**Biophotonic**
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**Lecture 14**
**Building Blocks**

Welcome back. Let us continue with our discussion on basics of biology. Remember, these are all high school stuff, and this is just to review some of the knowledge that is long forgotten.

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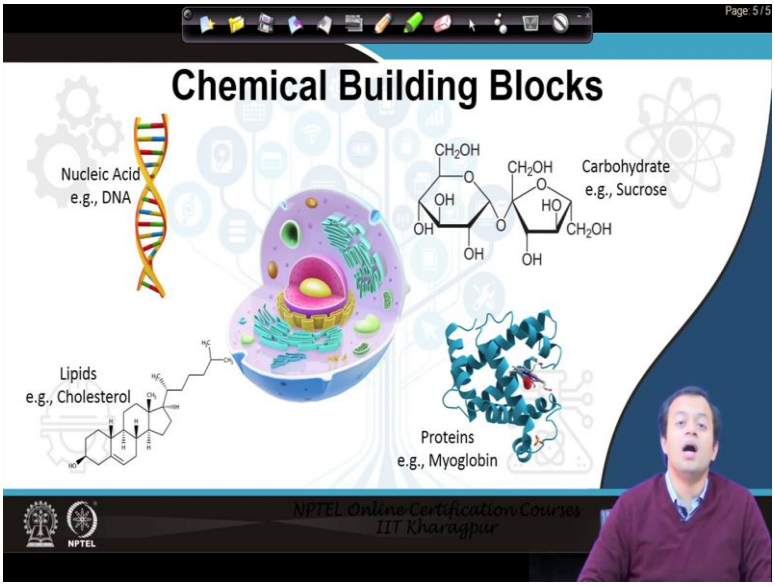


So, we need to understand what are the building blocks that makes the cell as it is. You obviously know by this time about nucleic acids like DNA, but the cell or cellular components also consists of carbohydrates. They consists of lipids and they consist of proteins. Proteins are the foremost important parts. However, we will quickly go through little bit of lipids and carbohydrates.

Lipids, as you know, are biomolecules, which can be dissolved in non-polar solvents like hexane. You have cholesterols, triglycerides are a type of lipids, which basically contains fats. So fats and lipids though use synonymously fats are a type of lipids. They are mostly used for storage of energy. They are there for signalling, and they overall give some kind of structural stability. So, fats or lipids are an integral part of cell and thereby life.

Carbohydrate, carbon, hydrogen oxygen, high school stuff you all know. Sugar can, it is synonymous with saccharin and thereby you call monosaccharides or polysaccharides, one sort of sugar form, large number of polymers, monosaccharides from polysaccharides. They

are also, sugars can also be broken down to create energy. This is mostly, glycogen, etc. They create energy, sucrose, fructose, etc. Sugar molecules, they are mostly for generation of energy, plus they form the structural building block, the black backbone of DNA, deoxyribose or ribose is the sugar.

And obviously the protein, as I said in last class, every single life processes, every single life processes of ours are determined by protein. And remember, if you have paid attention, I was telling you some kind of enzyme, DNA polymerase, or RNA polymerase was helping in creation of, or conversion or synthesis of DNA to RNA, RNA to protein. At the end of the day, protein is creating protein. For all intent and purpose in the essence, or protein is helping create proteins.

What are proteins? Proteins are long chains of amino acids. Okay. Amino seeds are basically this biomolecule that contains, Amine, NH2, carboxyl COOH and a side chain. These are the functional group. So large number of amines or amino acids, basically they are at 20 plus 2, gives rise to proteins.

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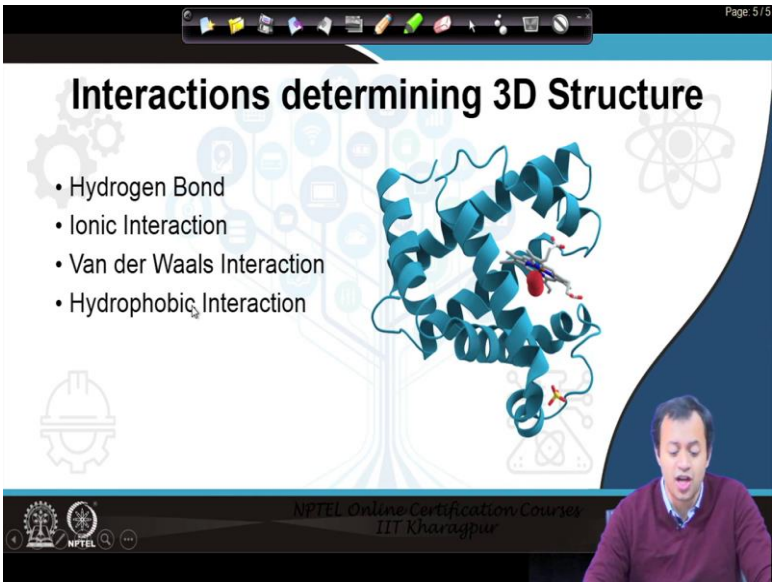


Now, we will look a little bit more on the proteins. So how exactly are these molecules, these proteins come to form this complex three-dimensional structure. How are the DNA in a helical structure, a double-stranded DNA, then single-stranded RNA, then protein has this previous structure that I showed you, this complicated structure as such. Well, the funny thing is the bond that actually make the DNA in this helical manner or the protein in this

coagulated coaxial manner are not covalent bonds, but these bonds, hydrogen bonds, ionic interaction, Van der Waals interaction and hydrophobic interaction.

And these are inherently weak. These are inherently weak. Hydrogen bond is simply when a hydrogen atom forms a bond with a electronegative atom and at one end, and an electron rich atom at one end. It is like two water molecules combining together. This is bi-hydrogen bond. Ionic interaction, it is simply interaction between ions or group of ions of different polarity. Van der Waals interaction, you already know, it is a random fluctuation between electron clouds, hydrophobic interaction, mostly CC and CH interaction, non-polar interaction.

Moral of the story. Biological compounds are very, very weakly joined to one another, you know, after 65 degrees Celsius, 65 degrees Celsius and above, the DNA, double strand start denaturising start opening up. So we require a very small amount of temperature to actually manipulate biological matter. It one way is good and another way is bad, bad because it can go bad very quickly. It can denature. It can rot things very rapidly.

At the same time, it can work at very normal ambient temperature. That is the overall temperature of our planet. Below 65 degrees Celsius and it stays and it proliferates. So there is a proliferation of life all over our system. Combination of all of these very, very weak bonds, not covalent bond, most definitely not covalent bond, creates this complicated structure. If it had been covalent bond, it could have been very rigid and thereby non flexible. And if it is not flexible, we might have only one specific type of life on this planet. The variety of life is because of this flexibility. The flexibility is because the bonds are relatively weak.

Every time I look into it, it reminds me of the four fundamental forces of nature. Remember physics student, back me up, there are four fundamental forces of nature, gravity, weak force, strong force, and electrostatic force, off which gravity is the weakest. Gravity is the only one thus far, which we know is the one which attracts. Every other force have an attraction and repulsion. Electrostatic forces positive - positive ripples, like poles repel, unlike poses attract, but gravity always attracts.

And gravity is the weakest of all forces. Yet when you look at the universe, the entire universe, the gravity runs supreme, the weakest force created the entire universe. Quite similarly, the weakest of the bonds created entire life in this planet, fascinating. So all of these bonds, hydrogen bond, very weak between hydrogen to hydrogen, ionic interaction, electrostatic interaction, Van der Waals interaction, random fluctuation of electron cloud,

thereby having a, some kind of an interaction and hydrophobic interaction. CC CH interaction give rise to this flexible polymeric, chain likes structure, which is either DNA or protein. And this manifests itself into life.

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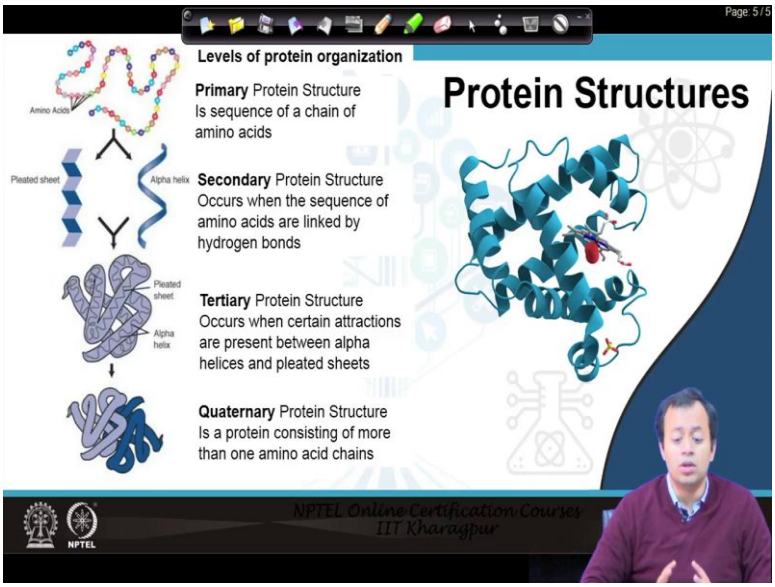


We will discuss protein because as I said, from your antibody, that is helping you fight against COVID to insulin, that is the hormone that is there for interaction with glucose, to the keratin, that gives rise to color of your hair. Everything is determined by protein. And how our protein forms, we told you from mRNA you get information about amino acids.

We even decoded formation of amino acids, these amino acids forms in beds, and after they get attracted by hydrogen bonds, remember amino acids contains amines and carboxyl group. Along with side chain, they form either this alpha helical structure or pleated sheets. Deep chemistry, deep biochemistry, biochemistry student look into your textbook you will know what exactly process is going on, suffices to say for this particular courses that hydrogen bond works on these amino acids to form either pleated sheets or alpha helix, which then coiled together, a combination of alpha helix and pleated sheet coil together to form the tertiary structure.

You start with a primary protein structure, which is basically a chain of amino acids. They upon attraction by hydrogen bond from the secondary protein structure to create alpha helix and pleated sheets. This pleated sheet and alpha helix then again, combine to form tertiary protein structure and large number of these tertiary protein structure, protein structure may be

one tertiary, another tertiary, another tertiary combine together to form quaternary protein structure, which contains more than one amino acid chains.

So, you start with one or two bids of amino acids. They coil together to form secondary structure. These secondary structure coiled together to form one sets of proteins, an other sets of proteins happen like this. These two combine, two different sets of proteins, and you get a quaternary protein structure and this protein structure can be your immunity boosting material. Or this is your antibody that is there to defeat the virus. Or this is what is causing lung cancer. Or this is the one that is coloring your eye. Or this is the one that is coloring your skin. Or this is the protein that is helping you with a very fast metabolic rate.

Some people eat quite a lot, but they are still thin, remember, and then there are few people who no matter how much they diet and exercise are still fat, why? Their metabolic rates are different, their metabolism are completely different. What determines the metabolism rate? Your proteins. What determines the proteins? Your genes. So would you like to change your gene? And if you change your gene, would you remain yourself?

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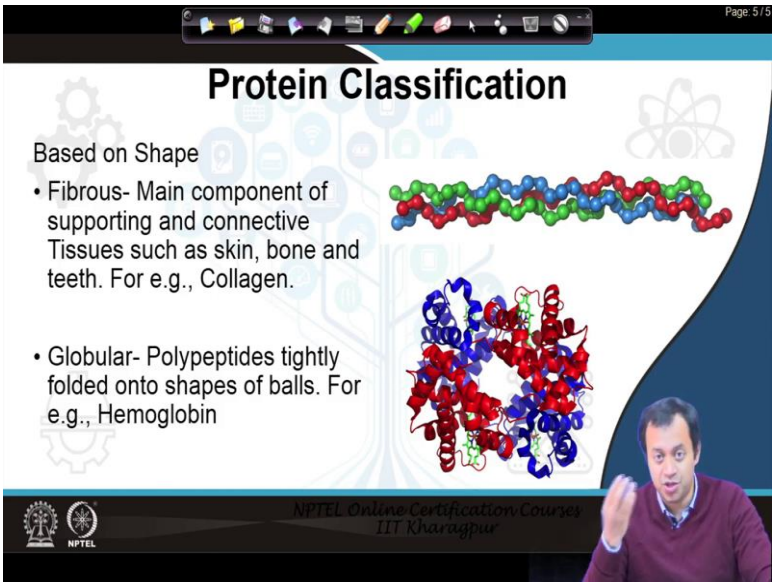


So, let us classify proteins very quickly. Proteins can be fibrous. Like this example in collagen, collagen is present in muscle, skins and bones and teeth, or it can be globular, in the form of a ball, which is hemoglobin. The green part is the heme part, which contains the iron. And this is basically a transport protein, which transport oxygen throughout our body. You know, blood contains hemoglobin, hemoglobin is the protein that transfer. So the transport oxygen to all our body.

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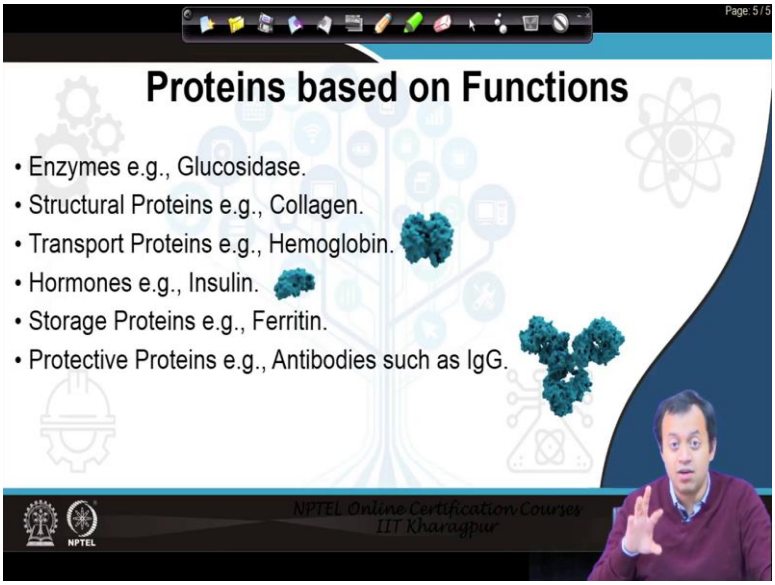


So, based on function, as I said, any life processes, you will see either direct involvement of protein or indirect involvement of protein. Most often than not, it is direct involvement. Enzymes, glucosidase, you have structural protein like collagen in your muscle, transport protein, as I said, hemoglobin, hormones like insulin.

Remember almost all of you have heard someone in your family or someone in your distance relative has some problem with diabetes because of the insulin formation. At the end of the day, it is a protein which is being created by your gene, which is present in your DNA. Storage protein, and protective proteins, which are antibodies such as IgG immunoglobulin G, you must have heard IgG test, antibody test for corona detection.

At the time, people are asking for antibody donation to those patients who have suffered from corona, meaning they have developed these IgG. They have developed antibodies, antibodies are basically those proteins that are there to fight off the infection fight of the virus. So, if you have defeated the virus, you might have antibodies in your body. If I can extract that from your body and transfer it to my body and thereby I have an artificial immunity by myself. At the end of the day, everything is protein.

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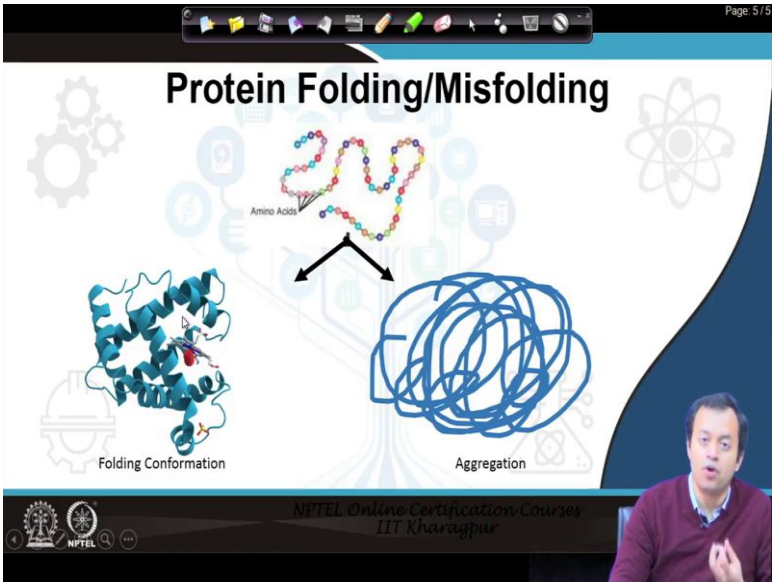


What you need to understand also is that the proteins have a three-dimensional structure, all those bond based interaction, all those bonds that came together, all those hydrogen bonds, ionic bond, that combined to form a specific three-dimensional structure of the protein. So when protein forms in this particular structure, this is not random. Each three dimensional structures allow the protein to perform a particular function.

So, you start with an amino acid and then the bonds start working on it. And it forms a particular three dimensional structure. A three-dimensional morphology. Sometime it may so happen, for several different reasons that these nurses do not conform into this particular three-dimensional shape, but into some kind of a clump. Some kind of an aggregated shape, even though this protein and this protein are chemically same, since they are physics, or since they are physical morphology, since their shape are different, they cannot perform the same function.

Body has or the cellular mechanism has capacity to overcome these proteins. This is like a misprint. Remember when you are printing from a printer, lines are coming one by one, but same amount of ink, same paper, but sometimes it may happen that one line gets on top of another. One word is missing. Something had happened. This is that part, this is the misprint, one or two misprints, the body can take care. The cellular mechanism can take care. If there is an overwhelming misprint, you cannot read whatever has printed out. Meaning body cannot perform that particular function.

All neurodegenerative diseases are characterized by this misfolded or aggregated proteins. We still do not know much about it. All of you must have heard of Alzheimer's disease or Parkinson's disease. These are neurodegenerative diseases. When you open up the head of a Parkinson's patient, you will, the proteins have misfolded on to something like this, a clump. We do not, why they have formed like this. Usually when there is a misprint, the body takes care of it.

But several times we see that the cellular mechanism is overwhelmed and the body is unable to take care of this misfolded proteins. The misfolded proteins start creating problem, bodies unable to understand what this is. It may get in the path, thereby blocking several cellular functions, several cellular mechanisms, it is a bad protein. It is a toxic protein. It is preventing other proteins from working. It is preventing other proteins from signalling to one another. And as a result, you see large number of problems, ailments, diseases start happening.

Parkinson's disease, Alzheimer's disease, where you start forgetting things, dementia or you might have heard of epilepsy. mriggy, where people get this fit. These are all because of this same protein, but in a different conformation, same protein with a different shape. The three-dimensional shape is changed. The three-dimensional shape is different. We do not know what are the exact mechanism that is creating the same source material, same amino acid, too fast, to usually go into this normal shape, to that of an abnormal shape.

What exactly is the reason, that is creating at a specific time amino acids to go into a abnormal state? We do not know. If we have been able to know, perhaps we could go for cure of this dementia. You see old people, you, it is usually seen in old people. They start forgetting. After some time, they start forgetting about the, even the faces or names of their own children, very tragic, but why does that happen? They could remember their old age, their younger part, old people can remember, their younger part, what they have done in their childhood completely, but they have gotten their child's name. And these people many times go missing.

We do not know exact mechanism of this dementia coming in, Alzheimer's disease, Parkinson's disease, prion disease. All of these are because of misfolding of protein and fascinating work is being done, Biophotonics has an important role to play in understanding by throwing light, literally into this protein conformation and what exactly is happening in this particular case that is allowing the protein to misfold.

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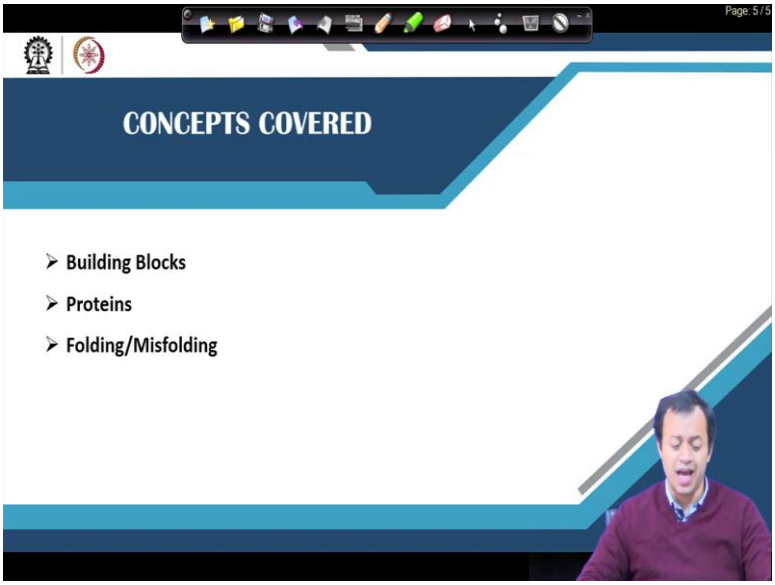


So, that is the end of today's class. The concepts that I covered mostly were proteins and misfolding, remember proteins are but an ocean. In 30 minutes time, it is impossible for me to tell you every bit of it. I just give you certain information that is relevant to the course. I strongly urge you to look into more detail on how protein actually folds, how three-dimensional bid, how like this form to a specific shape. And only when it is folded into this specific shape, it will work. If the same material is unfolded or wrongly folded, it will not make that particular function as such. We have to understand what exactly is going on. We still do not know.

Anyways, thank you very much. Please go through some of the references to know bit more detail, and I will see you in the next class where I am going to finish the basics of biology completely. Thank you very much.