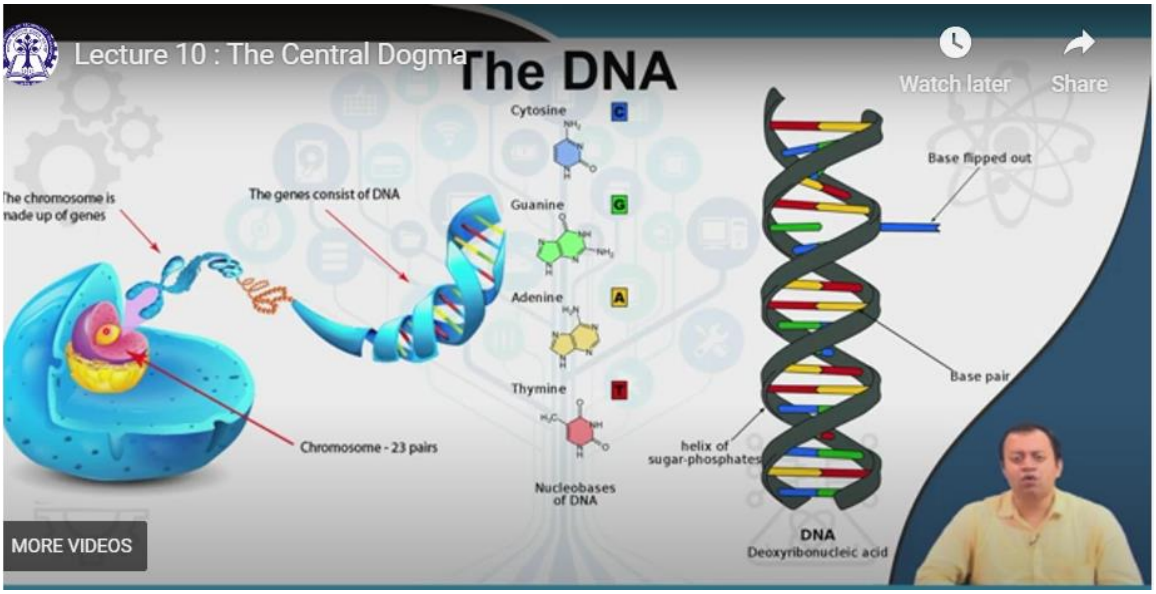
Nanobiophotonics: Touching Our Daily Life
Professor. Basudev Lahiri
Department of Electronics and Electrical Communication Engineering
Indian Institute of Technology, Kharagpur
Lecture No. 10
The Central Dogma

Welcome back. We are at the chapter number 2, end of chapter number 2 of basic biology and photonics. We are discussing biology. In the previous class, we have discussed very briefly the eukaryotic cell mostly. Today, we are going to discuss in the last lecture of chapter number 2 the central dogma. So, let us get started.



So, what exactly is a gene or how exactly are they related to us? Last time in your last class rather scandalously, I discussed I showed a CD-ROM in which I tried to discuss what nucleic acids or what genetic material are. So, what exactly is gene? So, I will make it very simple for computer science or electronics engineers or even physics people. You know you write codes, you write you know lines and dozens of codes, not all part of the code get converted into some kind of a program that is running. There are certain redundant bits, there are certain redundant bits you add it for packaging, you add it for compression, you add it for error fee etcetera.

So, we all have codes inside us. These codes are written in something called the nucleic acids of DNA. The DNA is basically the code of life whatever you are is present from your DNA. A gene is a part of DNA that can run just like a your program your code runs a particular program. Similarly, a gene is a part of DNA that has the capacity underline the

word has the capacity does not mean it will I have the capacity to do something great does not mean I will do something great.

Gene is a part of DNA that has the capacity to produce a specific specific protein. The central dogma of biology states that DNA produces RNA, RNA produces proteins. Where is this DNA present? This DNA is a wrapped around this x like structures inside the nucleus. So, a nucleus contains these x like structures in which a large amount of DNA is packed through. And in this DNA, this DNA has all the codes all the genetic information the gene basically that produces proteins and that proteins perform a specific function in our body.

Let us understand it once again. DNA contains the code. It is like the track of the CD. The track contains the sets of zeros and ones or whatever. And the sets of zeros and ones at the end of the day produce a beautiful movie, beautiful picture, beautiful music what not.

So, this sets of zeros and ones are presents inside DNA. And this DNA is inside this x like structure. This x like structure is called a chromosome. This chromosome is presents inside nucleus. This chromosome is present in side nucleus.

We human beings have 23 pairs of chromosome, 23 pairs of chromosomes ah. Human male have 22 pairs of chromosome and 1 pair of xy chromosome. Human female has 22 pairs of chromosome with 1 pair of xx chromosome. These last two x and y chromosome determine our sexes right. A man has 22, a human male has 22 chromosome and 1x y chromosome.

A human female has 22 chromosome with 1 pair of x well they look like x right. And this is inside them are the DNAs that are packed inside them DNAs are packed. So, this nucleus contains the chromosomes which packs the DNA. Granted there are other material associated with it histones we will see, but those are packaging material enzymes particularly proteins that helps in packaging something that helps like I showed you in that paper you put some extra packaging material for the CD room to survive a long journey. So, 23 pairs of them this x like these are the chromosomes and chromosomes contains DNA a part of DNA which has the capacity to produce information is the gene.

So, gene is that part of your program that part of your code that actually has the significant amount of information that is going to run. It is surrounded by other things that allows it to start or stop or package it or prevent error or help compress it etcetera. Now, this DNA is made up of basically four base pairs cytosine, guanine, adenine and thymine and they are bound with one another using this helix of sugar phosphate. So, phosphate kind of base and they are these base pairs. So, basically these are the sets of 0s and 1s like you have a digital sequence written in 0 1 1 1 0 1 1 1.

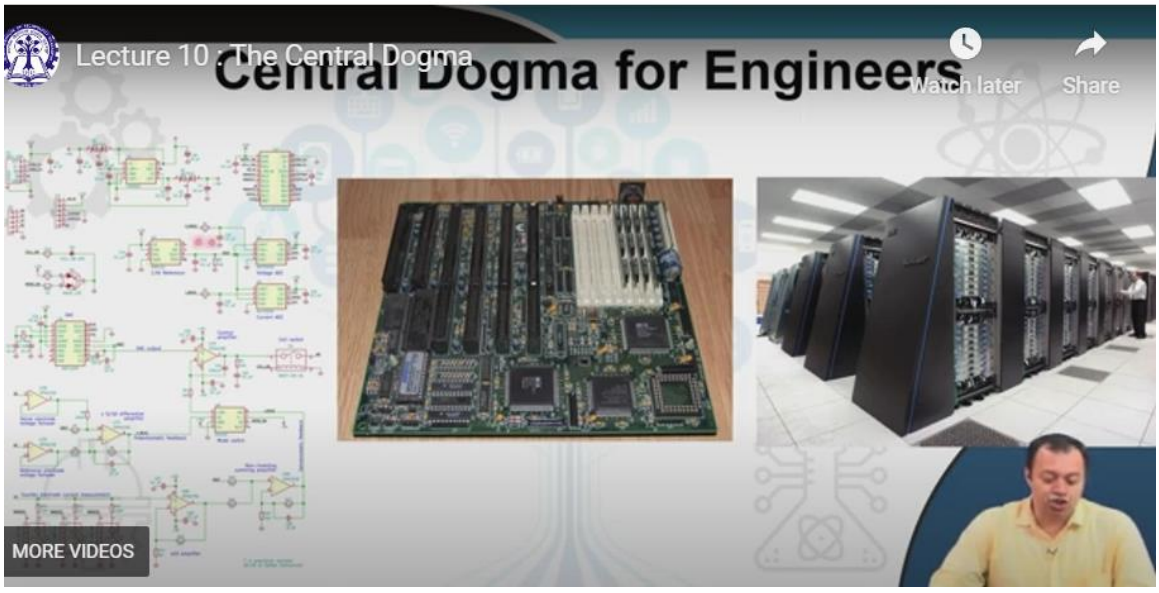
Similarly, a DNA base sequence is written in c g a t a a t t c c g g etcetera are the long chain of codes that contains that contains the information. The nucleic acid bases they are paired with one another. So, blue with green which basically means c and g combined together cytosine can combine with guanine and adenine can combine with thymine no other pairing is possible. So, basically if you see a single pair c g a t then you will understand immediately the thymine the the outer part is the opposite thymine is connecting with adenine, adenine is connecting with thymine, guanine is connecting with cytosine and cytosine is connecting with guanine. So, four bases these are the 0s and 1s of DNA this DNA is present or packed inside a chromosome, this chromosome goes inside nucleus and this nucleus goes inside the cell.

So, what exactly is the central dogma? Again I will try to use analogies for you non biologists to understand it no analogy is perfect. So, you have to use your imagination as such. Central dogma of biology states that DNA is the genetic material genetic code which is self replicating it can replicate by itself, it can duplicate it can replicate itself and hence it is the process is called replication. DNA can convert itself into RNA mRNA is been given messenger RNA, but for the time being considered as RNA the process of converting DNA to RNA is called transcription. The RNA molecules the chains of RNA's then with the help of ribosomes convert it into proteins create proteins not convert I think the proper term is synthesize proteins this process is called translation.

So, DNA creates RNA, RNA synthesizes proteins. In laboratory in laboratory we have done a reverse process in which RNA reconverts to DNA and that is called reverse transcription many of you know reverse transcription from RTPCR reverse transcription polymeric chain reaction this become incredibly popular for detection of coronavirus. Coronavirus has a RNA as its genetic material we were taking the RNA reverse transcripting it into DNA making a chain reaction to make large number of those DNA's

and those DNA's were then detected in order to see if a person has his or her own DNA human DNA along with the viral DNA. The virus itself did not contain any DNA it contained RNA the RNA was converted into a DNA, but this reverse transcription to the best of my knowledge there are exception there are reports to the best of my knowledge happens only in laboratory otherwise this is a one way traffic DNA converts RNA, RNA converts protein. I have given this analogy the DNA, DNA is the recipe book beg your pardon DNA is the recipe book that contains the code that contains all those information.

Based on this code the actual process of cooking takes place you require some cooks you require some utensils you require different things a cooker all of those things utensils tools are required based on the information present here and the final product the final product is the food which is the protein. So, it is a one way process DNA can be considered as a recipe book the entire process of cooking where you require additional tools is RNA protein is the final product. Now, remember when you have this final product you may no longer need this you may no longer need this you may no longer need this you may no longer need any of them all you need is this food. So, this tools are only part of translation process the cooking process or I will further give another example another analogy again no analogy is perfect this analogy was also not perfect, but this analogy is something that is specifically for electronics engineers that DNA is the circuit diagram ok. It is merely some kind of geometric shapes written on a piece of paper like you used to solve those Kirchhoff's voltage law Kirchhoff's current law in pen and paper you take a paper you draw this diagrams and you try to solve the final information what is happening that is your circuit diagram circuit diagram is basically certain geometric shapes lines on a paper.

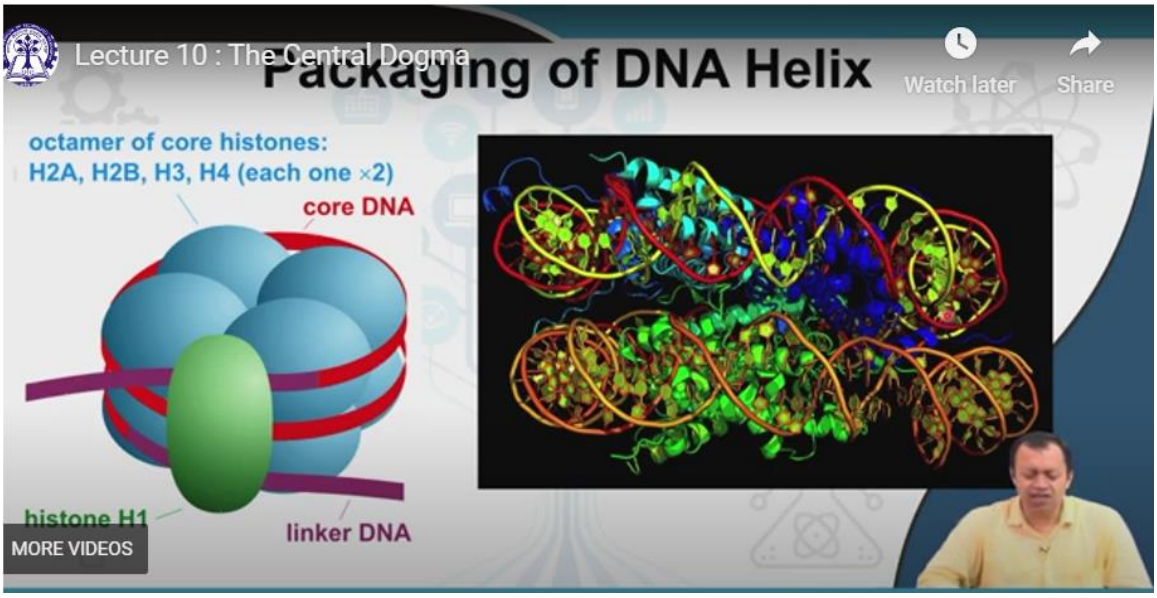


So, this is the information based on this circuit diagram if you make a motherboard if you make a printed circuit board per say based on this that is the RNA, but this is also not the final product this is also not the final product it require tools etcetera etcetera combining

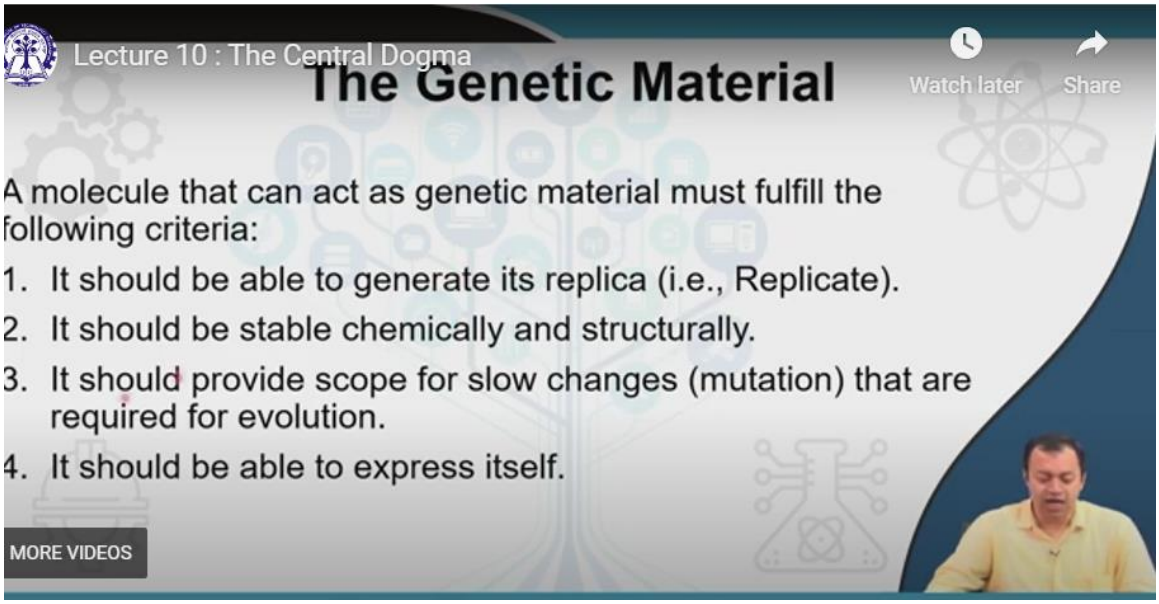
this into a device suppose I have given you image like this, but you can consider it as a mobile phone the mobile phone has a particular function the mobile phone has a particular function which contains this motherboard this motherboard is allowing this motherboard is based on certain circuit device, but the mobile phone has a particular function to make a long distance phone call. So, it has a specific purpose. So, this is exactly what the central dogma states the DNA is the information it gives this information to RNA the RNA is where the actual process actual analysis actual running of the program takes place and the final run after the program has run and it has come up you are seeing a particular device you are seeing a particular movie you are having a food that you are going to eat that is the central dogma if you have understood this you have understood it all. Our nucleus contains DNA that contains large number of the circuit diagrams one circuit diagram is giving you your height you will be taller or shorter one circuit diagram determine the color of your skin one circuit diagram determine whether you will be left handed or handed one circuit diagram giving you information about whether you will be susceptible to heart disease diabetes or not one will give you immunity against corona one will give you asymptomatic towards corona one will give you very very vulnerable towards corona so many and so forth information. These information are being translated through the RNA process into actual proteins these proteins are your antibodies these proteins are your melanin in the skin that determine skin color these proteins helps you create those bone cells that determine whether you will be taller whether you will be shorter these circuit diagrams determines what kind of heart muscle you will generate.

So, that you can run faster or not run faster whether you will have pulpition or not all of those things are based on this circuit diagram if the circuit diagram is bad then the motherboard will be faulty if the motherboard is faulty your mobile phone will not work as you want mischievously the circuit diagram can be externally made faulty you smoke a lot you drink a lot there are carcinogens carcinogens make this circuit make this DNA mute it the circuit diagrams gets bad the recipe gets bad someone wrote bad things about it instead of putting salt put sugar or instead of putting something else a particular masala particular ingredient put something else you follow it you produce a food which is unedible you produce a mobile phone that is not working and you can do it from a external source as well internally that is also possible. So, this is me making a feeble feeble attempt to create a analysis or an analogy for engineers to understand what central dogma actually means in biology. So, like we have ohms law Kirchhoff's voltage law like we have you know nyquist rate we have Schrodinger's wave equation in physics biologists have the central dogma this is the sacrosanct this is same sanctum songtorum you cannot you cannot challenge this though people have started challenging it as well well they have also started challenging Schrodinger wave equation. So, nothing is sacred anymore E is equal to m c square get challenge few every few years they figure out something or the other. So, similarly central dogma had this much power in biology like probably Schrodinger wave

equation have in physics or I do not know what is the electronics engineers favorite theory.

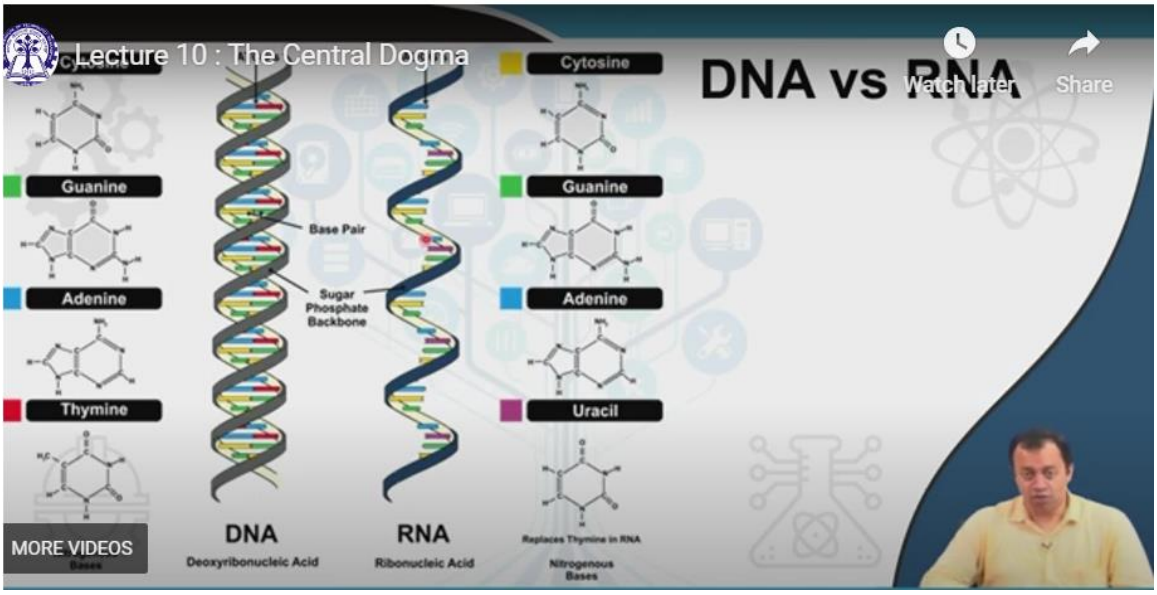


KVL KCL Kirchhoff's voltage law current law ohms law or diode equation I do not know you decide. DNAs are packed as I said inside chromosomes using certain enzymes called histones DNAs have slightly negative charge. So, thereby there is a charge pairing going on which allows them to pack we will be getting this little bit more detail when we discuss gene in the chapter of how biophotonics is helping detect genetic disorders where we will be discussing what genetic disorders are where do they come from what exactly is a gene how are DNAs packed in a far more detail, but for example, this is how DNAs are wrapped around packed inside those x looking chromosomes.



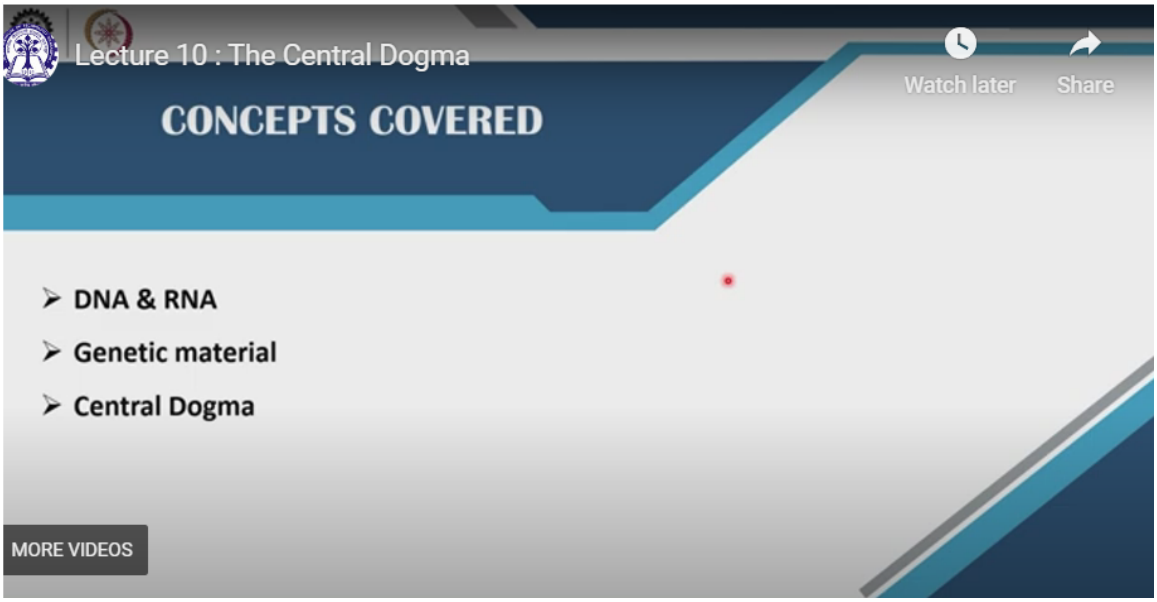
So, the genetic material has to perform certain conditions you cannot simply write code anywhere it should be able to the genetic material has to be able to generate its replica it

should be chemically stable and it could provide scope for slow changes mutation and it should be able to express itself express as in it could be converting into protein. Both DNA and RNA could be a genetic material there is no problem per say theoretically at least for RNA to not be a genetic material some there is a debate in the biology community that perhaps RNA was the already the first genetic material which performed all these functions.

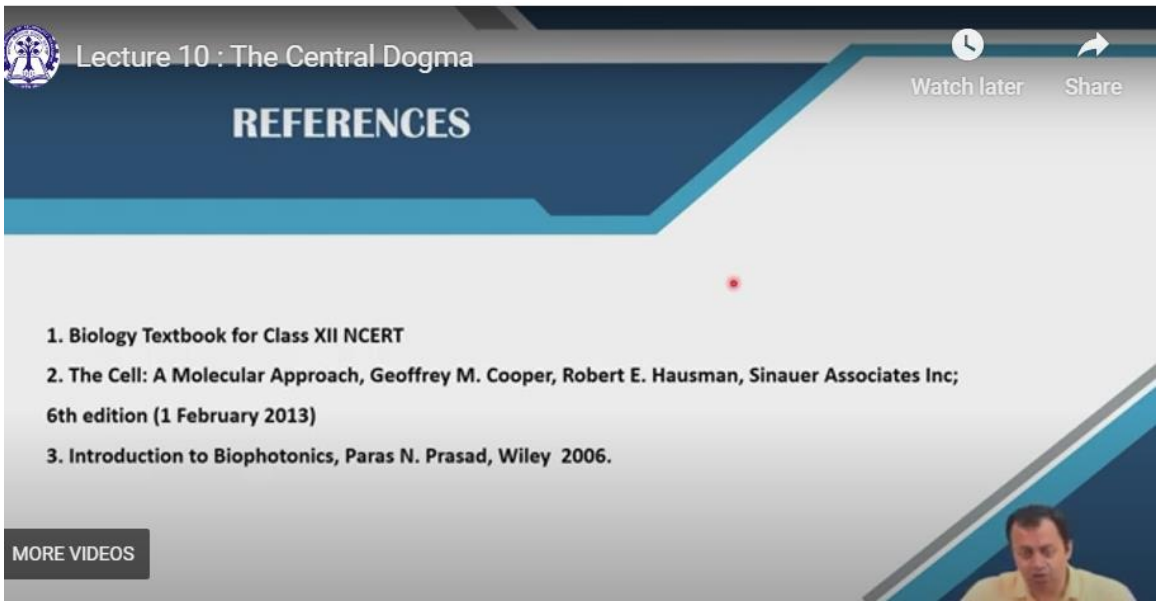


The difference between RNA and DNA is though DNA is a double helical structure RNA is single helix and instead of thiamine this particular base ATCG RNA has uracil. So, AUCG you can understand a DNA is far more stable just from the structure as well as if you compare the stability the reaction reactivity of thiamine with respect to uracil DNA is far far more stable it allows some amount of chemical changes taking place, but it is slow whereas, RNA is highly unstable it is constantly reacting with other molecules changing itself so that it achieves stability. Viruses which contains RNA's are mostly susceptible to mutation they mutate rapidly within you know few months or few weeks time think for example, coronavirus how many different strains of that virus came in there was the first version then there was delta version then there were omicron version now we are saying what kappa version or other other version they are constantly mutating because RNA is unstable the more it is unstable the more it wants to get stable and the move and the way it wants to get stable is reacting with different types of other base pairs or other molecules as such whereas, DNA is far far more stable it is structurally stable it is chemically stable the changes that comes into it is very slow, human beings evolved very very very slowly from you know pre pre existing apes or pre existing ape like structures ape like organisms etcetera single cell to multicell multicell to eukaryotic eukaryotic to plants and animals and then all of those things they took thousands and millions and millions of years as compared to RNA based organism which basically replicated itself in few few months or

few weeks time. So, RNA could also be a genetic material, but for us DNA is the stabler option this DNA synthesizes RNA, RNA then synthesizes proteins these proteins determines all the functions that is happening in your body.



So, that is the central dogma. So, I would like to finish it here those of you who thinks that you need to go detail into central dogma go further dig further, but as I said we will revisit some of these topics and go in detail I think in chapter 4 or chapter 5 where we are actually going to discuss the how genetic disorders are detected using biological materials.



So, with this I finish my chapter number 2 from next slide next class onwards we will be that will be the last part of the preliminary where we will be discussing little bit of nanotechnology and after these three chapters are finished we will actually officially go into the majority part of the course. Thank you very much.