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# The Structure of Proteins

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# Lecture Objectives

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**What are Polypeptides and Proteins?**

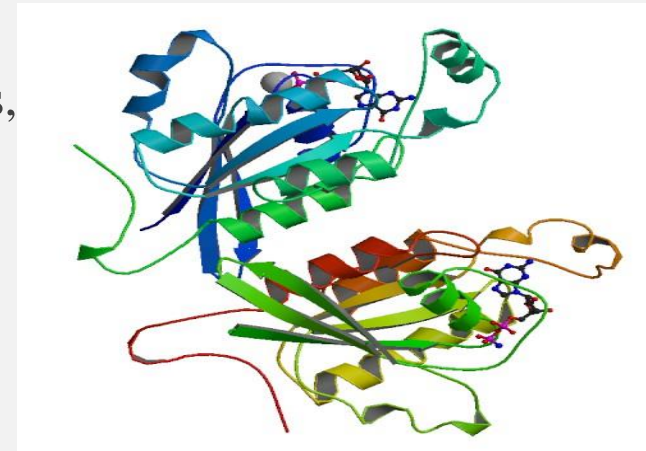
**What is functions of Protein ?**

**What are Levels of protein structure?**

# Proteins and Polypeptides

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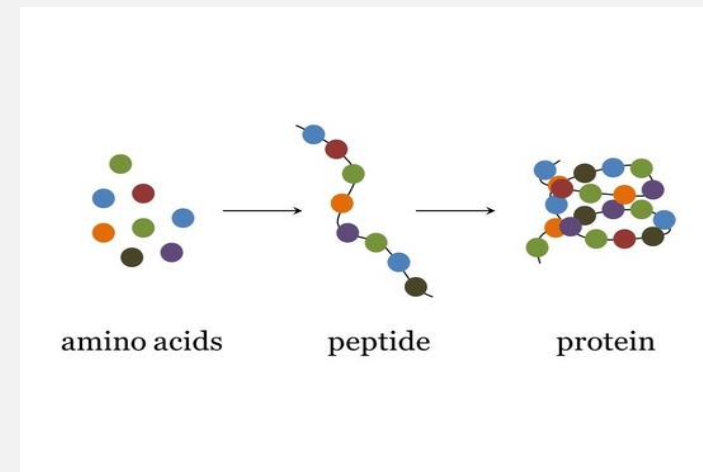
- All of the work in the cell: energy generation, synthesis of new components, response to environmental stimuli, etc., is performed by proteins.
- Proteins are the most abundant organic molecules of the living system.
- They constitute about 50% of the cellular dry weight.
- Proteins large complex molecules composed of **amino acids**.
- Contain carbon, hydrogen, oxygen, nitrogen.
- 20 different amino acids are used to make proteins.



# Proteins and Polypeptides

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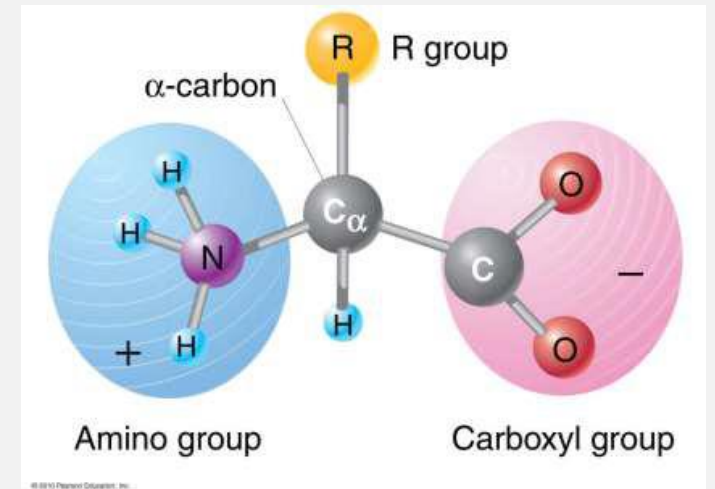
- Proteins are primarily composed of polypeptides: linear chains of amino acids.
- Some proteins are composed of a single polypeptide, while others have 2 or more (up to maybe 20 in very complex proteins) subunits.
- Some proteins have sugars, lipids, or other small molecules attached to them.



# Amino Acids

Amino acids are a group of organic compounds containing **two functional groups – amino and carboxyl.**

- amino group [  $-\text{NH}_2$  ] is **basic** in nature
- carboxyl group [  $-\text{COOH}$  ] is **acidic** in nature

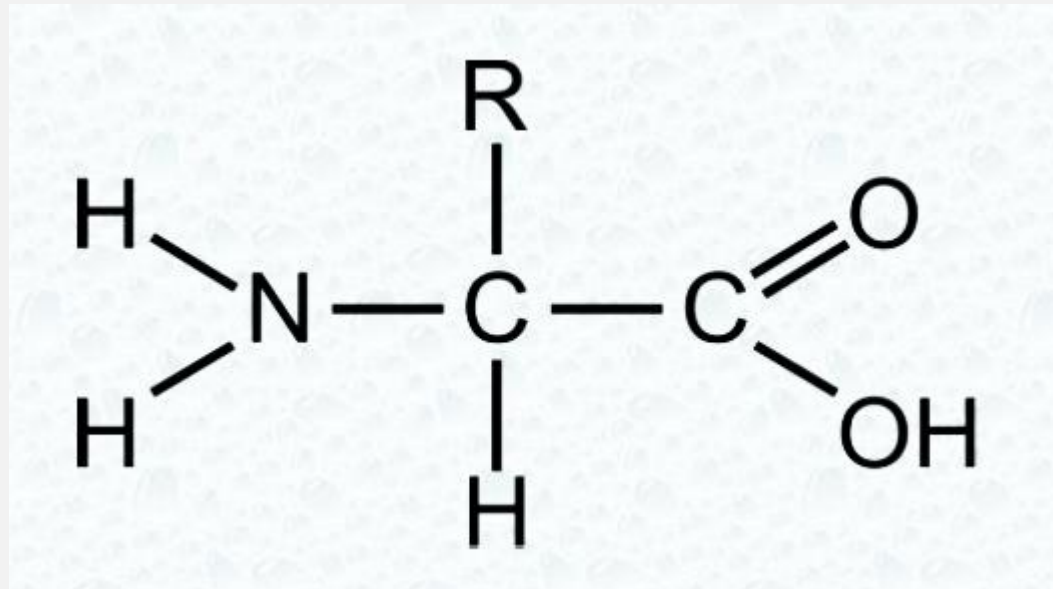


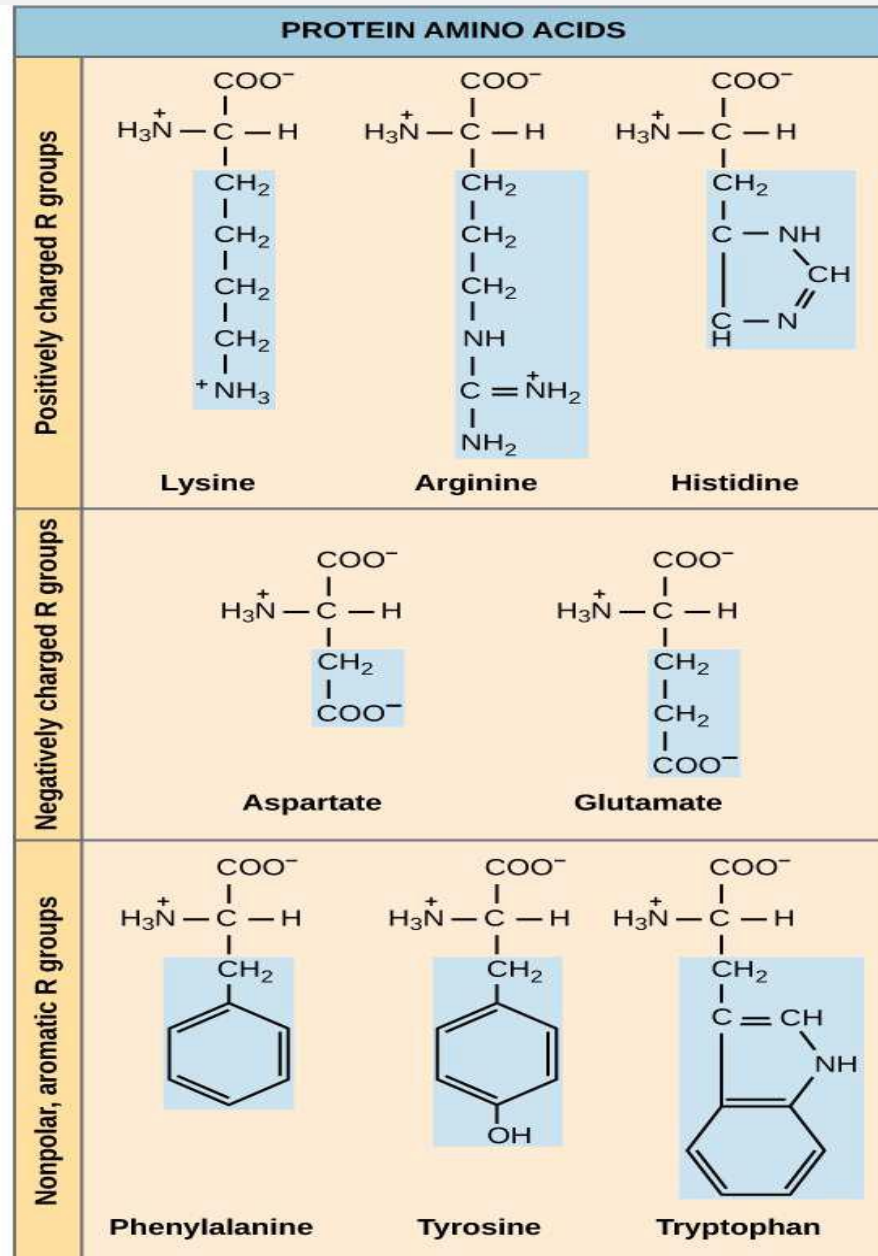
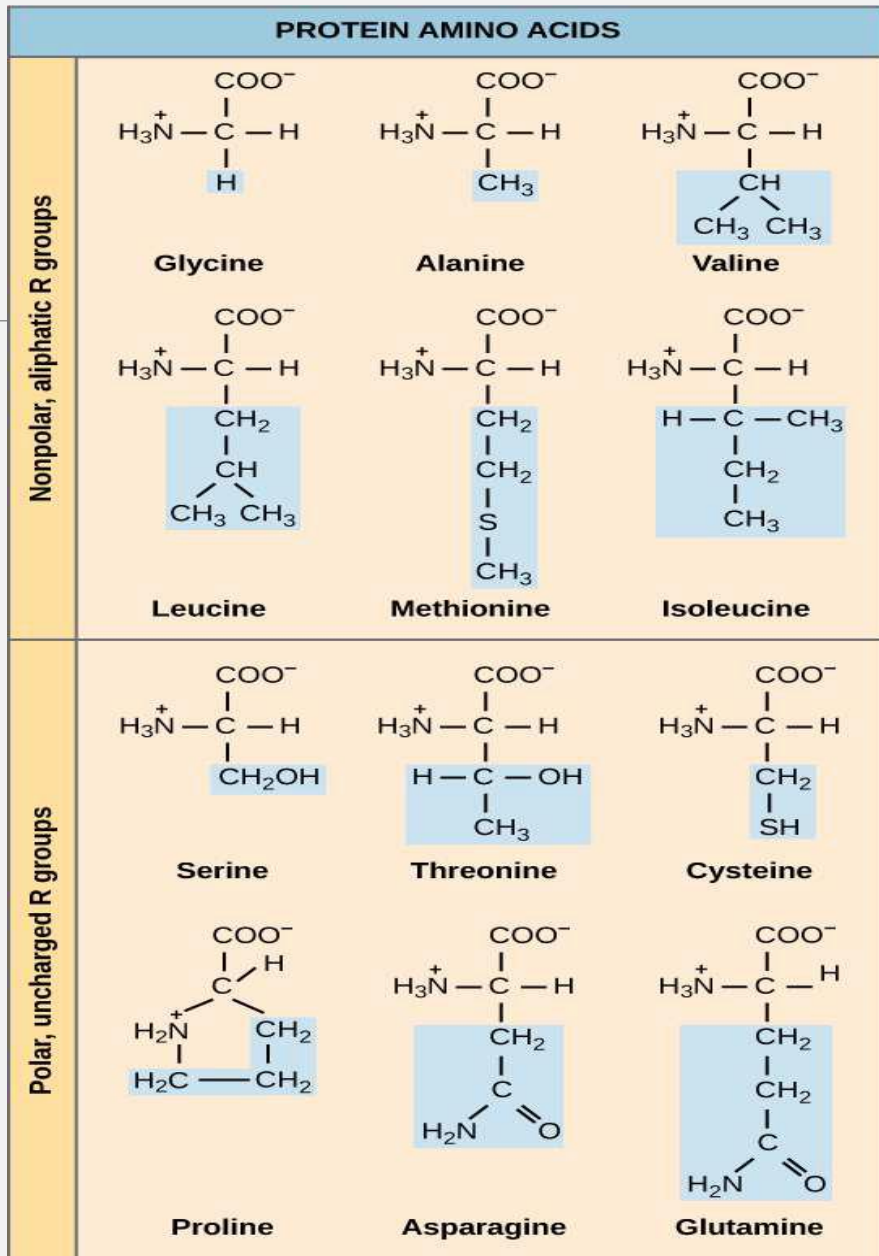
# Structure of Amino acid

Each amino acid has 4 different groups attached to  $\alpha$ -carbon ( which is C atom next to COOH).

These 4 groups are :

1. amino group,
2. COOH group ,
3. Hydrogen atom
4. side chain(R).





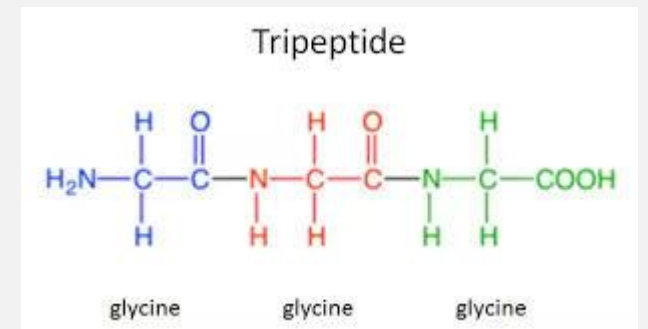
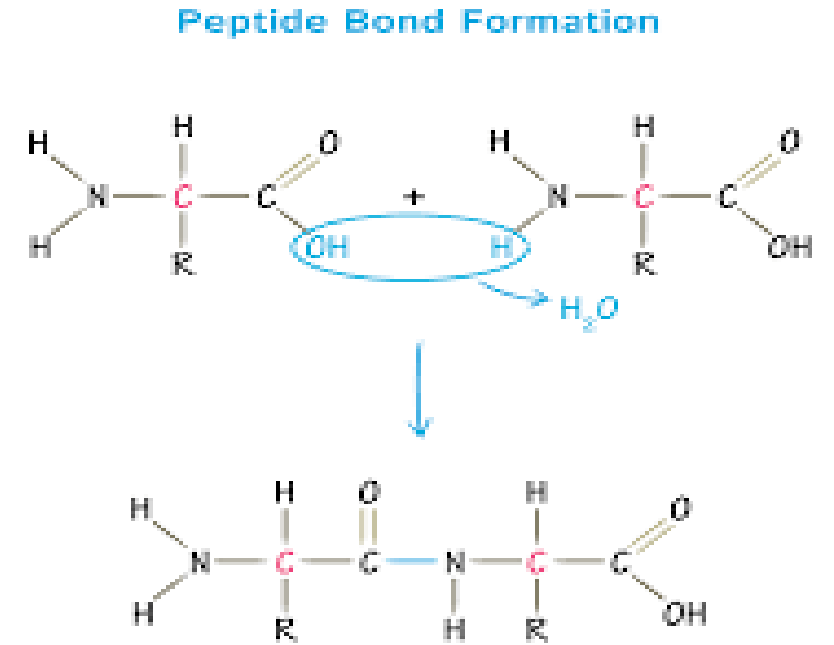
# What is Peptide bond?

A peptide bond is a chemical bond formed between two molecules when the carboxyl group of one molecule reacts with the amino group of the other molecule, releasing a molecule of water (H<sub>2</sub>O).

**The result is : Dipeptide.**

The dipeptide can then form a second peptide bond with a third amino acid (with side chain R<sub>3</sub>) to give **tripeptide**.

Repetition of this process generates a **polypeptide or protein**

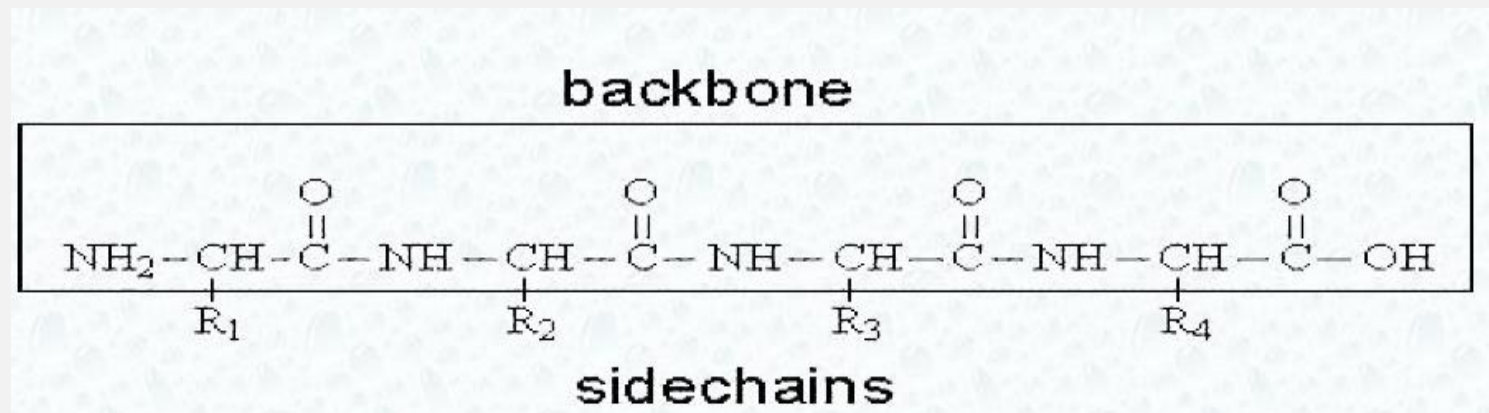




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Polypeptide backbone is the repeating sequence of the N-C-C-  
N-C-C... in the peptide bond.

- The side chain or R group is not part of the backbone or the peptide bond.



# Protein functions

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Proteins play an important role in many crucial biological processes and functions. They are very versatile and have many different functions in the body, as listed below:

Act as catalysts

Transport other molecules

Store other molecules

Provide mechanical support

Provide immune protection

Generate movement

Transmit nerve impulses

Control cell growth and differentiation

# Protein structure

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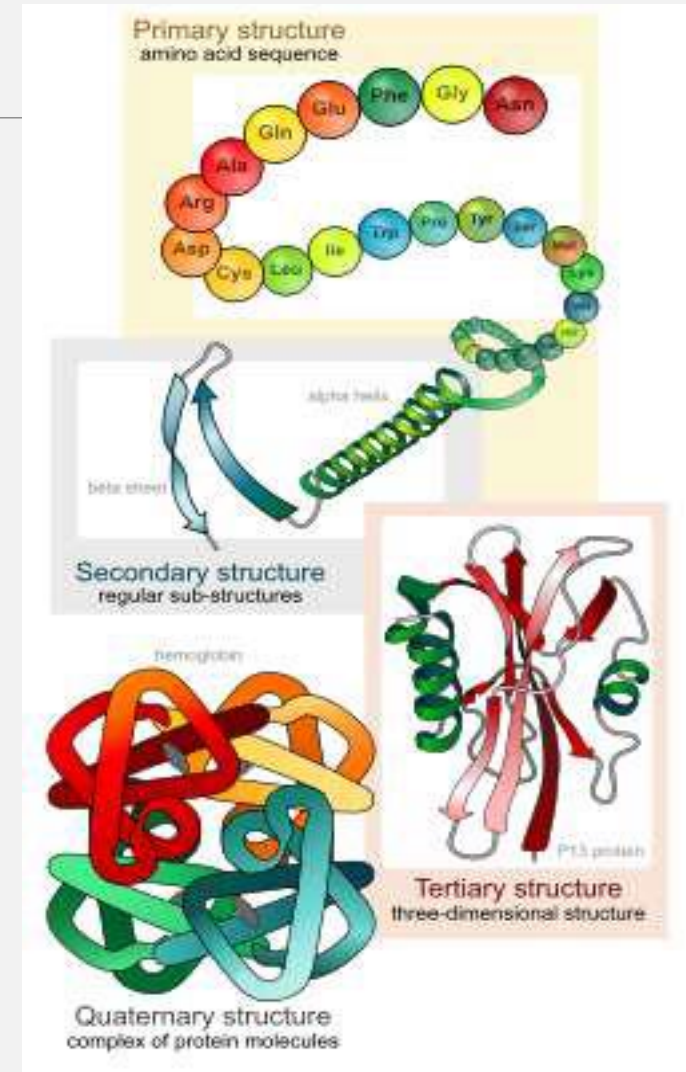
Proteins are made up of hundreds or thousands of smaller units called amino acids, which are attached to one another in long chains. There are 20 different types of amino acids that can be combined to make a protein. The sequence of amino acids determines each protein's unique 3-dimensional structure and its specific function.

The extent to which the structure of proteins has an impact on their function is shown by the effect of changes in the structure of a protein. Any change to a protein at any structural level, including slight changes in the folding and shape of the protein, may render it non-functional.

# Levels of protein structure

Proteins have different levels of organization

1. Primary Structure
2. Secondary Structure
3. Tertiary Structure
4. Quaternary Structure



# Primary Structure

- Proteins are made up of a long chain of amino acids.
- The simple sequencing of the protein is known as its primary structure.

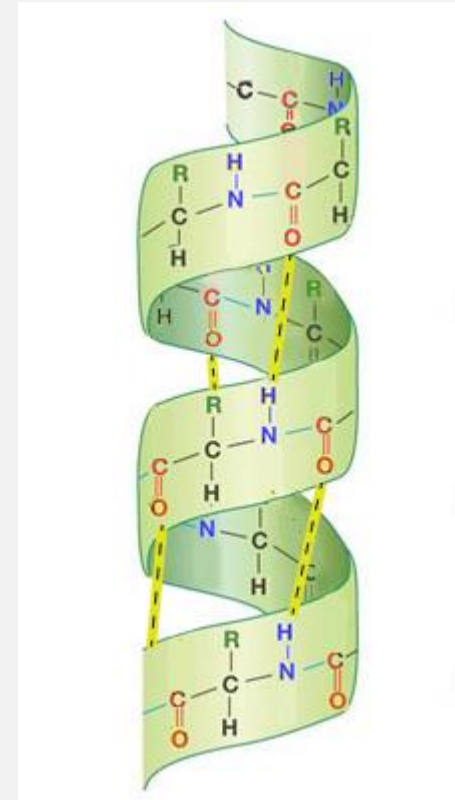


# Secondary Structure

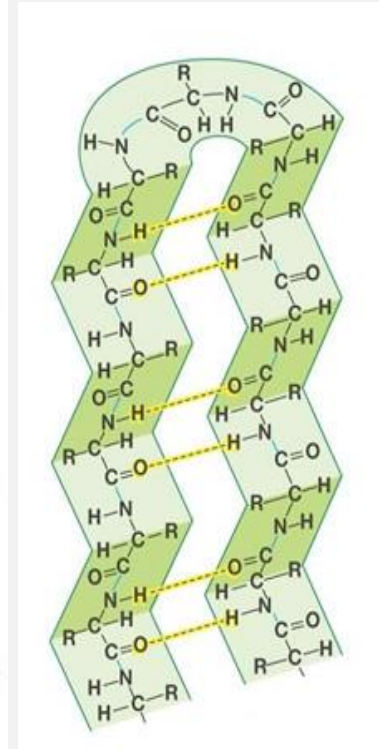
The secondary protein structure depends on the local interactions between parts of a protein chain, which can affect the folding and three-dimensional shape of the protein. The most common types of secondary structures are the:

**$\alpha$ -helix:** the carbonyl (C=O) of one amino acid is hydrogen bonded to the amino H (N-H) of an amino acid that is four down the chain. This pattern of bonding pulls the polypeptide chain into a helical structure that resembles a curled ribbon.

**$\beta$ -pleated sheet:** N-H groups in the backbone of one strand form hydrogen bonds with C=O groups in the backbone of a fully extended strand next to it.



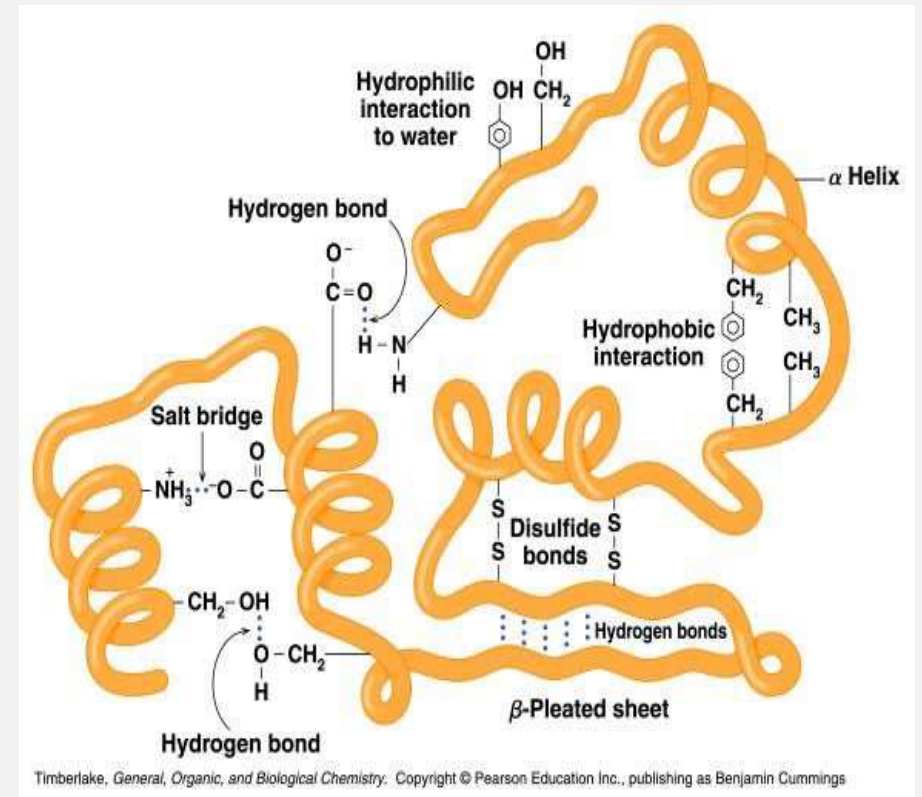
$\alpha$ -helix



$\beta$ -pleated sheet

# Tertiary structure

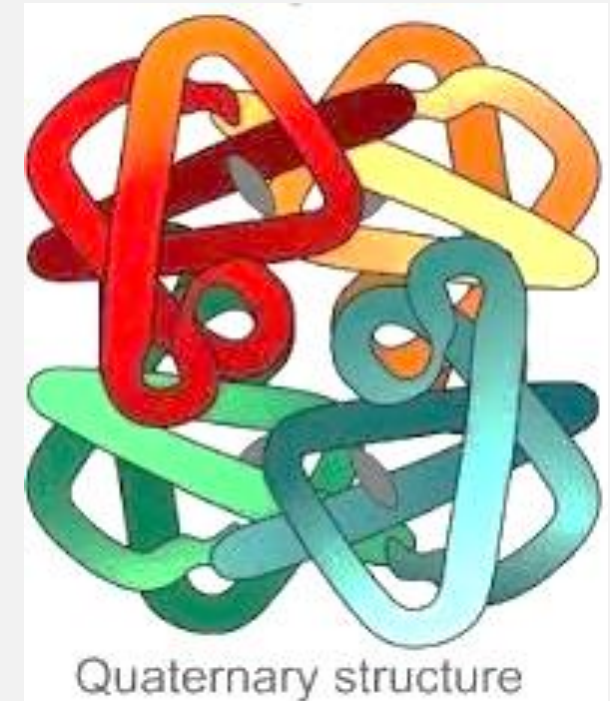
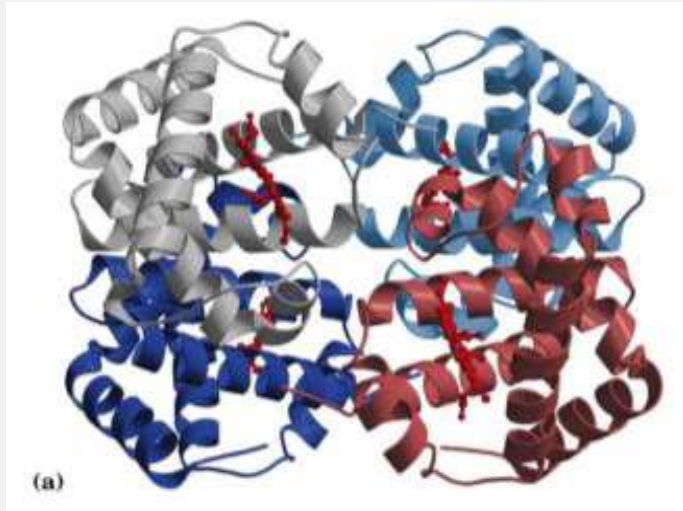
- The overall three-dimensional structure of a polypeptide is called its tertiary structure.
- The tertiary structure is primarily due to interactions between the R groups of the amino acids that make up the protein.



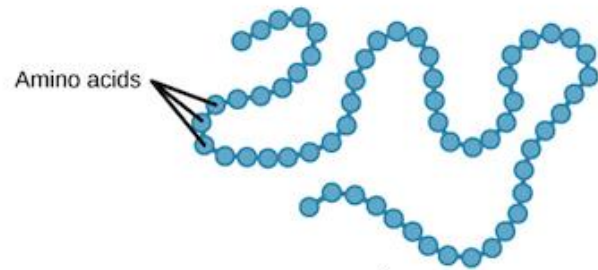
# Quaternary structure

Many proteins are composed of multiple polypeptide chains. The organization of these polypeptides is called the quaternary structure.

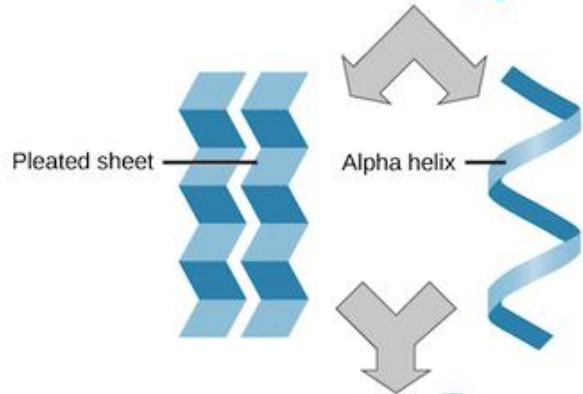
Hemoglobin (Hb) is shown as an example







**Primary protein structure**  
sequence of a chain of amino acids



**Secondary protein structure**  
hydrogen bonding of the peptide backbone causes the amino acids to fold into a repeating pattern



**Tertiary protein structure**  
three-dimensional folding pattern of a protein due to side chain interactions

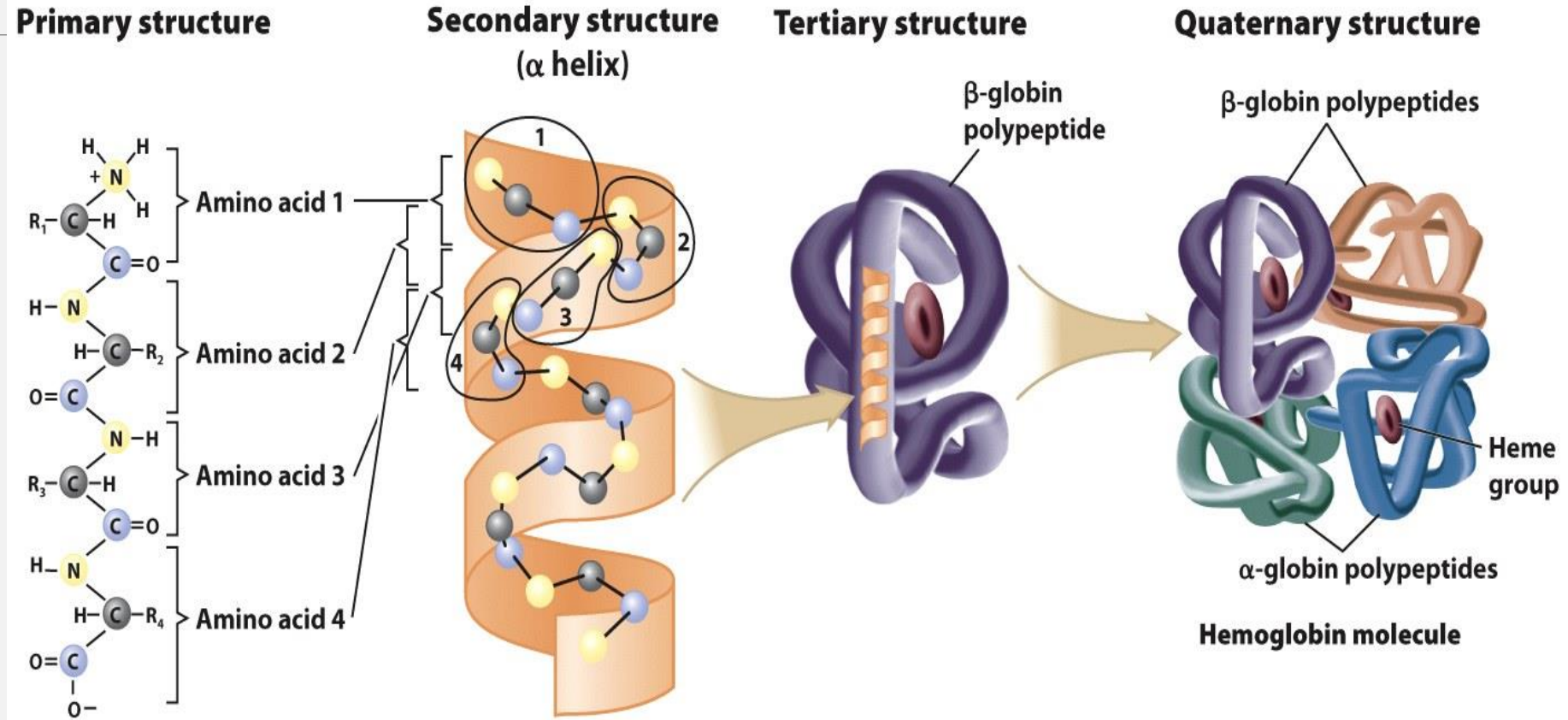


**Quaternary protein structure**  
protein consisting of more than one amino acid chain

# Summary of structural levels

Structural Level	Characteristics
Primary	The sequence of amino acids
Secondary	The coiled $\alpha$ -helix, $\beta$ -pleated sheet, or a triple helix formed by hydrogen bonding between peptide bonds along the chain
Tertiary	A folding of the protein into a compact, three-dimensional shape stabilized by interactions between side R groups of amino acids
Quaternary	A combination of two or more protein subunits to form a larger, biologically active protein

# Levels of Protein Structure



Alberts, B., et al., *Molecular Biology of the Cell*, 3/e, page 114. New York: Garland Publishing Inc., 1994.

# Mechanism of protein synthesis

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➤ The process of protein synthesis takes place in two steps:

Transcription

Translation