biology to rationalize human actions. And the simplest case there would be something like survival of the fittest. We always take the example of this phrase, survival of the fittest, to explain certain actions. Whether it's in day-to-day interactions, competition between friends, or on the wider stage.

So could you say something about that? I think you are right. So nature or the world outside us has been used to justify various things in society. It's even reflected in the word natural. Something is natural. If something is natural, therefore it is automatic in a sense.

It is inevitable. That's one interpretation. The other is a value judgment which is that it's good. And that's been used to justify or explain what we now consider about slavery, for example. Or the oppression of the landed class against those without land and so on. So socioeconomic differences, racial differences, gender differences in treatment and access to resources, and justice have all been explained like this. And it's such a common thing that, and I forget the philosopher's name, but it's a philosophical fallacy.

It's called the naturalistic fallacy. And it's summarized in this phrase that what is also ought to be. Because it is, it ought to be. So basically it justifies the status quo. The status quo normally favors those in power at that moment and those in power can be white male wealthy people.

In a global sense, India is a different set. So it's a fallacy. It's well known that it doesn't make logical sense. And it can be sort of reversed or disproved even by looking at nature itself. Because nature is not unitary. For every pattern I see in nature that justifies some view of mine, I can also find the opposite pattern.

So we find in many animals males are larger and dominate females. But there are also species where females are larger and dominate males. So which one of these lessons are we supposed to take from nature? We see situations in nature where there is a natural red in tooth and claw competition. Where animals might even fight to the death for some resource.

So that's one example. And we find the opposite. We find bees and ants and so on that live in large highly cooperative colonies. Where individuals sacrifice their lives for each other. And you might think those are ants and bees. So they are sufficiently distant from us and it's not relevant.

But there are also a few mammals that do this. Naked mole rats live in these highly social colonies. So again the question is what lesson do we take? And of course, the lesson that's taken is the convenient one. It's the lesson that I already wanted to take. So fundamentally it's not the way that people apply this.

It's not let's look to nature and draw lessons. I've already made up my mind and now what example can I cherry-pick from all the different examples to support my argument? So I think it's a self-serving and dishonest way of looking at things, to put it bluntly.

But we all pray. We all do it. Also when we talk about other kinds of things. For example, there used to be a time when the natural births were natural and so they were good. And when caesarean sections started there was this opposition. Now there may be concerns with caesarean section and doctors going for that too frequently unwarrantedly. But it's not the naturalness or the non-naturalness that should adjudicate these things.

It isn't to do with what's natural. You can think of examples around you, everyday examples about what you eat how you interact, and how you judge people who are different from you. And we use this language. It's very easy to fall into this trap. I think if we are making decisions about ethics or the way that our society should be structured those should follow some first principles that are human-generated.

Ethics for example is a human construct. Something humans have invented. Animals presumably don't know about ethics. Although some animals seem to have a sense of fairness. Many primates seem to have a strong sense of what is fair and what is not. That's fascinating. But one principle of ethics that has been invented and adopted in pretty much every civilization is what's called in English the golden rule.

Which is that one should behave towards others as you would want them to behave. And this is by the way in the absence of those social power differences. So if I am wealthy and you are poor, I shouldn't act towards the poor person as though the poor person might act towards me. It should be imagined the roles are reversed.

I am that person. That can act with gender, caste, and everything else. A society or an ethical structure that is derived from that would be extremely different from the majority of these examples that I see are cherry-picked from nature. It may resemble some parts of nature.

It may not resemble. But that's irrelevant. Whether it resembles nature or not is irrelevant. And that's one of the things that we are, humans are biological creatures. There's no question about it. We have a biological inheritance. Some things are very difficult for us to break from because we are creatures of biology and evolution. But at the same time, we also understand that we are extremely flexible, extremely malleable based on education and context and society, and so on.

And to the extent that we are malleable and flexible, I think we need to create our ethics for that rather than look to nature and say, aha, whatever is happening is what is right for us for these two, three reasons I mentioned. Okay. Then I had a question about scientific tempo or rationality. And then, on the other hand, we spoke about things like belief or metaphysical knowledge.

And many times it seems to me that we hold both these things together in ourselves. And the best example I can think of is during COVID, people were listening to scientists or medical practitioners and saying, okay, we need to wear a mask. We need to sanitize our hands. We shouldn't go out in crowds. There are very good reasons for that. But then also you heard about people doing all kinds of other practices and the belief that it would not infect them with this COVID-19 virus.

And so very often we are very comfortable holding these two sets of beliefs and somehow also we seem to think there is something very uniquely Indian about it. So is there something to be said about that? I think the first thing we said is that we all, every individual, you and I can guarantee me as well, we hold contradictory beliefs. Sometimes they are very deep enough that we don't know they are contradictory. Sometimes maybe it bubbles to the surface. I think this, you know, all over the world, it's, you know, some scientists maybe are developing the newest

vaccine or sending missions to Mars or whatever else.

But we'll go to their church, temple, or mosque and say a prayer before they do that. And we might say that these are contradictory. How can the same individual hold these beliefs? One very rational and mechanistic and the other metaphysical. I don't think it's particularly Indian. I think it's all over the world and perhaps all over the world there's a resurgence in religious and metaphysical belief.

Perhaps there used to be a time when people thought, oh, you know, that's receding. Old fashioned. But perhaps that's not the case. There's an argument, you know, there are two ways of looking at this. You know, there's a, I think Stephen Jay Gould coined this term. He called them non-overlapping magisteria. So let's make it simpler. Non-overlapping domains. Religion and science, if we take religion as a catch-all for various kinds of metaphysical, non-rational beliefs and science belong to two different domains. And so it's completely fine and rational to be a scientist, let's say, or an engineer or whatever else. But also be a religious person because they don't intrude or impede. There are clear boundaries between the two. Other people argue against that and say that no, in fact, one's religious or metaphysical beliefs make claims about the material world.

And those claims, any claim about the material world are the domain of science. And whenever those claims have been made and different claims have been made, over the decades and centuries, science has clarified, investigated, and answered those claims. And so these people claim that if there are these domains, the domain of religion is shrinking and the domain of science is expanding. So I just put that there without necessarily saying what I think. But I think everybody listening should think for themselves about, do they believe that these domains are non-overlapping or not.

In the example of Covid, for example, you could say that they are very much overlapping. If I have the belief that my prayer or something that I wear around my neck or something that I do has the material effect of killing viruses or protecting me from the infection, then that is a truth claim that can be investigated and evidence can be brought for or against that. And again, you could ask yourself, well, it doesn't matter in many cases because that thing is private to yourself. So whether you change the number of vowels in your name for some numerology purpose because that might bring you more success in life, it doesn't harm anybody else. And perhaps we might say that's fine.

But in the case of infectious diseases, you would say, well, no, it harms. It has consequences, not just for you. And your immediate family and so on, but also for others. And so there, unfortunately, the truth claims and the beliefs do matter for society as a whole. And I think governments and societies have responded by saying, I don't particularly care what you believe,

but you still have to wear a mask and you still have to sanitize. I do want to say also that one of the characteristics and the strength of science lends fuel to the beliefs of others, you know because science can sometimes seem a bit arbitrary.

Like when COVID first started, you know, people made a big deal about sanitizing surfaces. I can't imagine how much alcohol and sanitizer was spent scrubbing surfaces clean for months. Yeah, people were scrubbing and scrubbing. You can't re-enter this building until it's been sanitized. And the amount of sanitizer and plastic waste and so on, I can't. And later it became clear that the virus survives a very, very short period outside the body and most of the transmission is through droplets in the air.

And masks are much better and the kind of mask you wear and how careful you are, that's much more important than any of the surface sanitizing thing. So people who, again, you know, maybe in school or whatever else, haven't internalized this self-correcting, updating nature of science and evidence, can see this as just arbitrary stuff. So this scientist is arbitrarily telling me that one day I have to do this and the next day I have to do something else.

I might as well go say my prayer. It seems arbitrary. But it isn't, at least to my mind, it isn't as arbitrary. There is a logic and a reasoning and epistemology, to use that big word from earlier, behind it. And again, it's the literacy that people have in science that will allow or prevent them from seeing that and separating that from the belief that they might have, the faith they might have, that isn't based on evidence and scientific evidence, I should say. But I want to kind of make a counterargument about that.

Yeah, always good. So, it is about something very Indian, which is Ayurveda, which is a very ancient system of practice. And the idea is that actually, the two practices of Ayurveda or Allopathy are completely different, where Ayurveda looks at the whole person and somehow treats the whole person, whereas Allopathy, we say, is treating a particular condition and very kind directed, and focused. And so, where could I then draw the line and say, is this in the realm of science or not? Because people say, oh, but Ayurveda has not been tested out in a double-blind, randomized controlled trial. So, how do you know what is the efficacy of Ayurveda? Whereas, you know, we know that thousands of people in the country practice it and we know that it does confer benefit to people. So, what would one say about that? I like how you framed it. So, one thing, you know, Allopathy is a term, a pejorative term, which is an invented term to put down what we otherwise sometimes call modern medicine.

So, of course, modern medicine also, you could say, is a marketing term. So, we should be aware of the words we use and the hidden implications of the words we use. And you say, modern medicine, you know, everything modern is good? No, it's not necessarily true. A lot of modern medicine indeed is, and I should first start with a disclaimer that I don't know all that

much about modern medicine nor do I know all that much about Ayurveda.

But I think it is true that modern medicine often does treat individual conditions but not exclusively. That's not the entire thing. Modern medicine is not defined by treating individual conditions. It's defined by, I think, or it should be at least, defined by being evidence-based. So, there are two things when we want to treat a condition or something. We want to know, well, what is the evidence that this works? So, if I take paracetamol because I've got a headache, what is the evidence that it works? Does it reduce my headache compared to somebody who takes a pill that doesn't have paracetamol as an active ingredient? And that's the efficacy. The second thing that modern medicine or science generally likes to understand is through what mechanism does it work? I know it works but I don't know how it works.

And I want to know how it works. What kind of receptors in the nerve cells and so on does it bind to? And how does it then dull the pain and so on? And then you might think what other unintended side effects are there. Are there long-term consequences and so on as we often think about? To my mind, any system of medicine, no matter how ancient or new, still need to answer the first question if not the second. Does it work? You might say that you're treating the entire person but the person is coming to you with a particular problem.

They've got diabetes or they've got a knee problem or a back problem. There's some particular problem that people come to. There's some desired outcome. The question is whether any system of medicine gives the same drug, so paracetamol, paracetamol, paracetamol, or different formulations depending on different people. That's great if they're different formulations. But what is the desired outcome? We need to define that desired outcome. And is that desired outcome achieved in comparison to if I don't provide that treatment? So that's the, to my mind, basic evidence of whether something works or not.

And that standard of evidence can and should be applied regardless of what system of medicine. And I don't know whether this contrast you're making is so strong. Because I think that a lot of modern drugs have been, and I can't give you the percentage and so on, because I don't know, but some at least have been derived from traditional practice, from traditional medicinal practice.

I mean almost all modern drugs to some extent. Are they? Well, some. I don't know again. I mean perhaps you know better. Like quinine for malaria. Quinine is something that in the Amazon, perhaps somewhere in South America, indigenous communities used to use the bark of this particular tree to treat malaria. And then, you know, I don't know, some Westerners went there and found out and said, oh, this is interesting. I wonder if we can use the same thing.

And used the same, didn't know how it acted, or through what mechanism acted, but figured out that it worked. And then of course quinine became, for a while at least, the predominant

prophylactic against malaria and sometimes for treatment as well. And I think there are many, many examples like this. So there's kind of a seamless… I don't know whether one can make a very clear division. You know, this is traditional medicine and this is modern medicine and there's no bridge between the two. There are bridges and people… even today there are ayurvedic practitioners and companies that use techniques of modern science, including randomized control trials, to try and understand the efficacy of their formulations and different combinations of drugs and so on.

I think it is problematic if we take medication without there being any evidence of some nature that works over and above anecdotal evidence. That is, oh, I took it once and it helped me. Because we know that that isn't sufficient evidence certainly to spend lots of money. If it doesn't cost you money and if it doesn't have side effects, then sure, it doesn't harm anybody.

Go ahead and take it. But if those things are not true, then I would suggest that we need some better evidence. Could I end this interaction by asking you something about online teaching? I mean, here we are, we are recording this for the NPTEL online platform. What do you see going ahead or what could be some advantages of this mode of learning versus a more traditional classroom-based mode of learning? Yeah, I think that of course, they are not substitutes for each other. Maybe we will list the advantages of in-person learning first, which is that remote online learning can't give the quality of experience of an in-person course.

And I am not even talking yet about things like doing hands-on things and so on. Just regular classroom teaching. But just the in-person interaction, the ability to interact in real-time with not just the instructors but also with one's peers. I think one learns, can learn a tremendous amount from one's peers as well, which is very difficult online. So that you don't get. And of course then the hands-on things, you know, in biology, for example, there are field trips or lab things and so on. So with that said, I think that certainly for a country like ours, which as you say has thousands of colleges and so on, but has millions of people who are hungry to learn, different avenues to learn, providing different avenues to learn I think is crucial.

So you've got your colleges and so on, you have an avenue over there. Your teachers there will have some expertise, they will have some skills. But then you have other avenues like massive open online courses like this NPTEL course, where you can have the opportunity to interact with different teachers, who have different skills and interests, and who can bring different resources to the table. And I think the marriage of those two is really, would be ideal. And I know that there are colleges and college professors who try and marry these two. So they tell their students, you know, go watch the videos and take this course.

And then we'll come and discuss the content in class and then we'll do things. So that's a nice thing. But even if that doesn't happen, and going now beyond a college education, education is

such a thing, or learning let me say, such a thing that we imagine, you know, you go to college, you do your bachelor's or your master's degree or your PhD and then learning stops. Learning is a lifelong thing. Learning should be a lifelong thing because information and ideas and our understanding of the world need to be constantly updated in a world that's changing as rapidly as ours. One of the things that massive open online courses like this can do is to throw open that journey, that constant journey of learning to anybody interested.

And the NPTEL Swayam courses are perfect for this because they don't cost you anything. So anybody can take this, whether you are a homemaker who has an hour in the morning you can spend on this, or whether you run a shop somewhere and there are fewer customers you can do your courses. And I know because I am also part of another course on NPTEL, I know that a great diversity of people take these. And because they write and tell us, I know that they are thirsty for this and they appreciate the opportunity. And so congratulations to you and your colleagues this is great and exciting to be able to put a full-fledged biology undergraduate course there, which I guarantee you will be taken not only by biology undergraduates but will be taken by all kinds of people who you would never suspect.

So it's great and I am glad to be a small part of this as well. Okay, thank you. Thank you for that. And with that, we will end this interaction with Dr. Suhel Quader.