Biology for Engineers and other Non-Biologists
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Lecture Number 01
Introduction

Welcome to this course "Biology for Engineers and other Non-Biologists". This is for anybody who has an interest in biology. We will go through some initial aspects of this course in the first lecture which is this.

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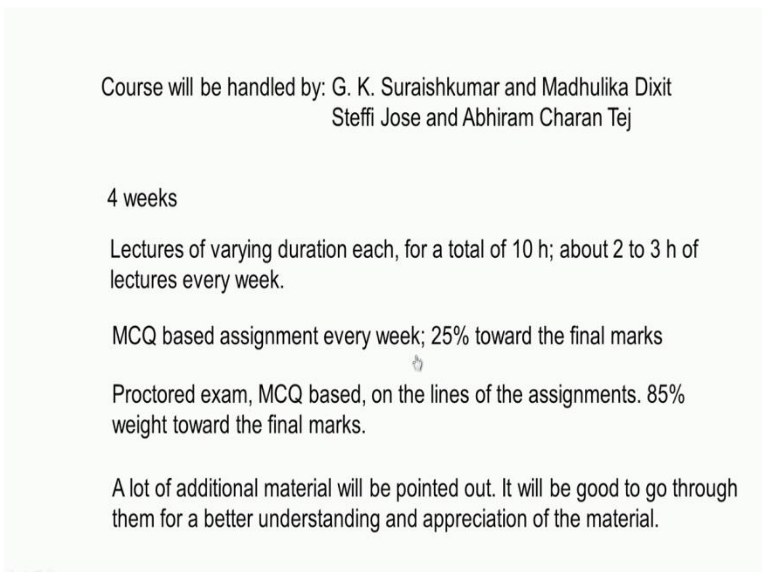

The course will be handled by me, G K Suraishkumar and my colleague, Dr. Madhulika Dixit. I am a Biological Engineer, Madhulika Dixit is a Biologist. So this combination is expected to bring out the best of biology for non-biologist engineers and other non-biologists. You will be ably helped by Steffi Jose and Abhiram Charan Tej. They will interact heavily with you.

This is a four-week course or a ten-hour course. In other words, the lectures by us, Madhulika and I, would be about ten hours long, and they would be of much shorter duration. In other words, each lecture would be about anywhere between fifteen minutes to about fourty minutes and all the lectures put together would be about a total of ten hours. And this would be given to you in four installments over four weeks. So that comes to about two to three hours of lectures each week, and we will work it out such that it is easy for you to assimilate, it'll be interesting for you to assimilate and so on.

This is for the evaluation. The learning is much more important than the evaluation is what we believe, but we also know that the evaluation is important for our audience. The evaluation would be two-fold, the first one is through assignments. There will be an assignment every week, typically about ten questions, and all of them or most of them would be multiple choice questions. All the four assignments together would carry twenty-five percent marks, twenty-five percent weightage toward the final marks. At the end of the course, there will be a crafted exam in different locations. This will be on the computer, again multiple choice questions based, and these, this exam would be on the lines of the assignments that are given. And this exam would carry eighty-five percent weight toward the final marks.

And as you would already know, the people who would opt to take the exam are eligible for a certificate depending on their performance. I think the details are given in the NPTEL website, they keep changing from time to time. I think it's typically, till about a certain percentage, you get the participation certificate and then you get three other certificates depending on the level of performance. I think the final one has something to do with the gold star and so on. You can look at the details in the NPTEL website. These, questions would be designed such that they are all across the spectrum.

What you should be aim for is that about thirty percent of the questions are amenable to all people who are taking the course, all the participants of the course would be able to answer about thirty percent of the questions. Thirty to eighty depending on the level of engagement, skill and interest would be able to answer and one needs to be really good to get the last twenty percent. That's the way we typically design our assignments as well as the exams. A lot of additional material will be pointed out during the lectures as material that is available to you on the site and so on. It will be really good if you can go through them for a better understanding, and appreciation of the material.

Some of those would just be additional material, some of those we really feel, that means I really feel that you should see those videos and those figures and, (readin) and go through those reading assignments for a good appreciation of the course. Therefore, that would, I would say somewhat mandatory. We may even ask you questions from that; whereas the others that are clearly pointed out as additional material, it is upto you, you can go and read them up for better understanding and so on so forth.

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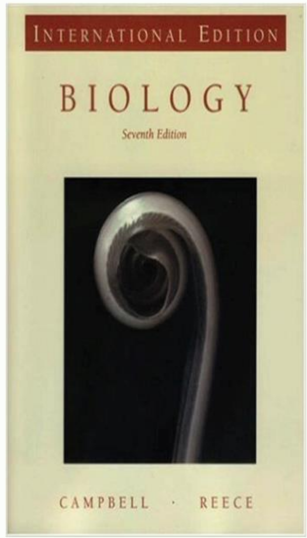

This is, the, cover of one of the reference books that will be used for this course. It's, “Biology” by Campbell and Reece, this is the seventh edition here, this is the international edition; the, country’s special editions may look different. This is a seventh edition which came out a while ago. Now we are in the tenth edition. However, I’ve gone through the table of contents of seventh, eighth and the tenth editions. There are differences but those differences will not matter for an initial exposure to biology. Therefore you don’t have to worry about this.

This is another thick book, and any biology book would be a reasonably thick book because of the information that is available now. We will not be looking at all parts of it; we’ll be looking at some chapters and some sections of some chapters in this book. If somebody’s interested, we can point that out to them what chapters we are going to do in this particular book. These are reference books, so we won't be following them in the way they have addressed the subject and so on so forth. We’d be taking information from them.

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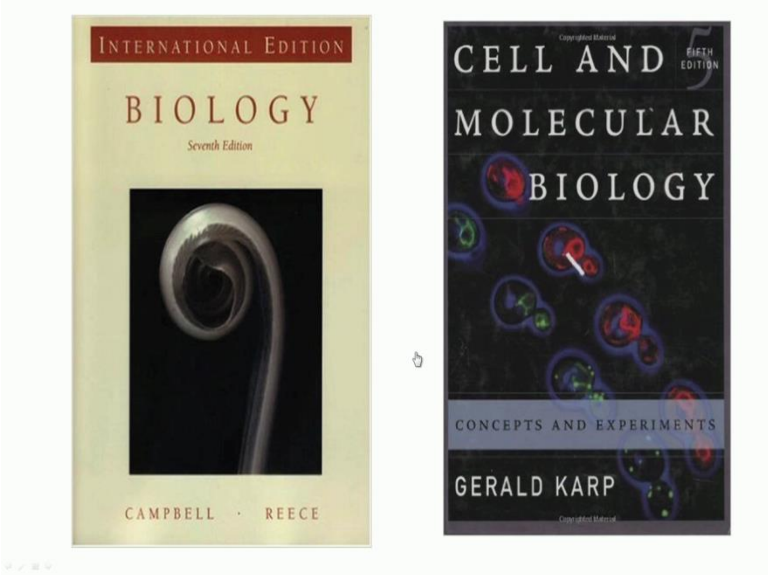

Another book that is also recommended as a reference book for the scores is “Cell and Molecular Biology” by Gerald Karp. This is also a nice book; it has a subtitle ‘Concepts and Experiments’. It's also a nice book. If you get your hands on these books, it might be good if you read them.

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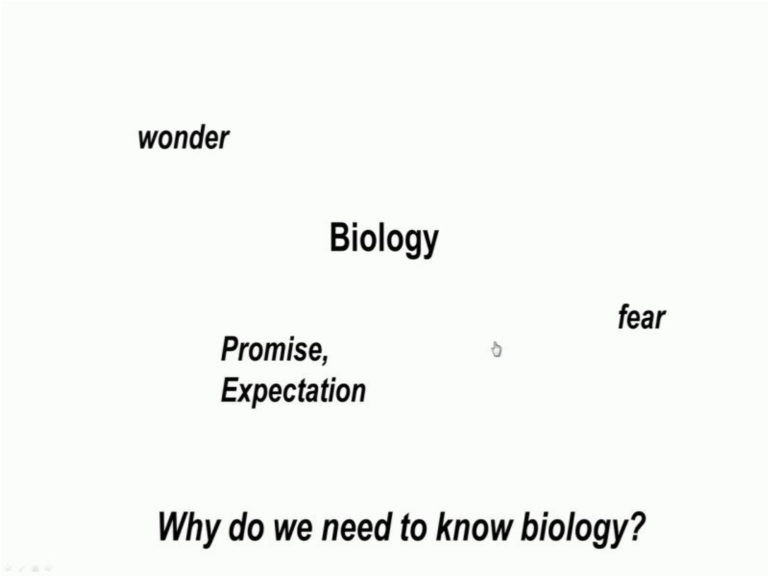

Now, let us start looking at “Biology”, okay? When you think of ‘Biology’, what does it bring to your mind? I’m used to dealing with a certain homogenous set of students, I now what comes to their mind. I’ll tell them, tell that to you in a little while. What comes to your mind?

Depending on your background, I think there is a certain aspect of wonder that comes to your mind when you think of biology. There's so much of things that you don't understand, we don't understand. We are fascinated about when we look closer at biology. There's so much to learn from biology and all these aspects are really wonderful. The same time, if you ask my students, who are typically engineers, they have a fear for biology, mostly because of the way they have been exposed to biology in school, nothing else. So, we have an introductory course here for all engineers, typically in their third semester, now I think it's in slightly later semesters, where we work on getting them, asking, making them getting over the fear for biology.

I'll tell you the reason why. Most likely, engineers in this century may be interfacing with some aspect of biology in terms of the field that they'd be contributing to, and there's no point in fearing that field and it's nothing to fear about. That is another aspect that could come to mind. In any case, there's a lot of promise, there's a lot of expectation from biology, especially in this century.

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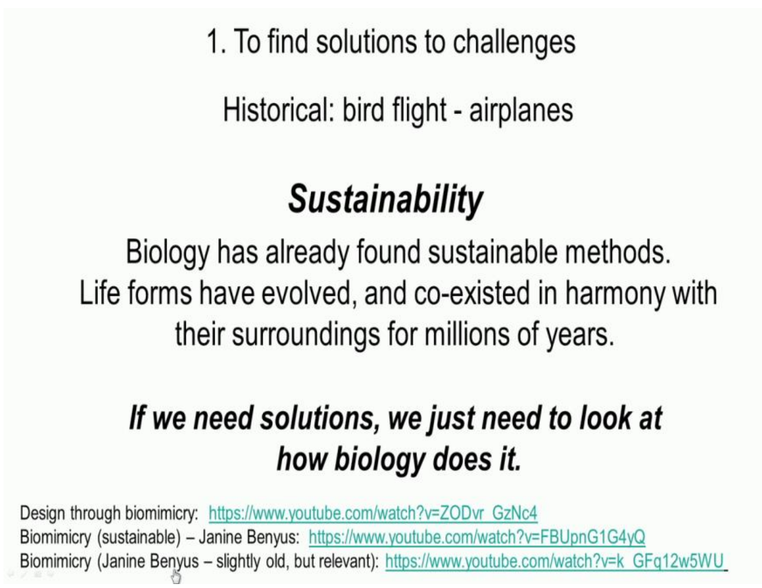

So, why do we need to know biology? First, to find solutions to challenges, that face mankind. You know, historically speaking, probably a century ago, airplanes became possible, atleast according to the history that we know. And, all of us know that the airplanes were inspired by a bird flying. Man saw a bird flying, he or she wanted to fly that way, and therefore made it possible to fly that way using airplanes. It was not an easy task, but ultimately, mankind got there, and nowadays it's a very standard form of travel that we take for granted.

Sustainability, it's a very big aspect nowadays. And, whatever we do, we like to do in a sustainable fashion, so that we don’t spoil the our planet, and leave it for the next generations in the best state that we can. What we normally fail to recognize, is that biology has already found sustainable methods. This earth is probably four point five billion years old, primates developed about sixty-five million years ago, mankind, humans developed about fifty million years ago round about that some million years ago. And, whereas earth itself has been around for billions of years, so about four point five billion years, and life evolved may be some billion years ago.

And, over time, biology has found methods to do things in a sustainable fashion. Life forms have evolved, co-existed in harmony with their surroundings for millions of years atleast, or even billions of years. So it's all, all there, we just have to look at it and learn from biology and adopt those practices to be able to lead a sustainable life, and sustainability is a very big challenge in front of us nowadays. So if you need solutions, just look at how biology does it, and it is there and we probably need to adapt to some of those. I would like you to look through these videos. There are three of them, let me list and then talk about them. Design through mimicry is this, there will be file that is available to you as a pdf file, along with the course material. This would be a clickable link in that file, it will be available with every lecture.

You just need to go and click on these appropriately to go and view these videos or papers or figures and so on, they cannot be included here for obvious reasons. But they are very good videos, the first one is designed through mimicry. This talks about design of things that we use, using principles that biology uses, okay? So bio-mimicry, we are trying to mimic biological aspects. So that's a nice small video, may be about three to four minutes long. Then bio-mimicry from a sustainable angle; Janine Benyus, who is a known person in bio-mimicry aspects. This is about again a short video, may be about three to for minutes long. The last one, bio-mimicry, is slightly old but very relevant, okay?

In this Janine Benyus talks about various examples, you know, the whale, she talks about this, one of the whales has a surface which does not allow bacteria to stick and grow on them, okay? And think about that. If we have some such surface, there is no coating, nothing like that, it's just the nature of the surface, that does not allow bacteria which causes a lot of bad things as we know, infections, that does not allow bacteria to grow on it's surface. So think about it. If we can have a similar surface at the micro scale in our hospitals, then the problem of infection is obviate, right? So, the implications are big. There are beetles which use moisture in the air for their water requirements.

Their body structure or their, the structure of a part of the skeleton is designed such that to, in such a way to capture the moisture from the air. It lives in very arid places and the water that is collected directly goes into it's mouth and so on. And, some similar structures can be used to capture water from, like the humid air around us, especially in Chennai it's very humid. So, if that can be done probably the water shortage can be handled to a certain extent. And it so happens that there are companies doing this already, we may not have, we may not be very familiar with it, but I know of one of my students' fathers having a company which does exactly this, and so on and so forth.

So there are various ways. Let me give you one more example. We have been looking at the solar energy, right? This uses, chemical based solar cells to capture light. In other words, light falls on it, and electrons go out of it. And that's how you get electricity. Okay? Photosynthesis does exactly the same thing in a very efficient fashion, right? So can we get inspiration from the way photosynthesis is done in nature, and translate it to more efficient solar cells? This is something being worked on right now. Some level of success, it's a long way before it becomes completely viable and so on.

So there are various different things that you can, various different ideas, various different ways of doing things that we can learn from nature and use it for our own needs. So these three, videos and bio-mimicry would be able to give you more information on that.

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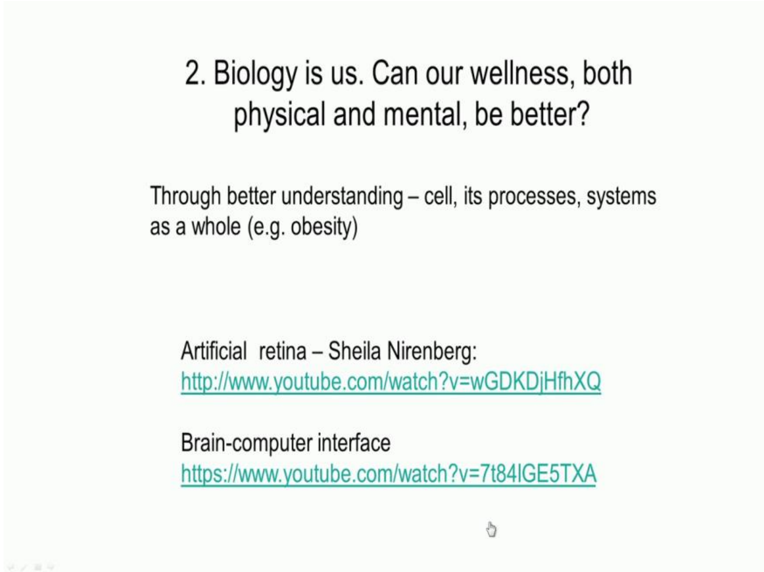

Second reason is, second reason for studying biology is that biology is us, we are all biological creatures. Can our wellness, both physical and mental be better? Surely. We all, all of us would like to feel good you know, be good without diseases, mentally be alert, mentally be mentally feel at peace and so on. Can that be done?

Through a better understanding of biology, the cell, it's processes, the systems as a whole, certainly yes. Even the simple things, such as obesity is not understood properly. You know, why people become obese? It's not a simple calorie counting kind of a situation here, and therefore can we understand that a lot better and so, so as to reproducibly get people to their appropriate weight without a lot of pain, as it is currently being done. There are a couple of videos that I'd like you to see and I say that these are essential videos to see, so were the first three.

The first one is a 20/11 Ted talk by Sheila Nirenberg, professor Sheila Nirenberg. This is on artificial retina, okay? This is the link to that which will be available on the other clickable pdf that you'll have. When you watch through these videos, I would like you to see how your field, the aspects of your field are being used to solve huge problems, huge challenges, overcome huge challenges as the ones that are being given here. This is artificial retina which talks about a means by which people with damaged retina could be would be able to see.

There's a good level of success already in this. This is 2016, a slightly old 2011, so there's a lot of development that has taken place after that, but the basic idea is all the same, the basic concepts are all the same. If you're an engineer, you could look at what all aspects, is it computer science, electrical engineering, mechanical engineering, materials engineering and so on and so forth that go into making this challenge, or making or addressing, making it possible to address this challenge. You could look at that.

This is about ten minutes long, and the next video that I would recommend is on a brain computer interface. The link is this. This talks about the possibility of a quadriplegic walking again. Just by using the brain, just by using the electrical signals in the brain, whether they'll be able to walk again. There's a lot of development that has happened. There was a, a well known, or there was a publicity aspect that was also a part of the recent world cup, where a quadriplegic was supposed to kick the football using some such principles. So you may want to watch this, and while you are watching this, think of what all fields of yours are being used here to solve these problems.

And it is because of these, to make these possible, especially, by people like you who would be in several different fields that may not be directly related to biology as you see it. Getting those people to contribute to this, getting those people interested in this, is the purpose of this whole course, or one of the purposes of this whole course.

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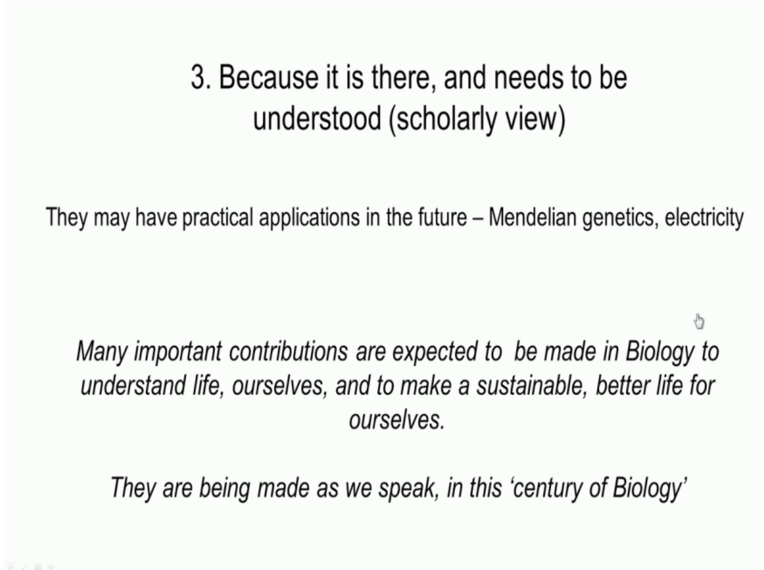

The third reason why we could, we would want to know biology, is because it is there, and needs to be understood. This is what is called a scholarly view, okay? Many somehow don't understand this view, that's okay. But, if you are oriented that way, you would already have a feel for it. You may not still accept it but you will certainly have a feel for it.

And with experience, you know that it is a very valid and a very high level kind of a view. Okay? Because it has significance over decades or probably even centuries. That is because you know we tend to appreciate something that has an immediate practical application. And such a view may not have an immediate practical application, you never know. Sometimes, something that seems very, scholarly, you know, you you want to understand it, you want to learn it just because it is there could have an application within a year as has happened in the past. And something like this, you know, we will be looking at Mendelian genetics. It's not a very standard or classic example of this kind, but Mendelian genetics is something that we would look at in a later lecture.

This was developed by Gregor Mendel, just because it was there. He was a monk, he wanted to study plants, and by studying plants, he came up the essence of inheritance. How human beings inherit things from their parents, often their grandparents, and so on, the principles of that, and that has become huge now, may be a century later, (much) much more than a century later to be able to predict whether a disease would occur in a certain child, and so on. A classic example is electricity. When electricity was found, people said all this is fine, but, is it really going to be useful?

And all the, all that the people could say who were involved with electricity is yes, may not be now, may be much later. And we all know what electricity is nowadays. We cannot even think of a life without support from electricity. So many important contributions are expected to be made in biology to understand life ourselves, and to make a sustainable better life for ourselves as well as our future generations, and those contributions are being made as we speak in this century for biology, or century of biology. Now let me, get a little deeper in this introduction itself.

I usually ask this question to our students, our engineering students, “How many of you have done biology in twelfth standard?” This is the first question I ask to students, when whenever I handled this course with my colleagues, and typically about, may be about five percent, or less than five percent would have done biology in their twelfth standard. Even in our own department, biotechnology, as it is called; the students who come into biotechnology, about ten percent would have done biology in their twelfth standard, ninety percent would not have. And in the case of, all departments put together, all engineering departments put together, about may be ninety-eight, ninety-five to ninety-eight percent would not have done biology in their twelfth standard. Okay?

That is because for entrance into the bachelor’s programmes here, they are tested on mathematics, physics, chemistry, and probably, yeah these are the main things that are tested, and therefore they don’t need biology one, not just that, there are other social aspects that, kind of, straight-jacket students into some fields, which may not be really, desirable for the overall growth of the country. And, when, such students are addressed, there is usually a preference in them for certain subjects, which is certainly not biology.

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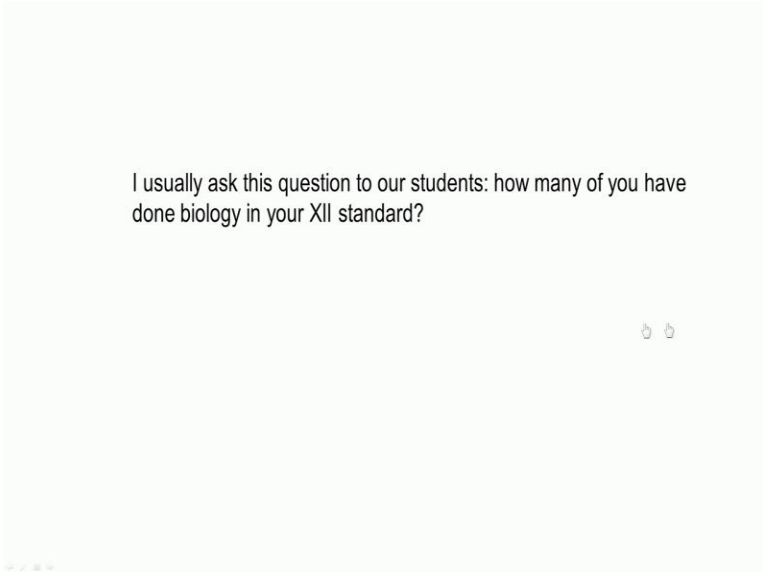

And many of them like mathematics a lot, irrespective of their own capability level in mathematics, they all like mathematics a lot. And, so, I asked them this question.

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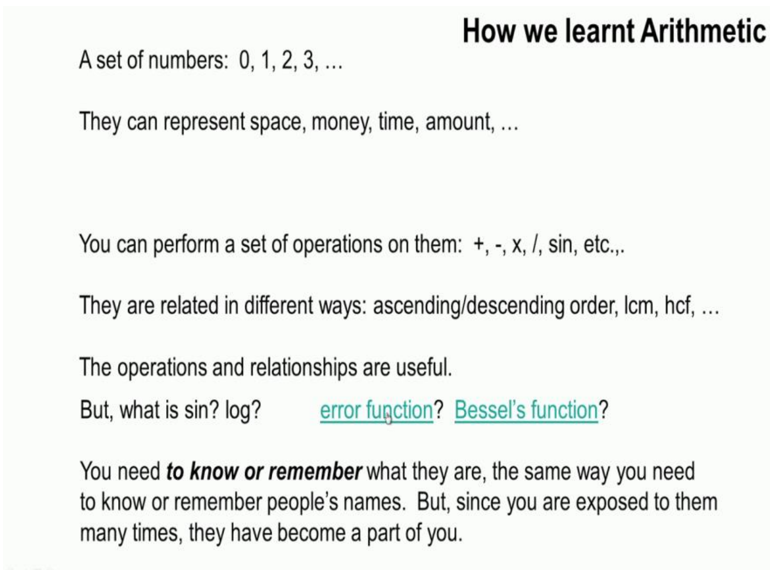

Let us think about how we learnt arithmetic, in mathematics. This is way back, may be in year, first standard, first grade, second grade and so on. There are a set of numbers, let's say, zero, one, two, three, and so on. Initially when you think of numbers, you start from zero, one, two, three. They can represent many different things, they can represent, let's say the space that you live in, the area, the volume and so on, the amount of money that one has, the amount of time that one has, the amounts of so many different things that are relevant to humans.

You can perform a set of operations on them, you can add two numbers together, you can subtract one number from another, you can multiply two numbers together, you can divide one number by another, you can; if after a certain while, you can take the sine of certain numbers, cosine of certain numbers, and so on so forth. You can perform a set of operations on them, and, you can also see that they are related in different ways, you could order them in an ascending descending order, if you have a set of numbers, there could be a least common multiple among them, there could be a highest common factor among them and so on.

And these operations, you know, these are the operations, these are the relationships, they are useful to us. For example, if you have five apples and four apples, together they make nine apples, right? And, if I have, let us say, hundred rupees, if somebody borrows twenty-five rupees, I have seventy-five rupees left. That would be subtraction. Similarly, multiplication, division sign when you have, psychic occurrences and so on. And similarly, there are relationships could be helpful, useful. But, what is even sine? This probably sine is learnt in your sixth, seventh, may be seventh, eighth standards, or may be ninth standard. And what is log? Which is again learnt sometime in high school.

When you start thinking about this, you start slightly doubting the level of comfort you have with numbers, okay? How did we kind of, look at this earlier, okay? Sine, log, probably ninth standard. Leave alone these. What is an error function? Okay. That's also mathematics. What's a Bessel’s function? That's also mathematics, heavily used in engineering and so on so forth, okay? And when you think of these things, we deconstruct and deconstruct how we learnt arithmetic, then we come to realize something, you know? What are we… excuse me, so comfortable with, you know, performing a set of operations on numbers, and knowing the relationship between numbers and so on and so forth that we are so comfortable with, became comfortable because of repeated doing of the same thing with those numbers, nothing else, okay?

But, when, you are exposed to them for the first time, error function, Bessel’s function and so on and so forth, you need to know or remember them, what they are, the same way that you need to know or remember people’s names, okay? There’s no difference. But since you are exposed to them so many times, they become a part of you, okay? That's all. There’s nothing else. Okay?

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$$\mathrm{erf}(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2} dt$$

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For people who have an interest in maths, you would like to know what an error function is. It is this, okay? Two by root pi integral e power minus t square dt, zero to z, okay? And, let me show you what a Bessel’s function is, just to make you happy.

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$$J_n(x) = \frac{x^n}{2^n \Gamma(n+1)} \left\{ 1 - \frac{x^2}{2(2n+2)} + \frac{x^4}{2 \cdot 4 (2n+2)(2n+4)} - \cdots \right\}$$
$$= \sum_{k=0}^{\infty} \frac{(-1)^k (x/2)^{n+2k}}{k! \Gamma(n+k+1)}$$

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It is this. Okay? So you can look through the details of the Bessel’s functions. There are Bessel’s functions of many kinds and so on so forth. They are very useful in some aspects of engineering, including biological engineering. Right?

And therefore, knowing and remembering and recalling and so on so forth is no different from the way biology is done largely in schools, right? And arithmetic, when you started out, was done that way. It's just that you have done, repeatedly so many times, that you become very comfortable in that. Right? And so there is probably no basis in terms of learning, to place maths here, physics here, which people normally do, our students.

And then chemistry here, and biology hmmm, right? There is absolutely no basis to do that. And, biology, biological engineering, both have a lot of maths in them, as of now. A lot of quantification has come in, and there’s a lot of maths even if you like maths, and you would be able to contribute a lot in biology even if you are a pure mathematician.

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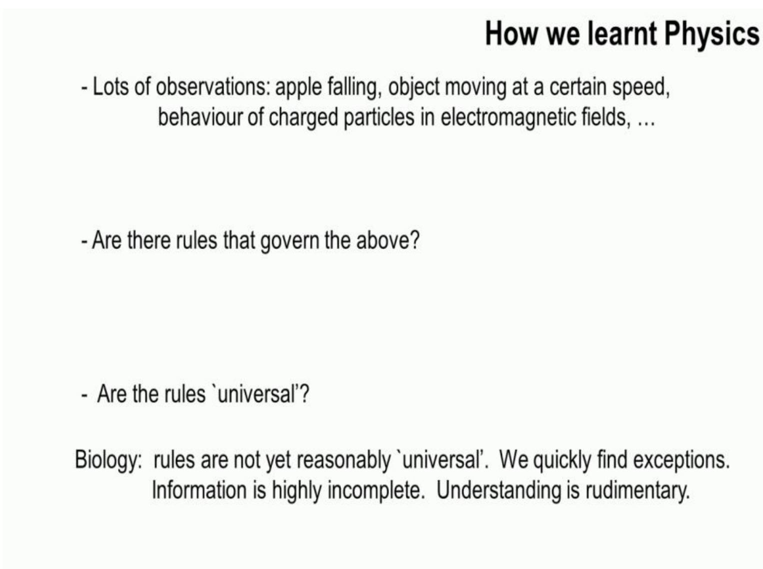

Let me go to physics now. How did we learn physics? Lot of observations, apple falling, object moving at a certain speed, behaviour of charged particles and electromagnetic fields, and so on. Are there rules that govern the above? Yes.

That's what physics is all about. Are the rules universal? Mostly yes, okay? There are a few exceptions, but mostly yes. But in biology, the rules are not yet reasonably universal, okay?

We’ll quickly find exceptions. Information is highly incomplete, understanding is rudimentary, and since it is a new science, there’s a lot of information that one needs to rely on. It's changing as we speak. They’ll all be, the information will be put into nicely understable packets, and then it becomes much easier to manipulate them, right? So, you need to keep this in mind when you are looking at biology.

So what we thought we would do, I think, I think, this is the, last slide in introduction. What we thought we would do, is pick up some aspects of biology, that, one would need to know as basic information, as to how life evolved, how life formed, how life evolved, every interesting aspects which could have a relevance to some of the things that we’re dealing with nowadays. And the very fundamentals of biology, the basic biomolecules, how they interact with each other to certain extent may be. Some genetics which are, which is helpful in, predicting diseases and some aspects of DNA, RNA, and so on so forth. Okay, we’ll give this to you as a ten hour module, and that would equip you with some level of biology with which you can learn further with ease and also start applying with ease. Hope you enjoy the course, with Madhulika and I, we will alternate our lectures here, and see you soon. Bye.