Hello students and welcome to this presentation. I am Dr. Sheryanne Velho Pereira and today I will be covering the module entitled protein structure, primary, secondary, tertiary, and quaternary. This module is under the unit macromolecules. So let's begin with the outline of this module. To begin with, we study the primary structure followed by the secondary under which you will be studying the two subtypes, namely alpha Helix and beta pleated sheet. After we are done with this, we'll be studying the tertiary structure and finally we culminate with the Quaternary structure.

Students, once we're done with this module, you will be able to confidently talk about the primary structure, secondary structure, tertiary and the quaternary structure. So here I've given you a picture of the various structures and you can see them. Very clearly the first one, A is the primary structure. It has a serially linked amino acids linked by these small bonds that are called as a peptide bonds. Then you have the alpha Helix, which is like I told you before, a subtype of the secondary structure. It is in the form of a ribbon, a Helix. And the next one here that you see is a beta pleated sheet. It is similar to you folding a paper. And then you have the tertiary structure. A wound structure like this. We'll know how and what in the latter slides, and then you have the quaternary structure. The example here that we've shown is hemoglobin.

So the primary structure of proteins is nothing but a sequence of chain of amino acids. As you can see here, very similar to a necklace, you know, string of pearls and the pearls that you see are nothing but the amino acids and the links that hold them together are the peptide bonds. The secondary structure of proteins are of two types, and this happens mainly because of the local folding of the polypeptide chain and it can take two forms, alpha Helix and beta pleated sheet. The next the tertiary protein structure. This is a 3-D structure and occurs on account of full link of the protein, primarily due to the,interactions between the chains. The last one is the quaternary protein structure wherein the protein consists of more than one amino acid chain. Let's delve into each one of them separately now. So we begin with the primary structure of proteins.

The primary structure of proteins is the number and the sequence of amino acids. Amino acids as you already know, are the building blocks of this macromolecule named as protein. The proteins consist either of one or more peptide chains. The main bonds that are involved include the peptide bond and it occurs between the alpha carboxylic group of 1 amino acid and the Alpha amino group of the adjacent or the one next to it.

So you can see here these colorful beads that you see are nothing but the different amino acids and they are linked with the peptide bonds. And an amino acid is clearly indicated to you here. It has the alpha carbon. It has hydrogen, the amino group, the variable R group, and the acidic carboxylic group. The chain of amnio acid has a free amino terminus at one end and it has a free carboxylic group at the other. So now this free carboxylic group will link with the amino group of the neighboring amino acid forming a peptide bond. I'm hoping this is clear now. The next one is a secondary structure and it refers to a specialist steric relationship of amino acids that are near to each other in the amino acid sequence. It mainly involves the folding of the peptide chain. Now the two subtypes that we discuss here are the alpha Helix and the beta pleated sheet. Let us now talk about the bonds. The bonds are mainly hydrogen bonds, and they could either be intermolecular or intramolecular. So now let's begin with the structure of the alpha Helix. A lovely picture is here to illustrate how it looks.Now the alpha Helix is a right-handed Helix. And from them there are radical R groups that are directed outwards at right angles? Alpha Helix can consist of either L or D amino acids.L being Laevo being dextro.

However, all the residues must have one stereoisomeric form. That means they could either be all L,or they could be all D if not,the alpha Helix tends to get disrupted. Now Alpha Helix is a very stable structure because all of the peptide groups peptide bonds.

Take part in two hydrogen bonds,one above and one below. Kindly note there are 3.6 amino acids per turn of this alpha Helix.Bonds. Alpha Helix stabilized by hydrogen bonds, which could either be intermolecular or intramolecular. Between the NH and the Co groups of the main chain. Peptide bonds.The OOH group of each amino acid is hydrogen bonded to the NH group of the. Amino acid that is situated 4 residues ahead. Now this you will understand better with this diagram. Have a look. This is the hydrogen bond OK and this is the H group of the amino group of this amino acid and you can see eight forms. A bond with the carbonyl group of the 4th amino acid that is situated ahead of this amino acid. So the hydrogen bond is formed between this amino group. And the carboxylic group of an amino acid that is located 4 residues apart.

Now let's study the second one, and that is the structure of the beta sheet or the beta pleated sheet. The polypeptide backbone is nearly fully extended into a zigzag strap. The radical groups like you can see here are directed outwards at right angles alternatively above and below the plane of the sheet. Now this is the plane of the sheet and you can see this is the radical above that is at right angles to the sheet and this one is below. The adjacent strands in the beta sheet can either be antiparallel, or they can be parallel. Now if they are parallel and they have the same N to C terminal orientations. But if it is antiparallel then they have opposite N to C terminal orientations. An important point to note is that all the amnio acids will be left handed. That is, there will be the L form.

The arrangement of several beta strands side-by-side form a planar type structure known as the beta sheet or the beta pleated sheet. What are the bonds? The bonds here are highlighted with this orange color and their hydrogen bonds that occur between the carboxylic group and the amino group. As seen here in this figure between the carboxylic group and the amino group, you can see these are the hydrogen bonds. The hydrogen bonding patterns are slightly different here in the. In the other form, that is the parallel form. OK, so the orientation you can see here. Kindly note that the antiparallel arrangement is much more stable in comparison to the parallel arrangement.

Let's study a second last one, and that is the tertiary structure. Now secondary structure may fold in certain specific patterns to produce a twisted 3D structure. And this is formed on account of interactions and repulsions of the various amino acids that constitute. The different part of the chain. The bonds involved are enlisted in this slide. First hydrophilic interactions. These occur between the external aqueous environment and the polar amino acid ready residues, pulling them to the outer surface of a protein.

The next one, a hydrophobic interactions which occur between the nonpolar amino acid residues, forming a nonpolar center within the interior of the protein. Next, the Salt Bridge is formed between the acidic and the basic amino acids. 4th one hydrogen bonds form between the hydrogen of a polar residue and the oxygen and nitrogen of the second polar amino acid residue. Finally, the fifth one are the disulfide bonds. Their covalent bonds that form when the SH groups of two cysteine residues are oxidized. That is, the hydrogen is removed. Here you can see in this figure all the bonds are marked in blue. You can see this is the ionic bond. This is the hydrophobic interaction, a disulfide linkage and the hydrogen bond. And it is because of these interactions these proteins fold in the manner that they do in the tertiary structure.

The quaternary structure. Certain proteins are made up of subunits of similar or dissimilar types. Of the polypeptide chains, namely the tertiary structure, these subunits interact with each other in a specific manner to give rise to the quarternary structure. The bonds involved are similar to the ones that are involved in the tertiary. That is, the disulfide hydrogen hydrophobic and ionic bonds. So now you can recap all the structures using this. Illustration here you can primary structure is the polypeptide chain, serially linked, amino acids. Then you have the alpha Helix and beta pleated sheet. The tertiary structure, which is a 3D structure and finally the quaternary structure which has more than one polypeptide chain and hence it is called a multi subunit complex. This is another one which clearly shows the primary structure, the alpha Helix, the beta pleated sheet, the tertiary and the quaternary structure. Now let's do a quick study check. The question is as follows. Indicate the type of protein structure. The options that are given to you are primary, alpha Helix and beta sheet. And the ones that you need to link these to. The options are polypeptide chains held side by side by hydrogen bonds, sequence of amino acids in a polypeptide chain Corkscrew shaped with hydrogen bonds between amino acids. Students, if you have understood all the structures, you will be able to answer this question.And, uh, I'm sure you will do it. So the options are like this.These are your answers.The beta pleated sheet is. Matches with a) that is polypeptide chains held side by side by hydrogen bonds. Primary structure is nothing but the sequence of amino acids in the polypeptide chain. And finally, the alpha Helix is the corkscrew shaped with hydrogen bonds between amino acids. I thank you students for your attention, and these are my references.

Thank you.