Biochemistry
Proteins
Dr Jilna Alex N

PROTEINS

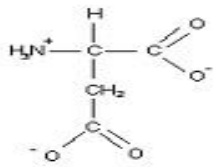
Proteins

- Are much abundant structural and functional organic constituents of the living matter formed by condensation polymerisation of aminoacids through peptide bonding
- Chemically they are amphoteric polyelectrolytes with colloidal, osmotic and buffering properties
- As many as 300 aminoacids are known to exist in nature. Of these 22 are essential for the formation of endless varieties of natural proteins. These are known as Proteogenic or

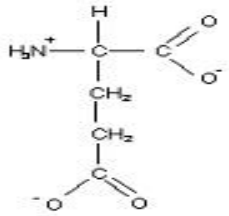
Table 3. Proteinogenic Amino Acids (Used For Protein Biosynthesis) and Their Abbreviations		
Amino acid	**3 letter code**	**1–letter code**
Alanine	ALA	A
Cysteine	CYS	C
Aspartic Acid	ASP	D
Glutamic Acid	GLU	E
Phenylalanine	PHE	F
Glycine	GLY	G
Histidine	HIS	H
Isoleucine	ILE	I
Lysine	LYS	K
Leucine	LEU	L
Methionine	MET	M
Asparagine	ASN	N
Proline	PRO	P
Glutamine	GLN	Q
Arginine	ARG	R
Serine	SER	S
Threonine	THR	T
Valine	VAL	V
Tryptophan	TRP	W
Tyrosine	TYR	Y
Selenocysteine	SEC	U
Pyrrolysine	PYL	O

Structures of the Twenty Amino Acids

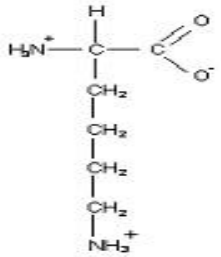
Polar	Non-polar	"Special"



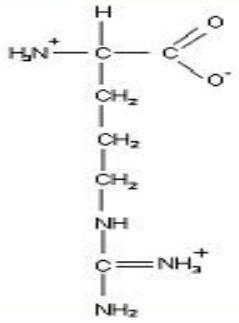
Aspartic Acid (asp or D)



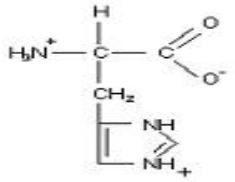
Glutamic Acid (glu or E)



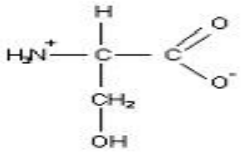
Lysine (lys or K)



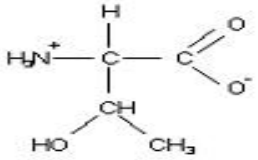
Arginine (arg or R)



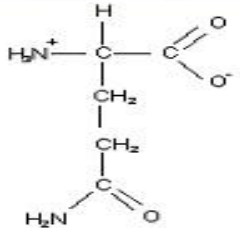
Histidine (his or H)



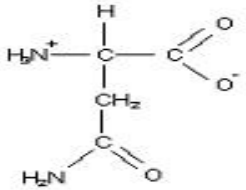
Serine (ser or S)



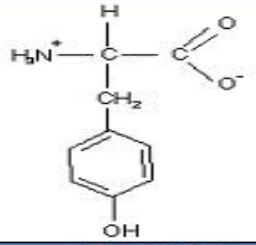
Threonine (thr or T)



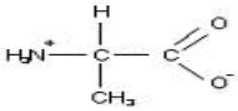
Glutamine (gln or Q)



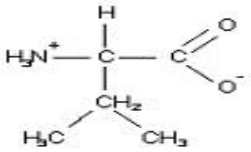
Asparagine (asn or N)



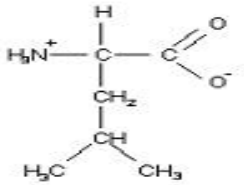
Tyrosine (tyr or Y)



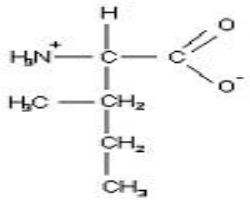
Alanine (ala or A)



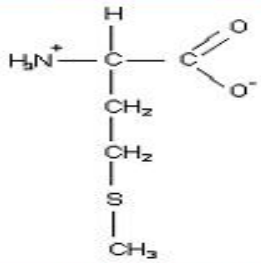
Valine (val or V)



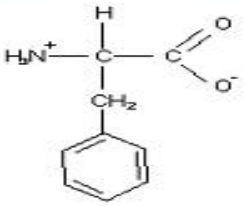
Leucine (leu or L)



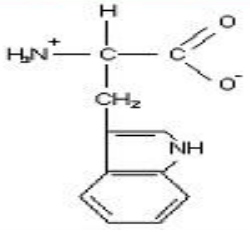
Isoleucine (ile or I)



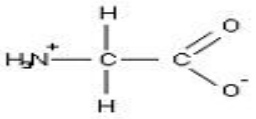
Methionine (met or M)



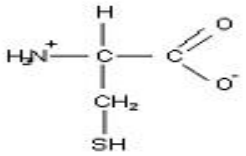
Phenylalanine (phe or F)



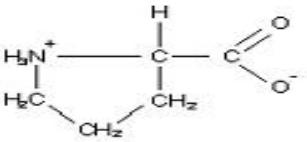
Tryptophan (trp or W)



Glycine (gly or G)



Cysteine (cys or C)



Proline (pro or P)

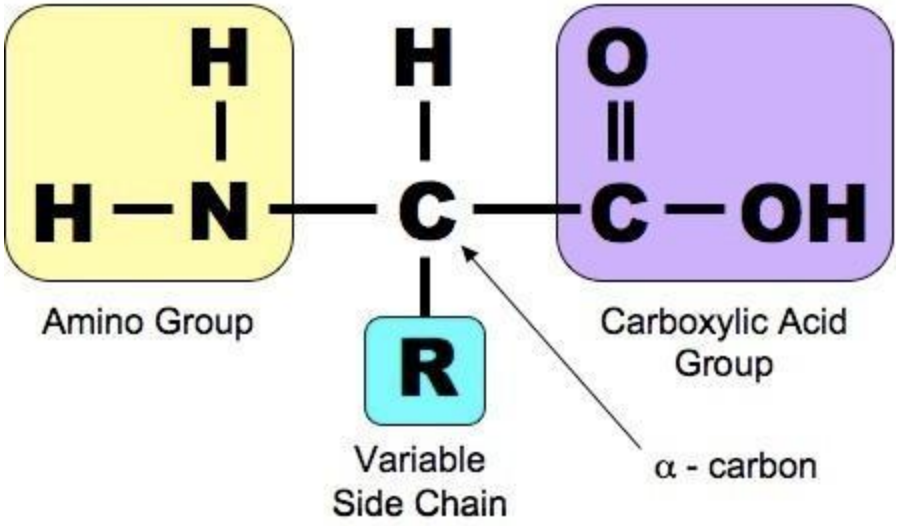
Non – Proteinogenic aminoacids

- Are derivatives of primary ones eg: hydroxy proline, hydroxy lysine, methyl lysine, carboxy glutamate etc.

- Theyoccur in free state or as a part of non-protein compounds eg: Ornithine, citruline, histamine, serotonin, epinephrine etc.

Amino acid - Structure

- Are organic carboxylic acids with a central aminated ($-NH_2$) and carboxylated (-COOH) carbon atom, called 'alpha carbon'. Attached to it there is also a hydrogen atom (H) and a side group (R)



- Since amino group is attached to α – carbon, amino acids are generally called α – amino acids with the exception of proline and hydroxy proline. They are α – imino acids with an attached iminogroup (-NH) in place of amino group
- α – carbon of all amino acids with the exception of glycine is asymmetric. Glycine, the simplest amino acid is without an asymmetric C atom where as threonine, isoleucine, hydroxylysine, hydroxy proline etc. have two asymmetric C atoms
- The amino and carboxyl groups of amino acids are ionisable
- The side group of amino acid is a

Classification of standard Amino acids

A) Bsaed on properties of side chain

Based on Side chain

Classes	Side chain	Polarity	Example
I	Aliphatic	Apolar	Gly, Ala, Val, Leu, and Ileu.
II	Sulphur	Apolar	Cys* and Met
III	Aromatic	Apolar	Phe, Tyr & Trp
IV	Hydroxyl	Polar	Ser, Thr and (Tyr)
V	Acidic	Polar	Asp , Asn and Glu, Gln
VI	Basic	Polar	Lys , Arg and His
VII	Imino	Apolar	Pro

USMLE !

B) Bsaed on acid-base properties and Pc

Amino Acid Classification Table (Latest)

Sl. No.	Name	Three letter code	Single letter code	Molecular Weight	pI	Essential/ Non-essential	No. of codons	Remarks
Nonpolar, aliphatic R-group								
1	Glycine	Gly	G	75	5.97	Nonessential	4	Smallest amino acid, Optically inactive
2	Alanine	Ala	A	89	6.01	Nonessential	4	
3	Proline	Pro	P	115	6.48	Nonessential*	4	Imino acid
4	Valine	Val	V	117	5.97	Essential	4	
5	Leucine	Leu	L	131	5.98	Essential	6	
6	Isoleucine	Ile	I	131	6.02	Essential	3	
7	Methionine	Met	M	149	5.74	Essential	1	Sulfur containing
Aromatic R-Group								
8	Phenylalanine	Phe	F	165	5.48	Essential	2	
9	Tyrosine	Tyr	Y	181	5.66	Nonessential*	2	
10	Tryptophan	Trp	W	204	5.89	Essential	1	Least occurring amino acid in proteins
Polar, uncharged R-group								
11	Serine	Ser	S	105	5.68	Nonessential*	6	
12	Threonine	Thr	T	119	5.87	Essential	4	
13	Cysteine	Cys	C	121	5.07	Nonessential*	2	Sulfur containing
14	Asparagine	Asn	N	132	5.41	Nonessential	2	
15	Glutamine	Gln	Q	146	5.65	Nonessential*	2	
Positively charged R-Group (Basic amino acids)								
16	Lysine	Lys	K	146	9.74	Essential	2	
17	Arginine	Arg	R	174	10.76	Nonessential*	6	Highest pI
18	Histidine	His	H	155	7.59	Essential	2	pI near physiological pH
Negatively charged R-Group (Acidic amino acids)								
19	Aspartate	Asp	D	133	2.77	Nonessential	2	
20	Glutamate	Glu	E	147	3.22	Nonessential	2	
Proteinogenic non-standard amino acids (coded by 'amber' stop codon – UAG)								
21	Selenocysteine	Sec	U	168	5.47	Nonessential*	1	Selenium containing, 21st amino acid
22	Pyrrolysine	Pyl	O	255	-	Nonessential*	1	Largest amino acid, 22nd amino acid, present in methanogenic archaea

* *Conditionally Essential*

C) Bsaed on nutritional importance

1) ***Essential or indispensable amino acids*** – Which cannot be synthesised in the animal body and hence have to be obtained from dietary sources eg: Valine, lysine, leucine,isoleucine, phenyl alanine, methionine, tryptophan and threonine
2) ***Semi Essential amino acids*** – which can be synthesised in adults but infants and children have to get it from diet Eg: Arginine and histidine
3) ***Non- Essential amino acids*** – which can be synthesised in the body in sufficient amounts eg: Alanine, serine, proline, glycine, cystein, tyrosine, aspartic acid

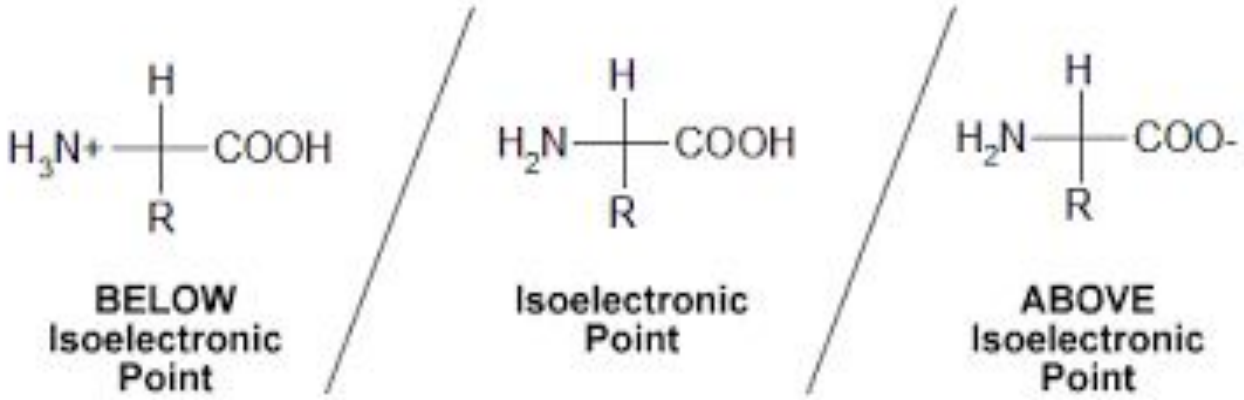
D) Bsaed on metabolic fate

1) ***Glucogenic amino acids*** – whose catabolic end products (such as pyruvic acid, oxaloacetic acid, α – keto glutaric acid) may enter into the gluconeogenic pathway and form glucose eg: Alanine, arginine, proline, serine, valine, cystein etc.
2) ***Ketogenic amino acids*** - whose catabolic end products enter the pathway of lipid metabolism and form ketone bodies such as acetoacetate, acetone, β – hydroxybutyrate etc. Eg: Leucine
3) ***Glucogenic as well as Ketogenic amino acids*** - end products enter to both

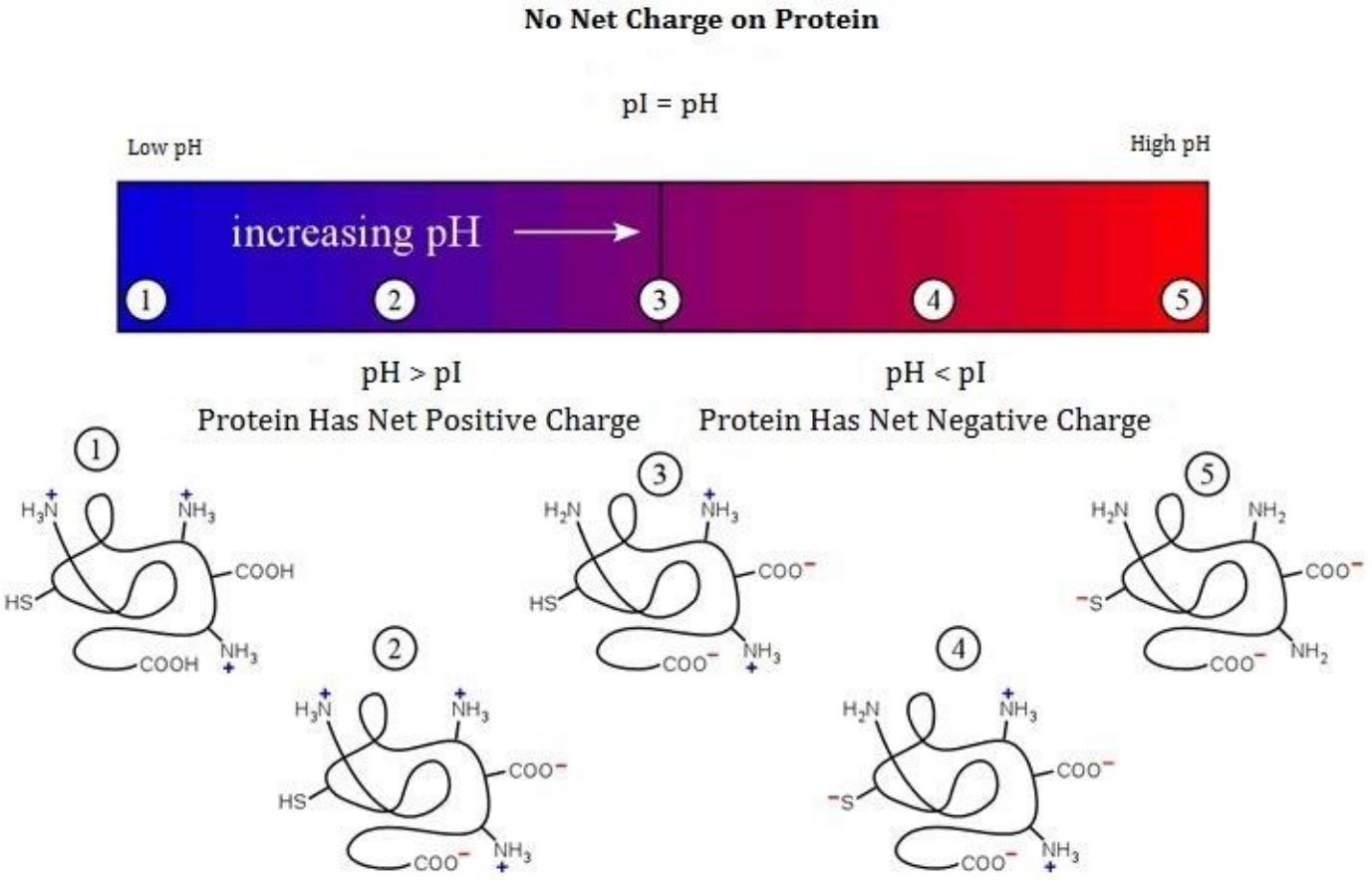
Properties of amino acids

1. Isoelectric point (Isoelectric pH or isoionic point)

- The state in which the net charge of an amino acid is zero is called isoelectric state. The pH of the isoelectric state at whi ral with poi

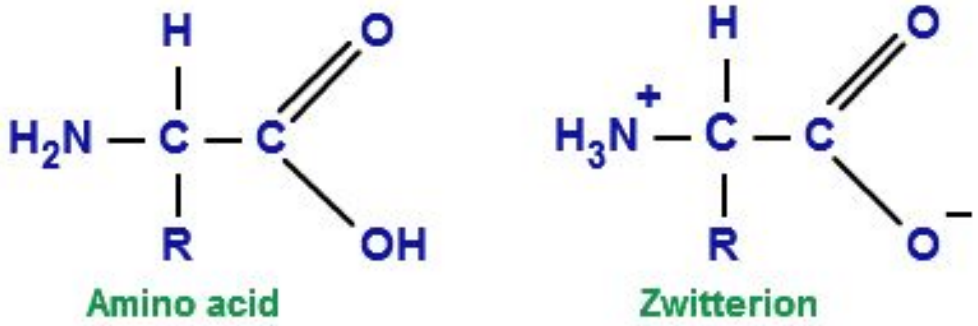


isoelectric
point, it will not move either to anode or to cathode. At isoelectric point aminoacids will have no mobilty and their
solubility and buffering capacity will be minimal



2. Zwitterion

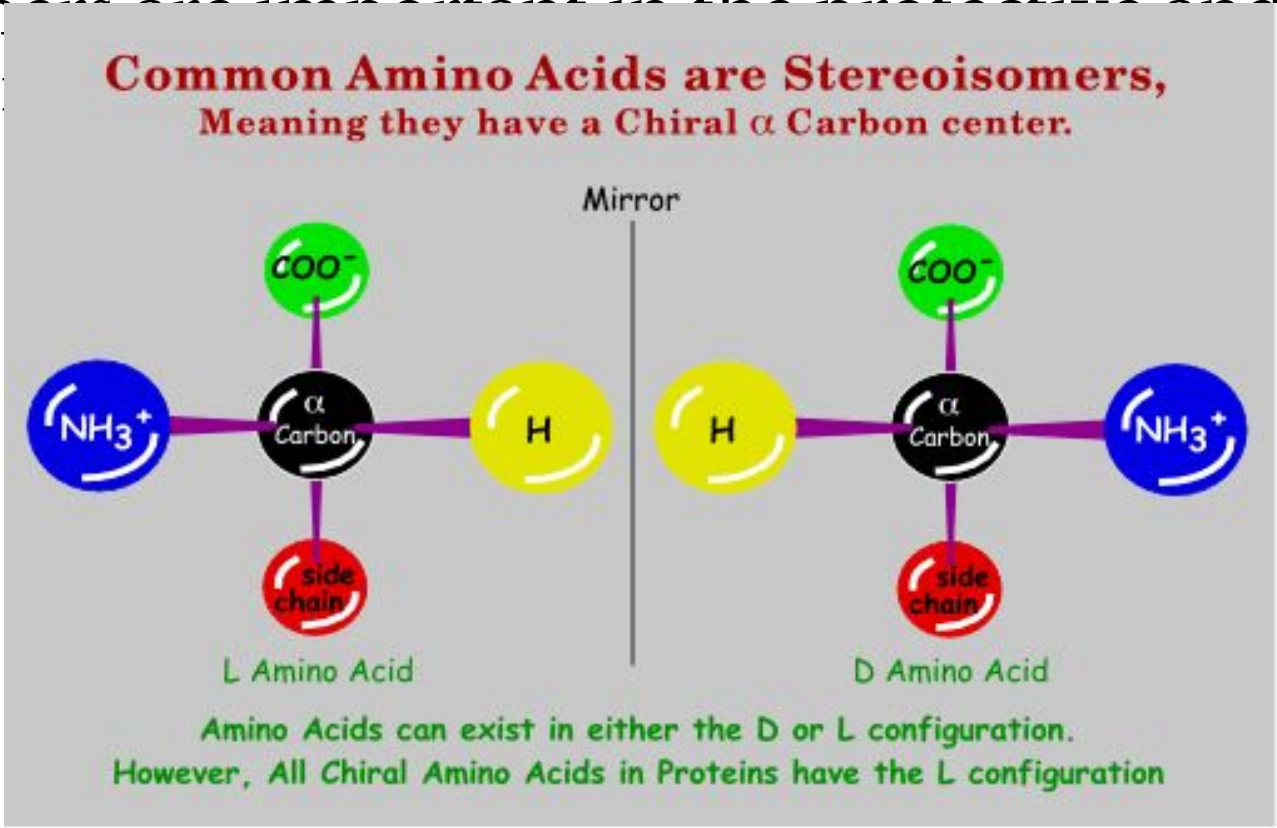
- In aqueous solution at neutral pH, amino acids are ionised and behave as anions and cations. Such molecules are known as zwitteri



- They are also dipolar having two oppositly charged poles and behave as amphoteric electrolytes in having the properties of both acids and bases

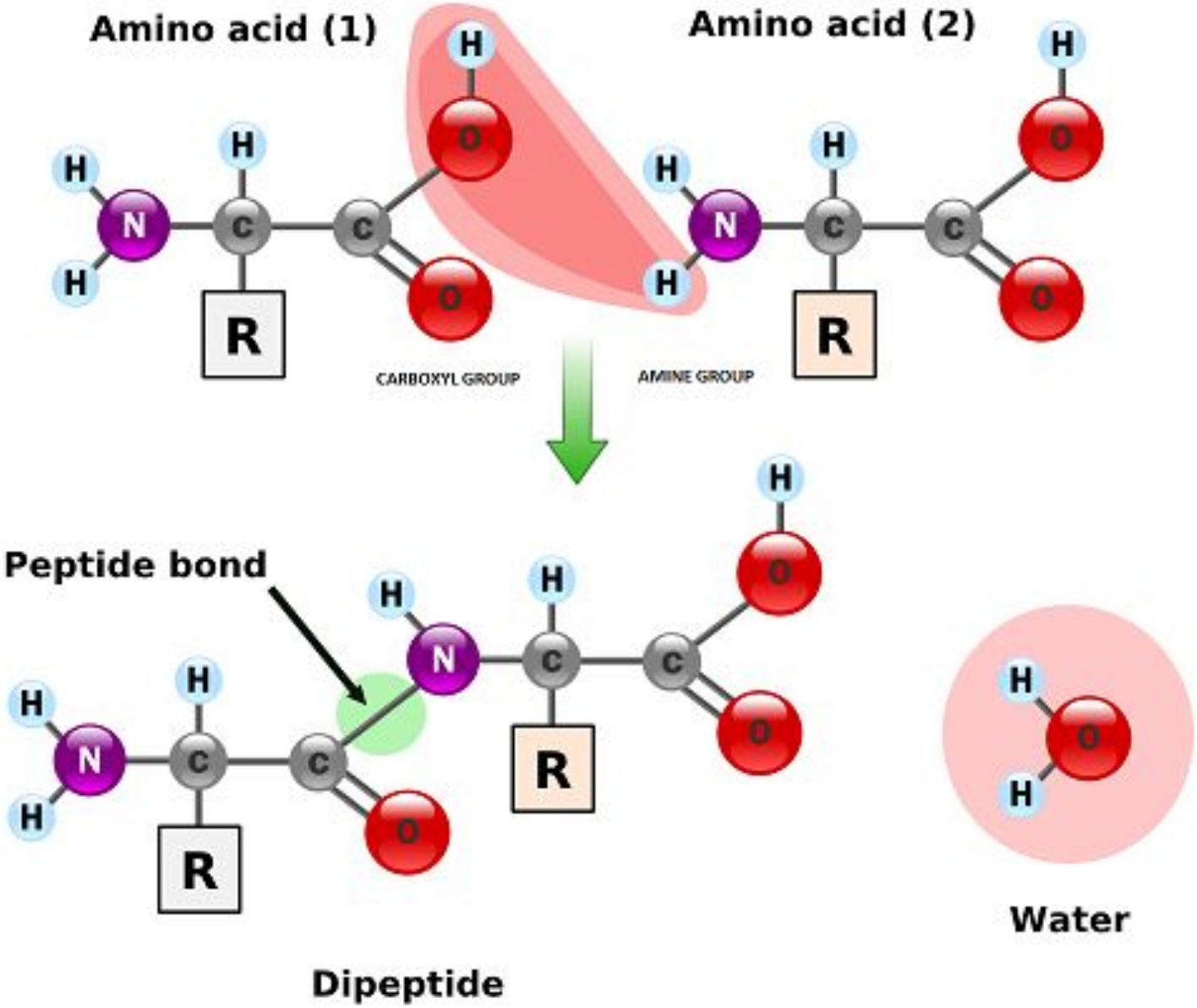
3. Optical isomerism

- All aminoacids other than glycine are optically active and enatiomeric chiral molecules exhibiting optical isomeism. All naturally occurring aminoacids are L isomers and D isom
defe



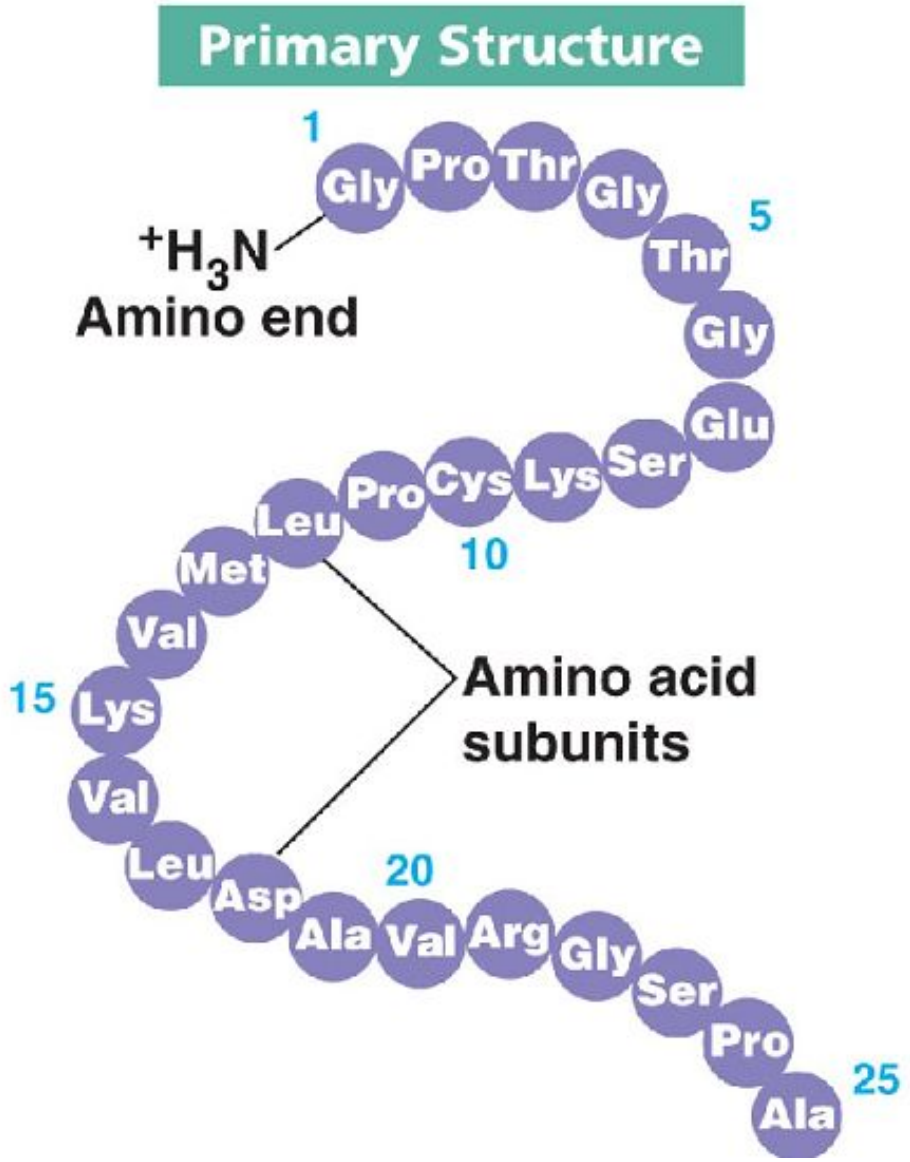
4. Peptide bond

- Is a type of covalent amide bond formed between the α –aminogroup of one aminoacid and α – carboxyl group of another with the elimination of one molecule of water
- Based on number of amino acid residues in a peptide thay are classified into Di, Tri, Tetra, oligo and polypeptides
- A polypeptide having 100 residues can attain 22^{100} possible combinations using


Amino acid (1)
Amino acid (2)
CARBOXYL GROUP
AMINE GROUP
Peptide bond
Dipeptide
Water

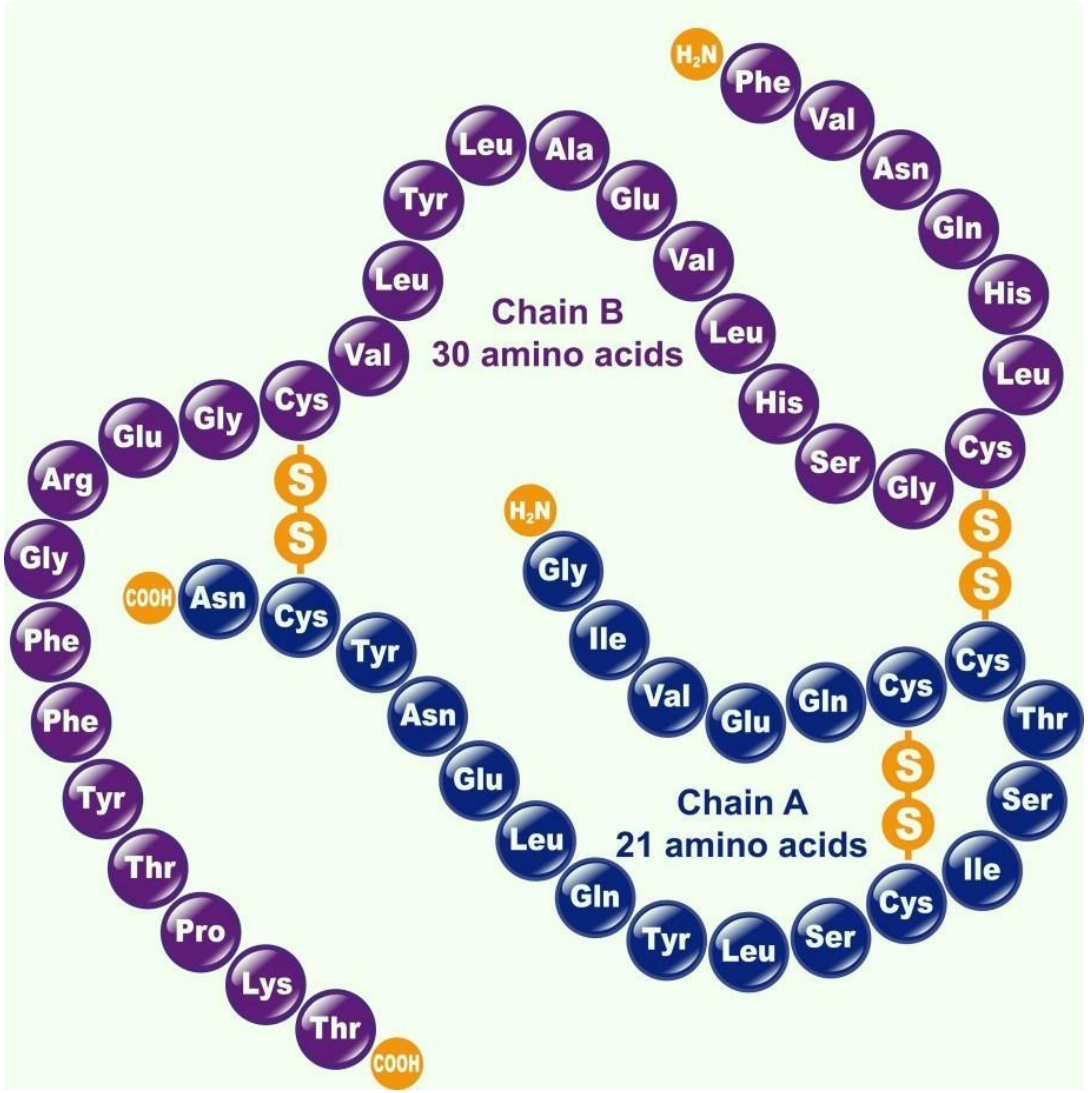
STRUCTURE OF PROTEIN

A) PRIMARY STRUCTURE



Amino Acid	Abbreviations
Alanine	Ala; A
Arginine	Arg; R
Asparagine	Asn; N
Aspartic acid	Asp; D
Cysteine	Cys; C
Glutamic acid	Glu; E
Glutamine	Gln; Q
Glycine	Gly; G
Histidine	His; H
Isoleucine	Ile; I
Leucine	Leu; L
Lysine	Lys; K
Methionine	Met; M
Phenylalanine	Phe; F
Proline	Pro; P
Serine	Ser; S
Threonine	Thr; T
Tyrosine	Tyr; Y
Tryptophan	Trp; W
Valine	Val; V

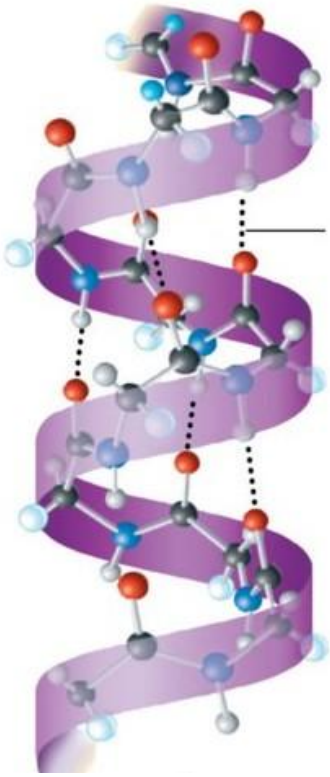
Primary structure of human insulin

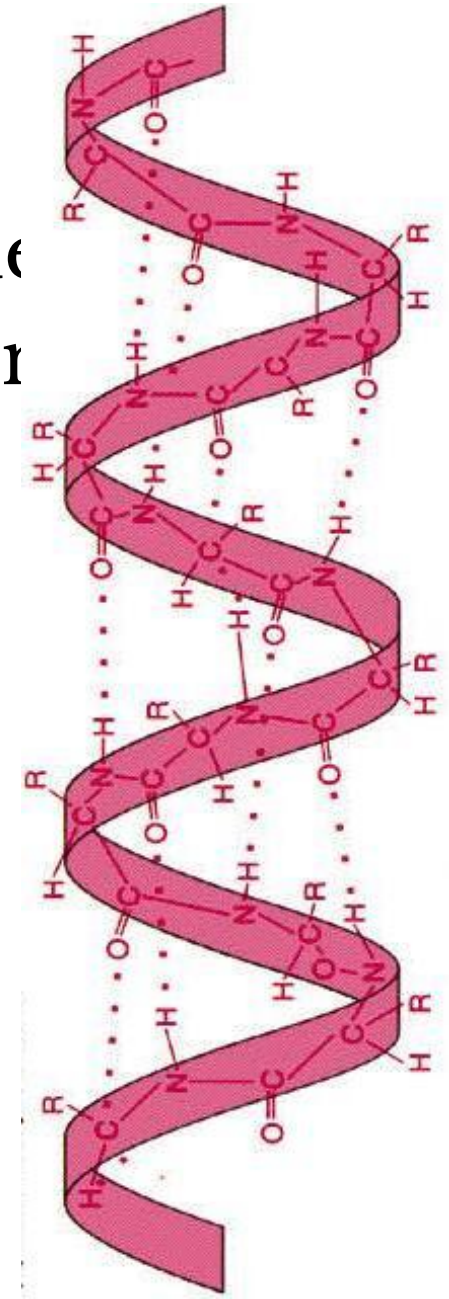


B) SECONDARY STRUCTURE

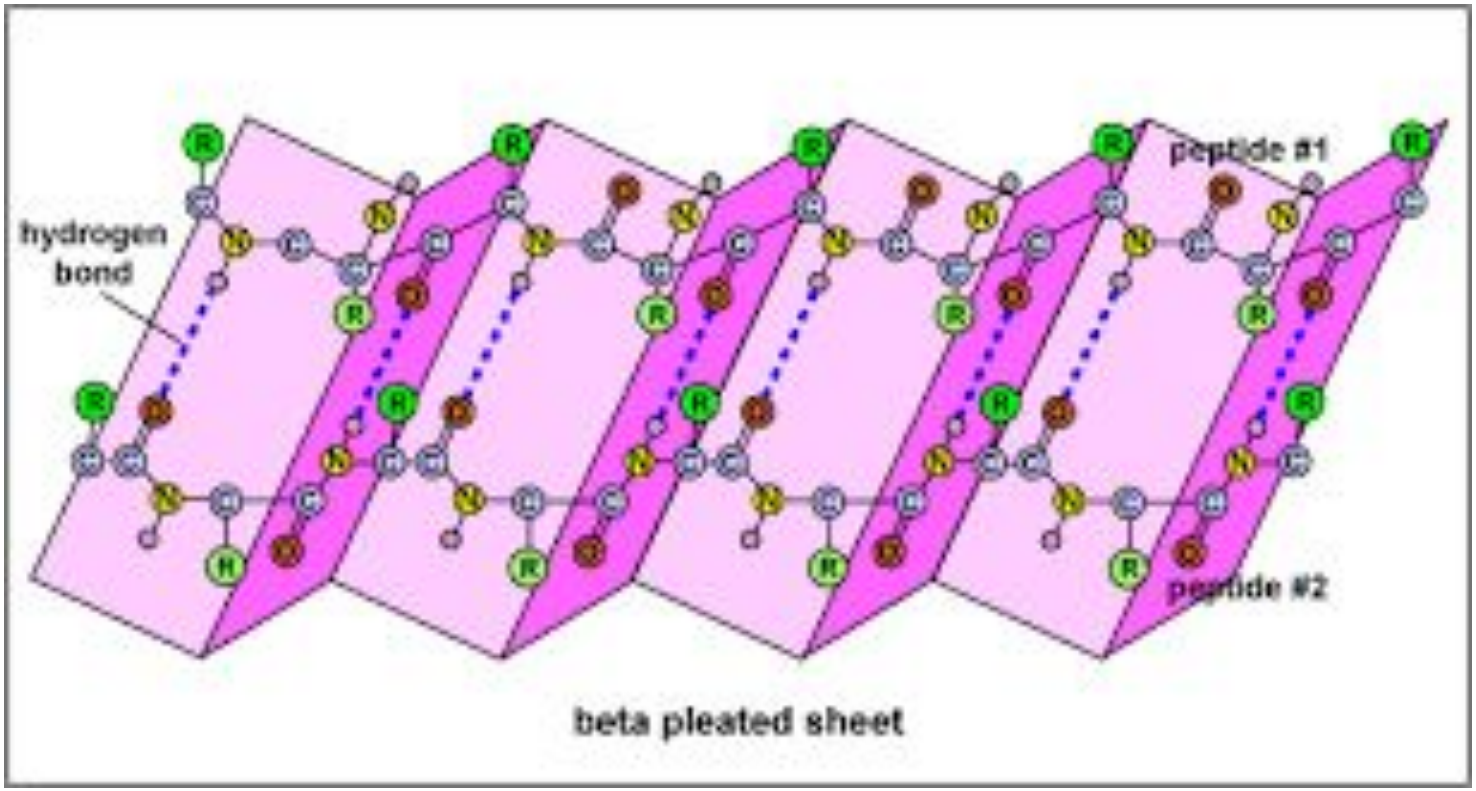
a) Alpha – helix structure

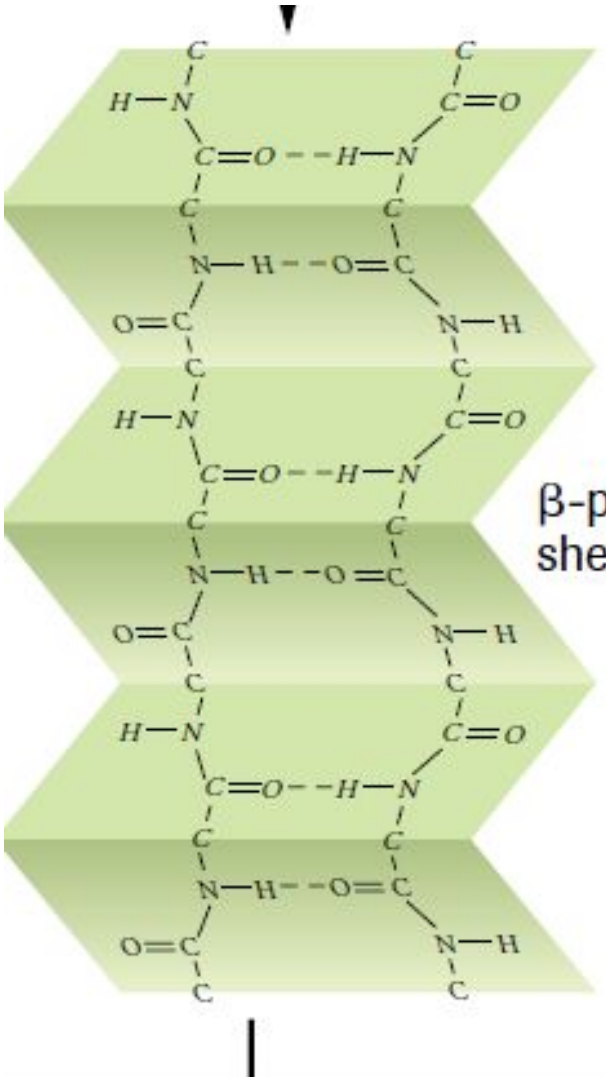
- Span over 10-15 aminoacid residue
- Eg: Keratin, collagen, haemoglobin myoglobin etc. (m 78%)



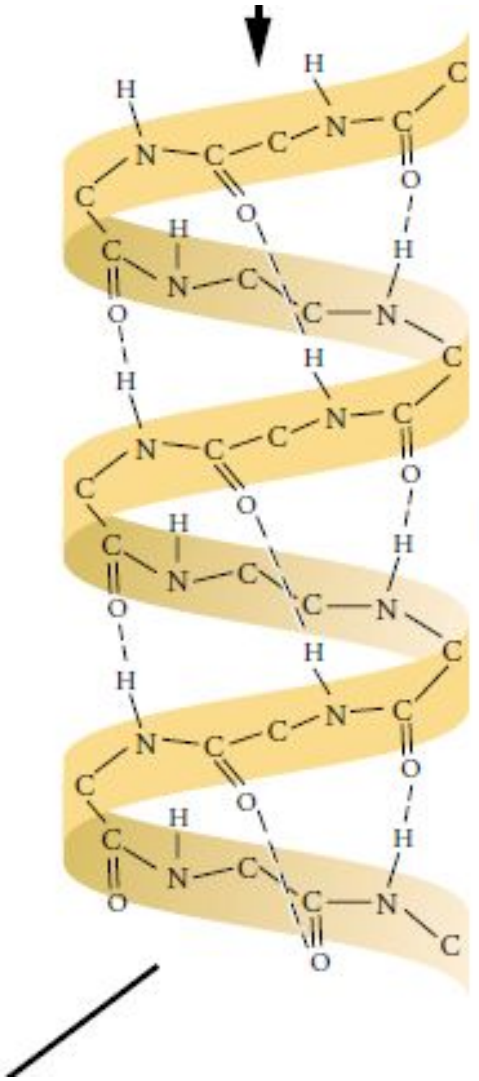


b) Beta – pleated sheet structure eg: silk protein fibroin

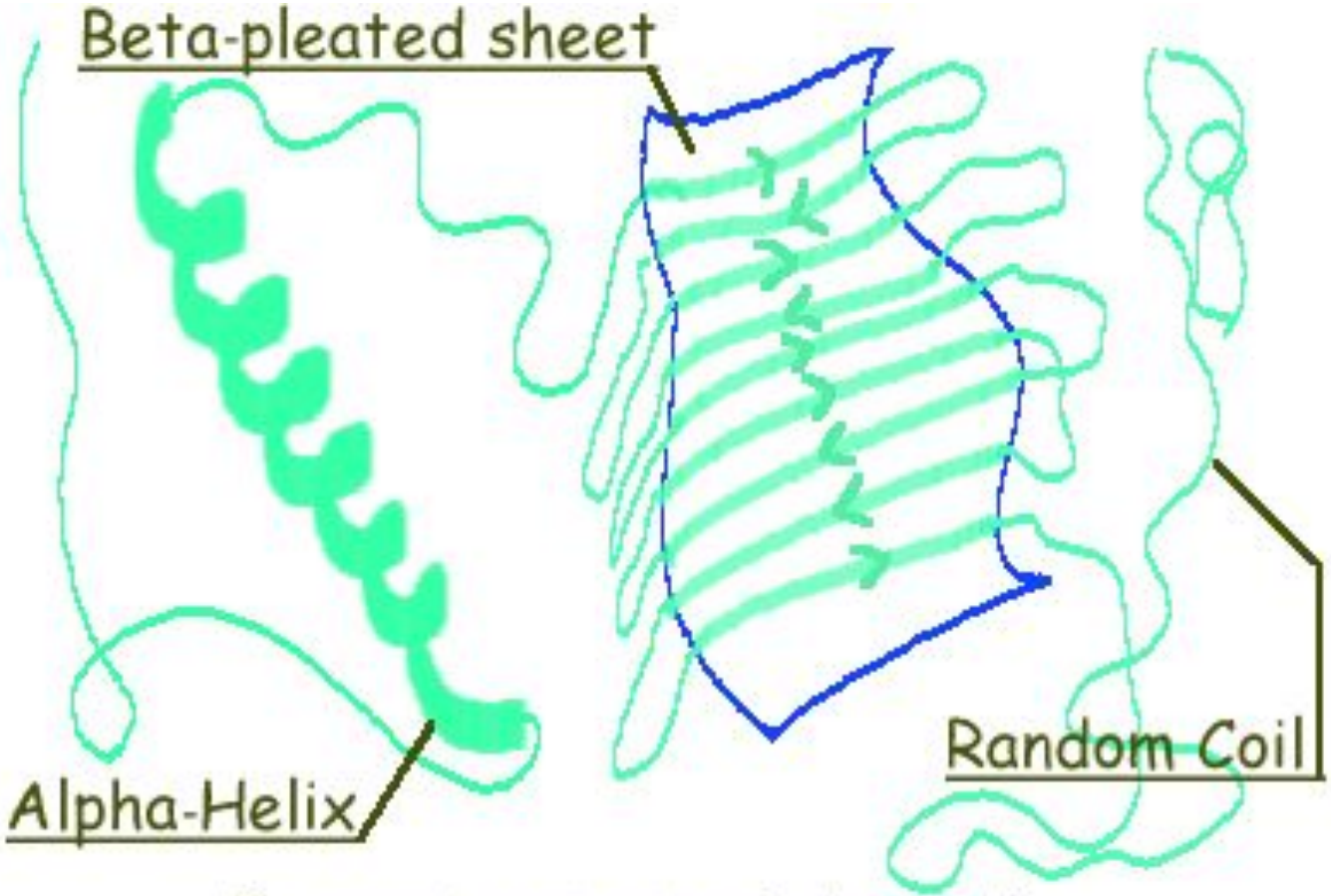




β-pleated sheet

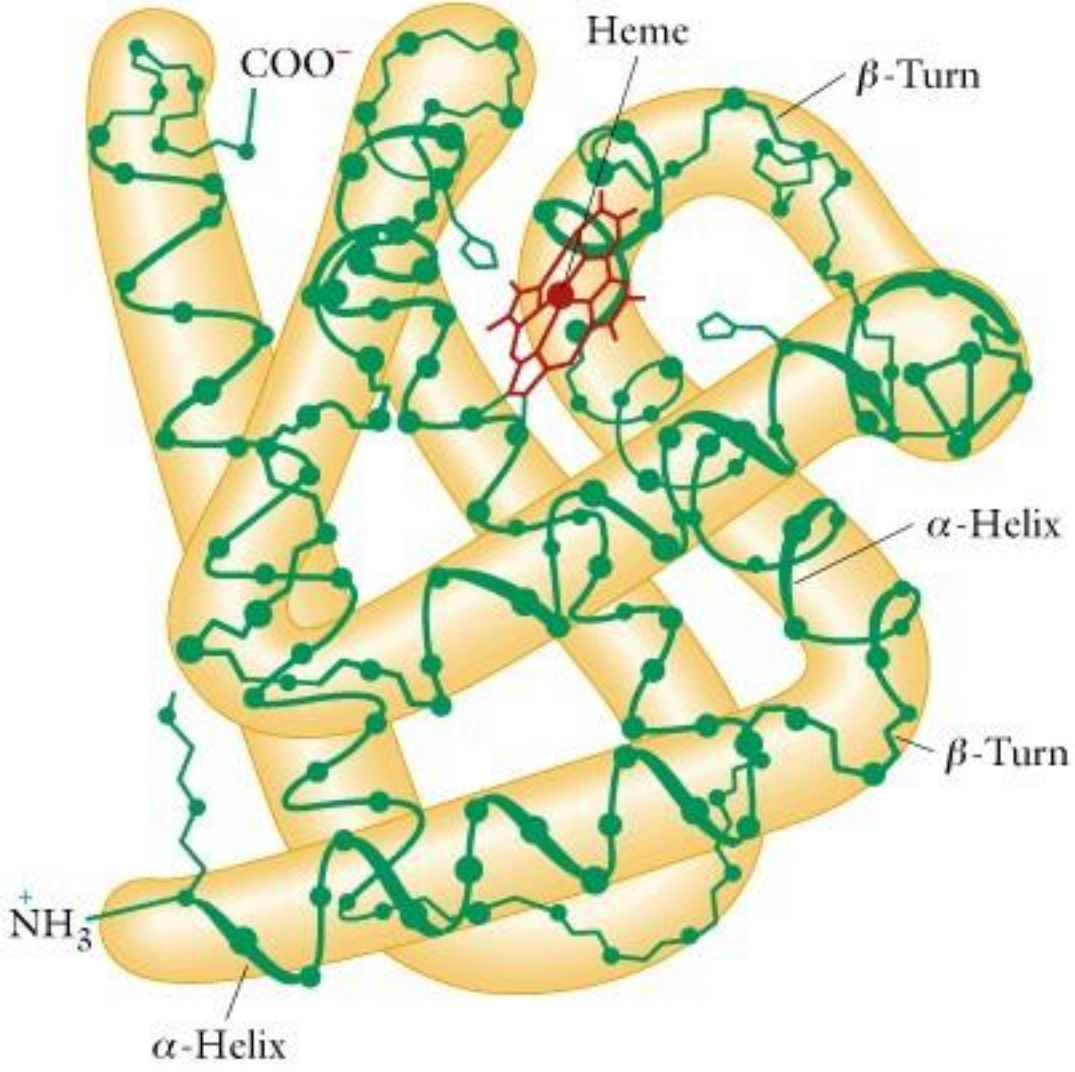


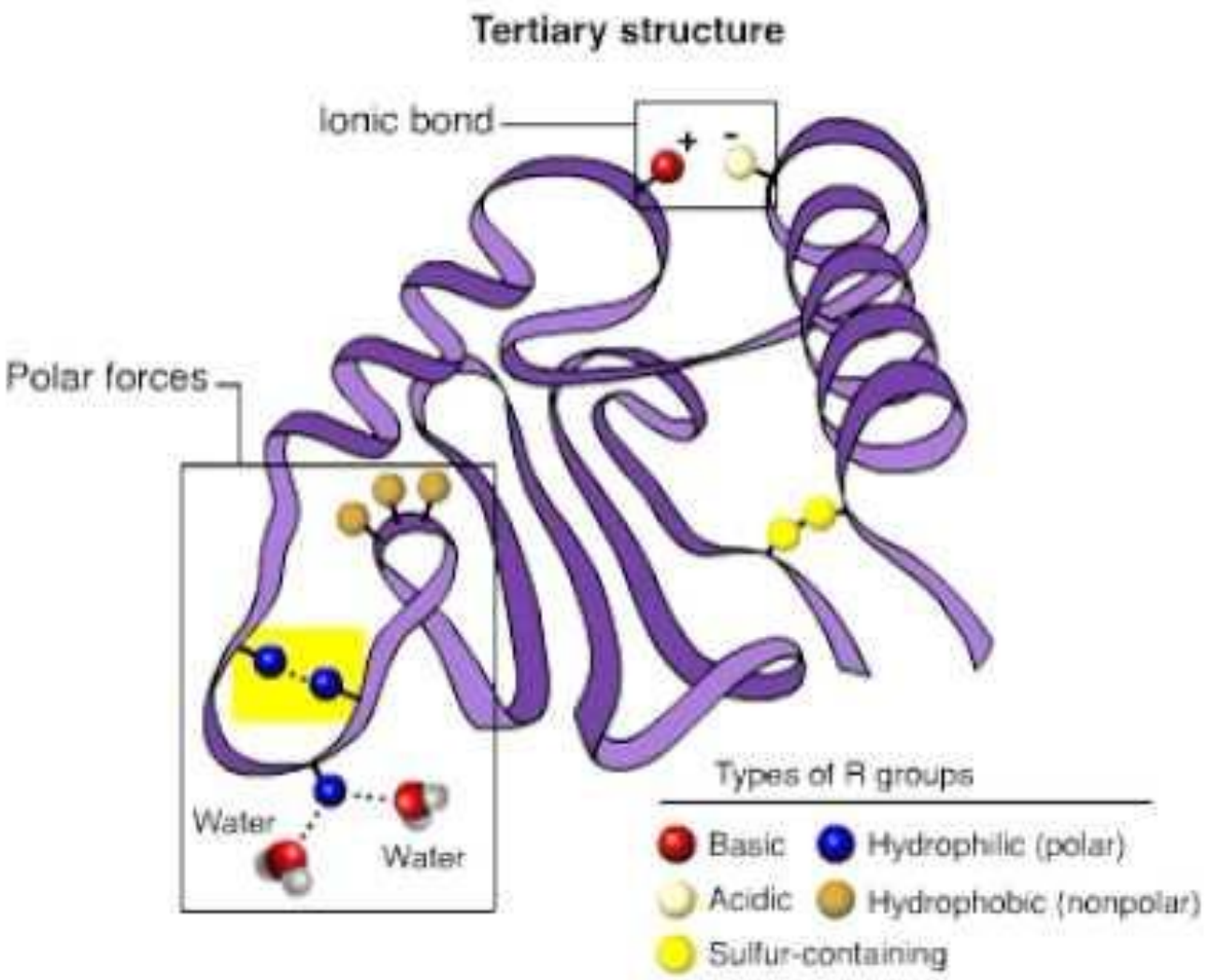
α helix



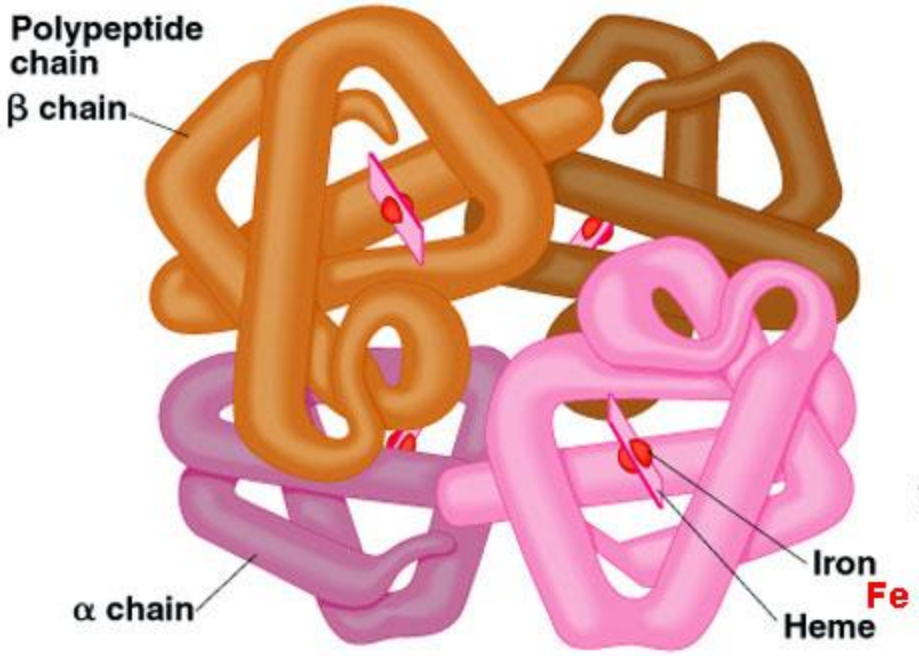
The secondary structure is observed in a localised portion of a protein.

C) TERTIARY STRUCTURE eg: Myoglobin

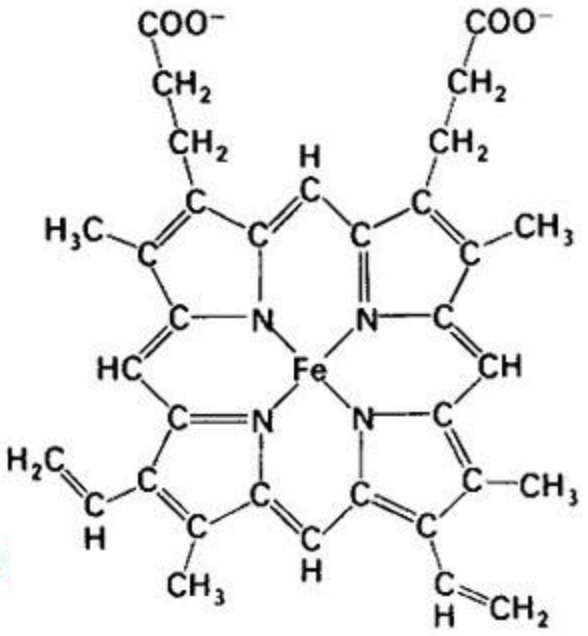



Tertiary structure
Ionic bond
+
-
Polar forces
Water
Water
Types of R groups
Basic
Hydrophilic (polar)
Acidic
Hydrophobic (nonpolar)
Sulfur-containing

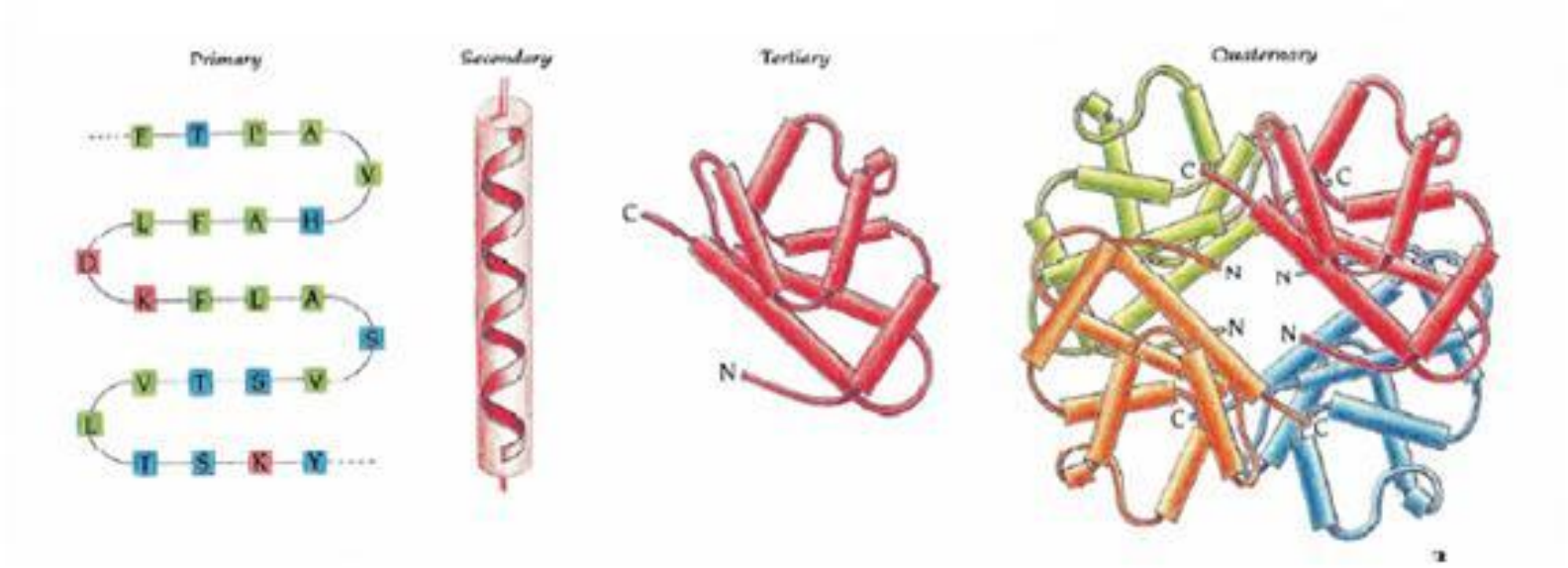
D) QUATERNARY STRUCTURE

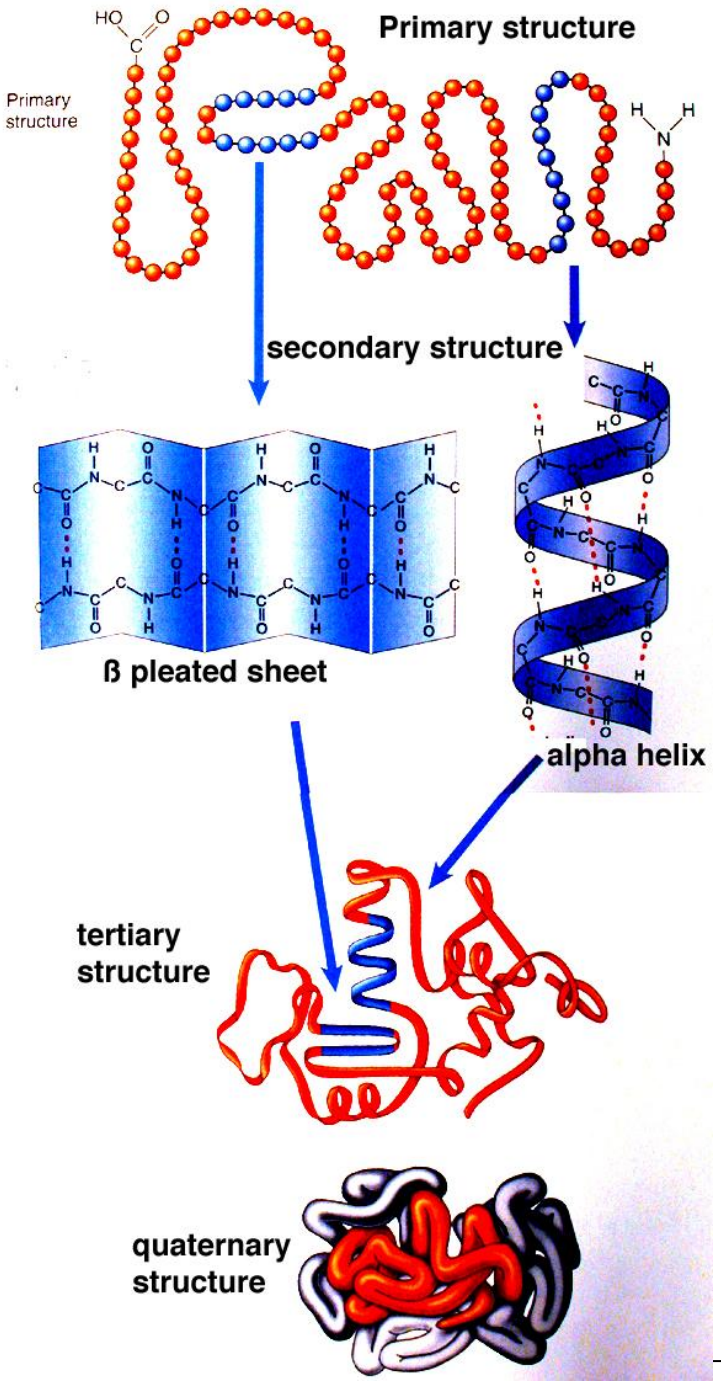


Hemoglobin

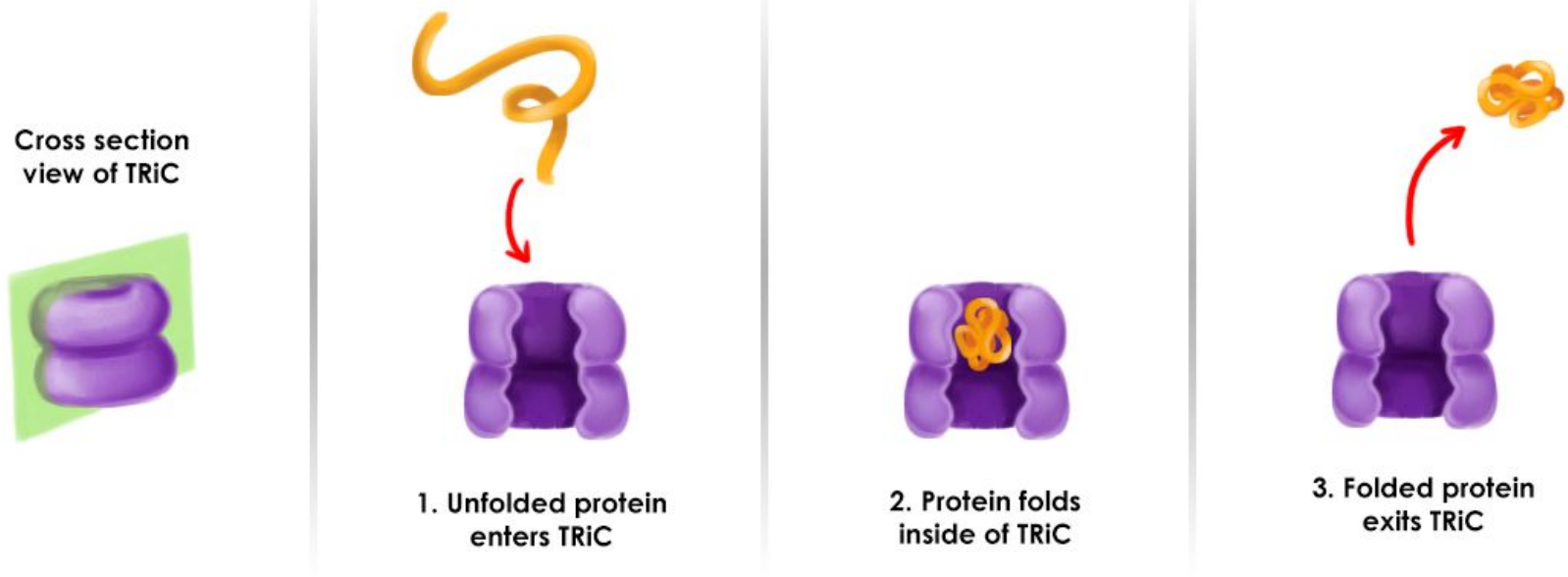


Heme
(Fe-protoporphyrin IX)


Primary
Secondary
Tertiary
Quaternary
C
N
C
N
N
N
C
C


Primary structure
Primary structure
secondary structure
ß pleated sheet
alpha helix
tertiary structure
quaternary structure

CHAPERONS – Are specialised proteins which allow individual polypeptide chains to fold into their final thermodynamically stable functional configuration



BIOLOGICAL FUNCTIONS OF PROTEIN

1. Serve as enzymes and accelerate catalytic conversions
2. Serve as hormones
3. Serve as energy transducers in ATP synthesis
4. Serve as carriers (haemoglobin) and storage molecules (transferin) in transport of materials
5. Actively participate in blood clotting
6. Serve major role in immunity forming antibodies, interferons, complement proteins etc