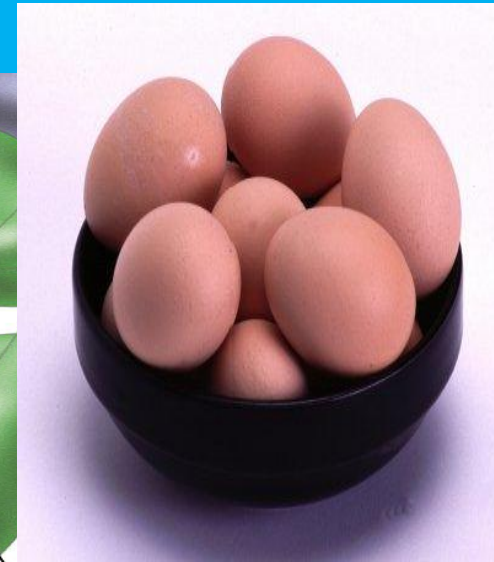
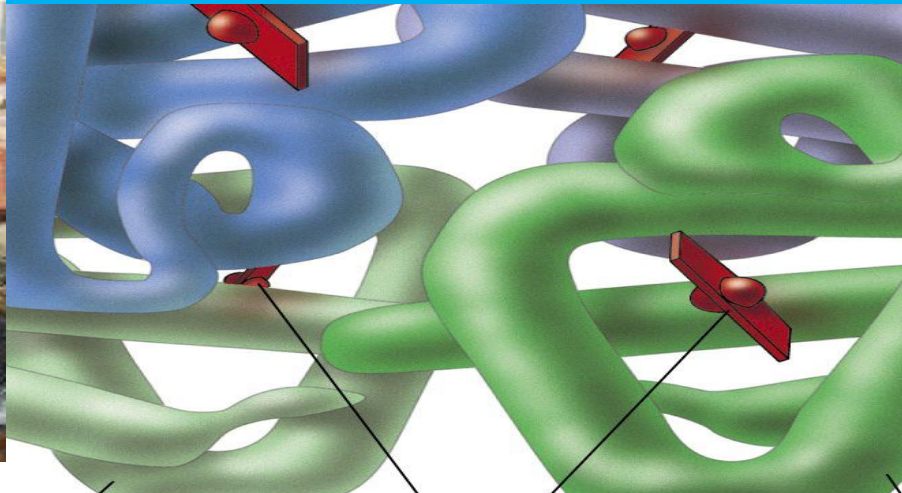


# AMINO ACIDS & PROTEINS

## 211 Chem



By

**Prof. ENTSAR ALI SAAD, Ph.D.**

2020

# ***Protein structures***

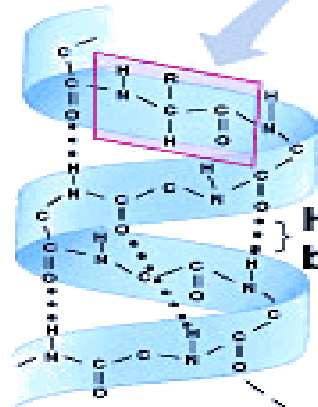
- In its **native state**, each protein molecule that consist of a single polypeptide chain has a characteristic three-dimensional (**3D**) shape.
- There are four levels of protein structure: **primary**, **secondary**, **tertiary** and **quaternary**

# Protein Structures



Amino acid

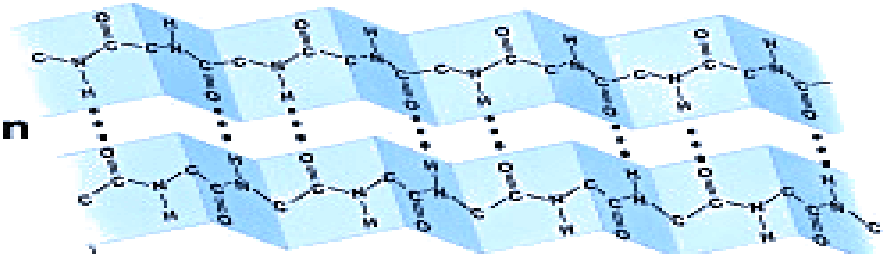
Primary structure



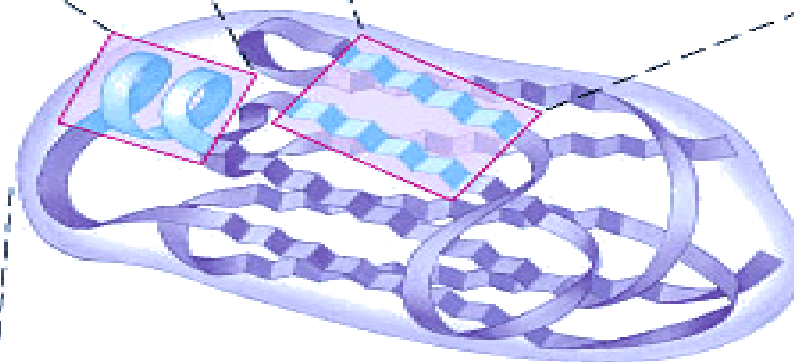
Hydrogen bond

Alpha helix

Secondary structure

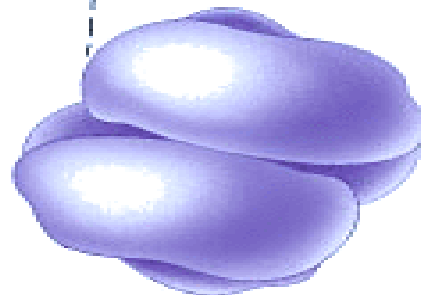


Pleated sheet



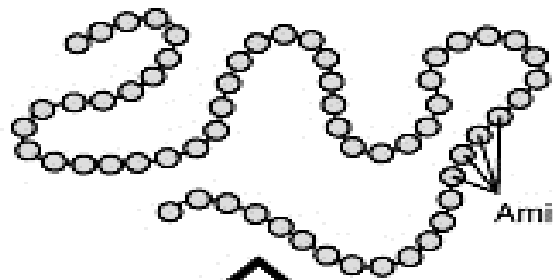
Polypeptide  
(single subunit  
of transthyretin)

Tertiary structure



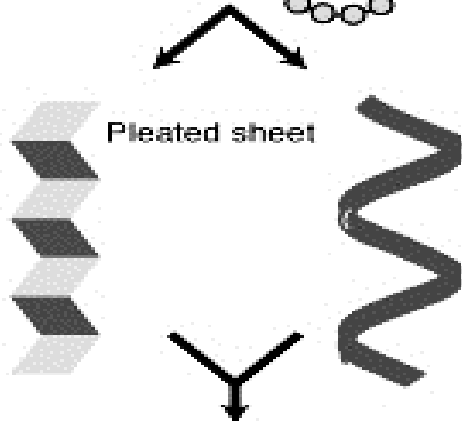
Transthyretin, with four  
identical polypeptide subunits

Quaternary structure



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

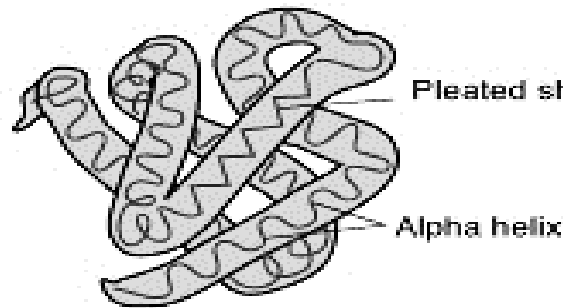
Amino Acids



Pleated sheet

Alpha helix

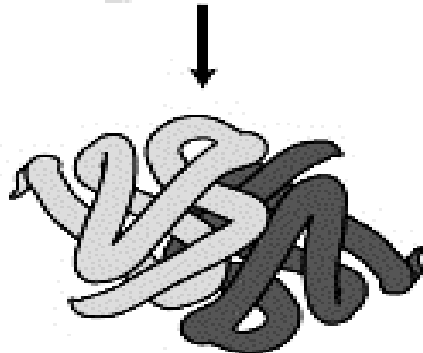
**Secondary protein structure**  
occurs when the sequence of amino acids  
are linked by hydrogen bonds



Pleated sheet

Alpha helix

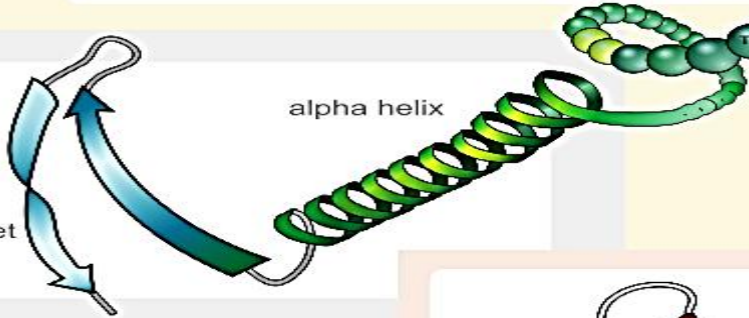
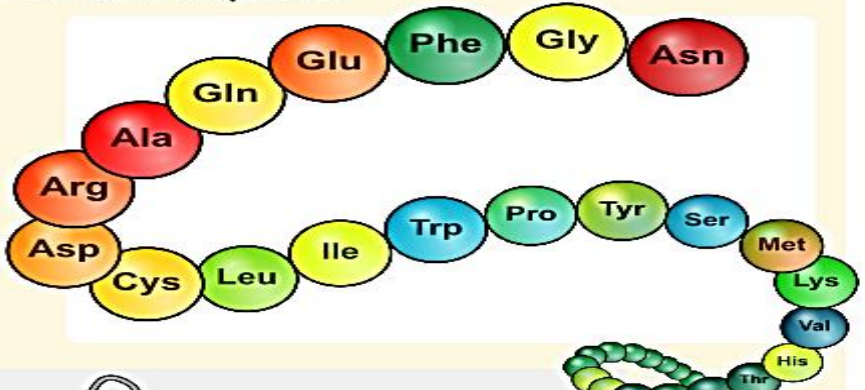
**Tertiary protein structure**  
occurs when certain attractions are present  
between alpha helices and pleated sheets.



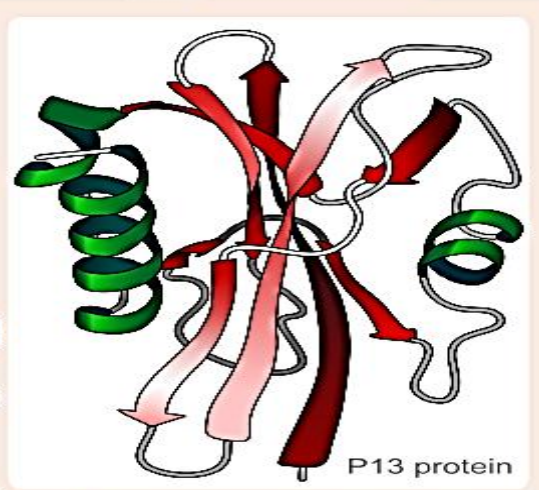
**Quaternary protein structure**  
is a protein consisting of more than one  
amino acid chain.

# Protein Structures

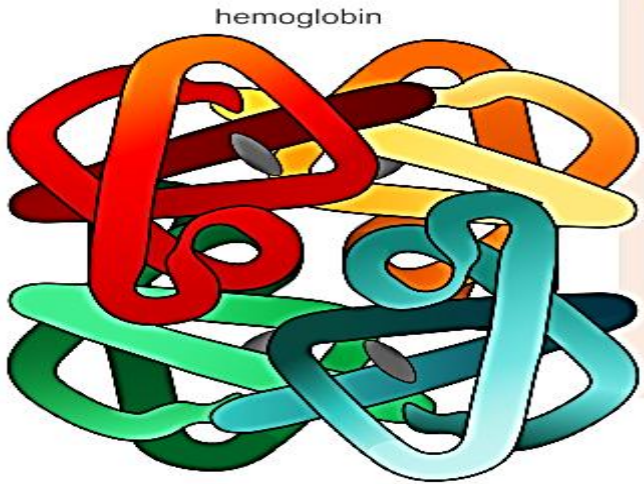
Primary structure  
amino acid sequence



Secondary structure  
regular sub-structures



Tertiary structure  
three-dimensional structure



Quaternary structure  
complex of protein molecules

# Protein Structures

# *Protein structures*

## **Primary structure of protein**

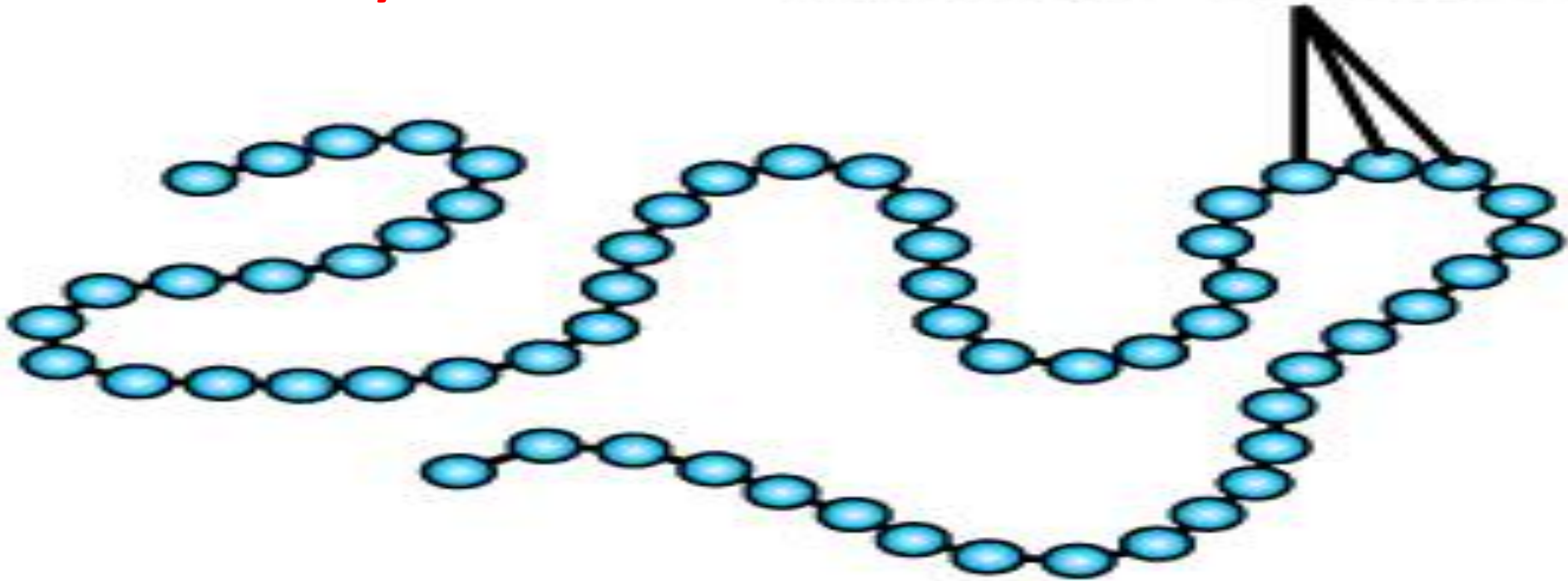
The primary structure of a protein is the unique sequence of amino acids in a polypeptide chain.

- The bonds responsible for stabilization of the primary structure are the **peptide bonds** between each amino acid.
- The polypeptide chain starts on the left side by amino acid number 1, which contains a free amino group (terminal amino group) and termed **N-terminus amino acid**.
- On the right side, at the end, the chain contains an amino acid with a free carboxylic group (terminal carboxylic group) and termed **C-terminus amino acid**.



# Protein Primary Structure

amino acids



## Primary Protein Structure

Sequence of a chain of amino acids

# *Protein structures*

## **Secondary structure of protein**

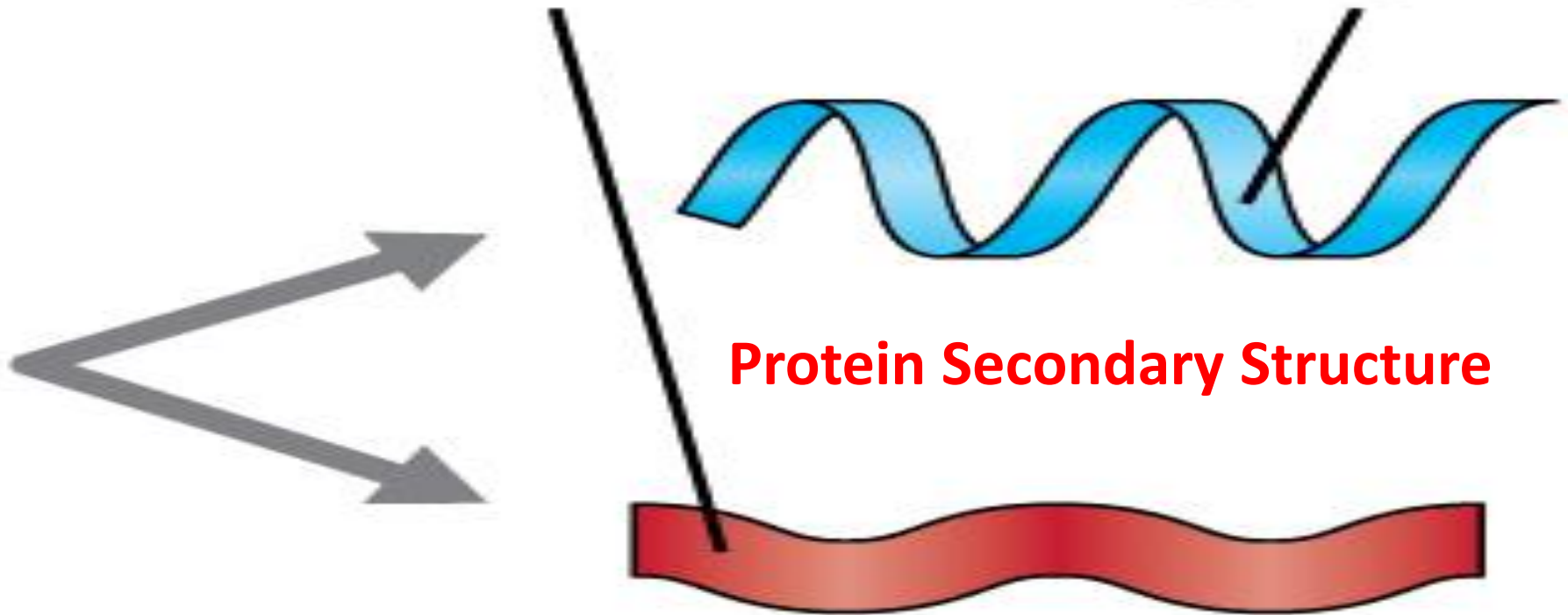
The local folding of the polypeptide in some regions gives rise to the secondary structure of the protein.

- There are two common shapes formed:
  - a)  ***$\alpha$ -helix*** and b)  ***$\beta$ -pleated sheet***
- The two shapes are very regular and exist as a result of **hydrogen bonds** between side chains that occur at regular intervals along the primary structure.



$\beta$ -pleated sheet

$\alpha$ -helix



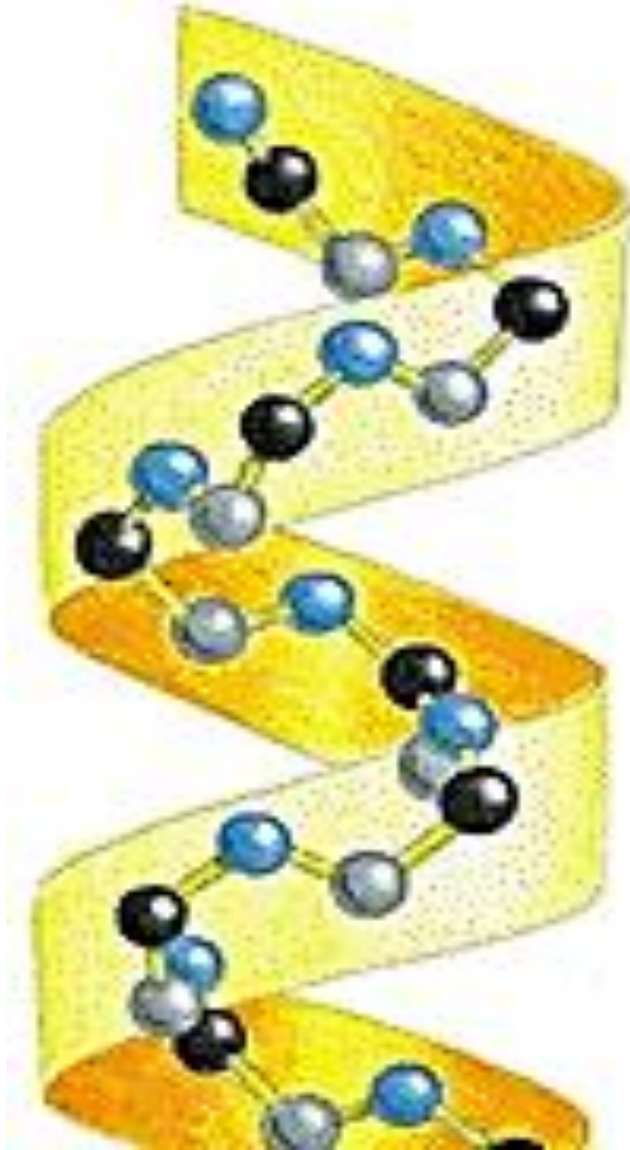
Protein Secondary Structure

## Secondary Protein Structure

Local folding of the polypeptide chain into helices or sheets

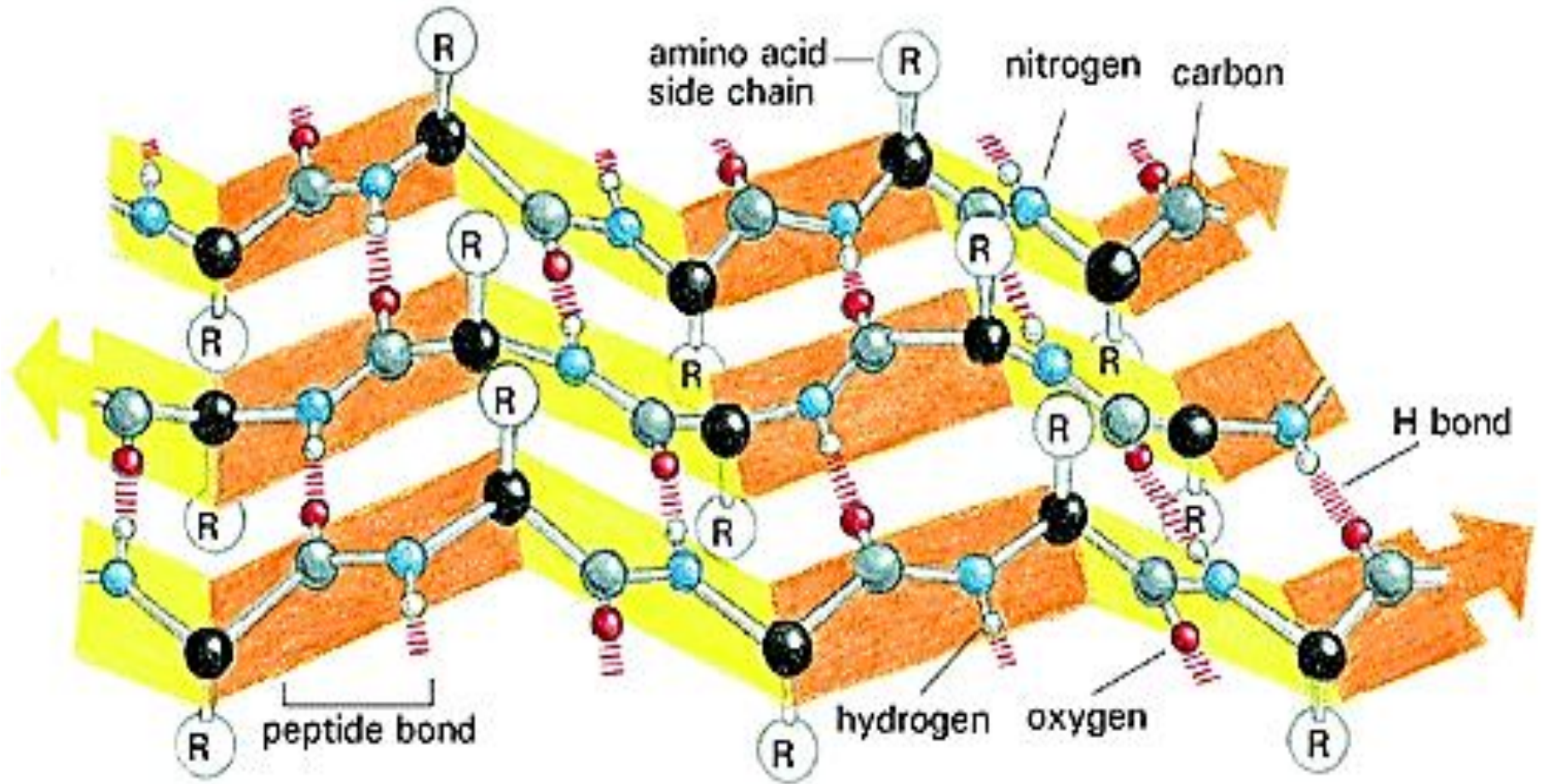
# Common Secondary Structure Elements

## $\alpha$ -helix



# Common Secondary Structure Elements

## $\beta$ -pleated sheet



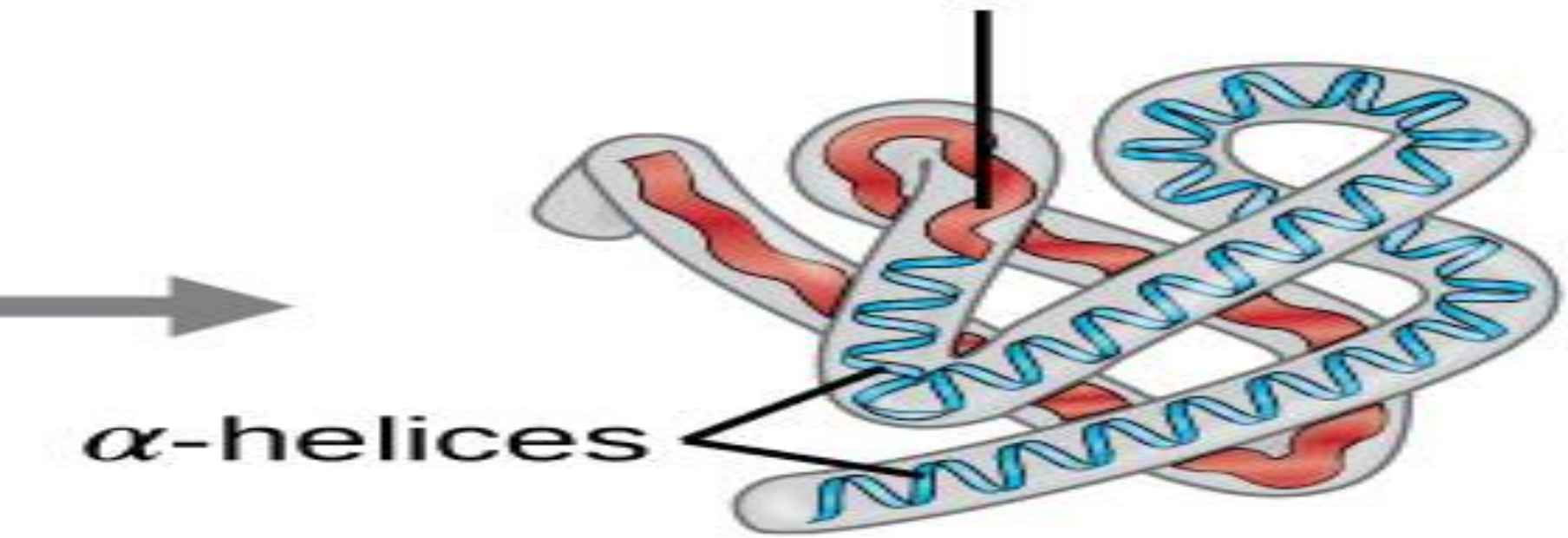
## Tertiary structure of protein

Tertiary structure is the result of further bonding between side chains within the protein and with any water that may be present around the protein.

- **Polar** amino acids move to the **outside** of the shape and **non-polar** amino acids move to the **inside** when placed in a **polar solution**.



# Protein Tertiary Structure



## Tertiary Protein Structure

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

## *Interactions (bonds) stabilize the tertiary structure*

**1) Disulfide bonds** formed between sulfur atoms in cysteine side chains.



**2) Ionic bonds** formed between acidic and basic side chains.



**3) Hydrogen bonds** formed between carbonyl groups and hydroxyl or amino groups.



**4) Hydrophobic interactions** formed between the nonpolar side chains of the amino acids present in the polypeptide chain and usually present in the interior part of the protein molecule.





# Quaternary structure of protein

It is the organization of subunits in a protein with multiple subunits.

- It is the result of the bonding between **two or more** polypeptide chains.
- Each polypeptide chain is called **subunit (monomer)**.
- The subunits of the protein complex may be **identical** or **different**.
- Subunits associate to form **dimers, trimers, tetramers** etc. (**oligomer**)

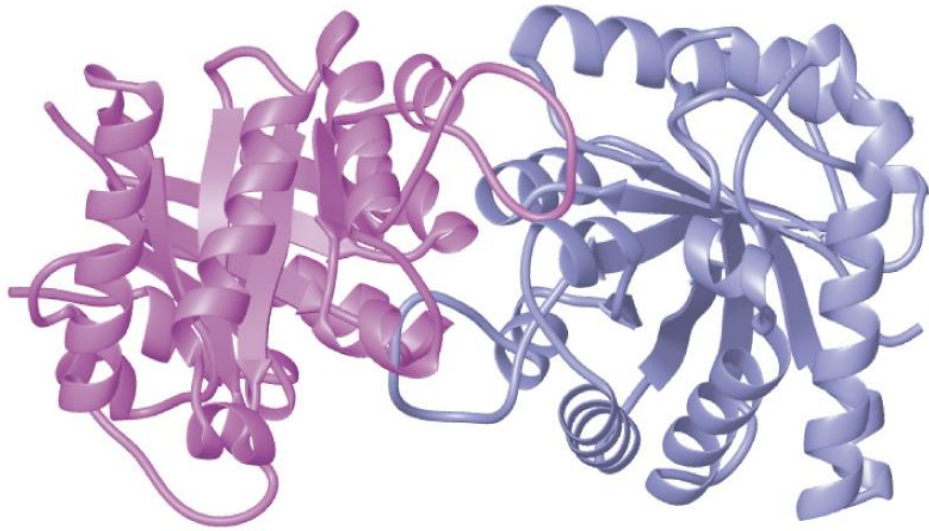
# Protein Quaternary Structure



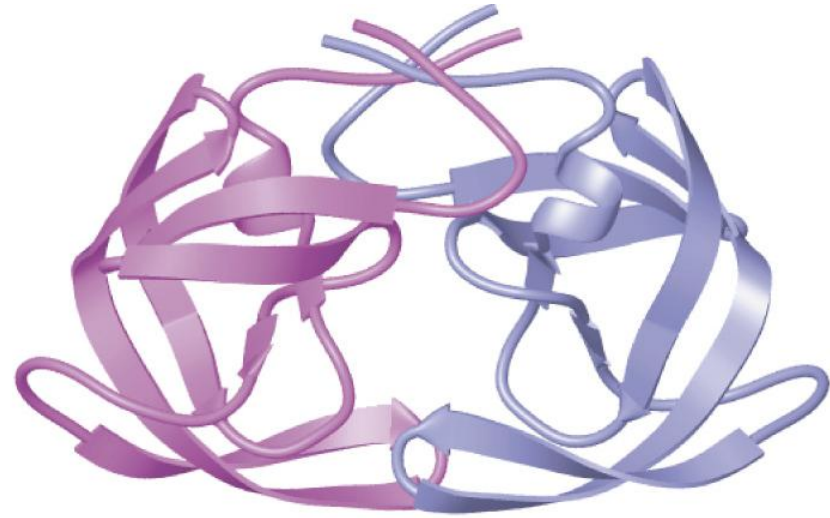
## **Quaternary Protein Structure**

protein consisting of more than one amino acid chain

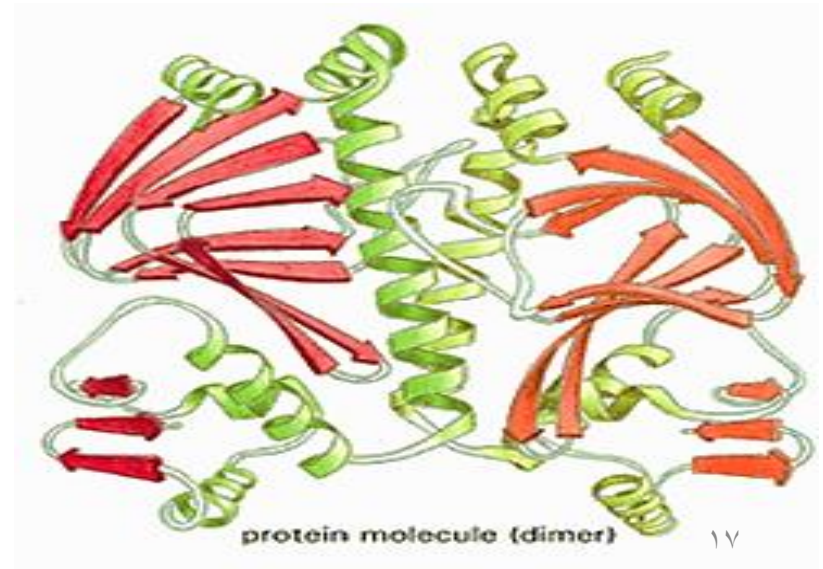
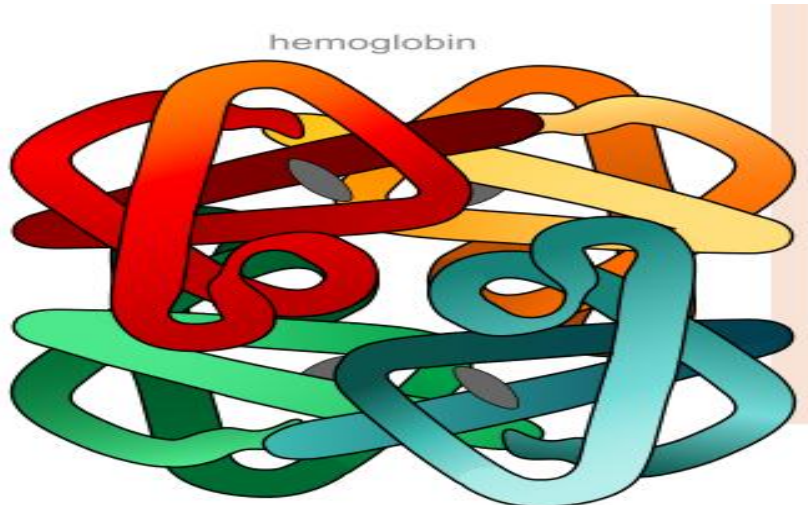
# Examples of Protein Quaternary Structure



Chicken triose phosphate isomerase



HIV-1 aspartic protease



# *Interactions (bonds) stabilize the quaternary structure*

Bonds formed and stabilized the quaternary structure are new further similar **as those found in the tertiary structure** of proteins.

**1) Disulfide bonds** formed between sulfur atoms in cysteine side chains.



**2) Ionic bonds** formed between acidic and basic side chains.



**3) Hydrogen bonds** formed between carbonyl groups and hydroxyl or amino groups.



**4) Hydrophobic interactions** formed between the nonpolar side chains of the amino acids present in the polypeptide chain and usually present in the interior part of the protein molecule.

