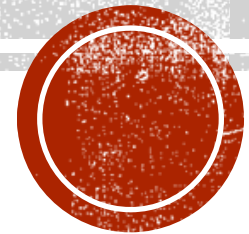
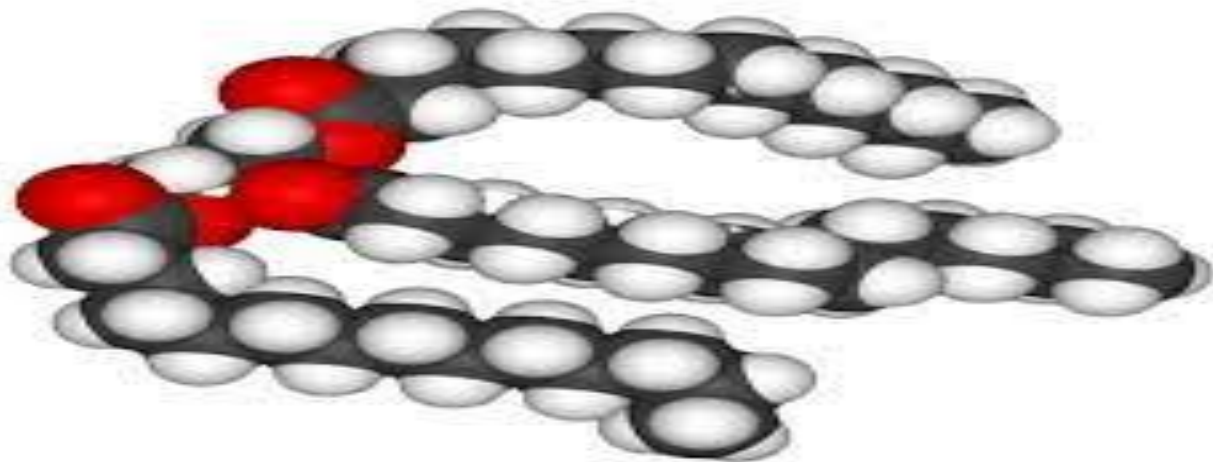


Protein & amino acids Chemistry



Students Learning Outcomes

❖ *By the end of this lecture, the students should be able to:*

1. **Describe the general structure of amino acids**
2. **Classify amino acids according to chemical , nutritional and metabolic classification**
3. **List the biological importance of proteins**
4. **Describe the general structure of proteins**
5. **Classify proteins**
6. **Summarize the characteristics of each type of the proteins**



Contents

I. Amino acids

- 1) Definition**
- 2) General Structure**
- 3) Classification**
 - a) Chemical classification
 - b) Nutritional classification
 - c) Metabolic classification

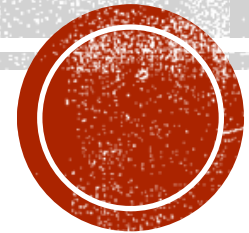
II. Protein

- 1. Definition**
- 2. General structure**
- 3. Biological importance**
- 4. Classification**
 - a) Simple protein
 - b) Conjugated protein
 - c) Derived protein



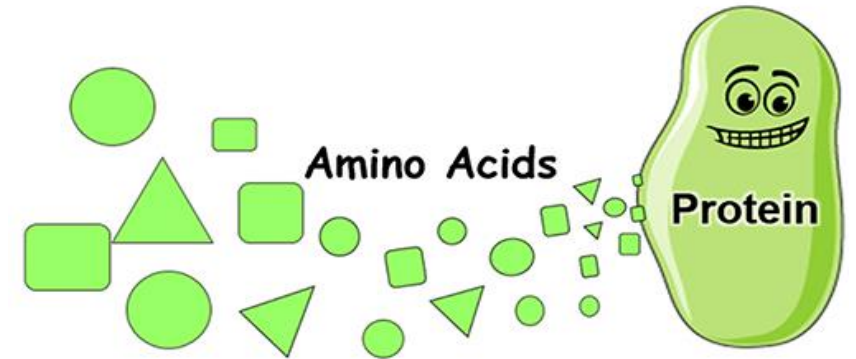
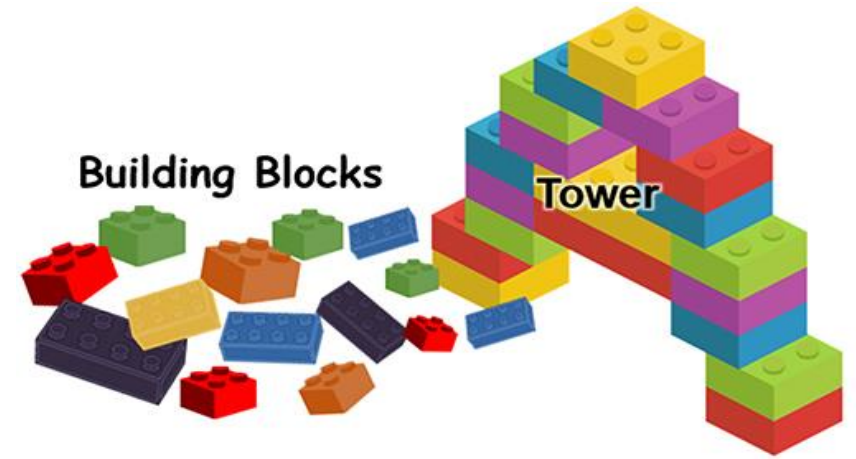
Amino acids

- 1. Definition**
- 2. General Structure**
- 3. Classification**



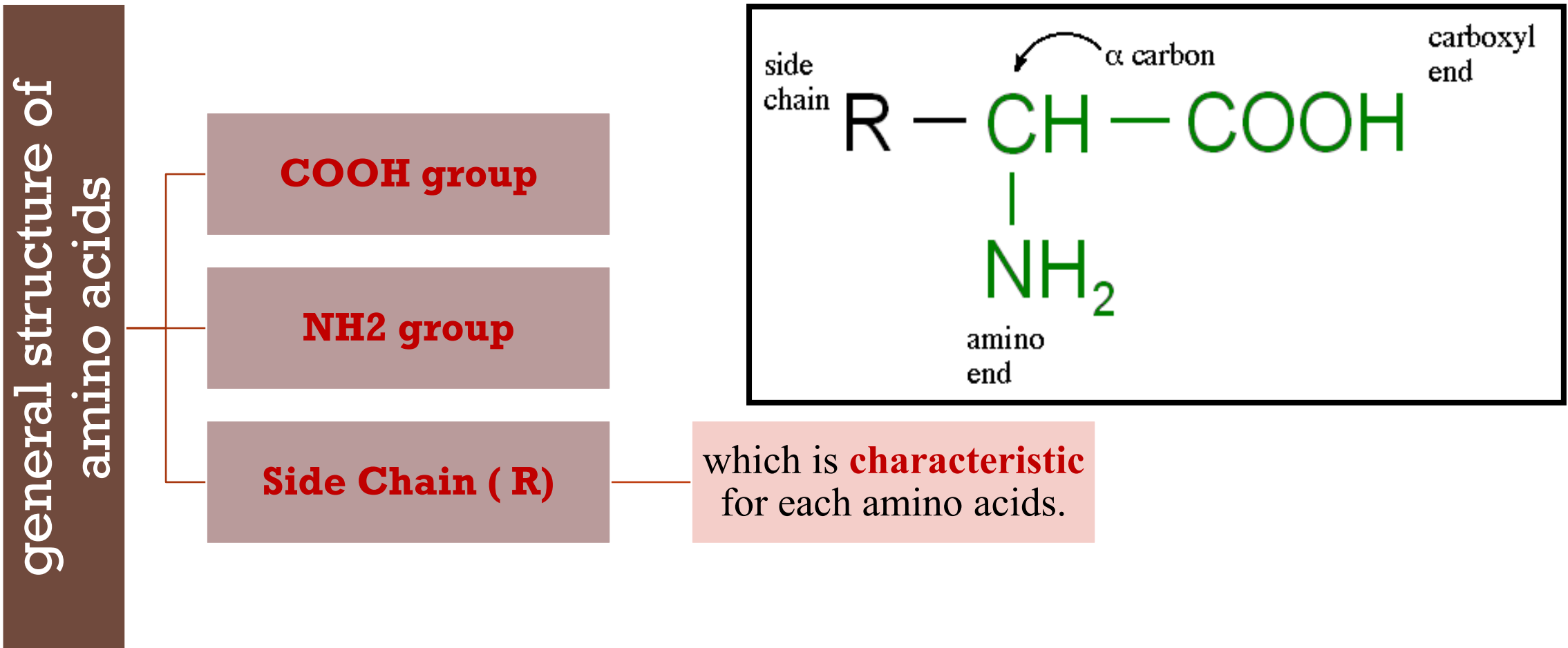
1. Definition of amino acids

- ✓ Amino acids are the **structural units** (building block) of proteins.
- ✓ **They** are obtained from protein by acid , alkali or enzymatic hydrolysis.
- ✓ There are **20** known amino acids
(**21** after adding **selenocysteine aa**)



2. General structure of amino acids

Each amino acid has the following groups or chain:



3. Classification of Amino Acids

Three classifications for amino acids:

A) Chemical classification	B) Nutritional classification	C) Metabolic classification
1. Neutral 2. Acidic 3. Basic	1. Essential 2. Non-essential	1. Glucogenic 2. Ketogenic 3. Mixed glucogenic & ketogenic

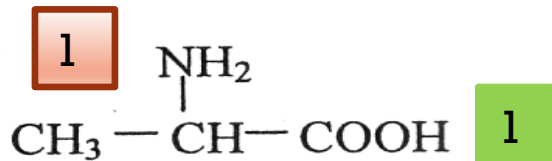


A) Chemical classification of AAs

According to the number of amino group and carboxylic group

Neutral AA

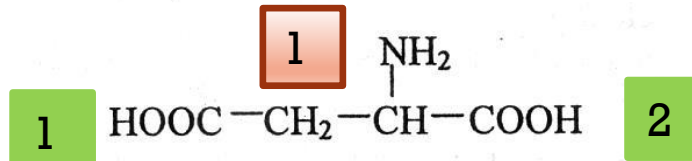
NH₂ = COOH
(Neutral)



Glycine, alanine, valine, leucine,
isoleucine.
Cysteine, cystine, methionine
phenylalanine, tyrosine, tryptophan]

Acidic AA

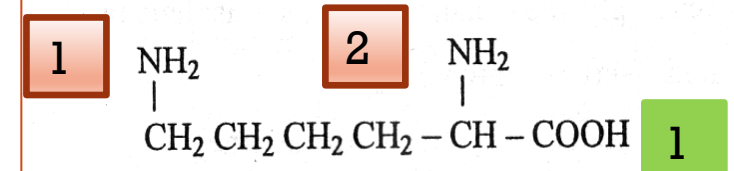
COOH > NH₂
(carry -ve charge)



Acids:
Aspartic acid
Glutamic Acids

Basic AA

NH₂ > COOH
(carry +ve charge)



AHLy: A: Arginine
H: Histidine
L: Lysine



B) Nutritional classification of AA

Essential AA	Non-essential AA
They are not synthesized in the body They should be taken in diet	They are synthesized in the body. They are not essential to be taken with diet.
Try This VIP Mall ✓ 1- Try: tryptophan ✓ 2- This (threonine, histidine) ✓ 3- VIP (Valine, isoleucine, phenylalanine) ✓ 4- Mall (Methionine, arginine, leucine, lysine)	The rest of amino acids ✓ Cysteine- cystine ✓ Proline – hydroxyproline ✓ Aspartic- glutamic ✓ Glycine- alanine ✓ Serine –tyrosine
Arginine is a semi essential AA synthesized in our body but in small, nonsufficient amount	



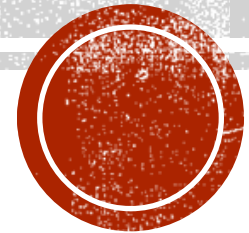
C) Metabolic classification of AAs

	Ketogenic AA	Mixed Glucogenic & ketogenic AA	Glucogenic AA
They are converted to	Ketone bodies only	Carbohydrate & Ketone bodies	Carbohydrate only
Example	Only 2 AA are pure ketogenic : Leucine Lysine	FITTT F: Phenylalanine I: Isoleucine T: Tyrosine T: Tryptophan T: Threonine	The remaining 13 AA are pure glucogenic Alanine, arginine, asparagine, aspartic Glutamic, glutamine, glycine Cysteine, histidine Methionine, proline, serin, Valin



Protein

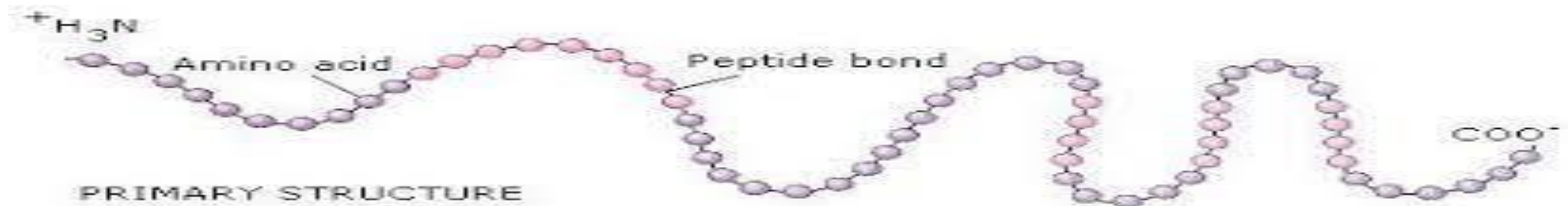
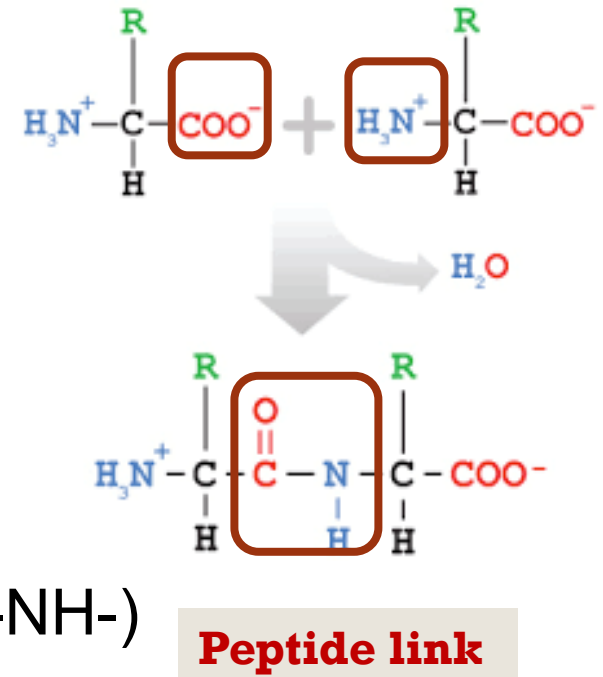
1. **Definition**
2. **Biological importance**
3. **Classification**



1. Definition & general structure of Proteins

Proteins are:

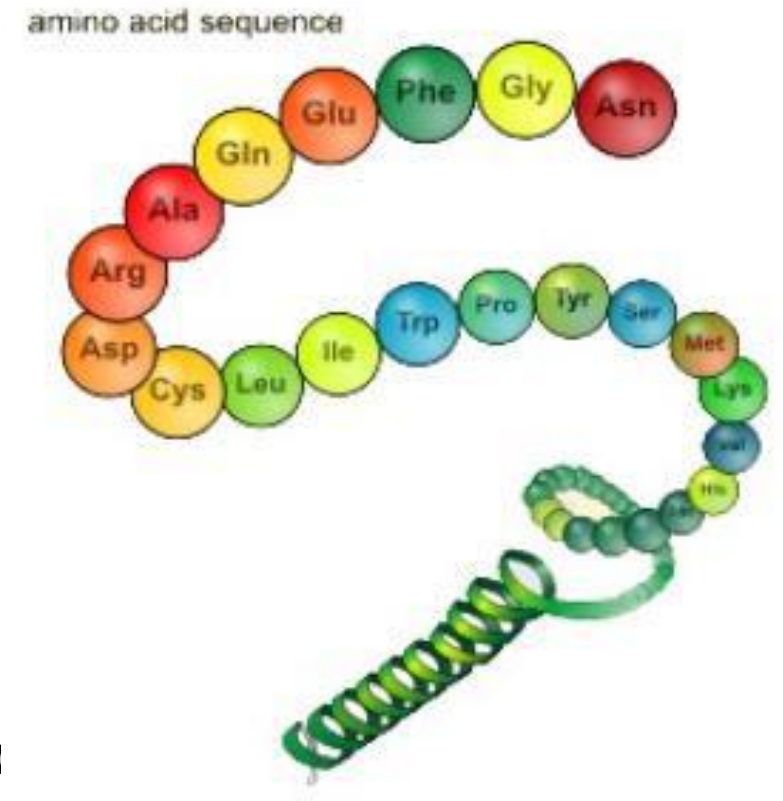
- ❖ Organic complex **nitrogenous** compounds
- ❖ Formed of C, H, O, **N** (+/- S)
- ❖ Forming **polymers** (chains) of amino acids = (polypeptides)
- ❖ The amino acids are connected together by **peptide link** (-CO-NH-)
(where COOH gp of the **1st AA** unites with the **NH₂** gp of the **2nd AA** and so on)
- ❖ Ends of the polypeptide chain:
 - ✓ **COOH group**: at one end → called **C-terminal**
 - ✓ **NH₂ group**: at the other end → called **N-terminal**



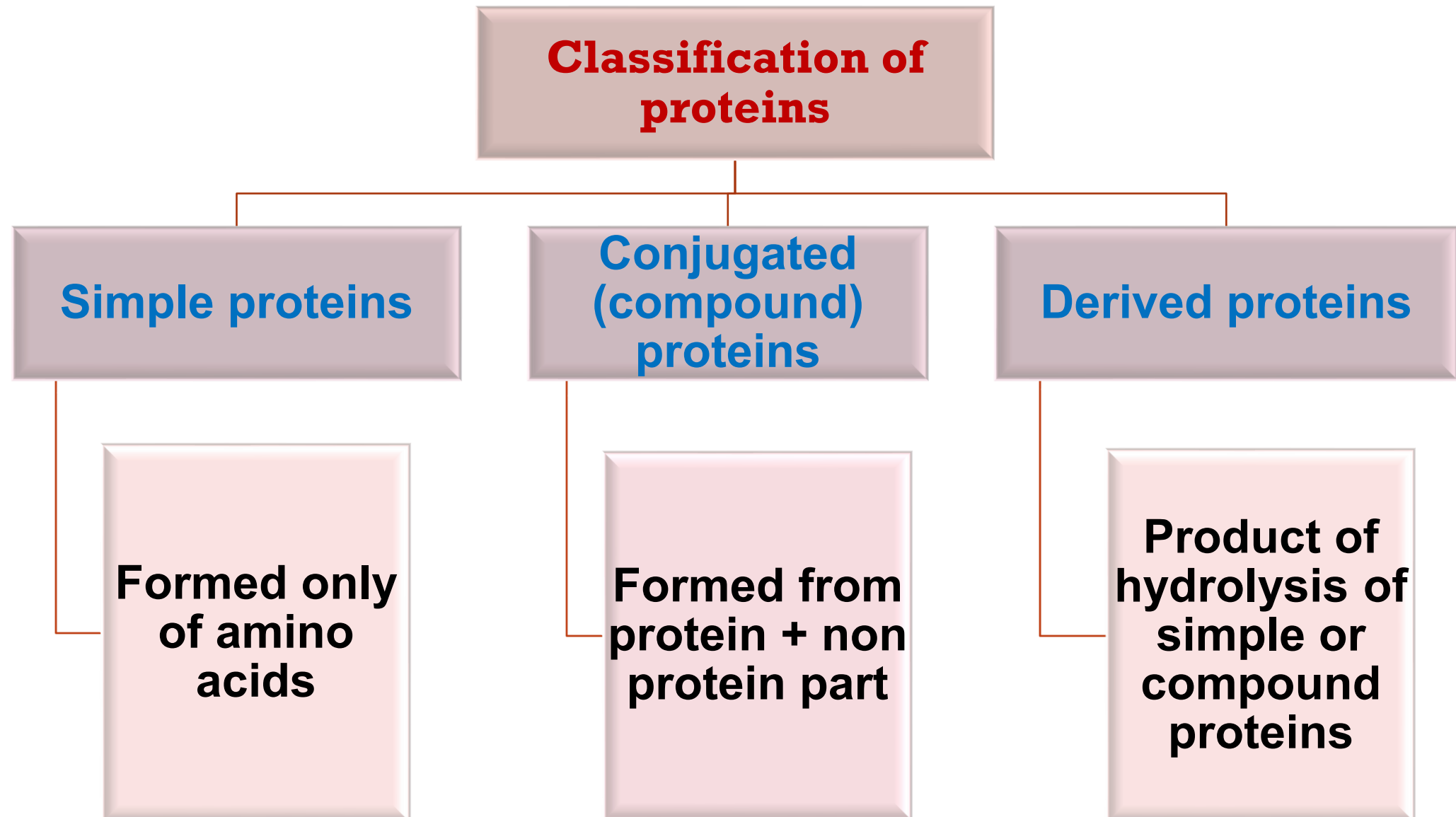
2. Biological importance of Proteins

Formation of:

1. Enzymes
2. Hormones (protein hormones)
3. Hemoglobin
4. Plasma protein (lipoproteins)
5. Immunoglobulins (antibodies)
6. Supporting structure (cartilage, skin, nail, hair, etc)



3. Classification of protein



A) Simple proteins

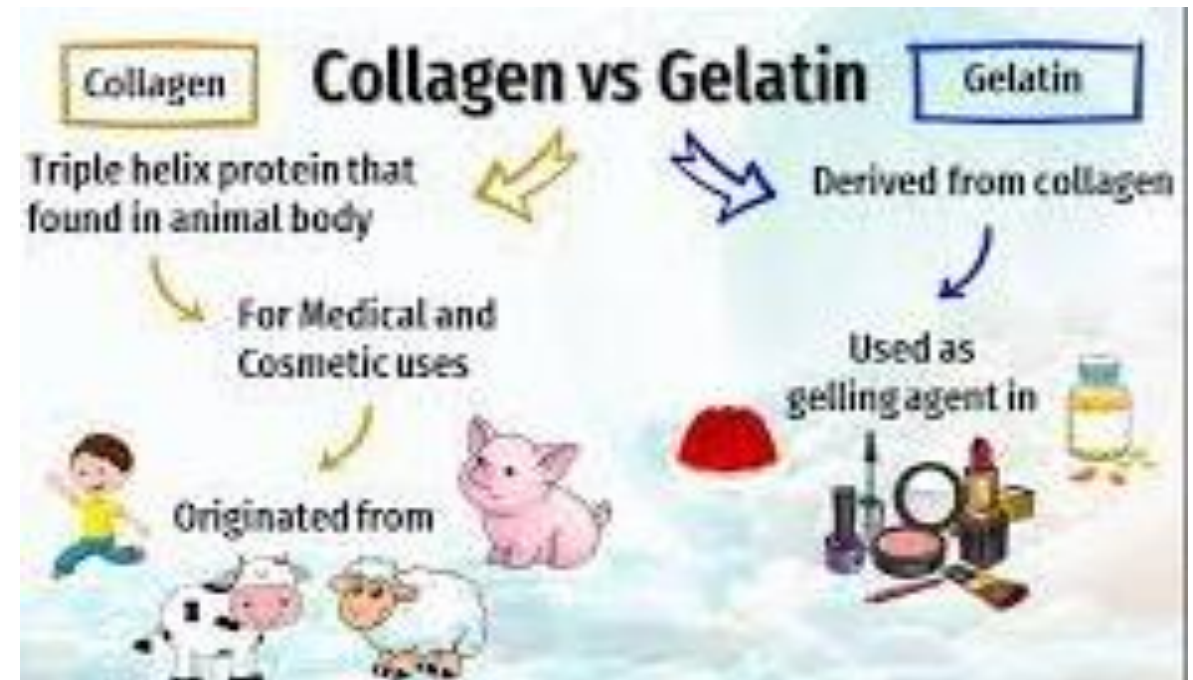
Definition: They are proteins that on hydrolysis gives **only amino acids**

Types : (7): Albumin, Globulin, Histone, Glutelin, Prolamin, Protamine, Albuminoids

Albumin	Globulin	Histones	Albuminoids (scleroproteins) (4 not)	
			Keratin	Collagen
1. Egg : egg albumin 2. milk : lactalbumin 3. Blood : serum albumin	1. Egg : egg globulin 2. milk : lactoglobulin. 3. Blood : serum globulin	1. Globin of Hemoglobin 2. With Nucleic acid	Hair, nail,	Skin, connective tissue Tendon, bones
Coagulated by heat Coagulation= change in the structure of protein (from a liquid form to solid or a thicker liquid)		Not Coagulated by heat	(4 NOT) • Not coagulated by heat • Not digested by enzymes • Not soluble • Not in plant • Supportive, protective function • Gelatin**	

Gelatin**

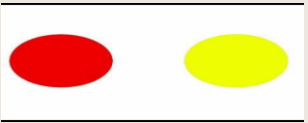
- ✓ Obtained from collagen by boiling
- ✓ Forming gel by cooling
- ✓ Easily digested
- ✓ It is not adequate diet (deficient in some AA **as tryptophan**) .



B) Conjugated (Compound) protein

Definition: They are protein conjugate with non protein part (other groups)

Types of conjugated proteins :(6)

Types	Non protein part	Example	Function
1. Glycoprotein	Carbohydrates	Hormones(FSH,LH) Antibodies, Blood gp A antigen	
2. Lipoproteins	Lipid	Chylomicrons, VLDL, LDL,HDL	Lipid transport in blood
3. Phosphoproteins	Phosphoric acids	Caseinogen	main protein of milk
4. Metalloproteins	Metals Cu, Zn, Fe	a-Ceruloplasmin(Cu) b-Insulin (Zn) c-Ferritin (Fe)	a- carry & store copper (Cu) b- Regulation of blood glucose c- storage of Fe
5. Chromoproteins 	Pigment 1-Hemoproteins (red pigment) 2-Flavoproteins (yellow pigment)	1-Hemoglobin(HB) & Cytochromes 2- FAD/FMN	1-HB: O2 transport 2- Reducing equivalent
6. Nucleoproteins	Nucleic acids 1- DNA 2- RNA	-Chromosome (Histone + DNA) -Ribosome (protein + RNA)	

C) Derived protein

Definition: These are the **denaturated** or **hydrolytic** products of **simple** or **conjugated** proteins.

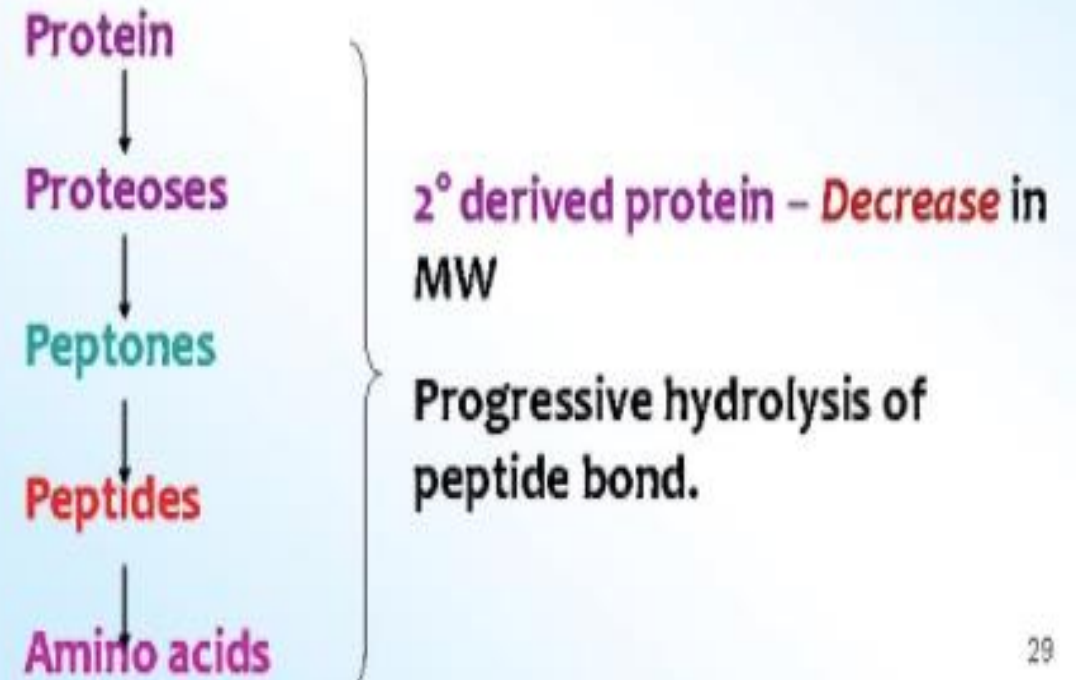
Types of derived proteins: (2)

	1-Primary protein derivatives	2-Secondary protein derivatives
1. Definition	They are Products of protein denaturation	They are Products of protein hydrolysis
2. Derived by	Action of denaturing agents on protein (eg. heat denaturation)	Action of hydrolysing agents on protein (eg. Enzymatic hydrolysis)
3. Peptide bond	No peptide bond break (no change in molecular weight (MW))	Peptide bonds break (decrease in molecular weight)
4. Example	1. coagulated albumin 2. coagulated globulin	1. Proteose 2. peptone 3. peptide. 4. Amino acids

1° derived protein – **denatured protein** by action of denaturing agents. No change in MW
(coagulated protein)

eg. coagulated albumin

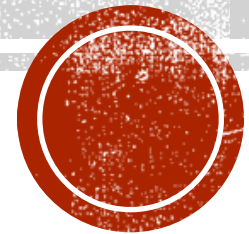
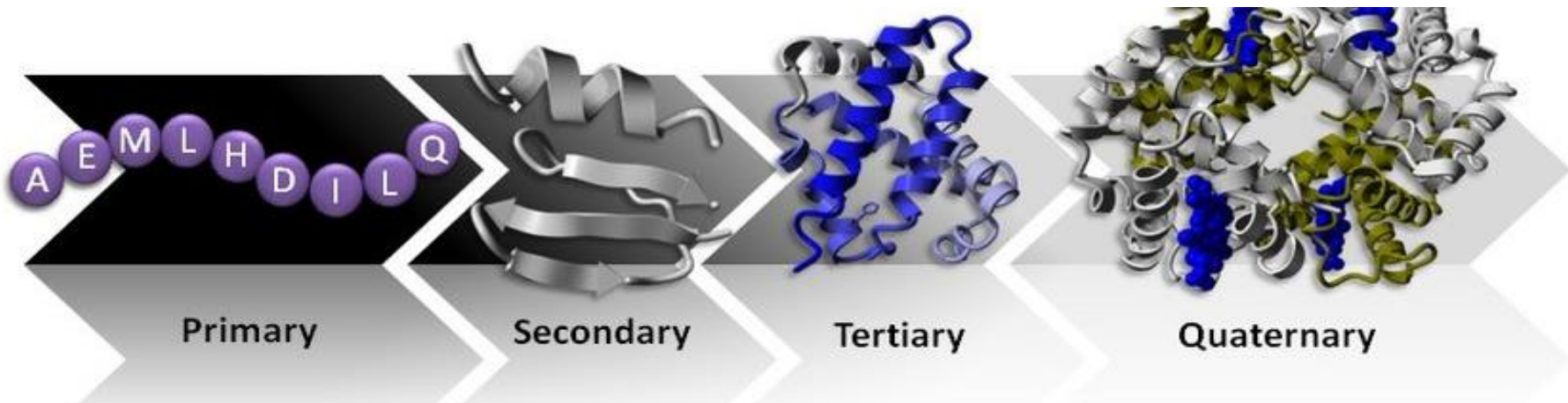
1ry proteins derivatives



2ry proteins derivatives



Protein structure & Protein Folding



Students Learning Outcomes

By the end of this lecture, the students should be able to:

- 1. Describe the different levels of protein structure.**
- 2. List the forces that stabilize the protein structure**
- 3. Identify protein folding and protein misfolding**



Contents

Protein folding

I. Definition

II. Levels of protein structure:

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

III. Protein misfolding



Case Scenario

A 72-year-old male is suffering from forgetting recent events or conversations that started 2 years ago, recently he didn't recognize his close relatives with sever memory impairment and lose the ability to carry out everyday tasks.

1-What is the diagnosis ?

2-Mention the possible cause of this disease



Protein Folding

Definition:

- ✓ Protein folding is a **process by which a polypeptide chain folds to become a biologically active protein in its native 3D structure.**

Importance

- ✓ Protein structure is crucial to its function.

Stabilization of the folded protein

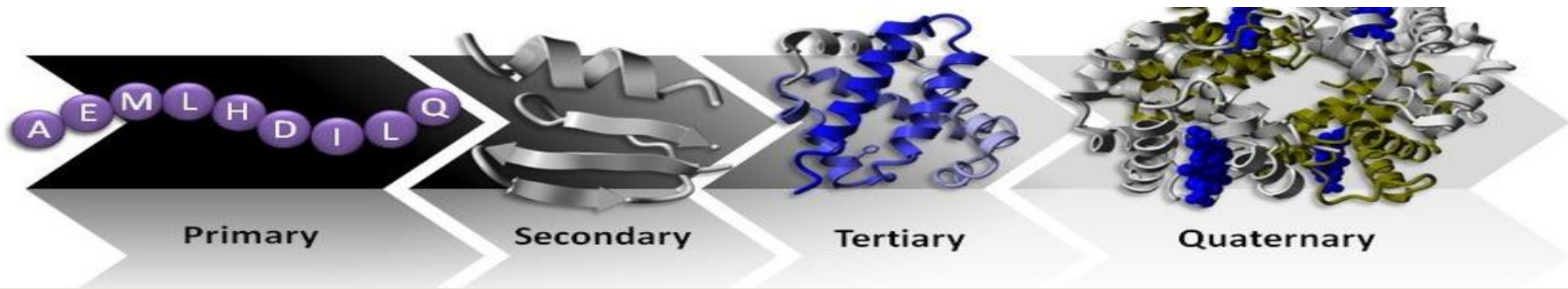
- ✓ Folded proteins are held together by various bonds / forces.

Levels (Stages) of protein folding

- ✓ The folding of a protein is a **complex** process,
- ✓ It involving four stages (**Levels**), arranged, from a primary to quaternary structure.
- ✓ The wide **variation in AAs** sequences → **different** conformations (**shapes**) of proteins

Levels of protein structure

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



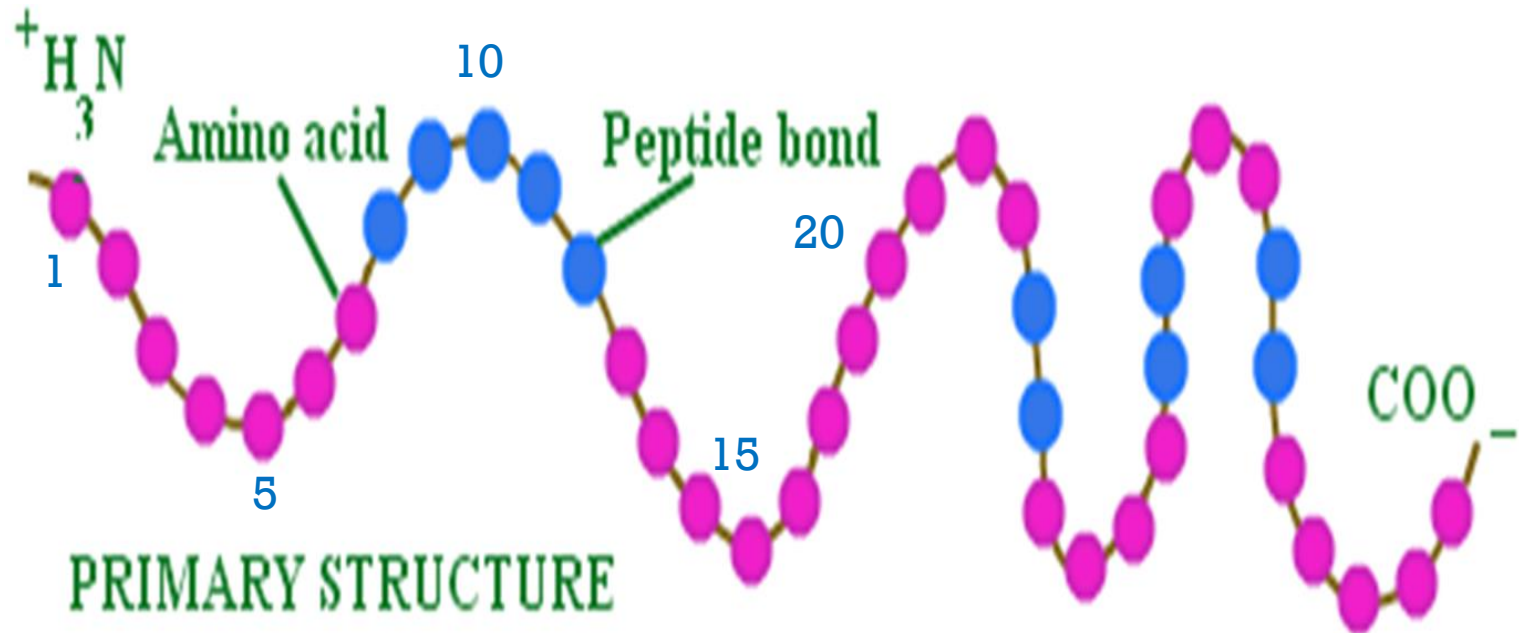
1. Primary structure

- ✓ It is the **number, type and sequence** of AAs in the polypeptide chain.
- ✓ Main bond: **Peptide bond** (-**CO-HN**-)
- ✓ Any **change** in 1 AA → **physiological** defect.
- ✓ The free -**NH₂ group** of the **1st AA** is called as **N-terminal** end
- ✓ The free -**COOH end** of the **last AA** is called as **C-terminal** end
- ✓ We count the AAs from the **N terminal**

N-terminal  C-terminal

NH_2 Amino acid 1 – Amino acid 2 – amino acid 3 – amino acid n – COOH

Primary sequence



2. Secondary structure

1ry structure (The polypeptide chain) will be **folded** by **hydrogen** bonds between **specific atoms** to give a specific **shape /form** which may be:

α -Helix

Shape

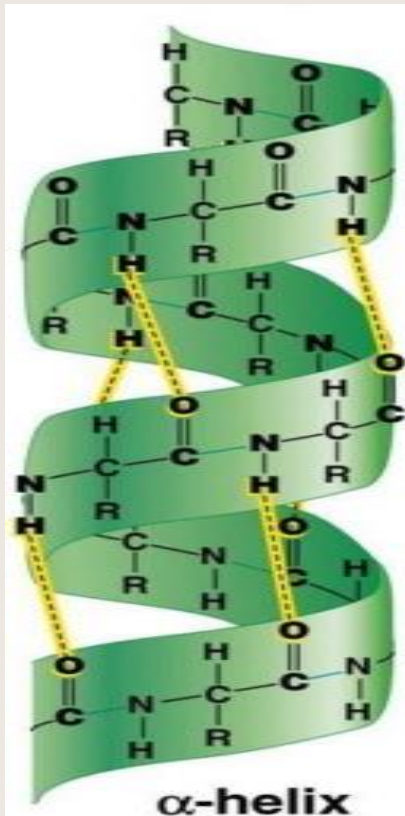
Helix (coiled) peptide chain

- Each turn contains 3.6 AA

Stabilized (held together) by:

Hydrogen bond

- between peptide bonds in the **same chain**



Education, Inc.

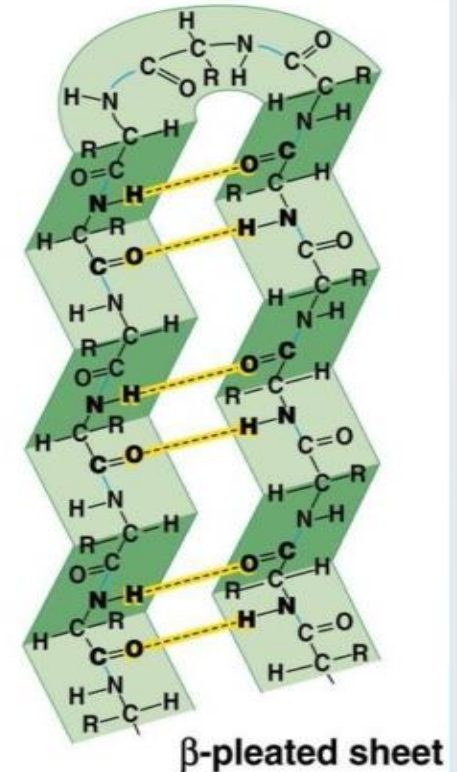
β -Sheets

Pleated (Zigzag) peptide chain

- Arranged side by side

Hydrogen bonds

- between **adjacent 2 polypeptide** chains
- or different segment of the **same chain**

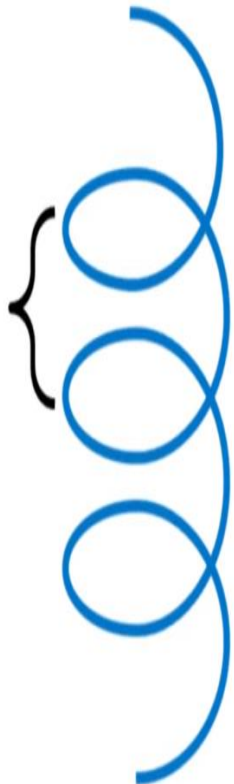


α -Helix

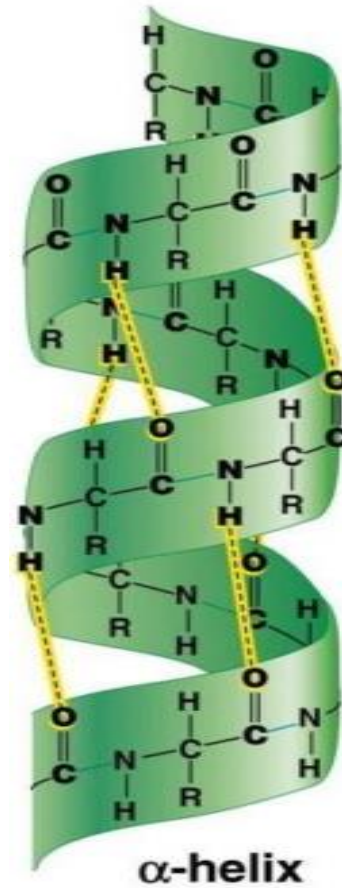
Secondary structure of protein

α Helix

3.6 amino
acid



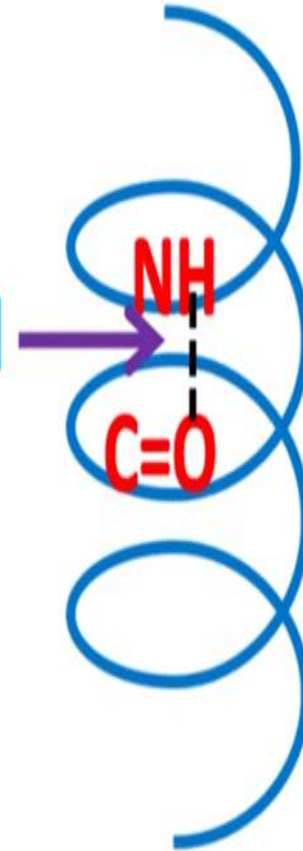
Spiral
structure



α -helix

Education, Inc.

H- bond



Spiral
structure

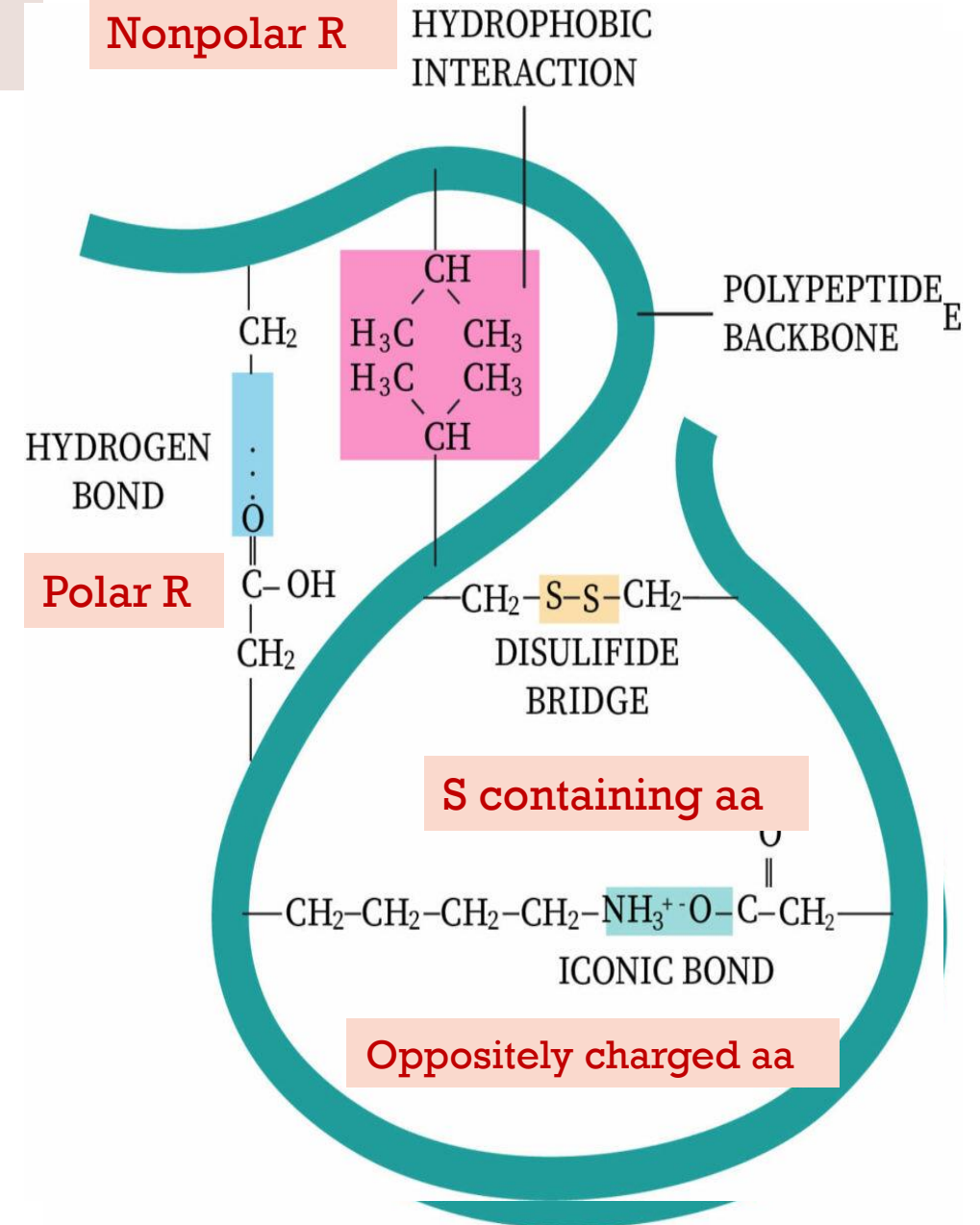
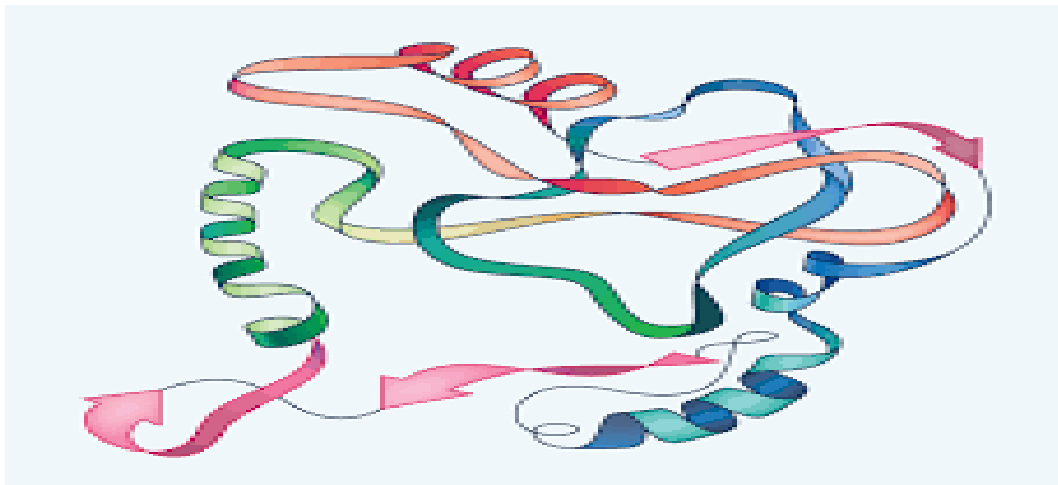
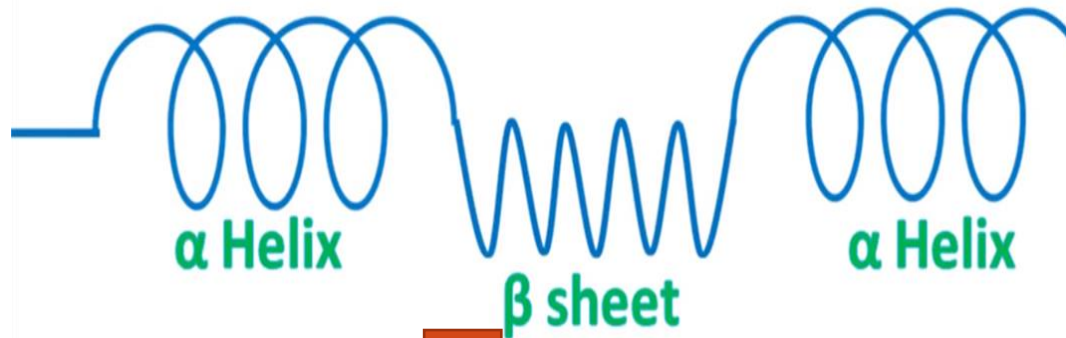


3. Tertiary structure

- ✓ **Definition:** It is three-dimensional (3D) shape of a protein (polypeptide chain)
- ✓ **Formed of :** Secondary structures (α and β) are arranged to form **final functional 3D** structure of protein called **domain**.
 - 3ry structure is the **final order** of organization of protein.
 - The **function of a protein** depend on its tertiary structure → If it is disrupted → protein loses its activity
- ✓ **Bonds (Forces)** stabilizing this 3ry structure
 - Bonds occur due to interaction between **side chains (R)** gp of AAs
 - Several bonds (forces) like:
 1. **Hydrogen bonds:** between **polar** side chains of AA
 2. **Hydrophobic forces:** between the **non-polar (R)** groups of AAs
 3. **Ionic bonds (Electrostatic forces):** between **oppositely charged (R)** of AAs
 4. **Disulfide bonds (Covalent bond) :** between **sulfur AA (cysteine)** .

3ry structure

Secondary



4. Quaternary Structure

✓ Definition:

- it is the association (arrangement) of several polypeptide chains or **subunits** into a closely packed arrangement.
- Each of the subunits has **its own primary, secondary, and tertiary** structure.

✓ Bonds (Forces): The subunits are held together by

1. **Hydrogen bonds**
2. **van der Waals forces** between nonpolar side chains.

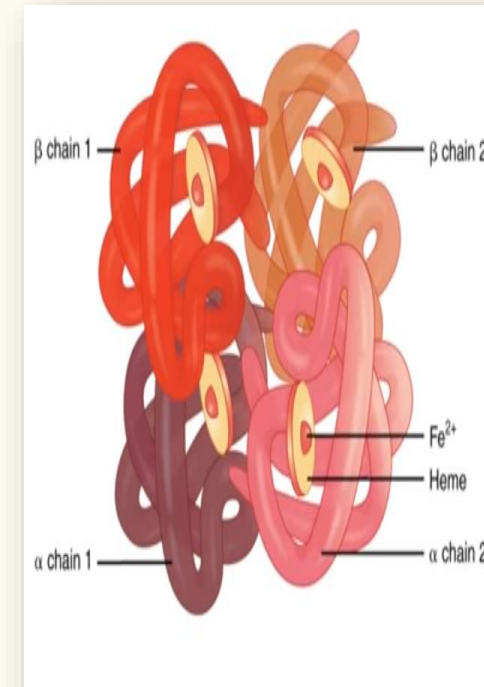
✓ Examples

1-Haemoglobin and lactate dehydrogenase (LDH) enzyme:
are tetramers (formed of 4 subunits)

2. Creatine kinase (CK) enzyme:
is dimer (formed of 2 subunits)

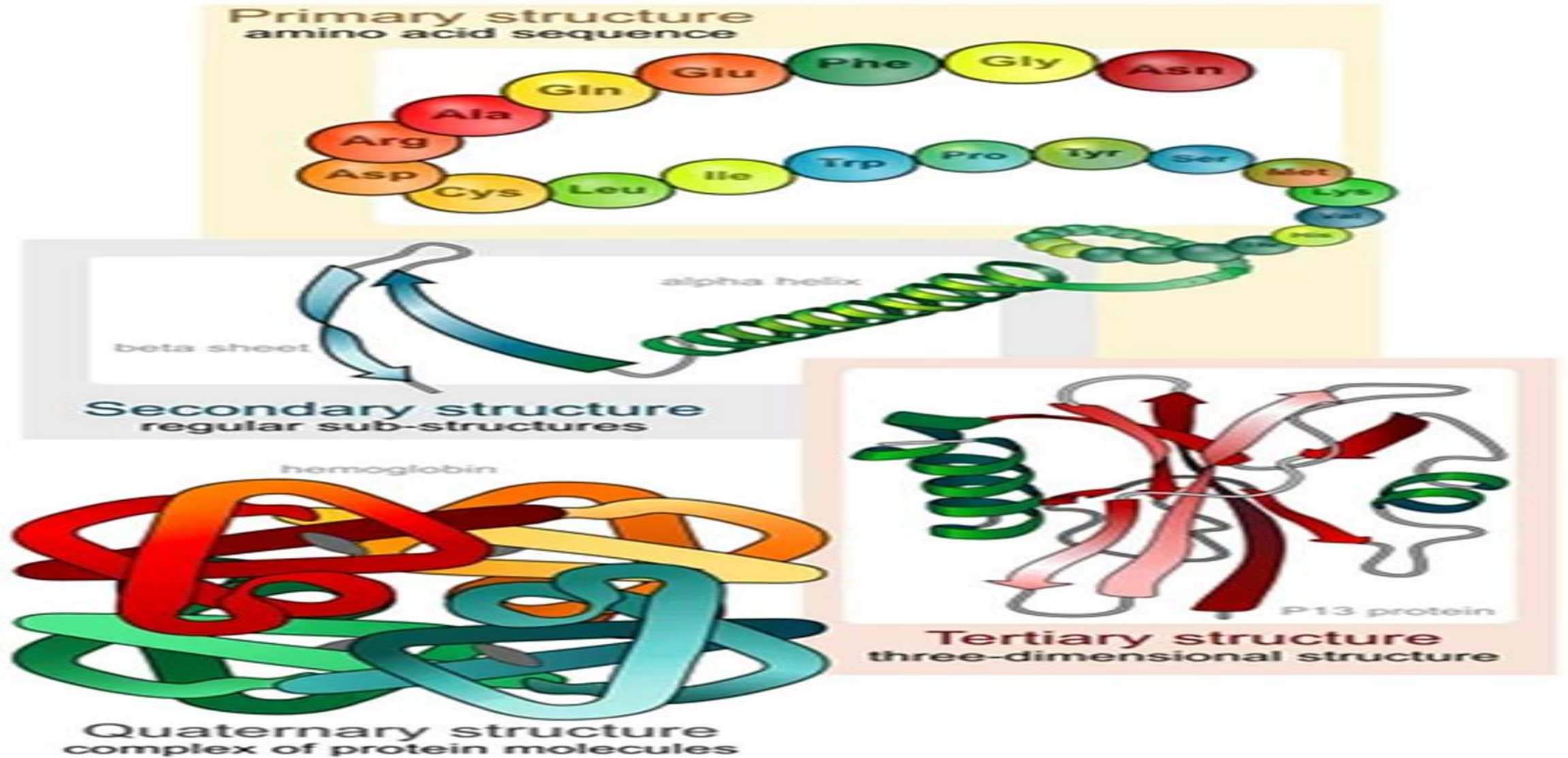


CK dimer



Hb tetramer

Summary



Protein misfolding

Definition

- Proteins that are **not able to form stable 3D structure** recognized as **misfolded proteins**
- **The misfolded protein → aggregates** (large size, insoluble) → loss its structure and function

Example of diseases related to misfolded protein:

1. Alzheimer's disease

- characterized by **dense plaques** in the brain caused by misfolding of the **β-sheets**
- **Memory loss, lack of recognition**

2. Cystic fibrosis (CF)

- caused by misfolding of (**CFTR**) protein.

3. Parkinson's disease



Case Scenario

A 72-year-old male is suffering from forgetting recent events or conversations that started 2 years ago, recently he didn't recognize his close relatives with sever memory impairment and lose the ability to carry out everyday tasks.

1-What is the diagnosis ?

Alzheimer's disease

2-Mention the possible cause of this disease

Protein misfolding



Life
isn't about
finding yourself.

...

Life
is about
creating yourself.



REFERENCES

- ❑ Chatterjea's Textbook of Medical Biochemistry, 8th edition.
- ❑ Vasudevan's Textbook of Biochemistry For Medical Students, 6th Edition.
- ❑ Lippincott's Illustrated Reviews: Biochemistry, 8th edition
- ❑ <https://www.youtube.com/watch?v=wvTv8TqWC48>
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