Biology for Engineers and Other Non-Biologists
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Week - 02
Lecture - 07
Biomolecules: Amino Acids, Proteins

Welcome to the next lecture in this module which is on biomolecules and their relationship to cell structure and function. We are progressing in terms of stories here in this module. We are into our third story and some (side) side stories and as a result of these stories we are picking up some basic information.

Our first story was about infection and so on, the second story was about sheer in bioreactors which led us to lipids and what lipids are and things like that, one major class of biomolecules. The third story is why curd gets formed which led us to carbohydrates because curd gets formed by acid formation that leads to protein aggregation, what carbohydrates were the second major class of biomolecules and we stopped at the point where we reached the third major class of biomolecules which happens to be proteins, proteins or amino acids as you call it. You will know the difference very soon.

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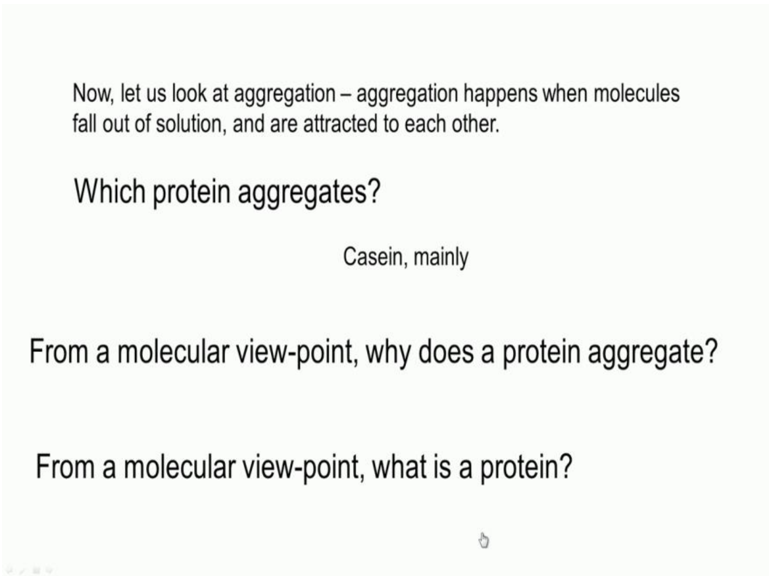

This is going to be a third major class of biomolecules, totally there are four. So in the last class, last lecture we left at a point, from a molecular viewpoint, what is a protein.

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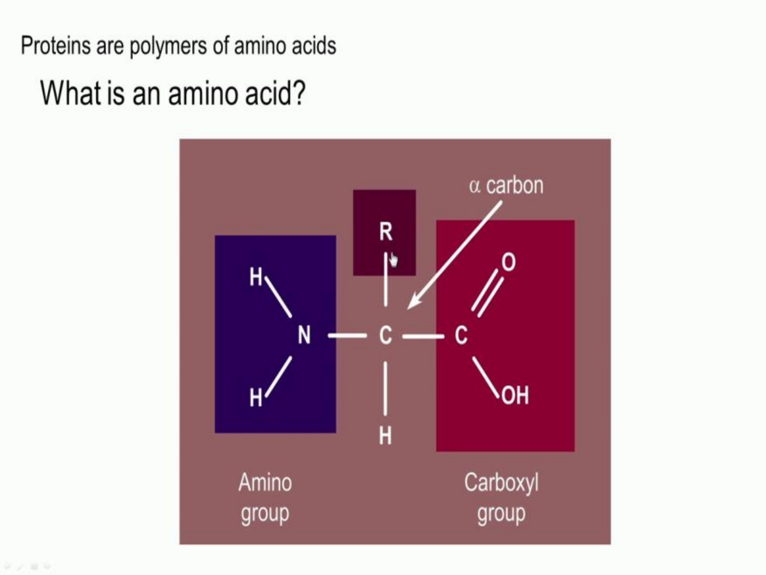

Proteins are polymers of (something) something called amino acids, okay? That’s what proteins are. They are polymers of amino acids. And what is an amino acid, okay? It’s very simple; this amino acid is very simple. You have the central carbon atom here in alpha carbon atom. This is called an amino acid, right?

So you have an amino group here and a carboxylic acid group here. So an amino acid, the amino group is an NH2 shown in blue here, the carboxyl group is a COOH which is shown in red here, okay? So, these two are attached with the opposite ends of the carbon molecule, the alpha carbon molecule, here. In addition you have a hydrogen atom here at the third and something called an R group as the fourth bond of the carbon, you know that carbon valancy is four.

So you have amino group, carboxy group, carboxylic acid group, so amino acid comes from that and you have H and various R groups. So differences in the R groups are what is what gives rise to the differences in the various types of amino acids, right? And you have polymer of these amino acids, then you get a protein.

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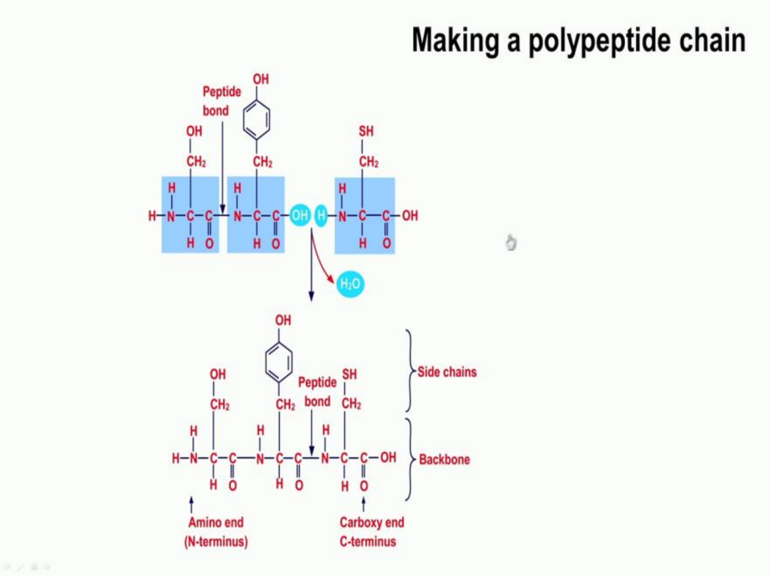

That is what is described here a polypeptide is a small (part), small protein you can say, okay let us say that for approximately now. A polypeptide is nothing but a shorter form of protein. A polypeptide formation is given here to illustrate how a protein gets made. As you can recognise here, this is one amino acid, this is CNH2COOHH and the R group happens to be CH2SH, right? When this meets, let us say, let us just focus on this amino acid here, which is already combined to another amino acid through what is called a peptide bond; let us look at the interaction between this amino acid and this amino acid.

This has a COOH group here this carbon atom; the NH2 group here which is actually bonded on through the peptide bond to the other amino acid. The H group here and the R group in this case happens to be the CH2 OH across a (benzene), across aromatic ring here. So when these two interact this OH of the COOH here, and this H of the NH2 here, condense out, the water comes out and it results in the formation of the CN bond here, the bond between this and this, this is called the peptide bond, okay?

This carbon carboxylic acid NH2 this forms the backbone, and these various R groups form what are called the side chains of this protein molecule here as a part of these various amino acids. And also it’s quite easy to see that there has to be one free end here of amino group, okay? If you assume that the growth happens this way of various amino acids attaching to form larger and larger polypeptide chains and the proteins and so on, so you have any protein will have one free amino end, okay, which is called the N terminus, and one free carboxy end, carboxylic acid end which is called the C terminus. So a protein has a C terminus and an N terminus, it has a backbone consisting of the various peptide bonds and carbon atoms, (hydroxy), carboxylic acid molecules and so on. And the side chains that are part of each amino acid R group that constitute the protein. This is how a protein gets made from the various amino acids.

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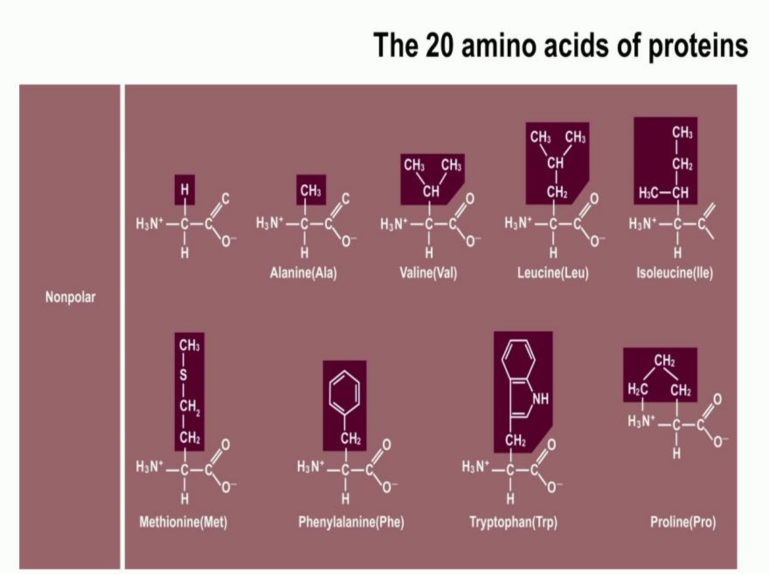

It so happens that there are twenty R groups, that exist in nature and therefore there are 20 different types of amino acids that exist in nature, right? There could be other types of amino acids, but they are not naturally occurring amino acids. And therefore there are 20 different types of amino acids in the proteins which are essentially polymers of amino acids. This has been grouped under these various heads depending on the nature of this R group here, okay? If they are group happens to be a nonpolar group, then it is grouped under this head. For example, this H group, CH3 group, CH3 and so on, don't worry about the names now.

Glycine is missing here, alanine, valine, sorry you have a H group, you have a CH3 group, that becomes alanine, you have a CH this has to be CH2 here, CH2CH3CH3 becomes valine and so on and so forth. In other words, all these are nonpolar groups the R groups and therefore they are grouped under this. Let's count the number of amino acids one, two, three, four, five, six, seven, eight, nine of the 20 R amino acids with nonpolar R groups.

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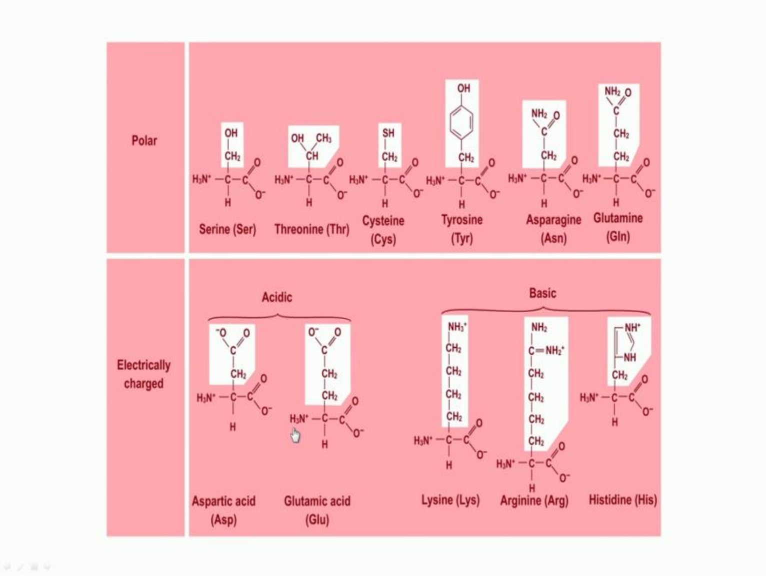

There could be polar R groups, such as CH2OH, CH CH3OH which is threonine, the earlier one was serine, cystine, cysteine this is, tyrosine, asparagine, and glutamine. These are all amino acids with the polar side group and this has also been categorised as the side groups that are acidic and basic, if they are acidic and basic they need to be electrically rather the the electrically charged groups are the ones that are on aspartic acid and glutamic acid and the basically basic groups are the ones that are on lysine, arginine and histidine.

You don't have to worry about the details here, I just mentioned the various things, as and when necessary, we can look at individual amino acids depending on our need, and a look at their properties. But these are the properties of the side groups that determine the properties of the proteins themselves. So we saw amino acids with nonpolar groups,we saw amino acids with polar groups, and electrically charged groups which could either be acidic or basic, that's good enough. Don't worry about anything else for now, you don't have to remember any names, don't worry about it.

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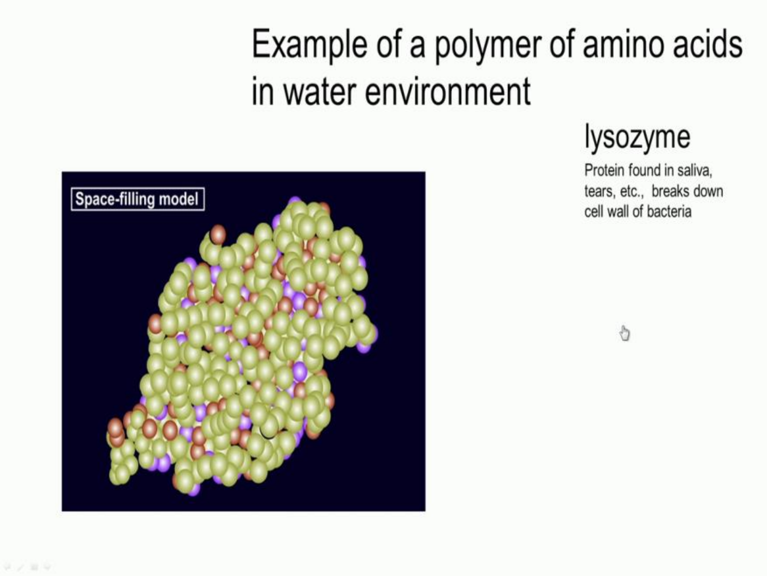

So this is the example, an example of a polymer of amino acids in a water environment, space filling model of lysozyme, water environment, this is surrounded with water it has to be in water. This lysozyme, it's actually a protein that is found in saliva, tears and so on; and it also breaks down the cell wall of bacteria.

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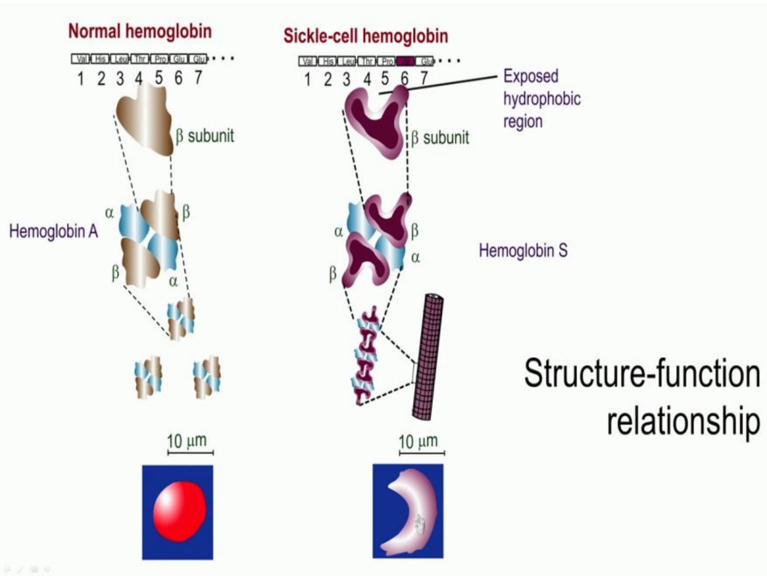

The nature of the amino acids, actually determines the nature of the proteins. Let us take an example here in the case of haemoglobin. The haemoglobin consists of various different amino acids here along chain of amino acids all connected together by peptide bonds, okay? Some of these are given here, valine, histidine, leucine, threonine, proline, glutamine, glutamic acid glutamic acid, okay? And because of this it forms various units and four units need to come together to form haemoglobin molecule and if its folds correctly, will come to all these things later, the folding and so on. If it folds correctly, then it will do its job properly, right? It’s folding correctly is what is going to result in a functional red blood cell which can carry haemoglobin, okay? If there is a slight change in the amino acid sequence here, for example this glutamic acid, (glu) at the sixth position, has been replaced with something else.

Then we get a disease, we get what is called sickle cell anaemia, right? That’s the only reason why we get sickle cell anaemia; this glutamic acid at the sixth position has been replaced by another amino acid. What happens to that what happens as a result of that? The, we get a disease (that) that’s a result. Why does that happen? That is because; (the) there is a lot of interaction that happens between the various parts of the protein, the various amino acids in the protein, okay?

We all saw that the amino acid the side groups of the amino acids could be so different they could interact with each other depending on their chemical nature and you have a long chain of amino acids so one amino acid here one side chain could find another side chain attractive here, and therefore it will start interacting here as a result it will bend the entire protein here, right? The (entire) (the) this, this part of the proteinwould be bent because this side group wants to interact with this side group, okay?

And that is what results in protein folding by itself, okay? Its (it) happens spontaneously, because of the need for the chemical interaction between the side groups. And this folding, the way it folds because of the various side chains and so on so forth, is what gives protein its functionality. If that doesn’t fold properly, then the protein will not be functional. And that is what happens here, in the case of normal haemoglobin it folds properly to carry haemoglobin and you have a functional red blood cell.

Just one change here, glutamic acid going to some other amino acid, changes the structure, the folding of the haemoglobin protein and thereby changes the structure of the haemoglobin protein, as a result it I mean a sickle cell structure of the red blood cell results which is unable to carry oxygen through haemoglobin. And that results in sickle cell anaemia.

So the structure function relationship is so pronounce in the case of proteins, a proper structure is what results in proper function and this is a very nice example of that. I think we will stop here for this particular lecture, we saw we started out by asking what proteins were, then we said that proteins are polymers of amino acids, then we saw what amino acids were, it has a central carbon atom and amino group on one side, a carboxylic acid group on the other side, so amino acid, and then you have a H group here, and various different types of R groups, one for each amino acid on the other side.

Then when you put all these together you have the protein and when you put all these together, there is a need for interaction of one (group) R group with the other and probably other kinds of interactions with the water around it and so on so forth. Therefore the protein molecule folds and the folding of the protein molecule is what results in its function. (And) and a very striking example is the case of haemoglobin in the normal case it results in the normal ability to carry oxygen to various parts of the body, a normal red blood cell.

In the case of one change at the sixth position, the amino acid being different, we get sickle cell anaemia, that is because of sickle cell haemoglobin being formed, which has different folding and therefore different it does not have the functionality that is associated with the normal haemoglobin. And it also results in a sickle cell shape of the red blood cells and the disease. We will stop here; we will continue our stories further when we meet next. See you then.