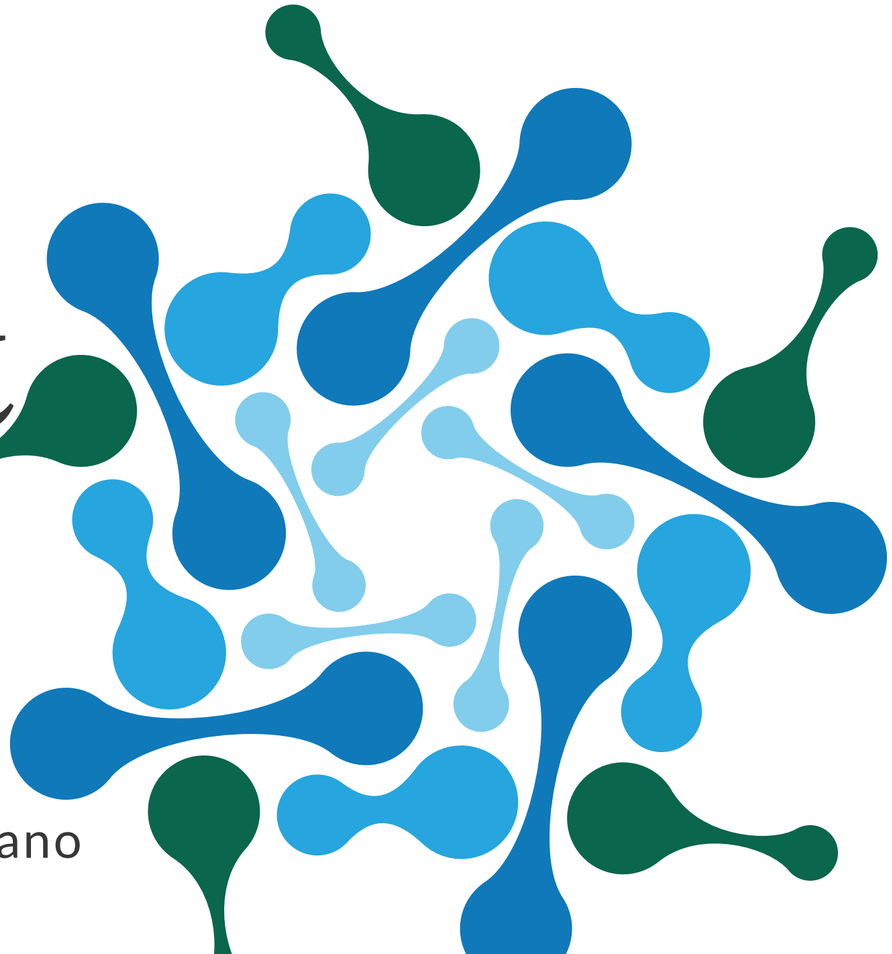
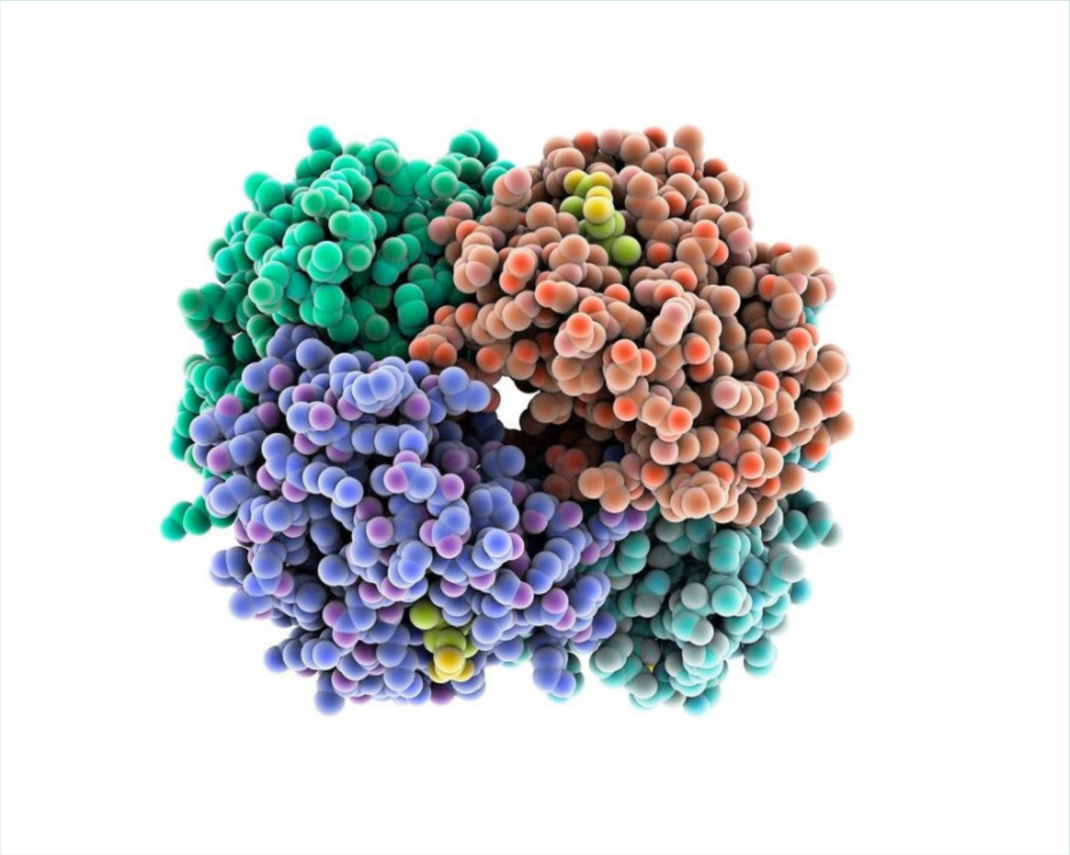
CHEM113

Amino Acids & Proteins



Prepared by Robert D. Unciano



Core Concepts

1. Characteristics of Proteins
2. Amino Acids: The Building Blocks for Proteins
3. Chirality and Amino Acids
4. Acid–Base Properties of Amino Acids
5. Cysteine: A Chemically Unique Amino Acid
6. Peptides
7. Biochemically Important Small Peptides
8. General Structural Characteristics of Proteins
9. Primary Structure of Proteins
10. Secondary Structure of Proteins
11. Tertiary Structure of Proteins
12. Quaternary Structure of Proteins
13. Classification Based on Shape
14. Protein Classification Based on Function
15. Protein Hydrolysis
16. Protein Denaturation
17. Glycoproteins
18. Lipoproteins

Characteristics of a Protein

A protein is a naturally-occurring, unbranched polymer in which the monomer units are amino acids

Proteins are most abundant molecules in the cells after water – account for about 15% of a cell's overall mass

Elemental composition - Contain Carbon (C), Hydrogen (H), Nitrogen (N), Oxygen (O), most also contain Sulfur (S)

Characteristics of a Protein

The average nitrogen content of proteins is 15.4% by mass

Also present are Iron (Fe), phosphorus (P) and some other metals in some specialized proteins

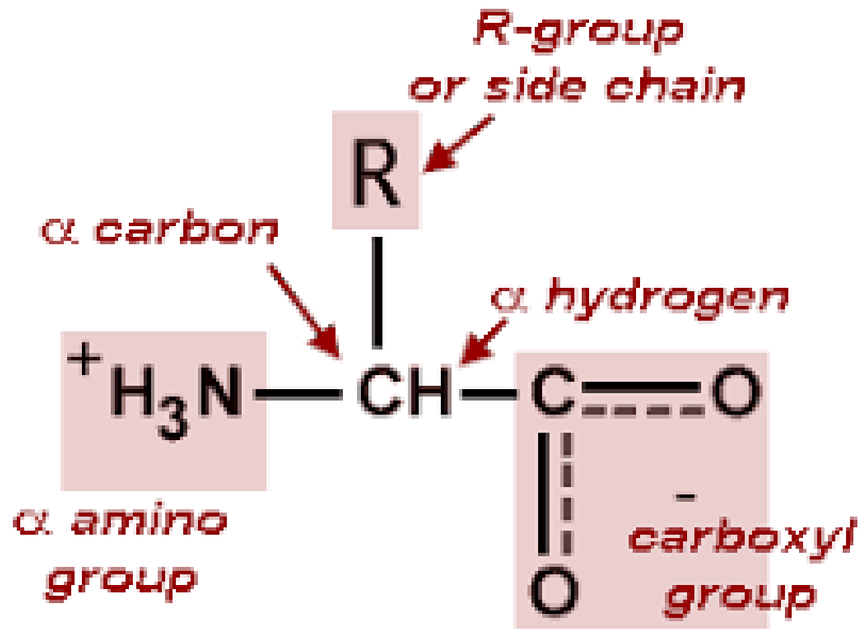
Amino Acids: The Building Blocks for Proteins

- *Amino acid - An organic compound that contains both an amino (-NH2) and carboxyl (-COOH) groups attached to same carbon atom*
- *The position of carbon atom is Alpha (a)*

-NH2 group is attached at alpha (a) carbon atom.

-COOH group is attached at alpha (a) carbon atom.

- R = side chain –vary in size, shape, charge, acidity, functional groups present, hydrogen-bonding ability, and chemical reactivity.
- >700 amino acids are known
- Based on common “R” groups, there are 20 standard amino acids

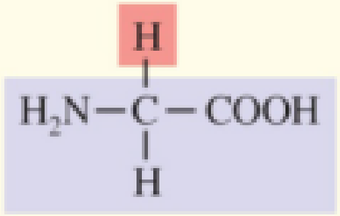


Amino Acids: The Building Blocks for Proteins

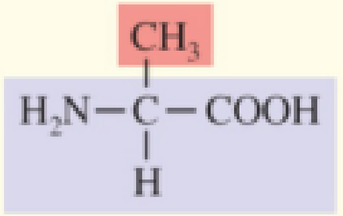
- *All amino acids differ from one another by their R-groups*
- *Standard amino acids are divided into four groups based on the properties of R-groups*
- *Non-polar amino acids: R-groups are non-polar*

1. *Such amino acids are hydrophobic-water fearing (insoluble in water)*
2. *8 of the 20 standard amino acids are non polar*
3. *When present in proteins, they are located in the interior of protein where there is no polarity*

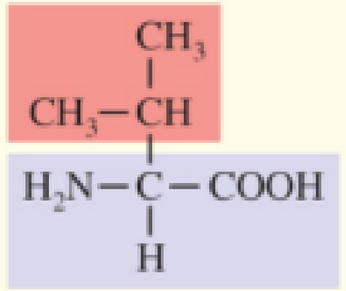
Nonpolar Amino Acids



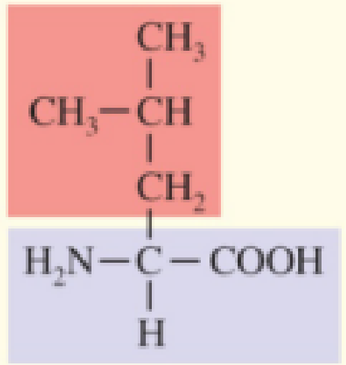
Glycine (Gly, G)
GLY-seen



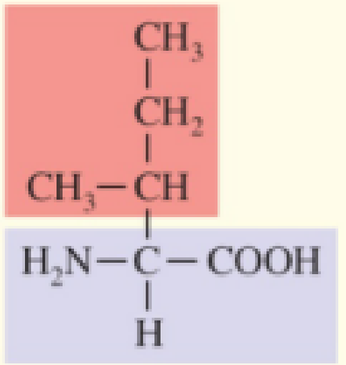
Alanine (Ala, A)
AL-ah-neen



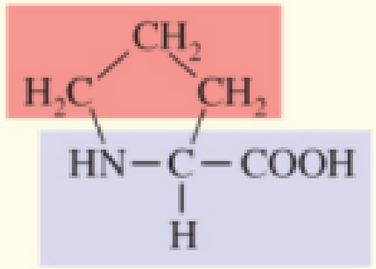
Valine (Val, V)
VAY-leen



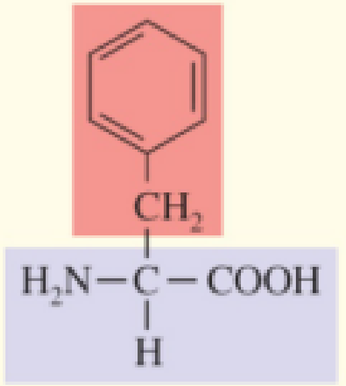
Leucine (Leu, L)
LOO-seen



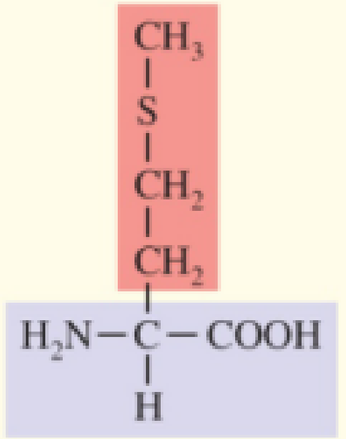
Isoleucine (Ile, I)
eye-so-LOO-seen



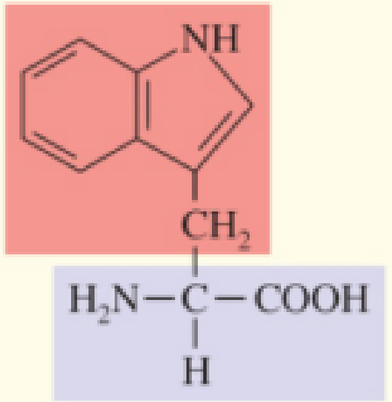
Proline (Pro, P)
PRO-leen



Phenylalanine (Phe, F)
fen-il-AL-ah-neen



Methionine (Met, M)
me-THIGH-oh-neen

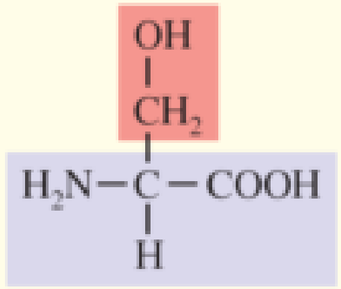


Tryptophan (Trp, W)
TRIP-toe-fane

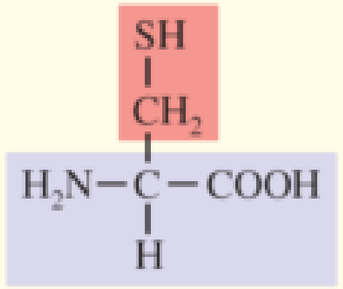
Amino Acids: The Building Blocks for Proteins

- *Polar amino acids: R-groups are polar*
- *Three types: Polar neutral; Polar acidic; and Polar basic*
- *Polar-neutral: contains polar but neutral side chains*
- *Seven amino acids belong to this category*
- *Polar acidic: Contain carboxyl group as part of the side chains*
- *Two amino acids belong to this category*
- *Polar basic: Contain amino group as part of the side chain*
- *Two amino acids belong to this category*

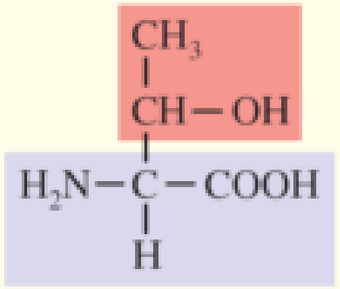
Polar Neutral Amino Acids



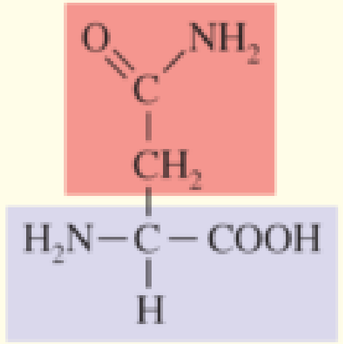
Serine (Ser, S)
SEER-een



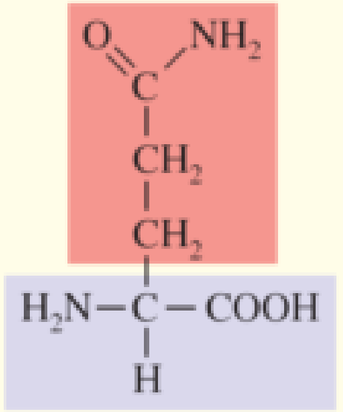
Cysteine (Cys, C)
SIS-teh-een



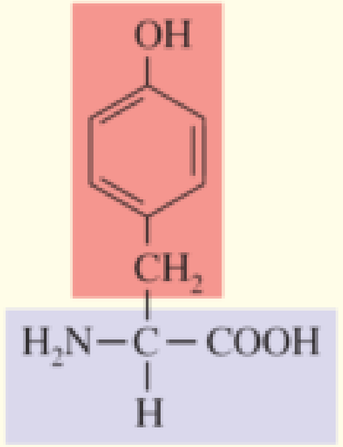
Threonine (Thr, T)
THREE-oh-neen



Asparagine (Asn, N)
ah-SPAR-ah geen

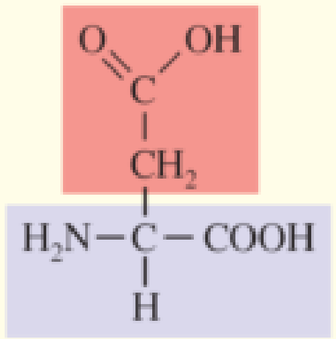


Glutamine (Gln, Q)
GLU-tah-meen

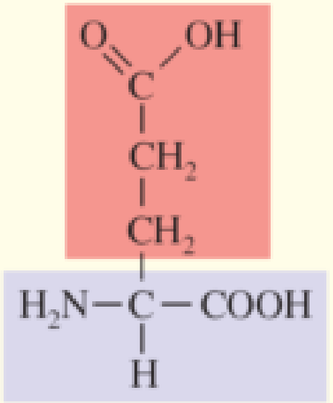


Tyrosine (Tyr, Y)
(TIE-roe-seen)

Polar Acidic Amino Acids

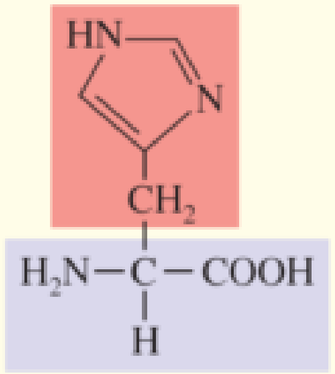


Aspartic acid (Asp, D)
ah-SPAR-tic acid

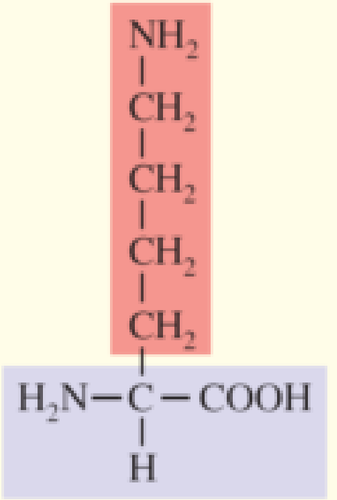


Glutamic acid (Glu, E)
glu-TAM-ic acid

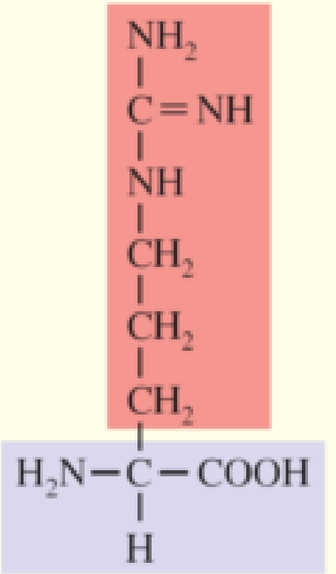
Polar Basic Amino Acids



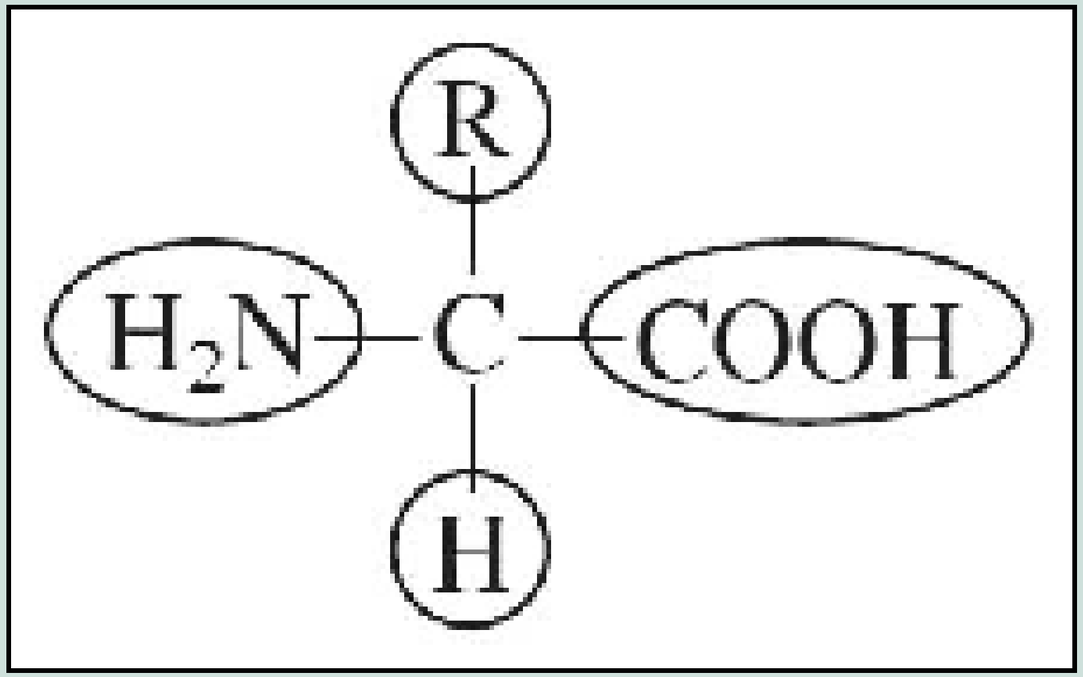
Histidine (His, H)
HISS-tuh-deen



Lysine (Lys, K)
LYE-seen



Arginine (Arg, R)
ARG-ih-neen



Chirality of Amino Acids

- Four different groups are attached to the a-carbon atom in all of the standard amino acids except glycine
- In glycine R-group is hydrogen
- Therefore 19 of the 20 standard amino acids contain a chiral center
- Chiral centers exhibit enantiomerism (left- and right-handed forms)
- Each of the 19 amino acids exist in left and right handed forms

A GUIDE TO THE TWENTY COMMON AMINO ACIDS

AMINO ACIDS ARE THE BUILDING BLOCKS OF PROTEINS IN LIVING ORGANISMS. THERE ARE OVER 500 AMINO ACIDS FOUND IN NATURE - HOWEVER, THE HUMAN GENETIC CODE ONLY DIRECTLY ENCODES 20. 'ESSENTIAL' AMINO ACIDS MUST BE OBTAINED FROM THE DIET, WHILST NON-ESSENTIAL AMINO ACIDS CAN BE SYNTHESISED IN THE BODY.

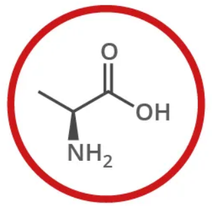
Chart Key: ALIPHATIC · AROMATIC · ACIDIC · BASIC · HYDROXYLIC · SULFUR-CONTAINING · AMIDIC · NON-ESSENTIAL · ESSENTIAL

Chemical Structure

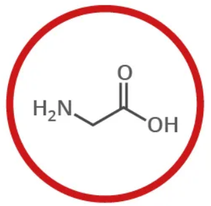
single letter code

NAME (A)

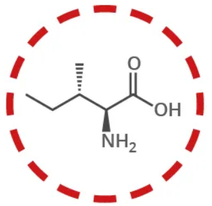
three letter code



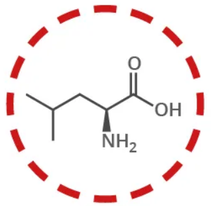
ALANINE (A)
ala



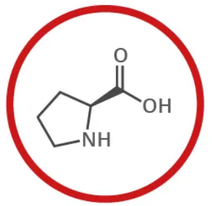
GLYCINE (G)
gly



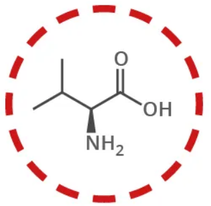
ISOLEUCINE (I)
ile



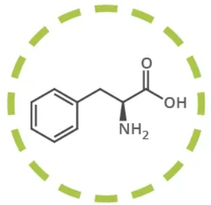
LEUCINE (L)
leu



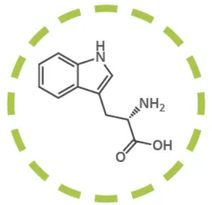
PROLINE (P)
pro



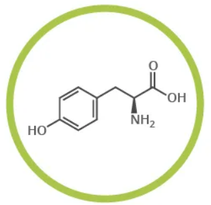
VALINE (V)
val



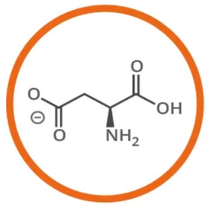
PHENYLALANINE (F)
phe



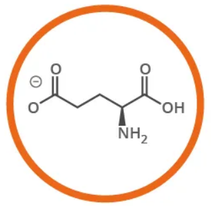
TRYPTOPHAN (W)
trp



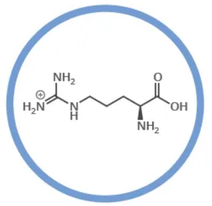
TYROSINE (Y)
tyr



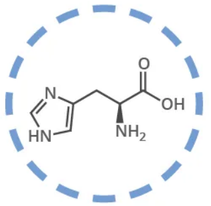
ASPARTIC ACID (D)
asp



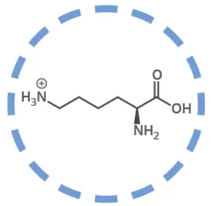
GLUTAMIC ACID (E)
glu



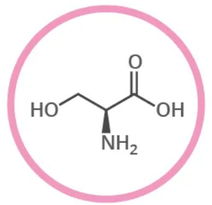
ARGININE (R)
arg



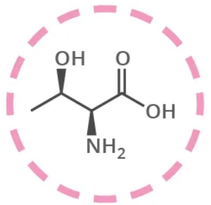
HISTIDINE (H)
his



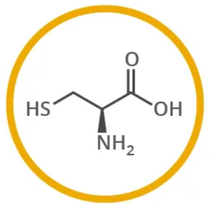
LYSINE (K)
lys



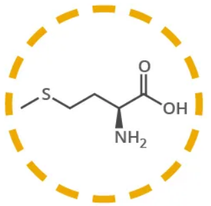
SERINE (S)
ser



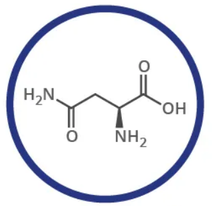
THREONINE (T)
thr



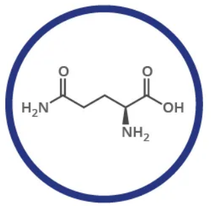
CYSTEINE (C)
cys



METHIONINE (M)
met

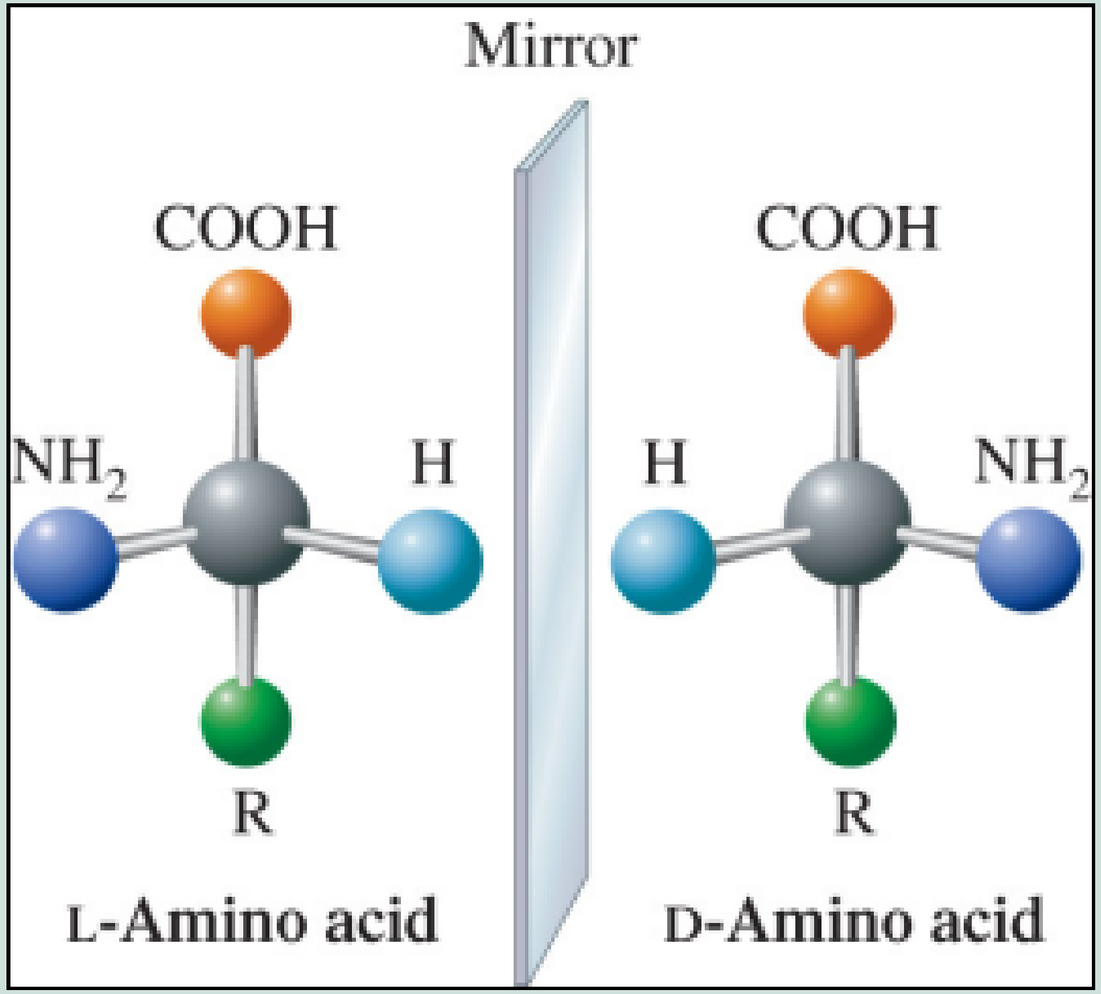


ASPARAGINE (N)
asn



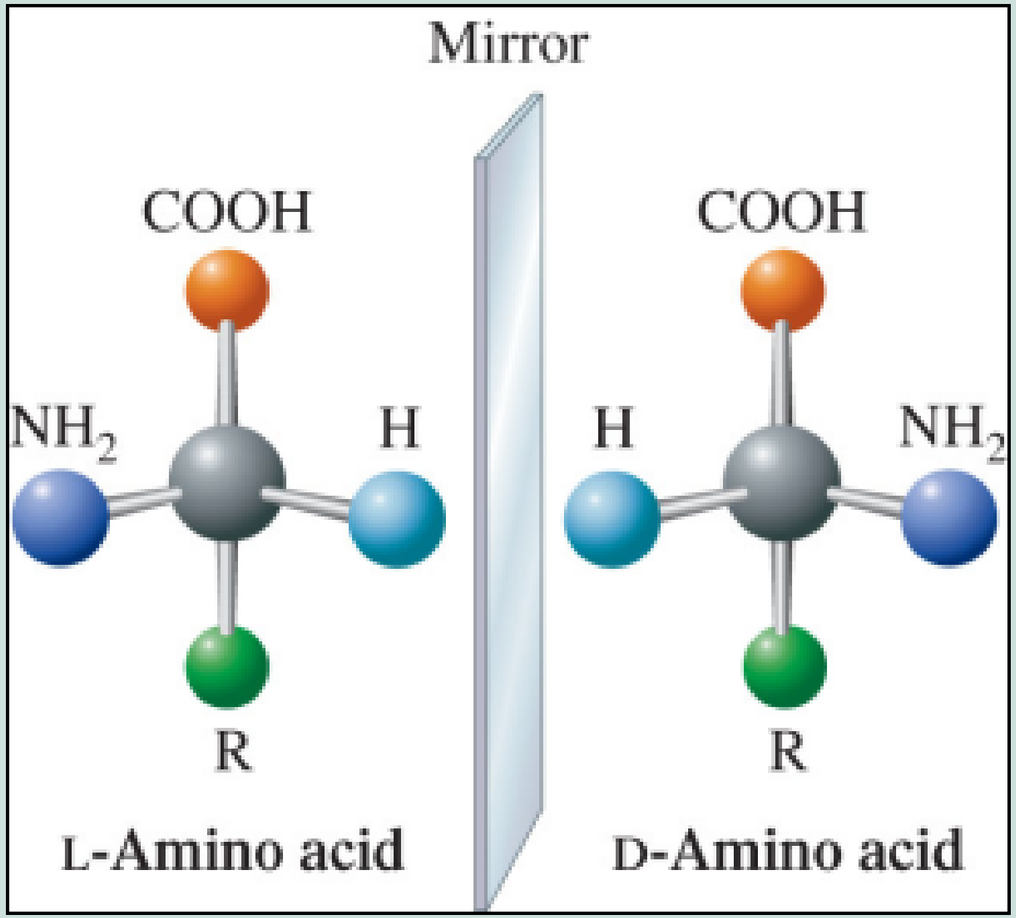
GLUTAMINE (Q)
gln

Note: This chart only shows those amino acids for which the human genetic code directly codes for. Selenocysteine is often referred to as the 21st amino acid, but is encoded in a special manner. In some cases, distinguishing between asparagine/aspartic acid and glutamine/glutamic acid is difficult. In these cases, the codes asx (B) and glx (Z) are respectively used.



Chirality of Amino Acids

- The amino acids found in nature as well as in proteins are L isomers.
- Bacteria do have some D-amino acidsWith monosaccharides nature favors D-isomers
- The rules for drawing Fischer projection formulas for amino acid structures

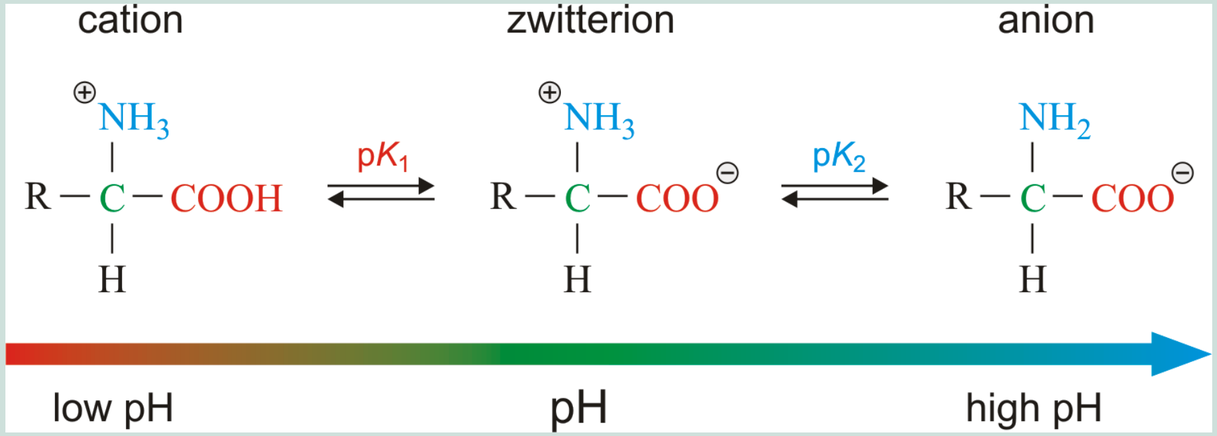


Chirality of Amino Acids

- The — COOH group is put at the top, the R group at the bottom to position the carbon chain vertically
- The — NH2 group is in a horizontal position.
- Positioning — NH2 on the left - L isomer
- Positioning — NH2 on the right - D isomer.

Acid-Base Properties of Amino Acids

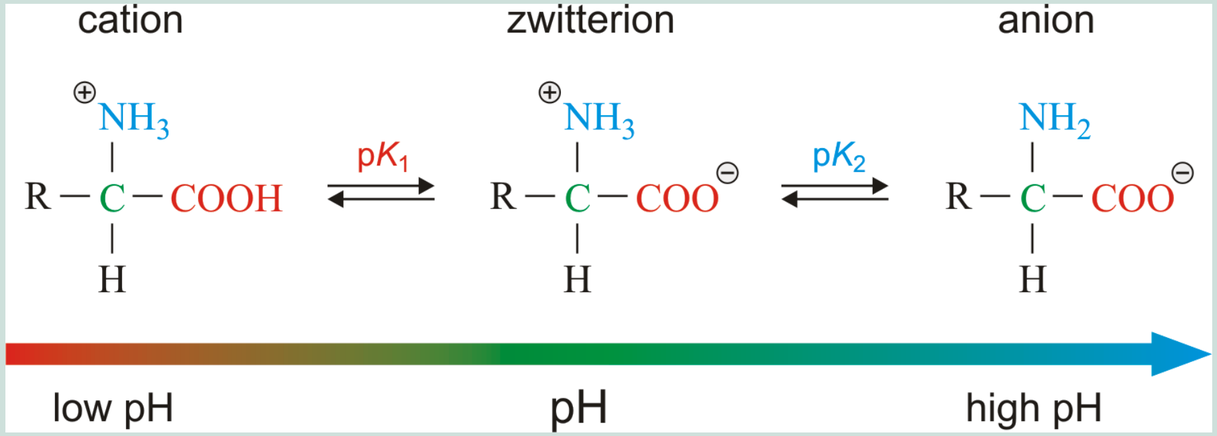
- *In pure form amino acids are white crystalline solids*
- *Most amino acids decompose before they melt*
- *Not very soluble in water*
- *Exists as Zwitterion: An ion with + (positive) and – (Nagetive) charges on the same molecule with a net zero charge*
- *Carboxyl groups give-up a proton to get negative charge*
- *Amino groups accept a proton to become positive*



Zwitterion

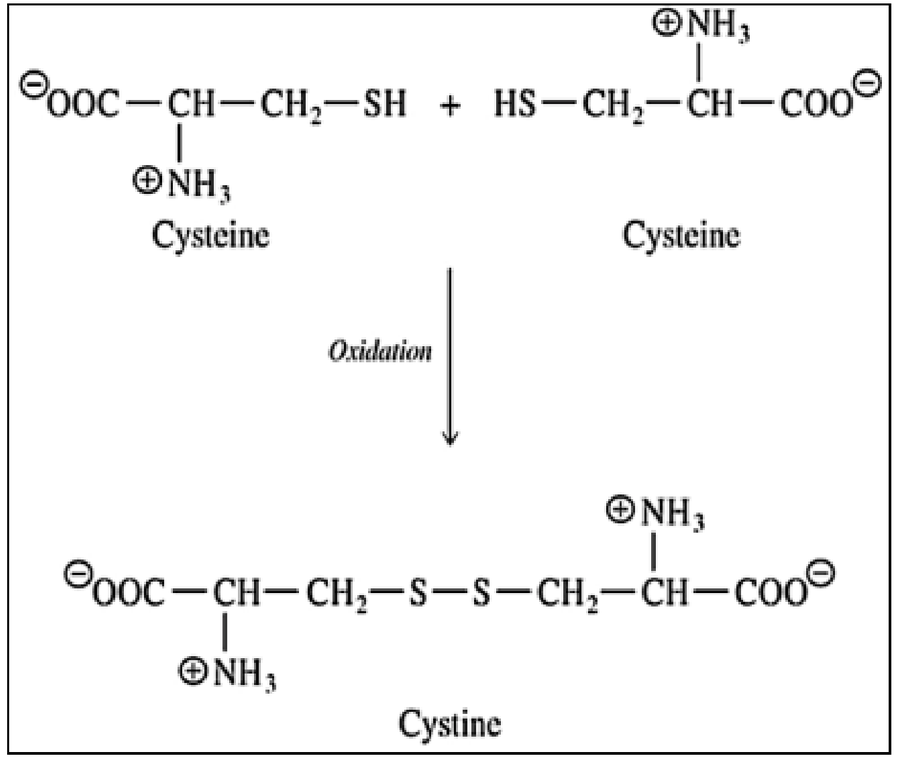
Acid-Base Properties of Amino Acids

- *Amino acids in solution exist in three different species (zwitterions, positive ion, and negative ion) - Equilibrium shifts with change in pH*
- *Isoelectric point (pI) – pH at which the concentration of Zwitterion is maximum -- net charge is zero*
- *Different amino acids have different isoelectric points*
- *At isoelectric point - amino acids are not attracted towards an applied electric field because they net zero charge.*



Zwitterion

Cystine:
A chemically unique Amino Acid



- *Cysteine: the only standard amino acid with a sulfhydryl group (— SH group).*

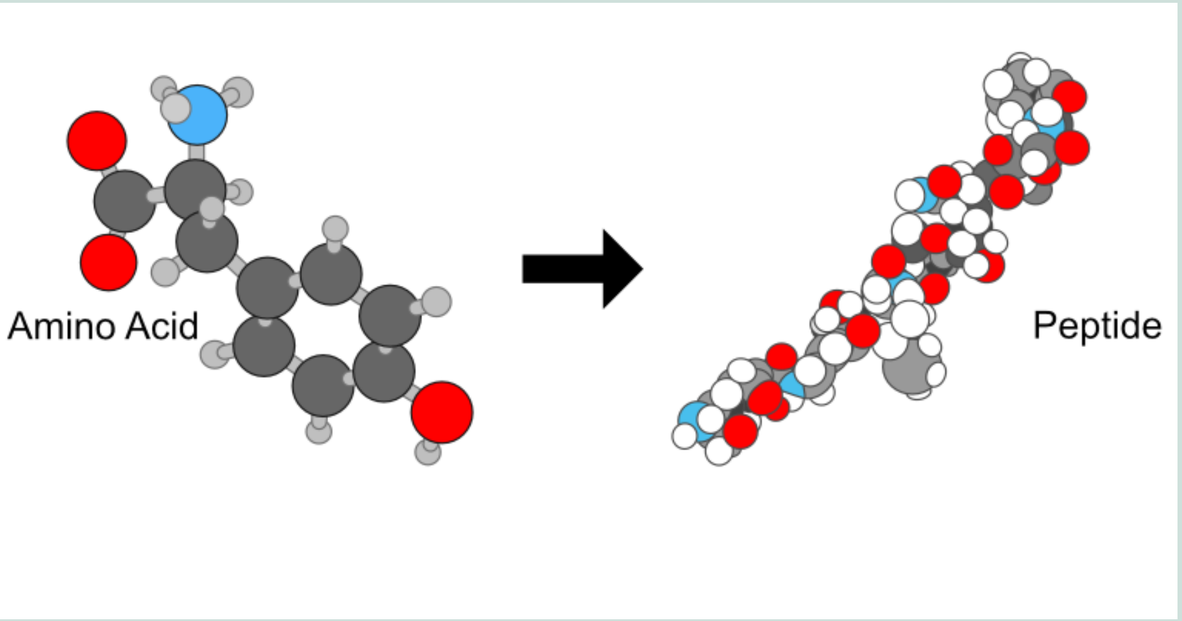
- *The sulfhydryl group imparts cysteine a chemical property unique among the standard amino acids.*

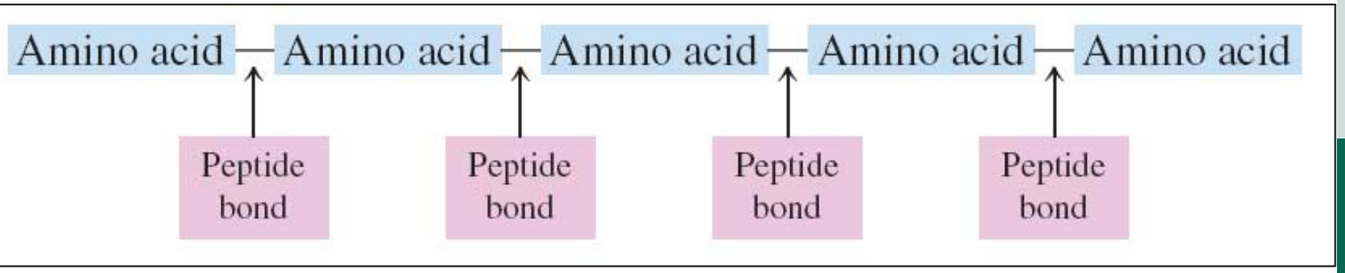
- *Cysteine in the presence of mild oxidizing agents dimerizes to form a cystine molecule.*

1. Cystine - two cysteine residues linked via a covalent disulfide bond.

Peptides

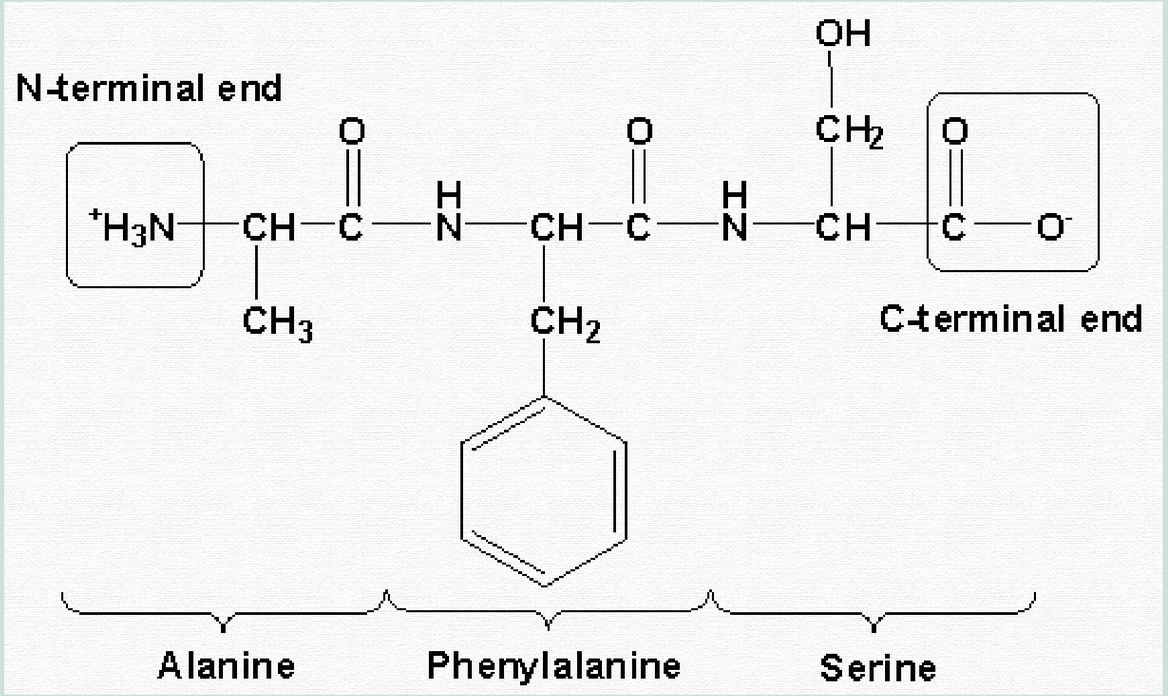
- *Under proper conditions, amino acids can bond together to produce an unbranched chain of amino acids.*
- *The length of the amino acid chain can vary from a few amino acids to many amino acids.*
- *Such a chain of covalently-linked amino acids is called a peptide.*
- *The covalent bonds between amino acids in a peptide are called peptide bonds*

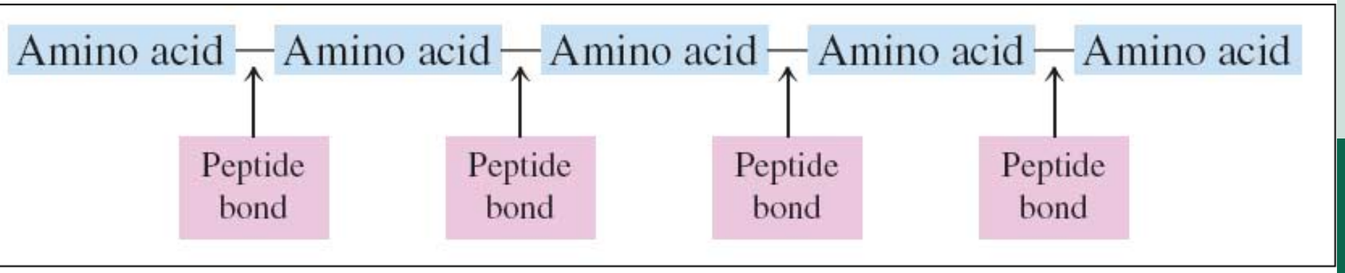




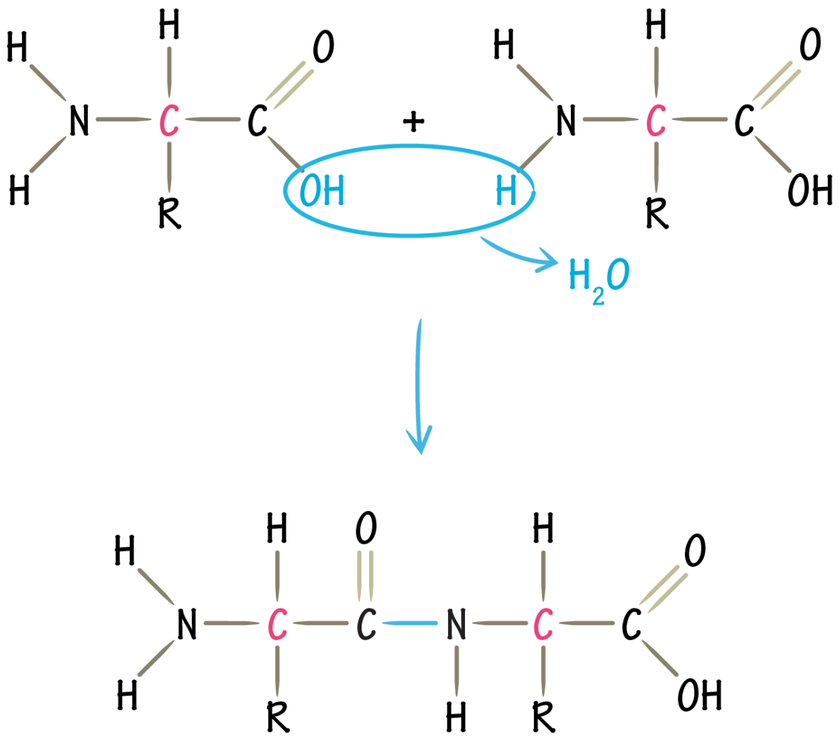
Peptides

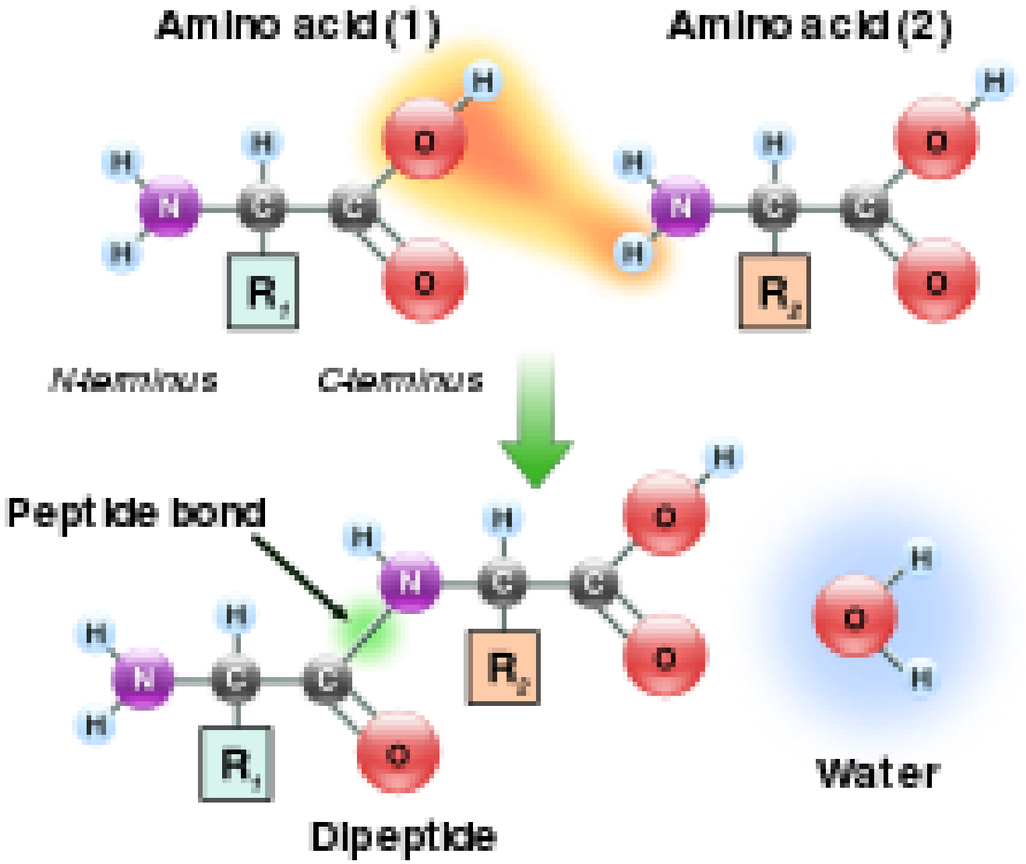
- *Dipeptide: bond between two amino acids*
- *Oligopeptide: bond between ~ 10 - 20 amino acids*
- *Polypeptide: bond between large number of amino acids*
- *Every peptide has an N-terminal end and a C-terminal end*
- *+H3N-aa-aa-aa-aa-aa-aa-aa-aa-aa-COO-*





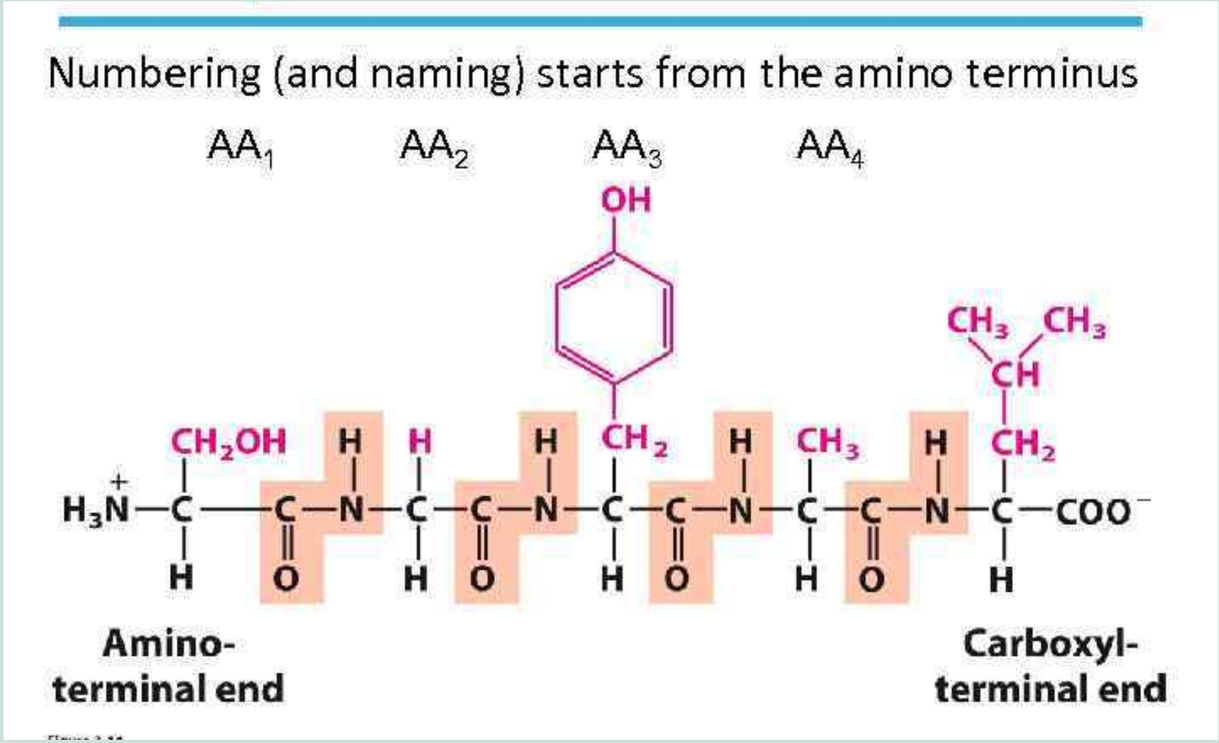
Peptide Bond Formation

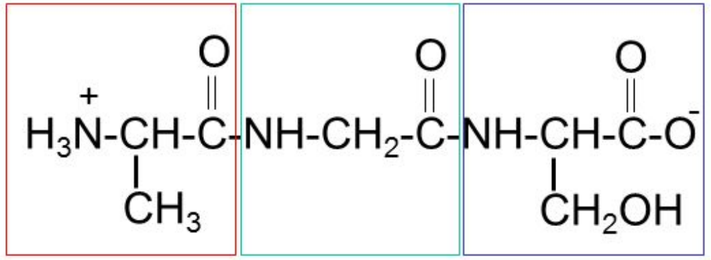




Peptide Nomenclature

- *The C-terminal amino acid residue keeps its full amino acid name.*
- *All of the other amino acid residues have names that end in -yl. The -yl suffi x replaces the -ine or -ic acid ending of the amino acid name, except for tryptophan, for which -yl is added to the name.*
- *The amino acid naming sequence begins at the N-terminal amino acid residue.*
- *Example:*
- *Ala-leu-gly has the IUPAC name of alanylleucylglycine*

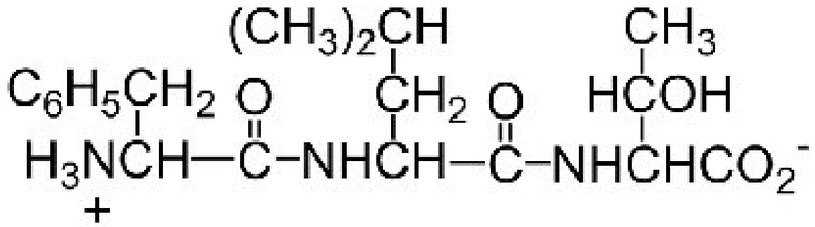




Alanylglycylserine
(Ala-Gly-Ser)

- **Using full amino acid names**
  - **Serylglycyltyrosylalanylleucine**
- **Using the three-letter code abbreviation**
  - **Ser-Gly-Tyr-Ala-Leu**
- **For longer peptides (like proteins) the one-letter code can be used**
  - **SGYAL**

L-alanyl-L-seryl-L-aspartic acid
[aspartate]
Alanylserylaspartate
AlaSerAsp
ASD

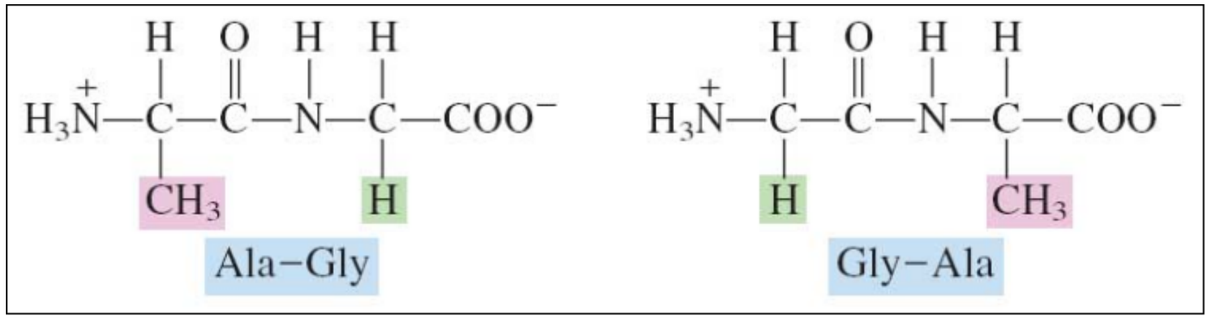


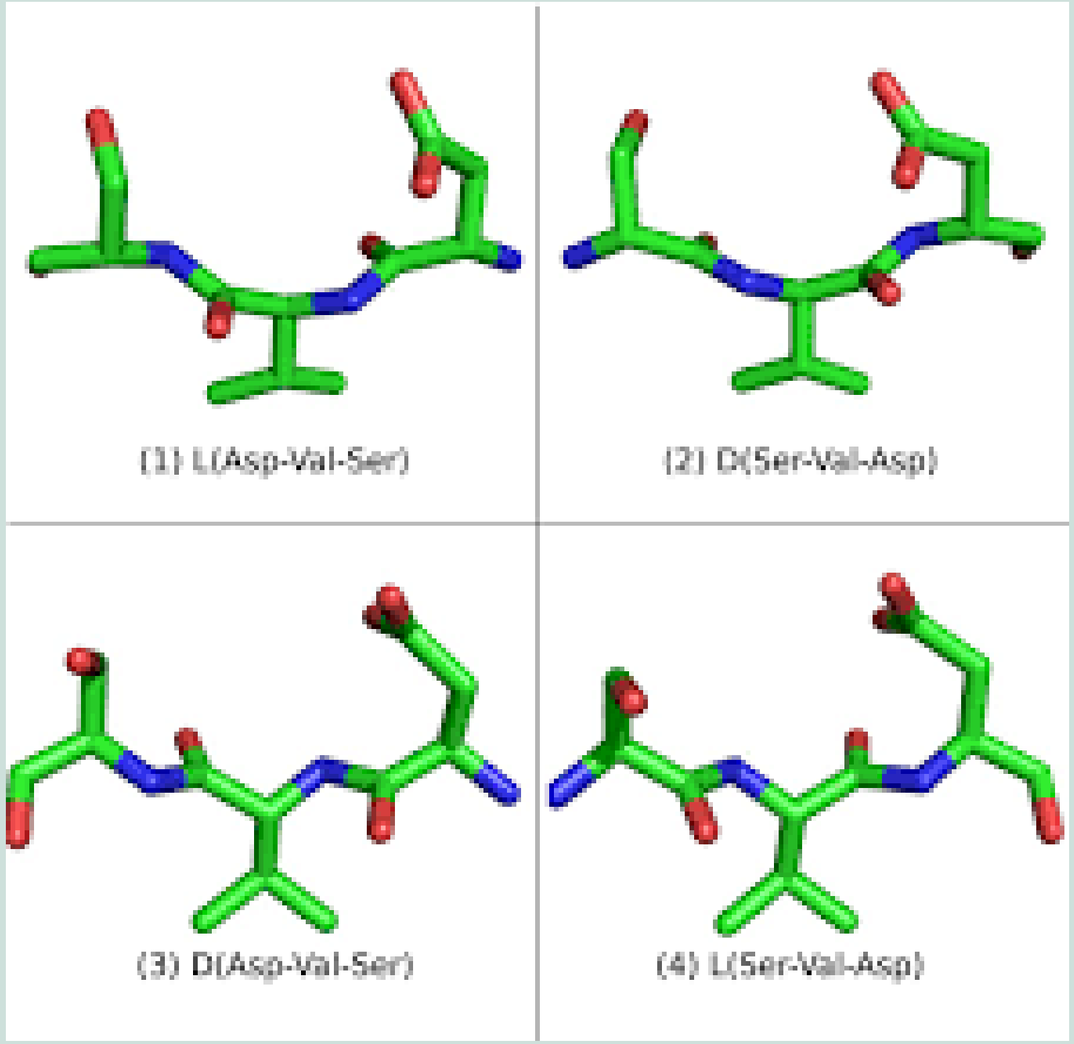
phenylalanylleucylthreonine

Phe-Leu-Thr

Isomeric Peptides

- *Peptides that contain the same amino acids but present in different order are different molecules (constitutional isomers) with different properties*
- *For example, two different dipeptides can be formed between alanine and glycine*
- *The number of isomeric peptides possible increases rapidly as the length of the peptide chain increases*

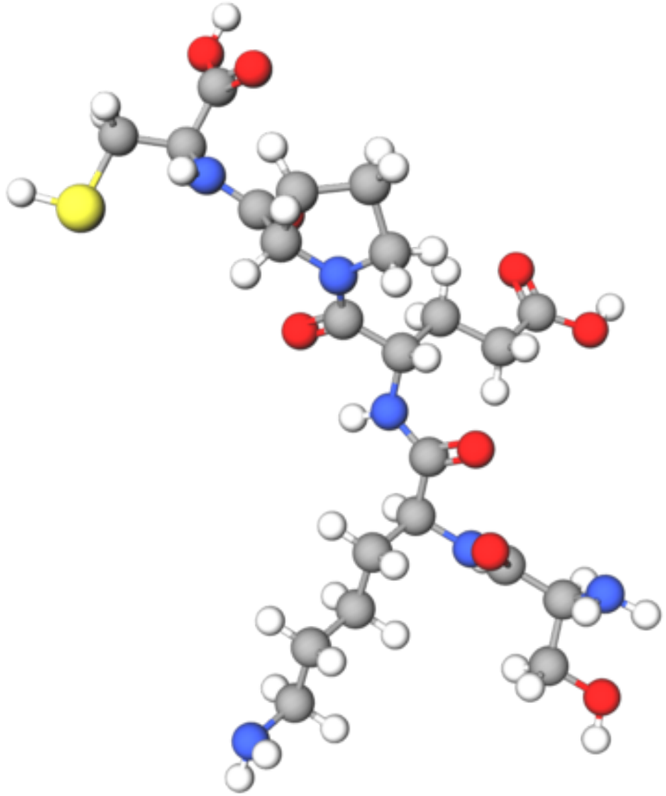




Biochemically important small peptides

Many relatively small peptides are biochemically active:

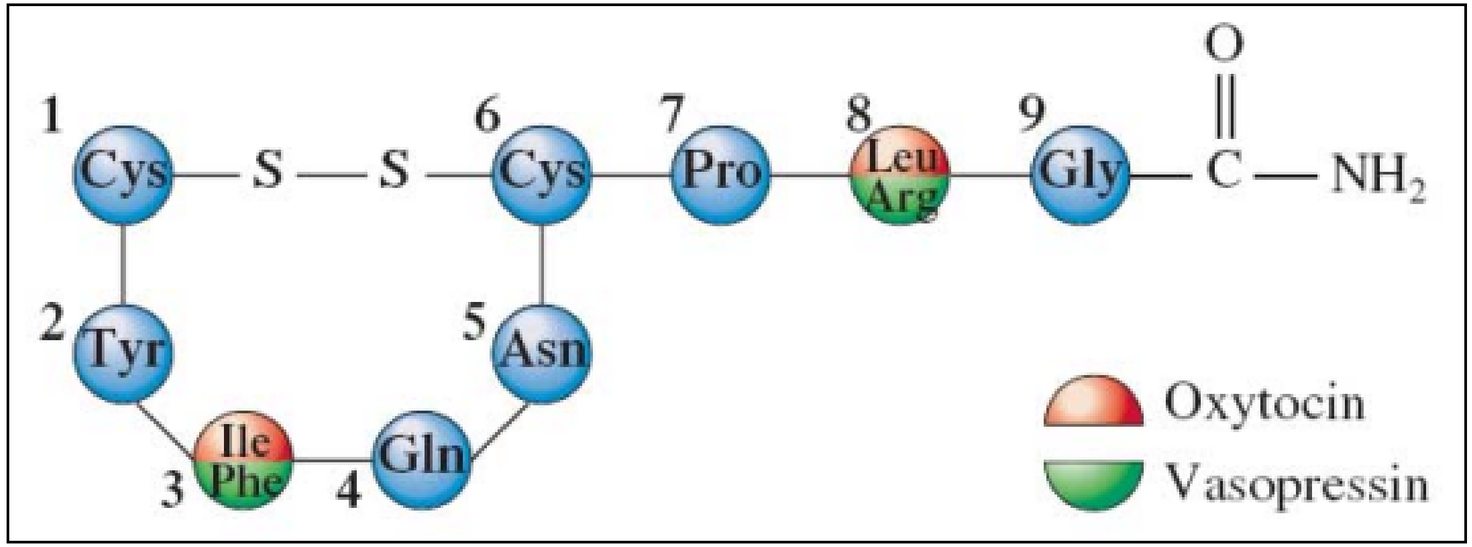
- *Hormones*
- *Neurotransmitters*
- *Antioxidants*



Biochemically important small peptides

Antioxidants Small Peptide Hormones:

- *Best-known peptide hormones: oxytocin and vasopressin*
- *Produced by the pituitary gland*
- *nonapeptide (nine amino acid residues) with six of the residues held in the form of a loop by a disulfide bond formed between two cysteine residues.*



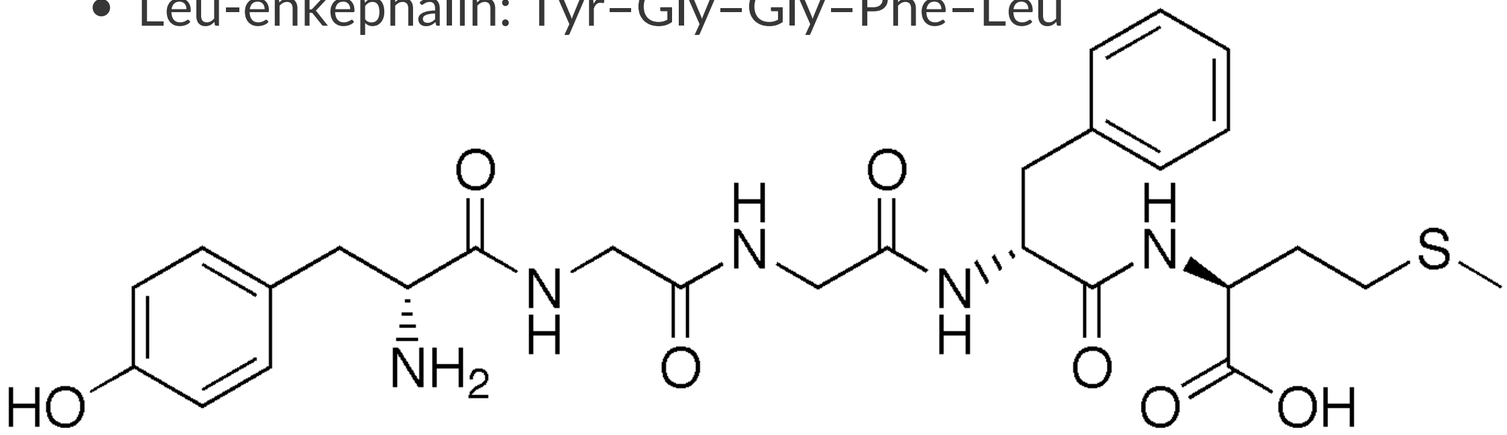
Oxytocin and Vasopressin

Site of Release	Hormone	Target	Effect
Hypothalamus (Posterior Pituitary)	Oxytocin	Uterus Mammary glands	Myometrial contraction Milk ejection
Hypothalamus (Posterior Pituitary)	ADH (Vasopressin)	Kidneys Vascular smooth muscle	Water reabsorbtion Vasoconstriction

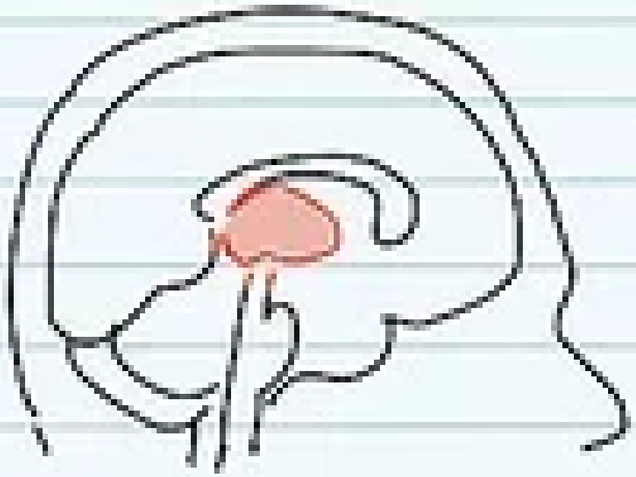
Biochemically important small peptides

Small Peptide Neurotransmitters

- Enkephalins are pentapeptide neurotransmitters produced by the brain and bind receptor within the brain
- Help reduce pain
- Best-known enkephalins:
- Met-enkephalin: Tyr–Gly–Gly–Phe–Met
- Leu-enkephalin: Tyr–Gly–Gly–Phe–Leu



Enkephalins



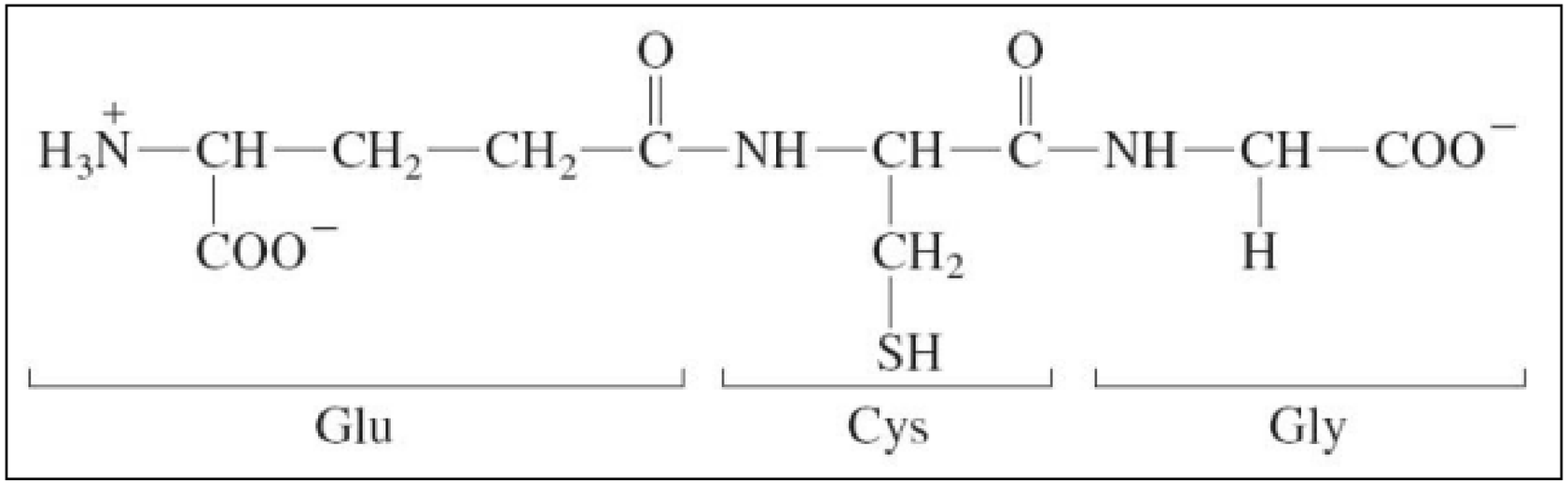
found in the thalamus;

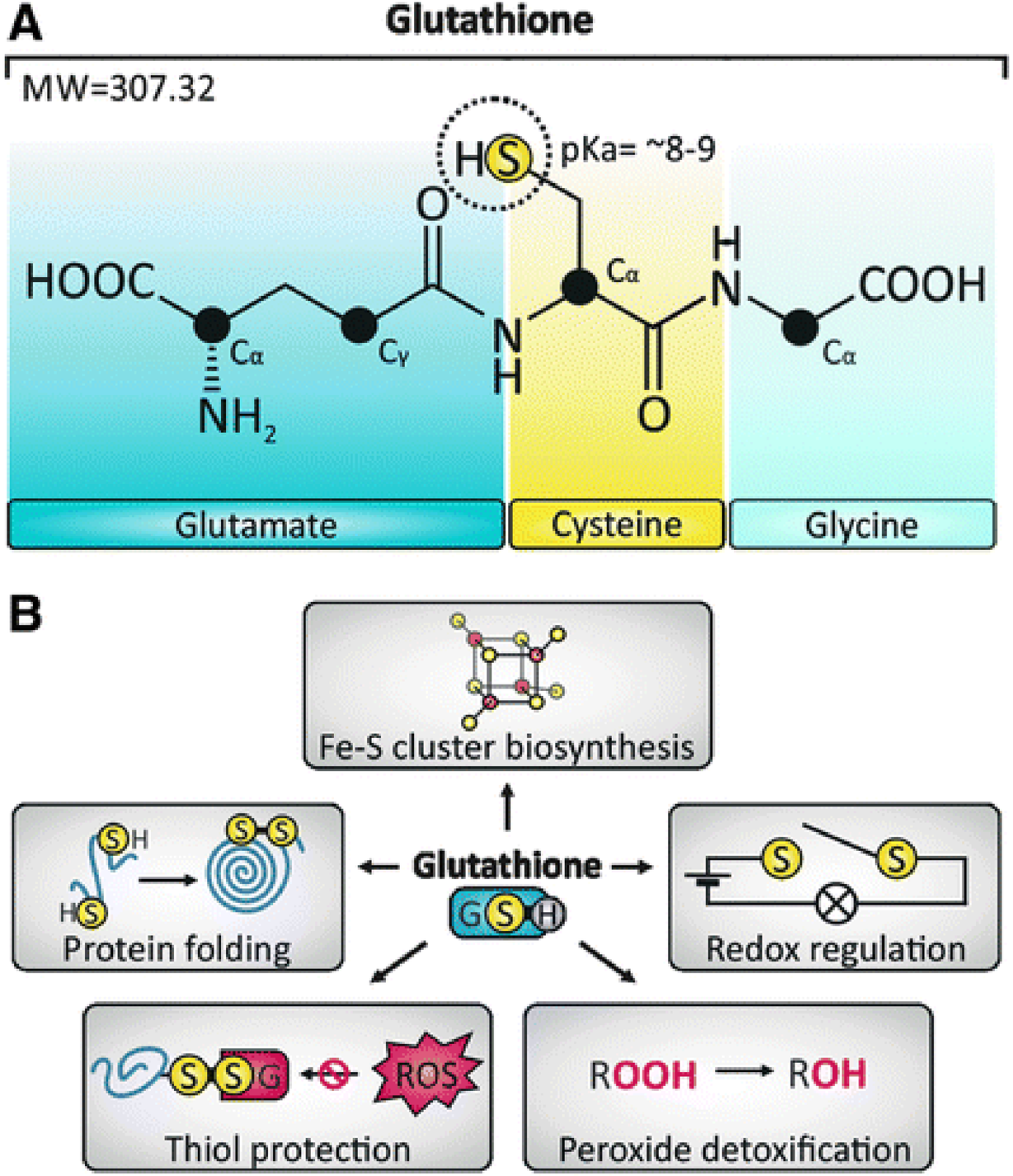
help moderate pain by suppressing pain signals in the brain.

Biochemically important small peptides

Small Peptide Antioxidants

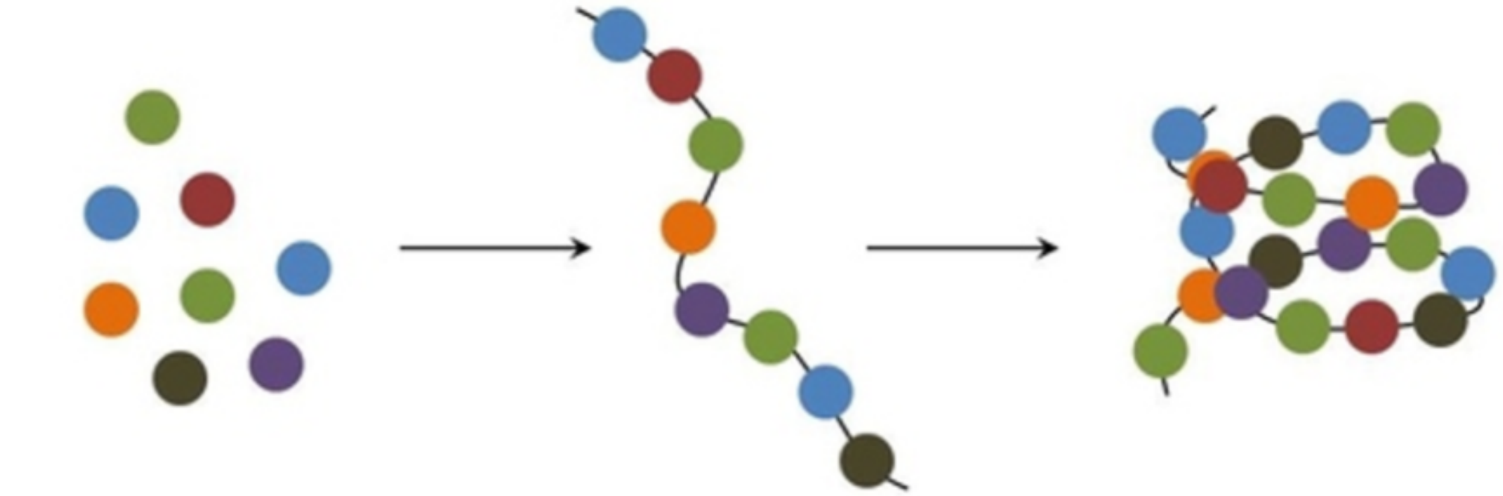
- Glutathione (Glu–Cys–Gly) – a tripeptide – is present is in high levels in most cells
- Regulator of oxidation–reduction reactions.
- Glutathione is an antioxidant and protects cellular contents from oxidizing agents such as peroxides and superoxides
- Highly reactive forms of oxygen often generated within the cell in response to bacterial invasion
- Unusual structural feature – Glu is bonded to Cys through the side-chain carboxyl group.




A
Glutathione
MW=307.32
pKa= ~8-9
HOOC
Cα
Cγ
NH2
O
N
H
Cα
H
N
O
COOH
Cα
Glutamate
Cysteine
Glycine
B
Fe-S cluster biosynthesis
Glutathione
Protein folding
Redox regulation
Thiol protection
ROS
ROOH → ROH
Peroxide detoxification

General structural characteristics of Proteins

General definition: A protein is a naturally-occurring, unbranched polymer in which the monomer units are amino acids.



amino acids peptide protein

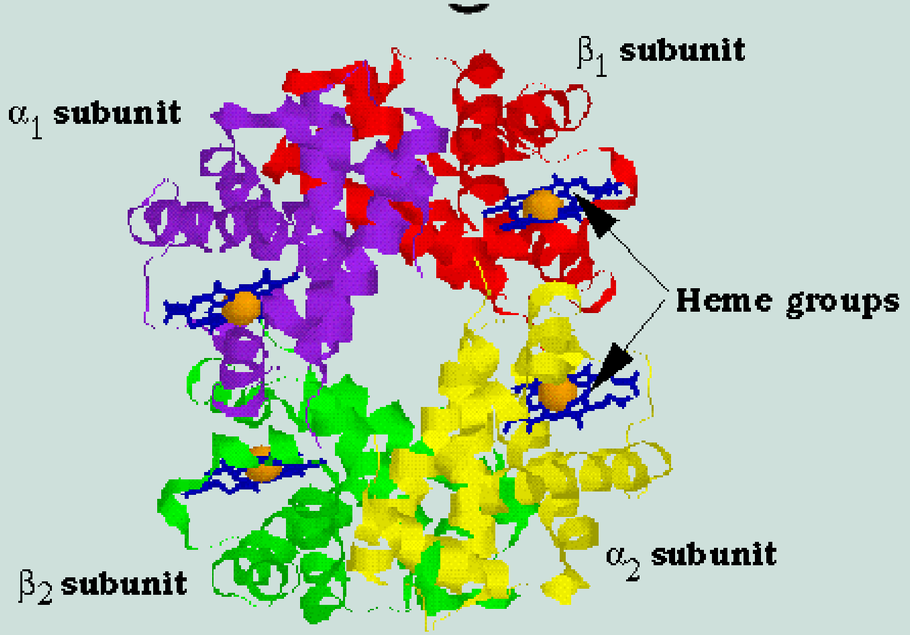
General structural characteristics of Proteins

Specific definition: A protein is a peptide in which at least 40 amino acid residues are present:

- *The terms polypeptide and protein are often used interchangeably used to describe a protein*
- *Several proteins with >10,000 amino acid residues are known*
- *Common proteins contain 400–500 amino acid residues*
- *Small proteins contain 40–100 amino acid residues*

General structural characteristics of Proteins

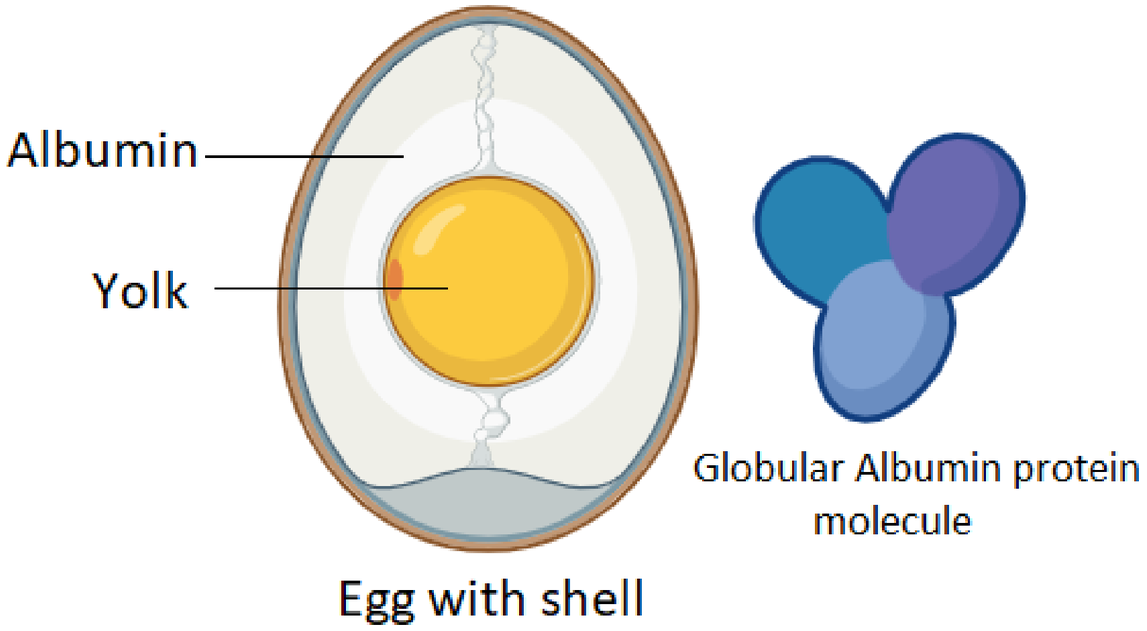
Monomeric : A monomeric protein contains one peptide chain

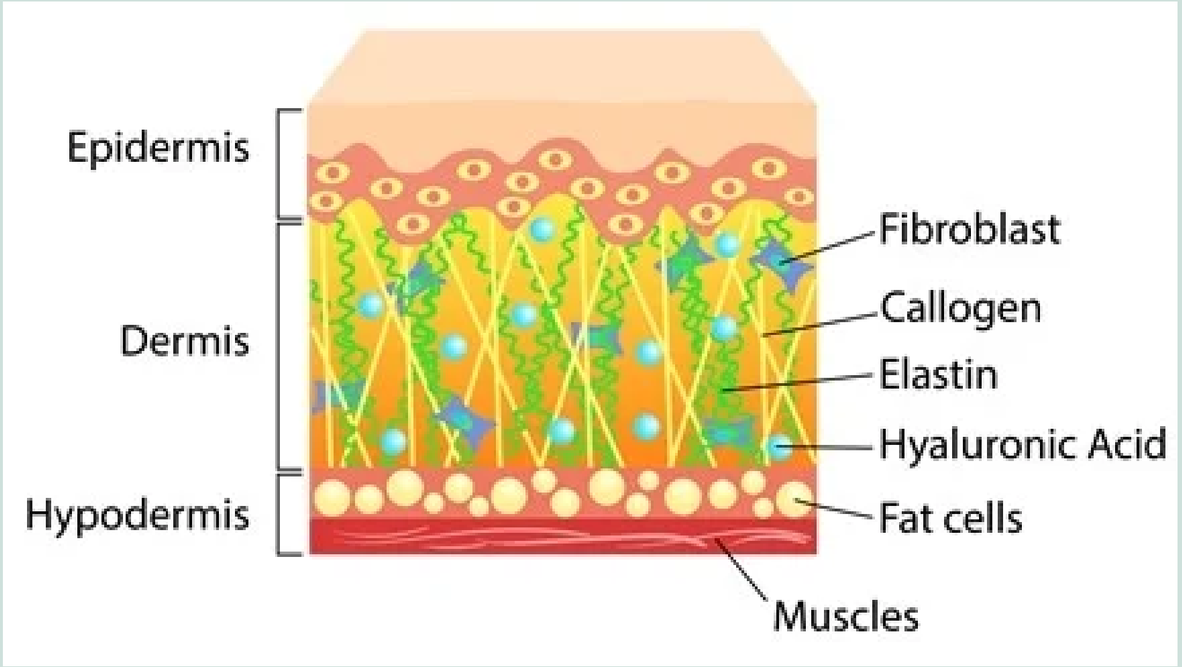


Multimeric: A multimeric protein contains more than one peptide chain

Protein Classification Based on Chemical Composition

Simple proteins: A protein in which only amino acid residues are present:
More than one protein subunit may be present but all subunits contain only amino acids

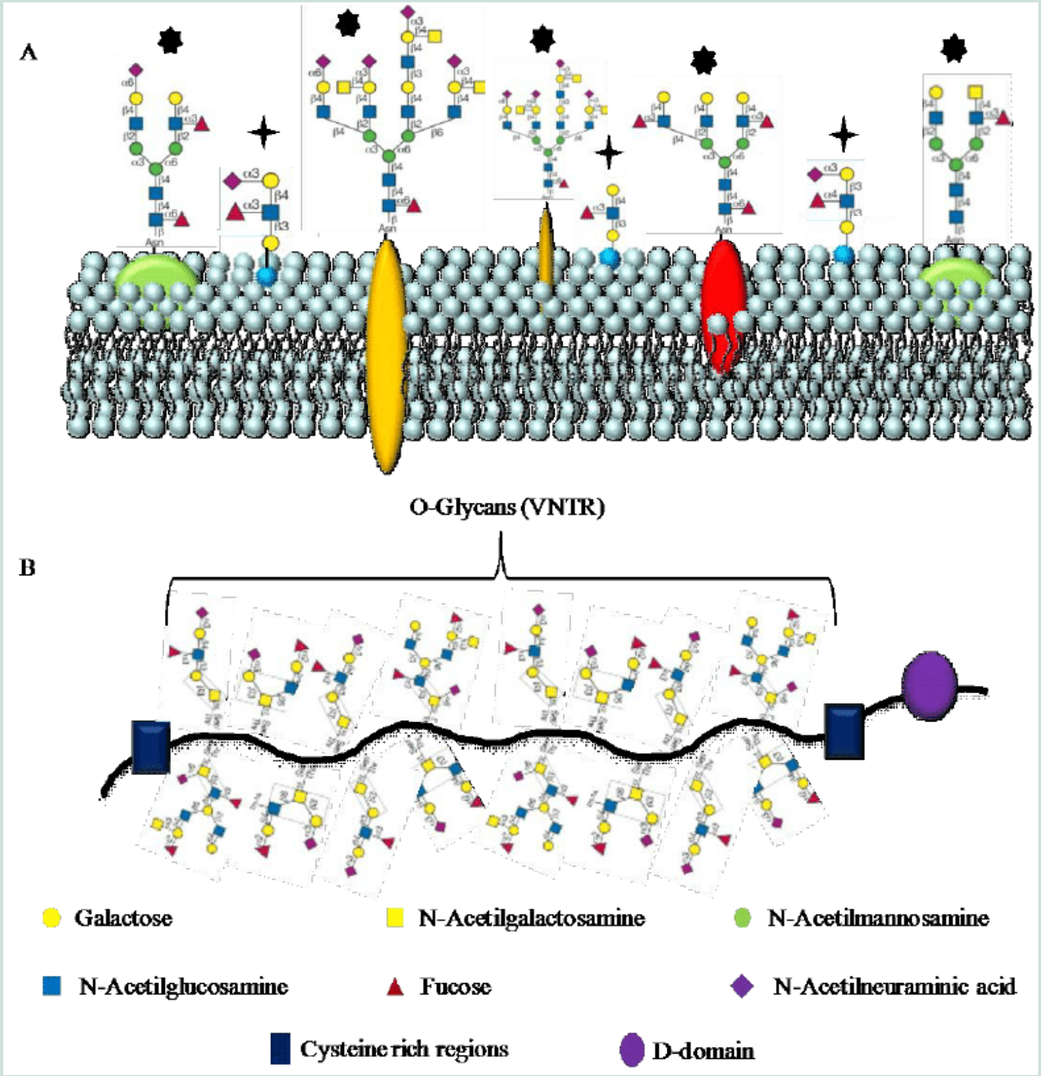




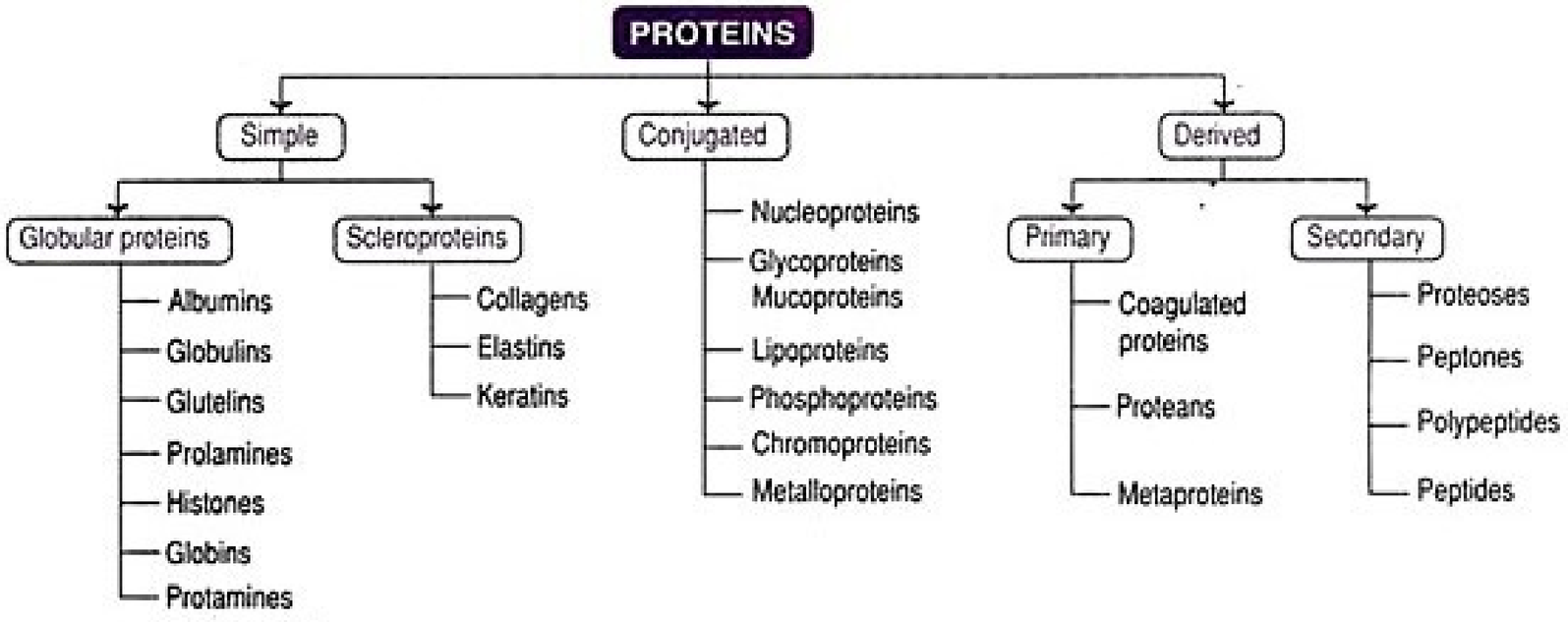
Protein Classification Based on Chemical Composition

Conjugated protein: A protein that has one or more non-amino acid entities (prosthetic groups) present in its structure:

- *One or more polypeptide chains may be present*
- *Non-amino acid components - may be organic or inorganic - prosthetic groups*
- *Lipoproteins contain lipid prosthetic groups*
- *Glycoproteins contain carbohydrate groups,*
- *Metalloproteins contain a specific metal as prosthetic group*

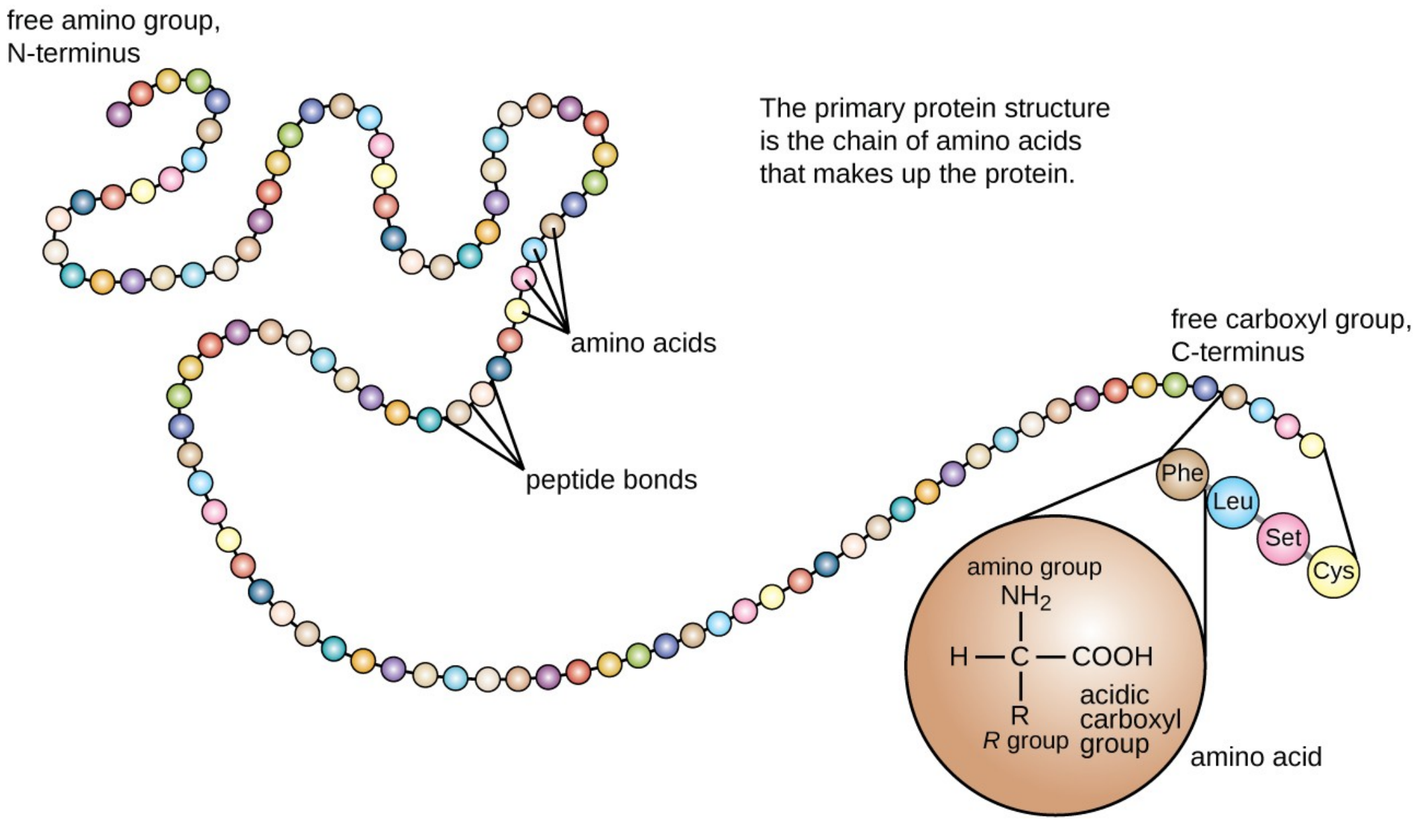


Protein Classification Based on Chemical Composition



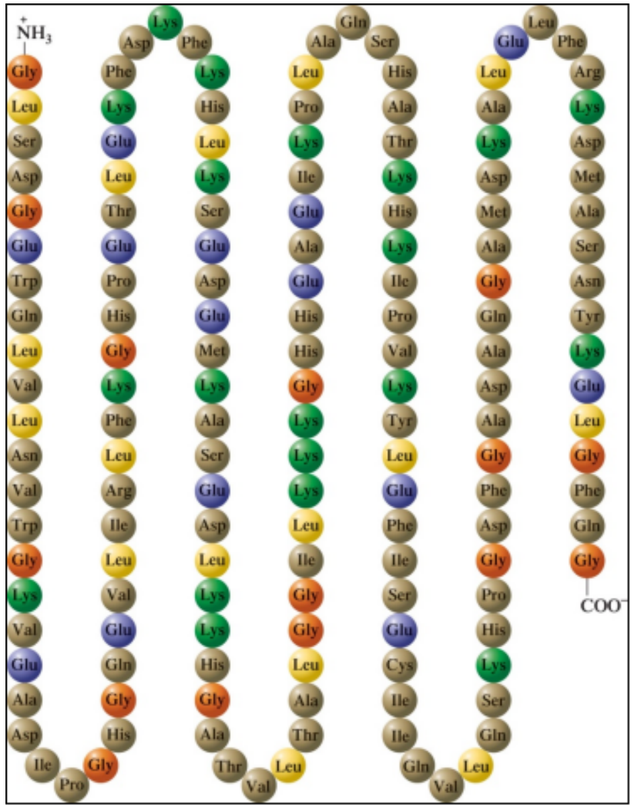
Four Types of Structures:
Primary Structure

- Primary structure of protein refers to the order in which amino acids are linked together in a protein
- Every protein has its own unique amino acid sequence
- Frederick Sanger (1953) sequenced and determined the primary structure for the first protein - Insulin



Four Types of Structures:

Primary Structure

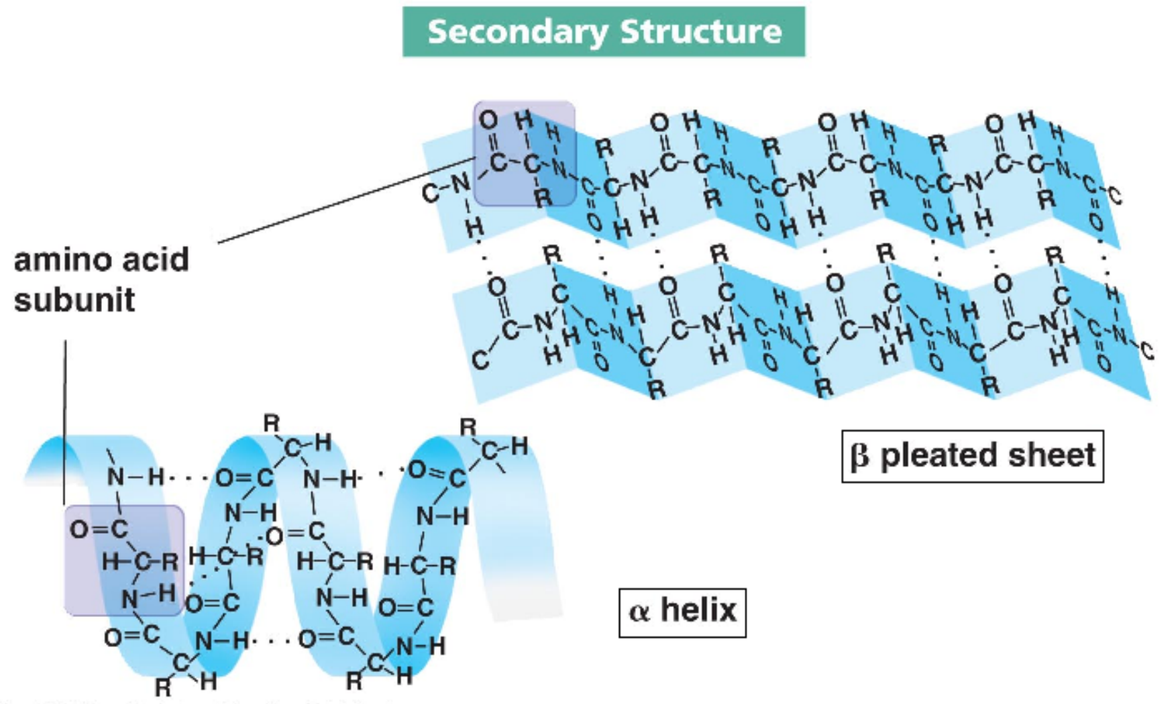


- Proteins of the same organism always same sequence (cows, pigs, etc.)
- Different sources: Insulin from pigs, cows, sheep, humans similar
- Some differences:

Species	Chain A			Chain B
	AA #8	AA #9	AA #10	AA #30
Human	Thr	Ser	Ile	Thr
Pig (porcine)	Thr	Ser	Ile	Ala
Cow (bovine)	Ala	Ser	Val	Ala

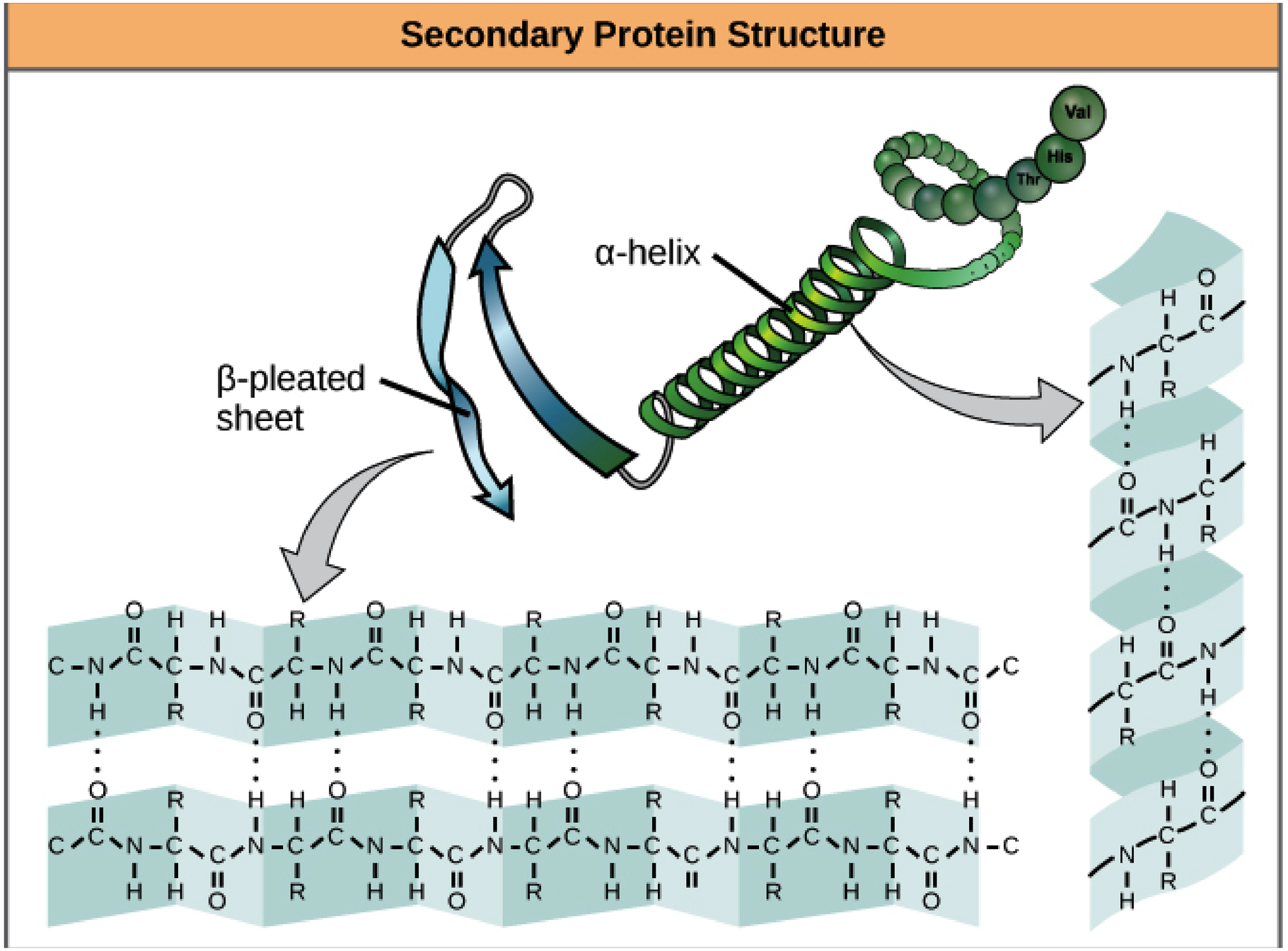
- Due to differences insulin may show some reaction over time
- Now human insulin produced from genetically engineered bacteria

Four Types of Structures: Secondary Structure



- Arrangement of atoms of backbone in space.
- The two most common types : alpha-helix (a-helix) and the beta-pleated sheet (b-pleated sheet).
- The peptide linkages are essentially planar thus allows only two possible arrangements for the peptide backbone for the following reasons:
- For two amino acids linked through a peptide bond six atoms lie in the same plane
- The planar peptide linkage structure has considerable rigidity, therefore rotation of groups about the C–N bond is hindered
- Cis–trans isomerism is possible about C–N bond.
- The trans isomer is the preferred orientation

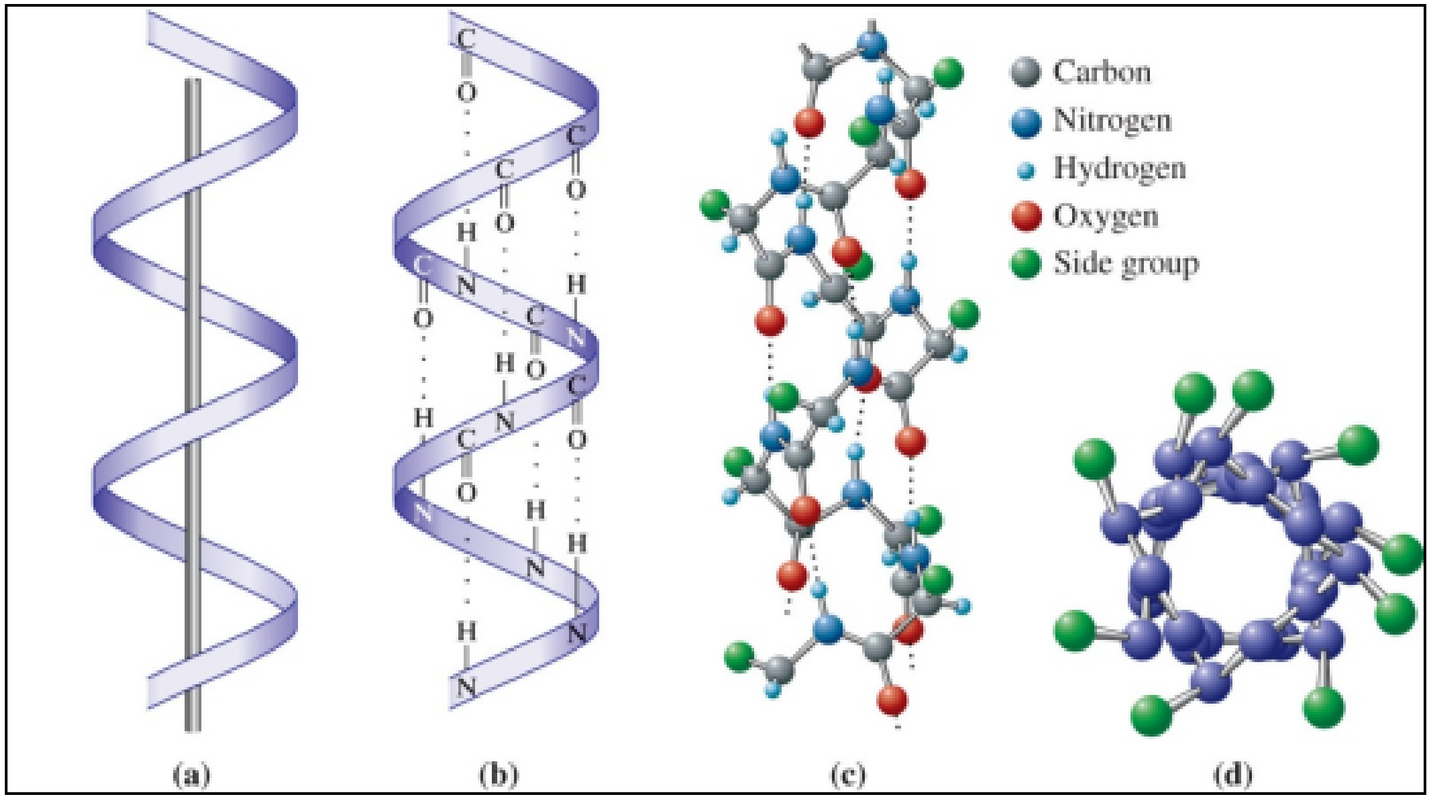
Secondary Protein Structure



Four Types of Structures:
Secondary Structure

Alpha-helix (a-helix)

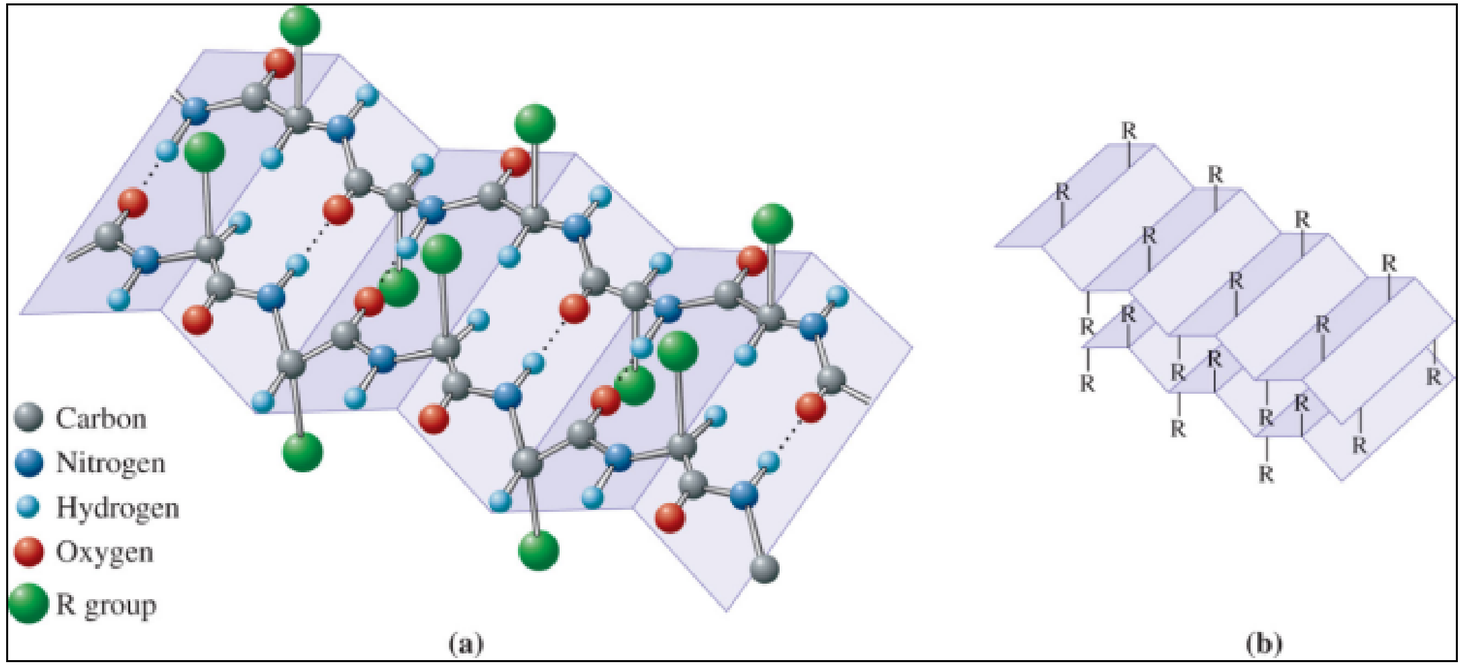
- A single protein chain adopts a shape that resembles a coiled spring (helix):
- H-bonding between same amino acid chains –intra molecular
- Coiled helical spring
- R-group outside of the helix -- not enough room for them to stay inside



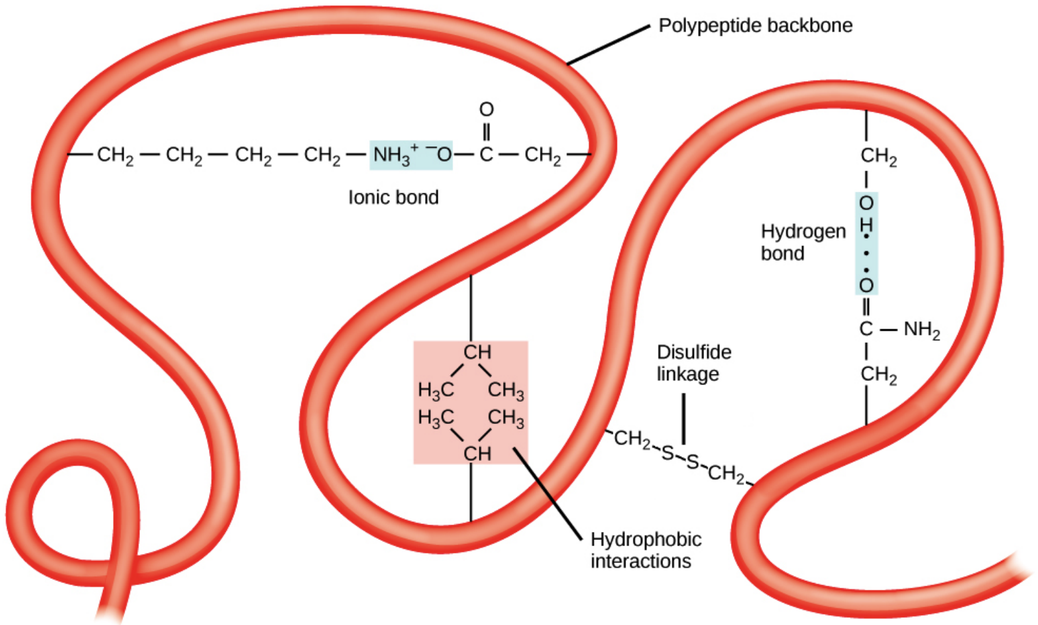
Four Types of Structures: Secondary Structure

Beta-Pleated Sheets

- Completely extended amino acid chains
- H-bonding between two different chains – inter and/or intramolecular
- Side chains below or above the axis



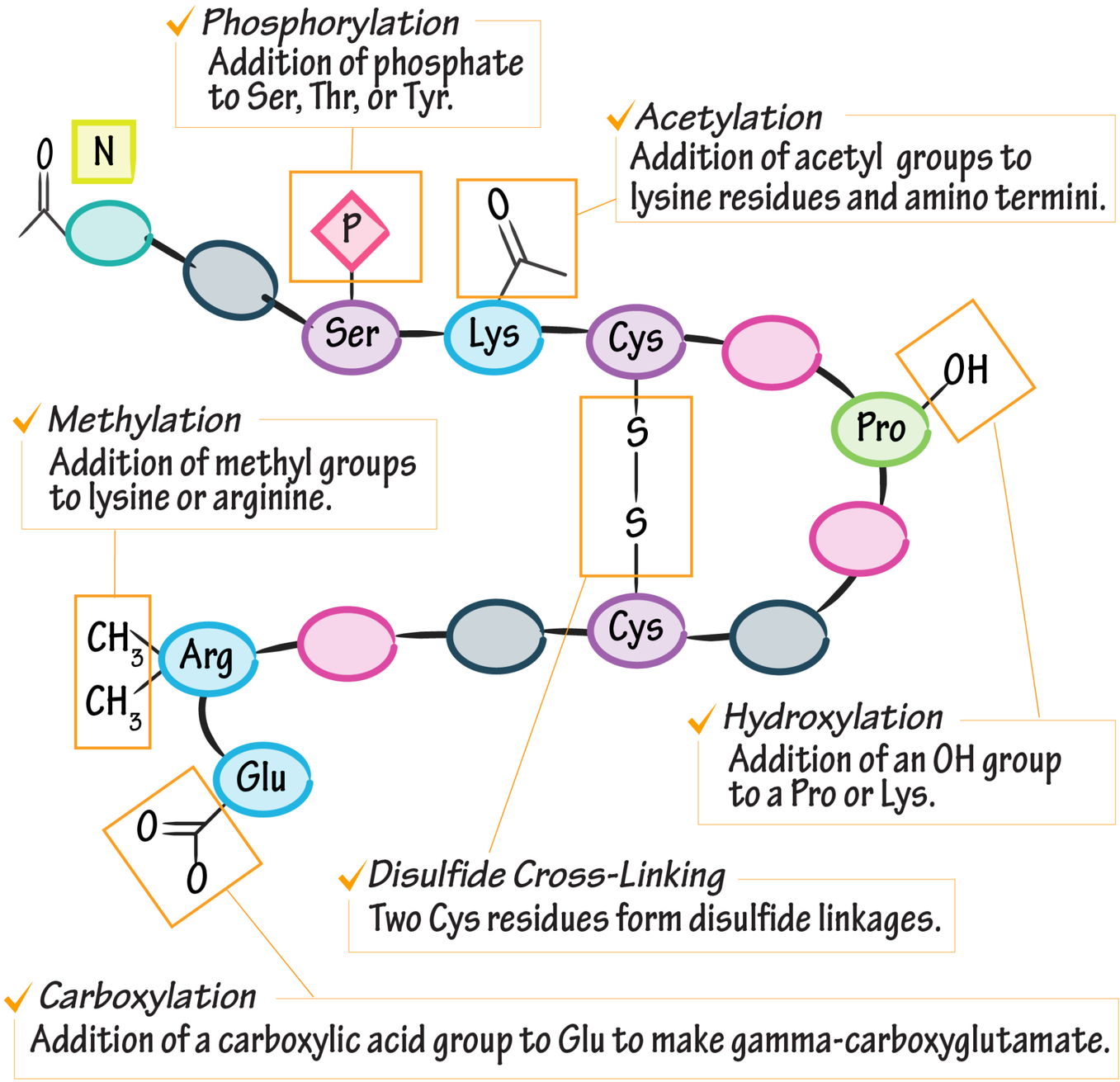
Four Types of Structures: Tertiary Structure



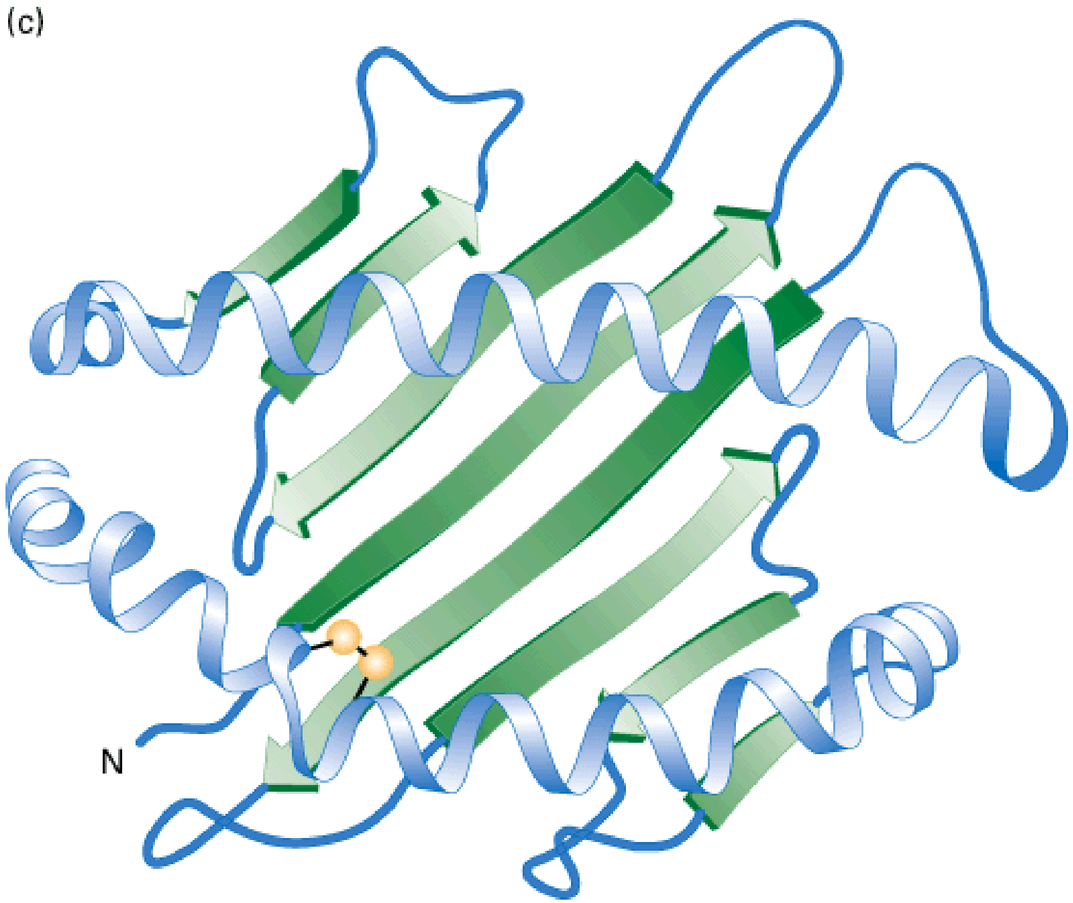
- The overall three-dimensional shape of a protein
- Results from the interactions between amino acid side chains (R groups) that are widely separated from each other.

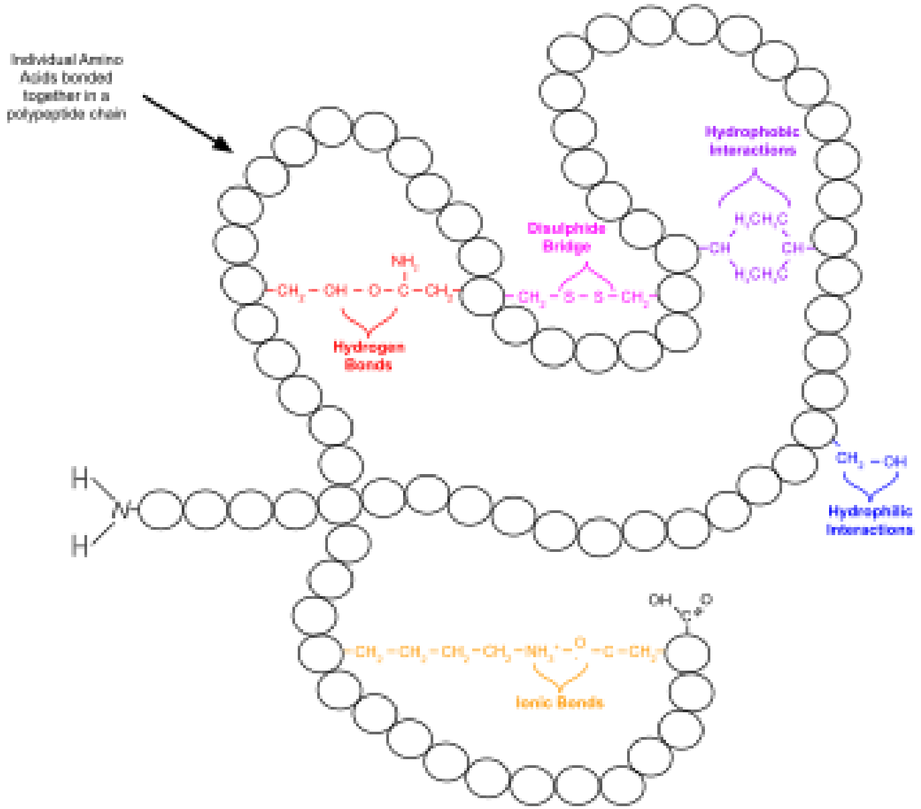
Four Types of Interactions

- Disulfide bond: covalent, strong, between two cysteine groups
- Electrostatic interactions: Salt Bridge between charged side chains of acidic and basic amino acids
- -OH, -NH2, -COOH, -CONH2
- H-Bonding between polar, acidic and/or basic R groups
- For H-bonding to occur, the H must be attached on O, N or F
- Hydrophobic interactions: Between non-polar side chains


Phosphorylation
Addition of phosphate to Ser, Thr, or Tyr.
Acetylation
Addition of acetyl groups to lysine residues and amino termini.
Methylation
Addition of methyl groups to lysine or arginine.
Hydroxylation
Addition of an OH group to a Pro or Lys.
Disulfide Cross-Linking
Two Cys residues form disulfide linkages.
Carboxylation
Addition of a carboxylic acid group to Glu to make gamma-carboxyglutamate.
O
N
P
O
Ser
Lys
Cys
OH
Pro
S
S
Cys
CH3
CH3
Arg
Glu
O
O

Four Types of Structures:
Tertiary Structure





Bond Types

Hydrophobic Interactions: These amino acids orient themselves towards the center of the polypeptide to avoid the water

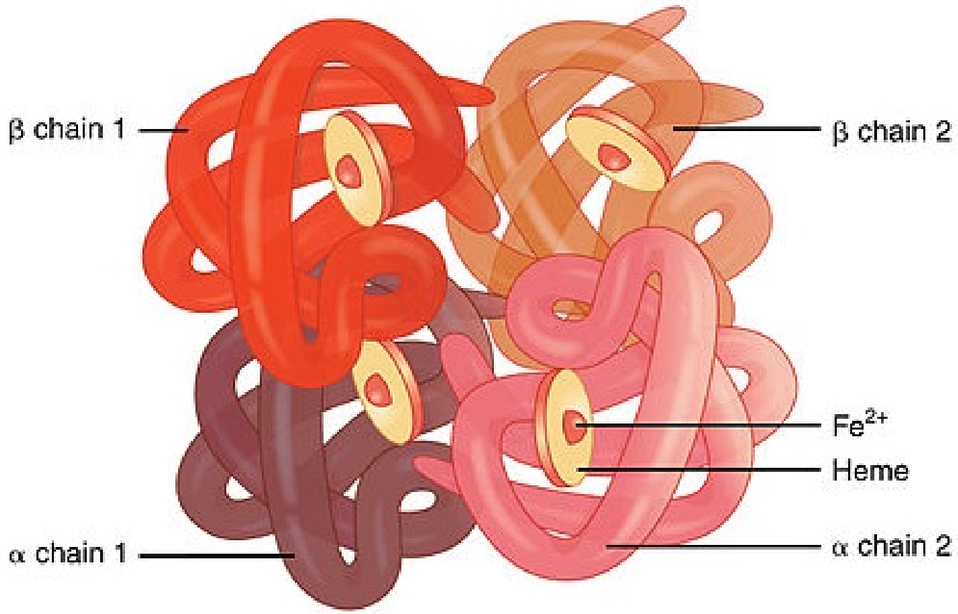
Disulphide Bridge: The amino acid cysteine forms a bond with another cysteine through its R group

Hydrogen Bonds: Polar "R" groups on the amino acids form bonds with other Polar R groups

Hydrophilic Interactions: These amino acids orient themselves outward to be close to the water

Ionic Bonds: Positively charged R groups bond together

Four Types of Structures: Quaternary Structure

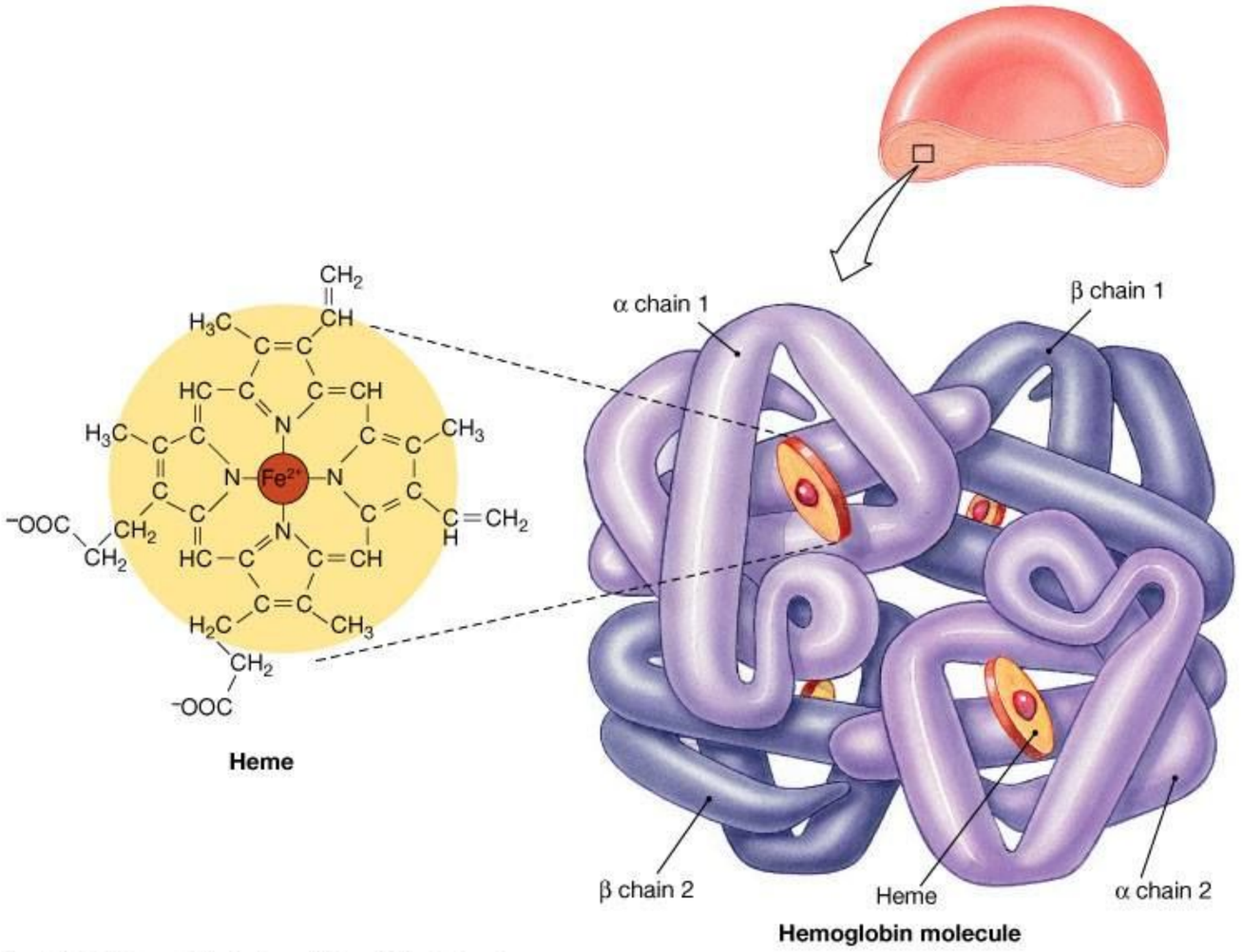


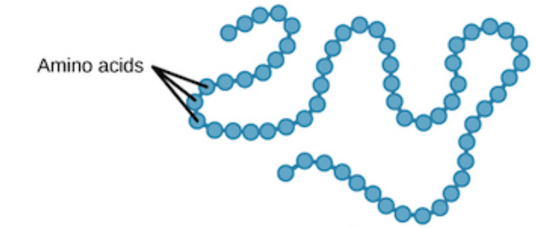
(a)

Quaternary structure of protein refers to the organization among the various peptide chains in a multimeric protein:

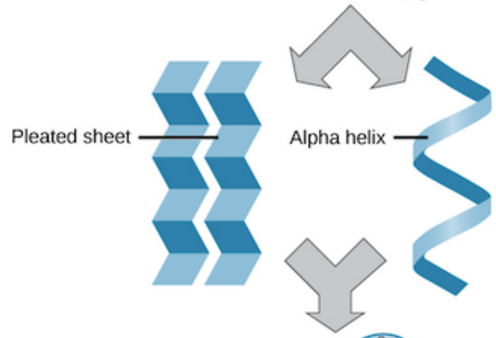
- Highest level of protein organization
- Present only in proteins that have 2 or more polypeptide chains (subunits)
- Subunits are generally Independent of each other - not covalently bonded
- Proteins with quartenary structure are often referred to as oligomeric proteins
- Contain even number of subunits

Four Types of Structures:



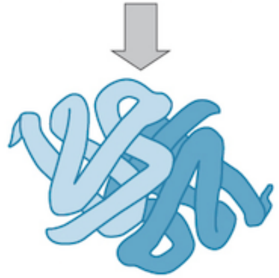


Primary protein structure
sequence of a chain of animo acids

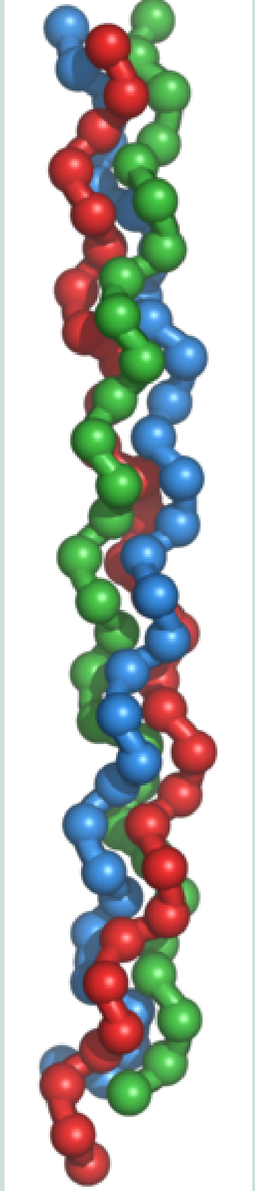


Secondary protein structure
hydrogen bonding of the peptide backbone causes the amino acids to fold into a repeating pattern

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

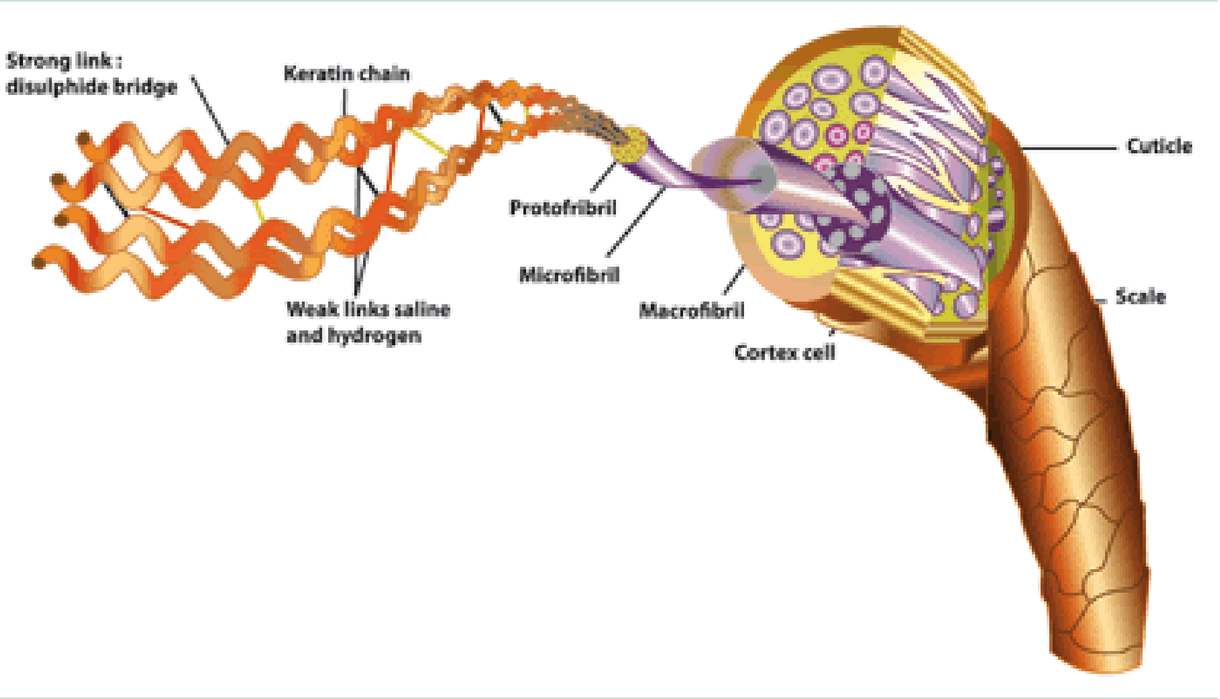


Quaternary protein structure
protein consisting of more than one amino acid chain



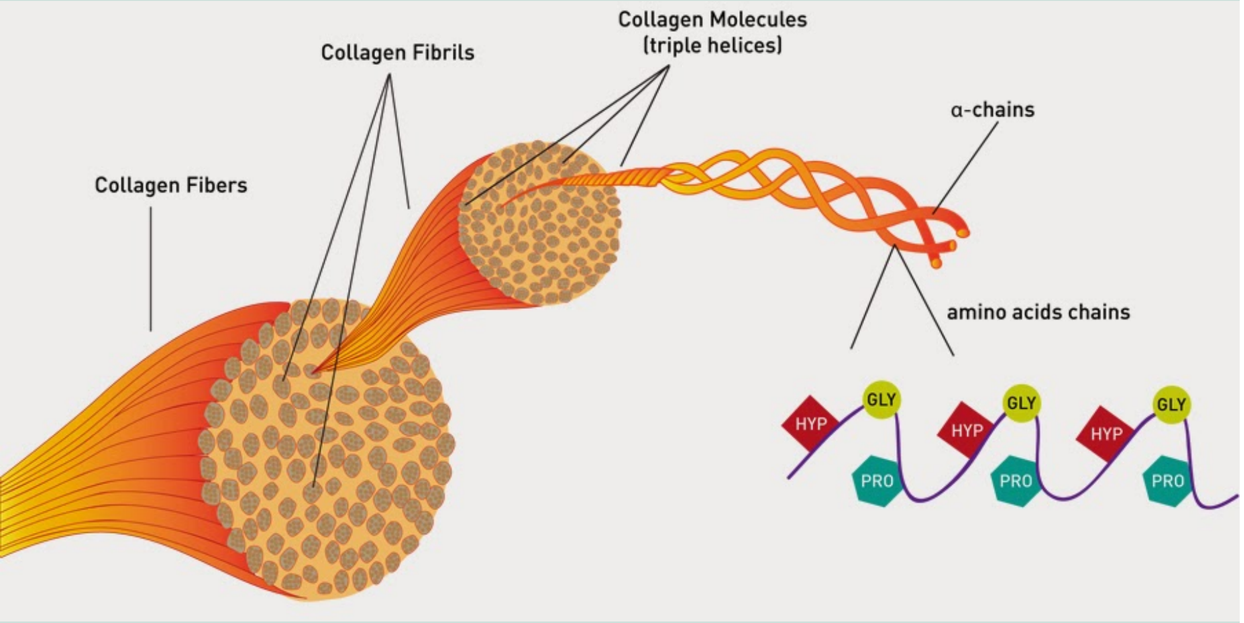
Protein classification based on shape

- Fibrous proteins: protein molecules with elongated shape:
- Generally insoluble in water
- Single type of secondary structure
- Tend to have simple, regular, linear structures
- Tend to aggregate together to form macromolecular structures, e.g., hair, nails, etc



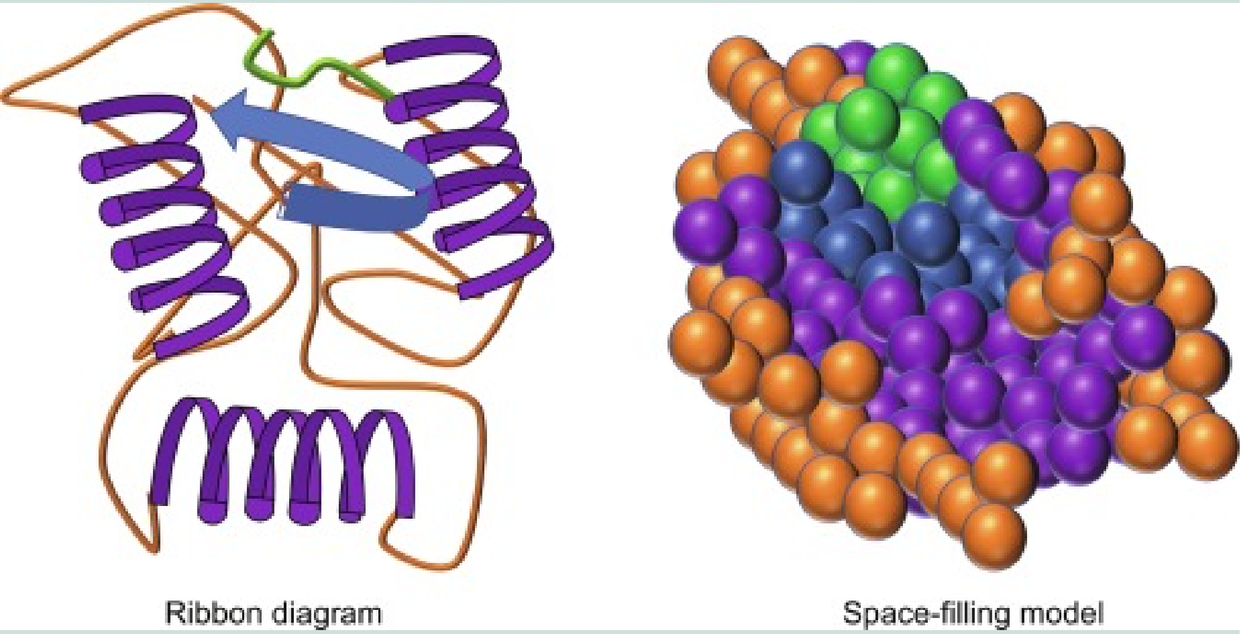
Fibrous Proteins: Alpha-Keratin

- Provide protective coating for organs
- Major protein constituent of hair, feather, nails, horns and turtle shells
- Mainly made of hydrophobic amino acid residues
- Hardness of keratin depends upon -S-S- bonds
- more –S-S– bonds make nail and bones hard



Fibrous Proteins: Collagen

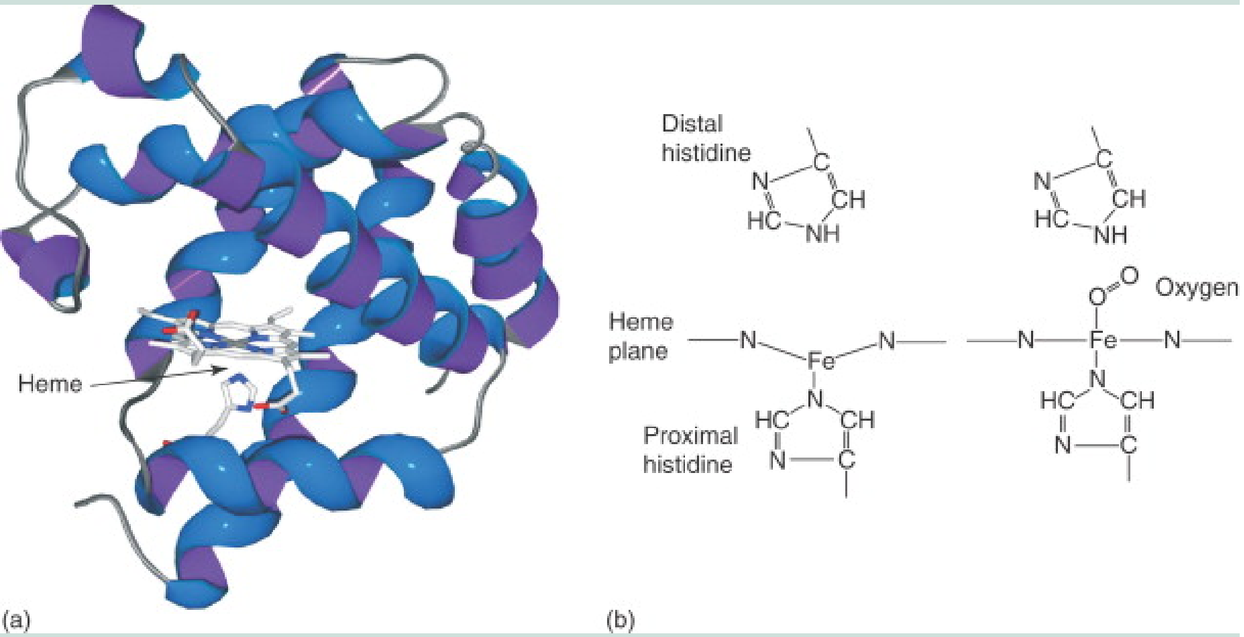
- Most abundant proteins in humans (30% of total body protein)
- Major structural material in tendons, ligaments, blood vessels, and skin
- Organic component of bones and teeth
- Predominant structure - triple helix
- Rich in proline (up to 20%) – important to maintain structure



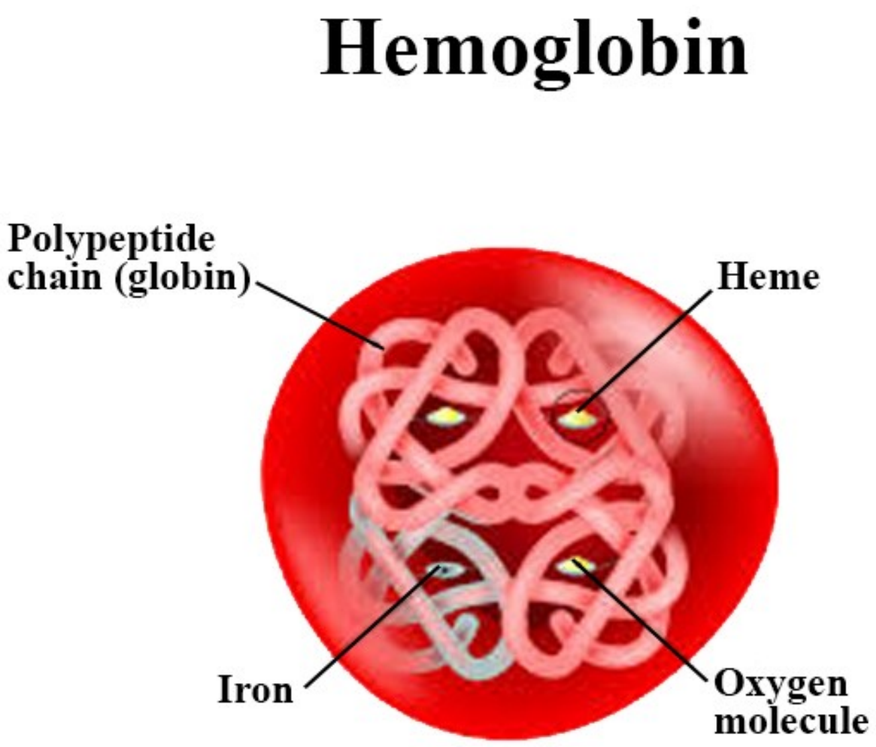
Protein classification based on shape

- Globular proteins: protein molecules with peptide chains folded into spherical or globular shapes:
- Generally water soluble – hydrophobic amino acid residues in the protein core
- Function as enzymes and intracellular signaling molecules

Globular Proteins: Myoglobin



- Globular Proteins: Myoglobin:
- An oxygen storage molecule in muscles.
- Monomer - single peptide chain with one heme unit
- Binds one O2 molecule
- Has a higher affinity for oxygen than hemoglobin.
- Oxygen stored in myoglobin molecules serves as a reserve oxygen source for working muscles



Globular Proteins: Hemoglobin

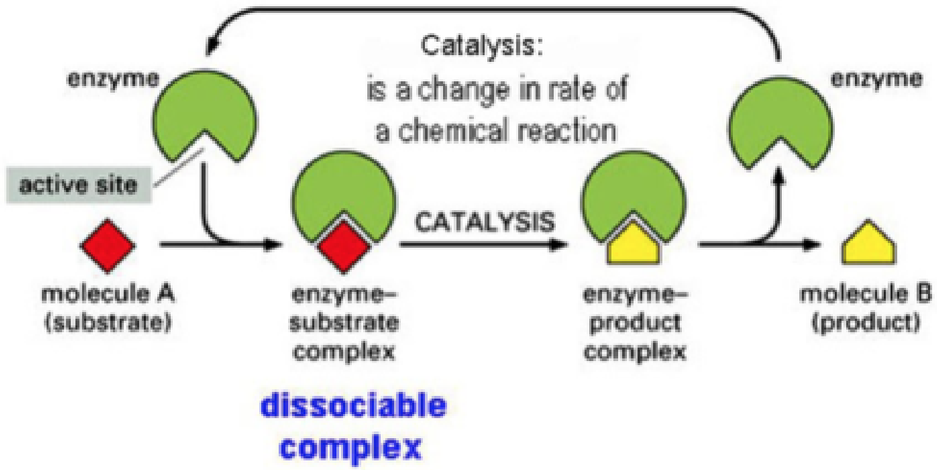
- An oxygen carrier molecule in blood
- Transports oxygen from lungs to tissues
- Tetramer (four peptide chains) - each subunit has a heme group
- Can transport up to 4 oxygen molecules at time
- Iron atom in heme interacts with oxygen

Protein classification based on function

Proteins play crucial roles in most biochemical processes.

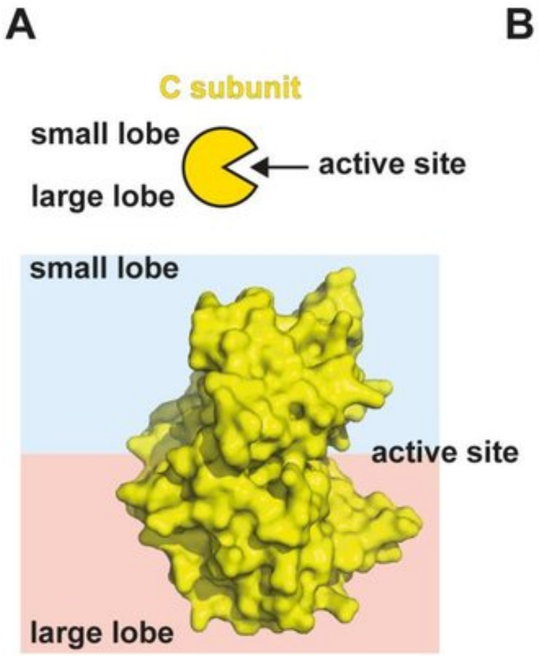
- *The diversity of functions exhibited by proteins far exceeds the role of other biochemical molecules*
- *The functional versatility of proteins stems from:*
- *Ability to bind small molecules specifically and strongly*
- *Ability to bind other proteins and form fiber-like structures, and*
- *Ability integrated into cell membranes*

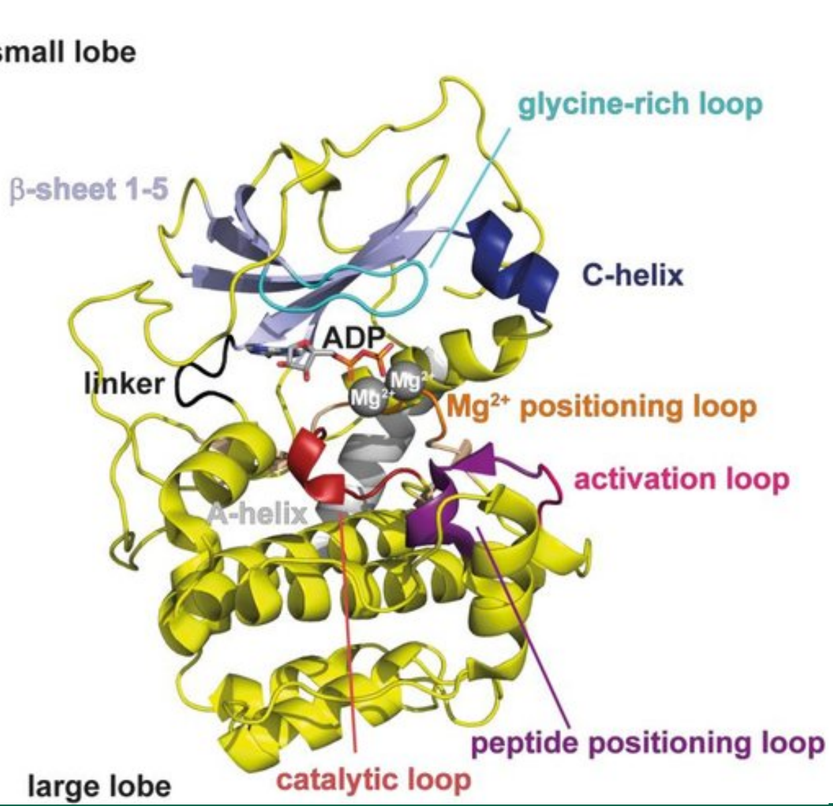
Major Categories of Proteins Based on Function



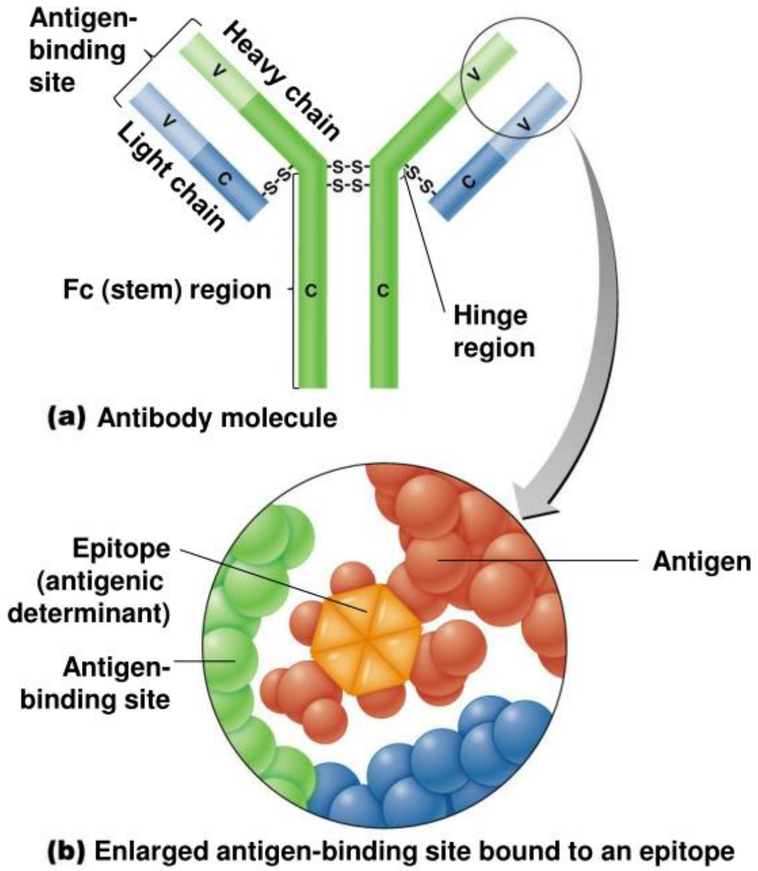
Catalytic proteins:

- Enzymes are best known for their catalytic role.
- Almost every chemical reaction in the body is driven by an enzyme



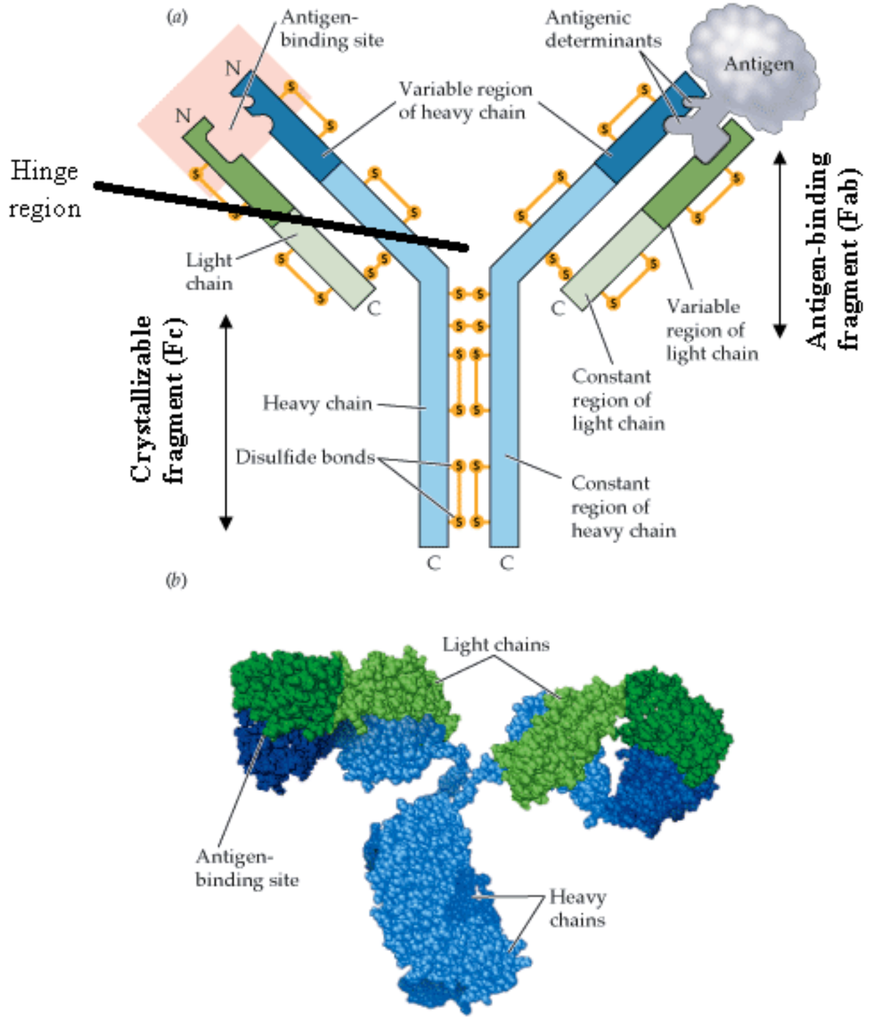


Major Categories of Proteins Based on Function

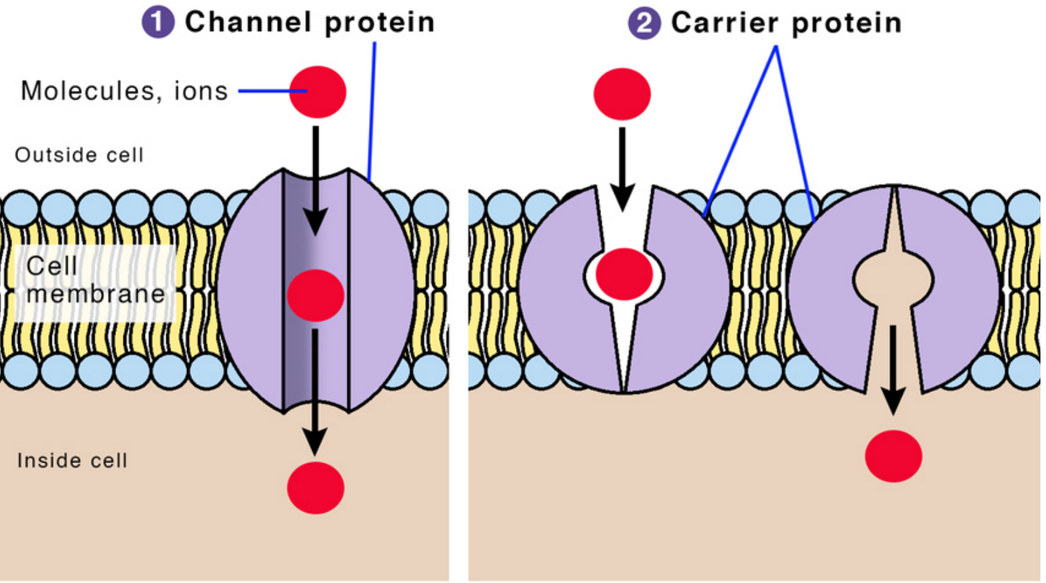


Defense proteins:

- Immunoglobulins or antibodies are central to functioning of the body's immune system.

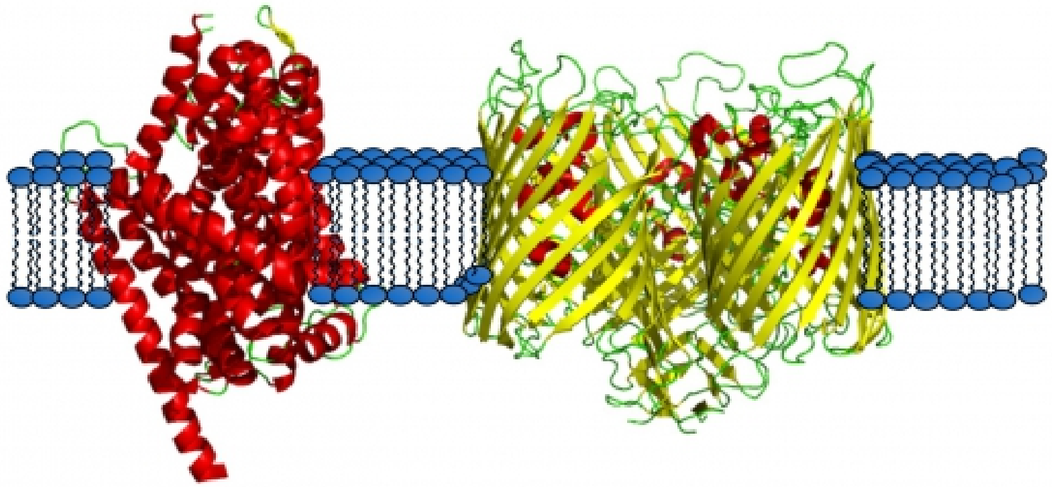


Major Categories of Proteins Based on Function



Transport proteins:

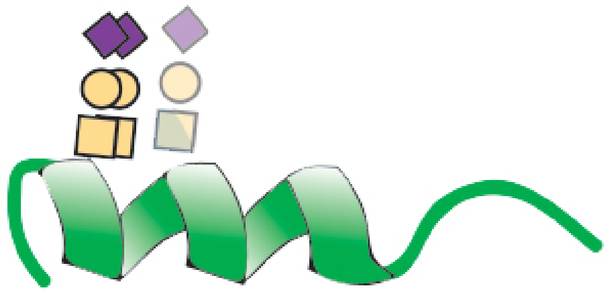
- Bind small biomolecules, e.g., oxygen and other ligands, and transport them to other locations in the body and release them on demand.



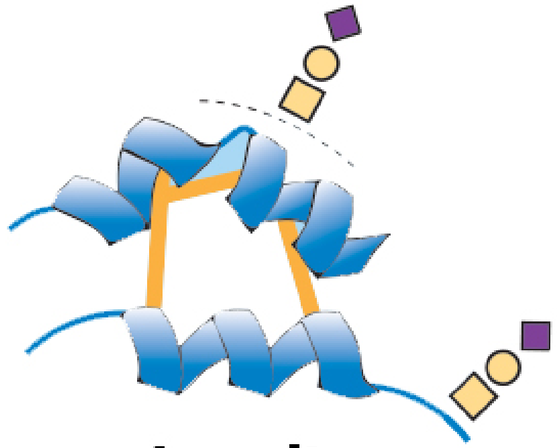
Alpha-helical bundles

β-barrels

Major Categories of Proteins Based on Function



Glucagon



Insulin

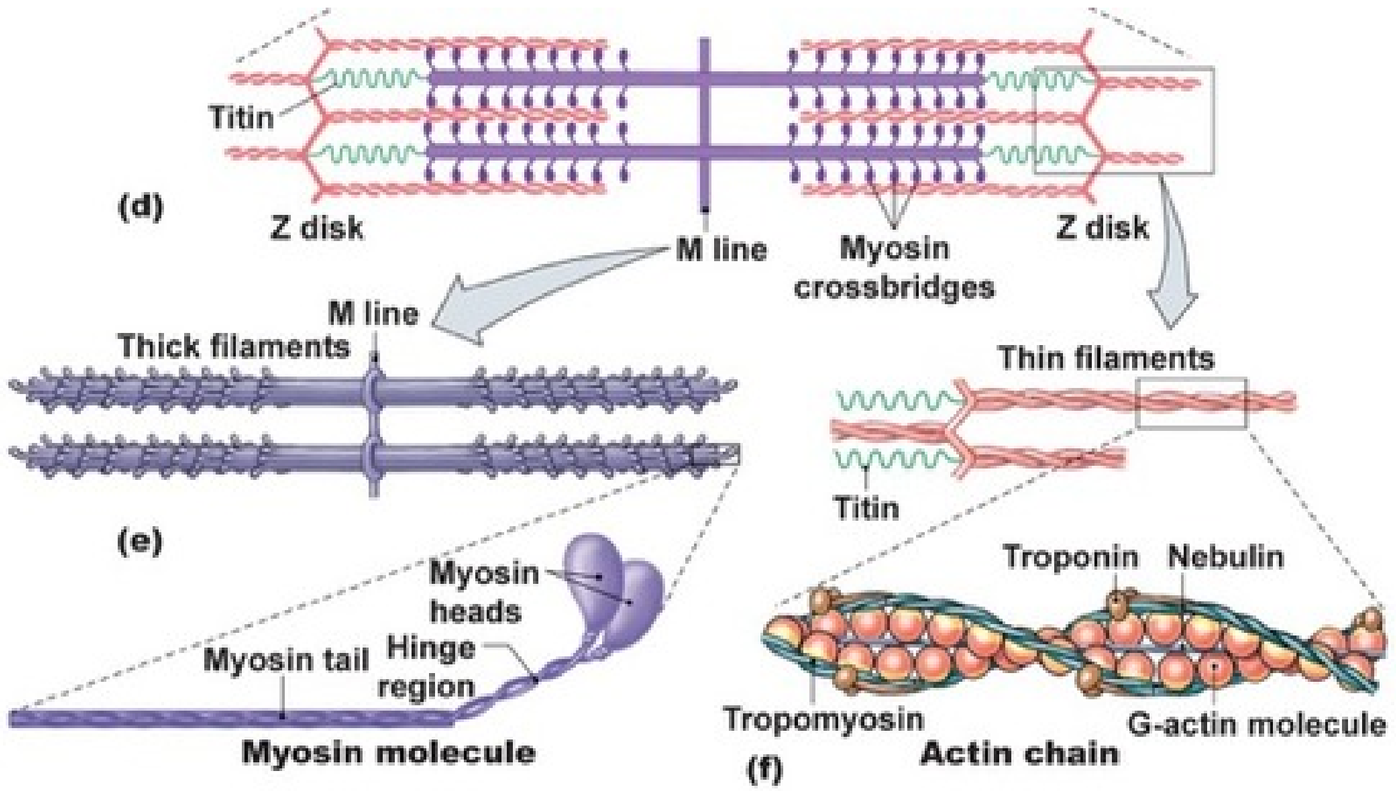
Messenger proteins:

- transmit signals to coordinate biochemical processes between different cells, tissues, and organs.
- Insulin and glucagon - regulate carbohydrate metabolism
- Human growth hormone – regulate body growth

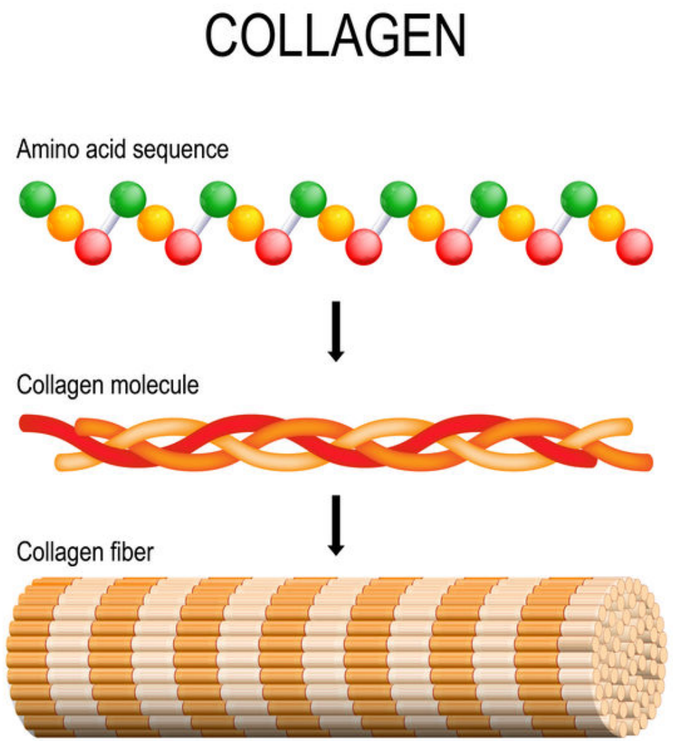
Major Categories of Proteins Based on Function

Contractile proteins:

- Necessary for all forms of movement.
- Muscles contain filament-like contractile proteins (actin and myosin).
- Human reproduction depends on the movement of sperm – possible because of contractile proteins.

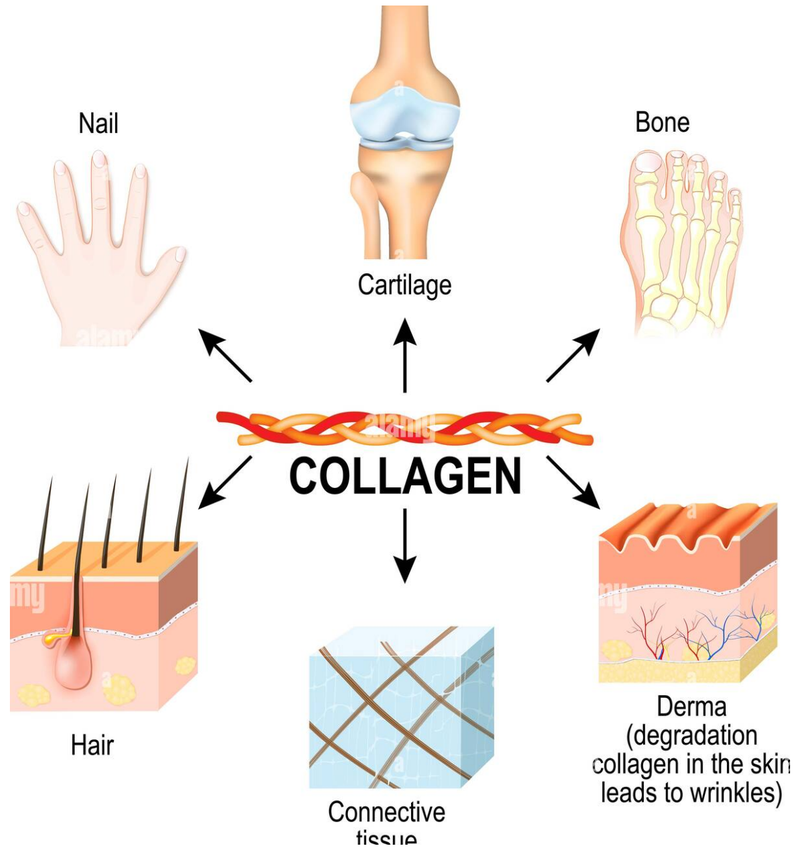


Major Categories of Proteins Based on Function



Structural proteins:

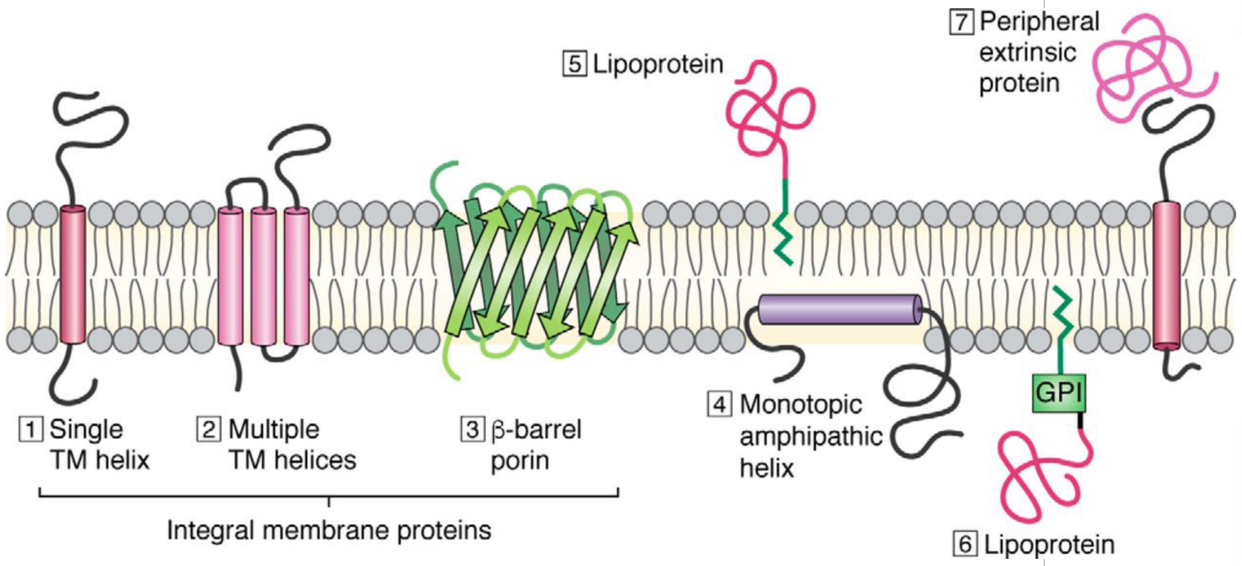
- Confer stiffness and rigidity
- Collagen is a component of cartilage a Keratin gives mechanical strength as well as protective covering to hair, fingernails, feathers, hooves, etc..

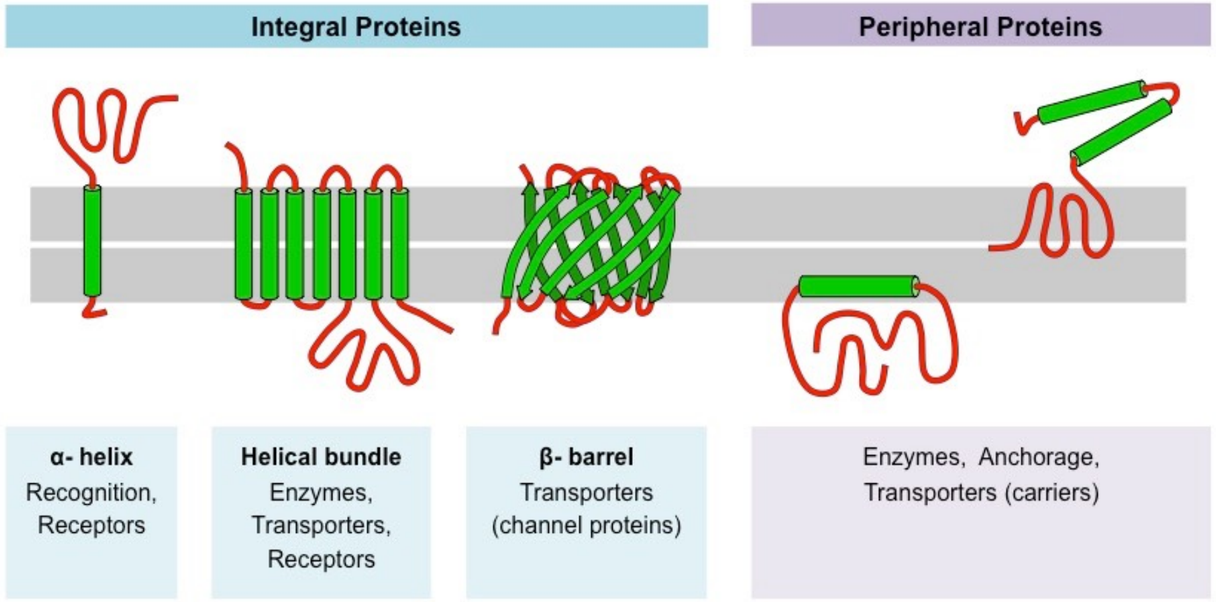


Major Categories of Proteins Based on Function

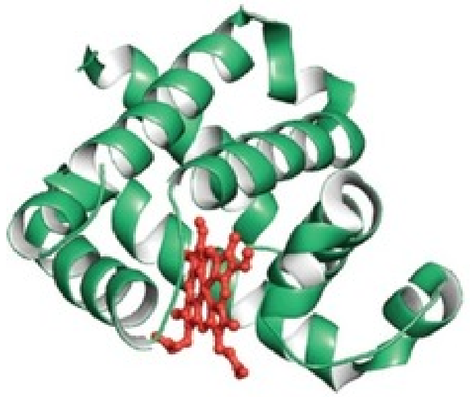
Transmembrane proteins:

- Span a cell membrane and help control the movement of small molecules and ions.
- Have channels – help molecules can enter and exist the cell.
- Transport is very selective - allow passage of one type of molecule or ion.

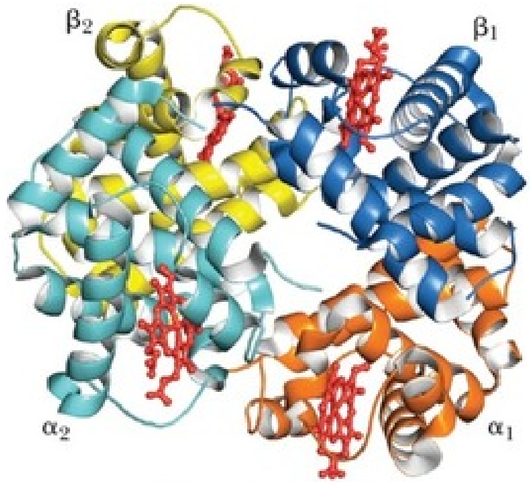




Major Categories of Proteins Based on Function



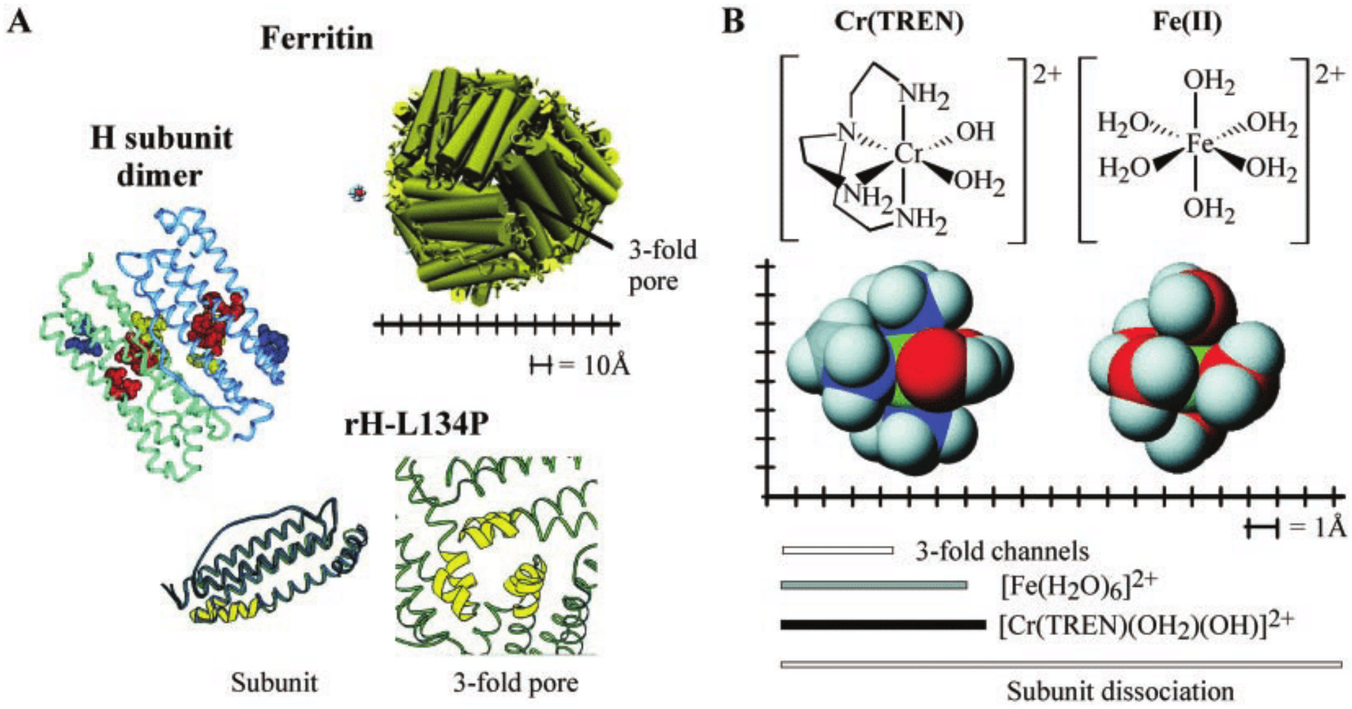
Myoglobin (Mb)



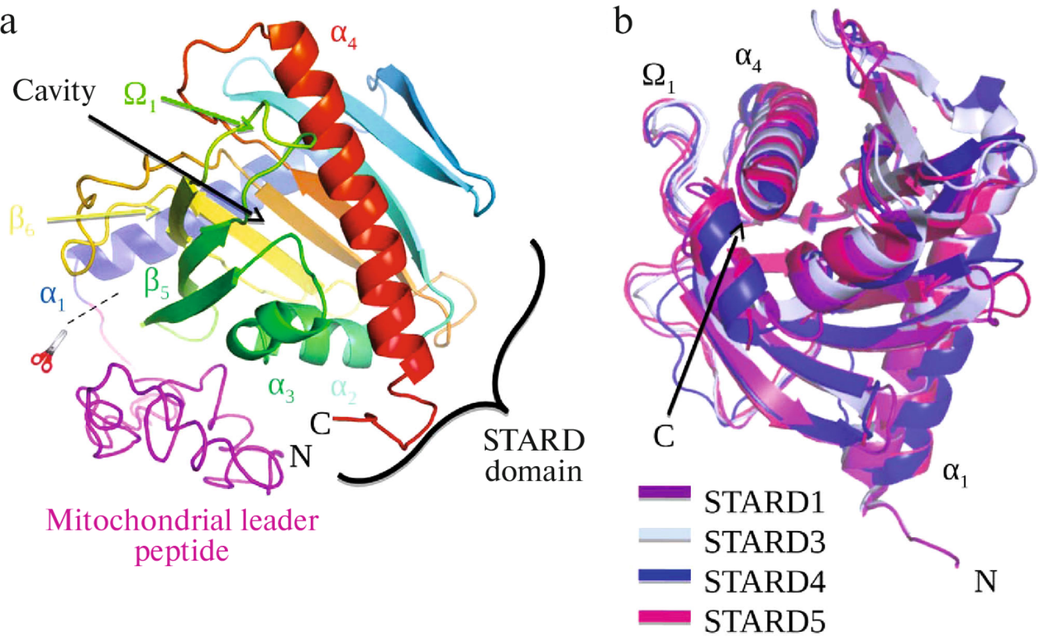
Hemoglobin (Hb)

Storage proteins:

- Bind (and store) small molecules.
- Ferritin - an iron-storage protein - saves iron for use in the biosynthesis of new hemoglobin molecules.
- Myoglobin - an oxygen-storage protein present in muscle



Major Categories of Proteins Based on Function



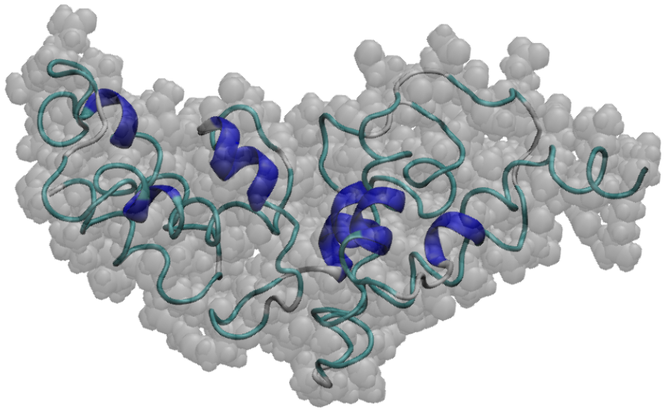
Regulatory proteins:

- Often found “embedded” in the exterior surface of cell membranes - act as sites for receptor molecules
- Often the molecules that bind to enzymes (catalytic proteins), thereby turning them “on” and “off,” and thus controlling enzymatic action.

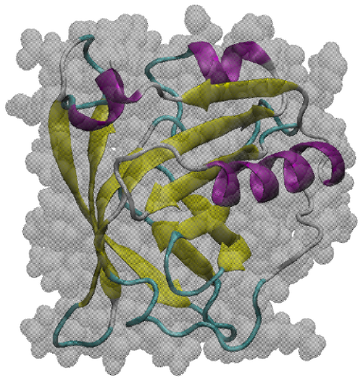
Major Categories of Proteins Based on Function

Nutrient proteins:

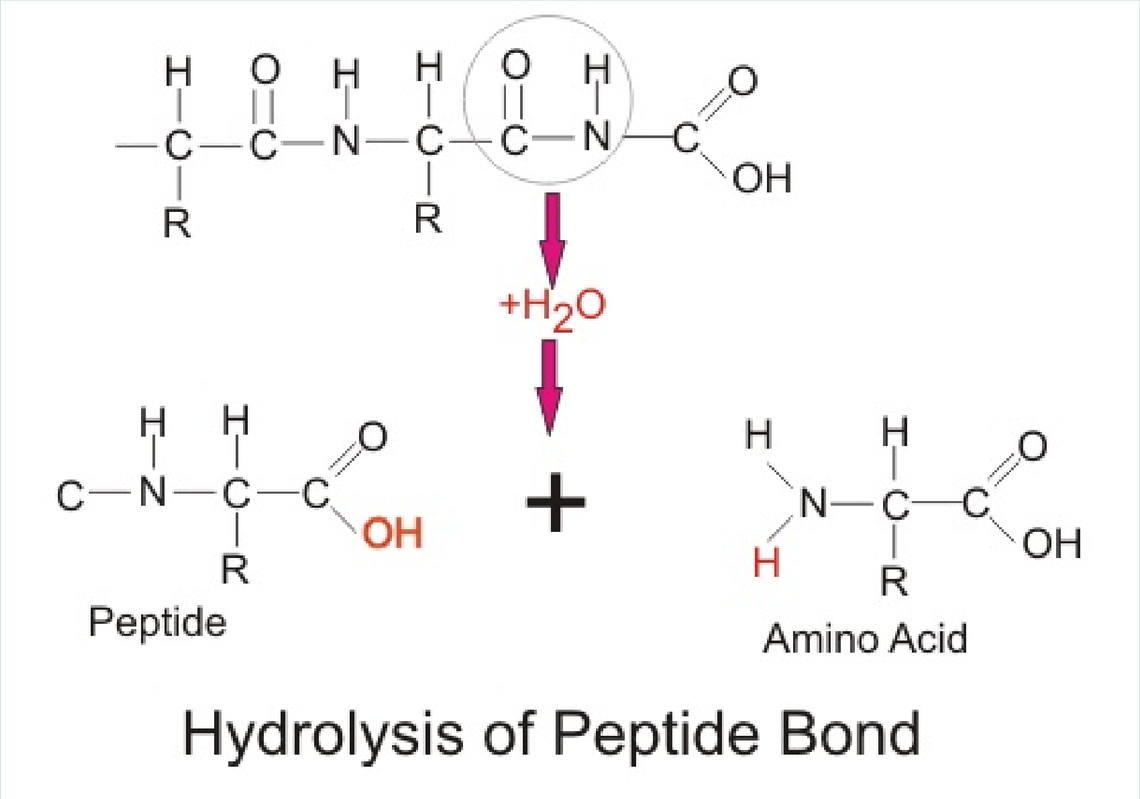
- Particularly important in the early stages of life - from embryo to infant.
- Casein (milk) and ovalalbumin (egg white) are nutrient proteins
- Milk also provide immunological protection for mammalian young.



β-casein

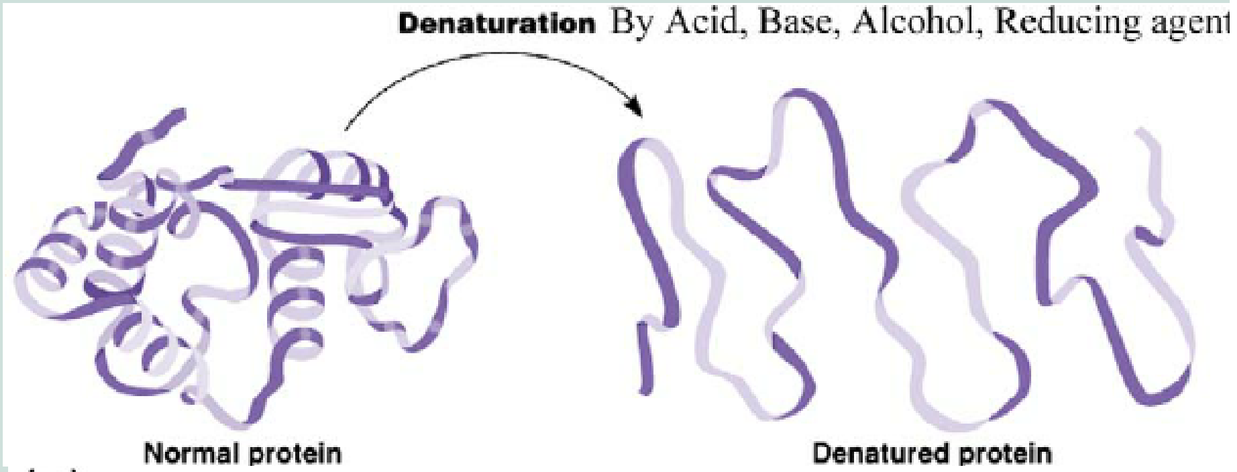


β-lactoglobulin



Protein Hydrolysis

- Hydrolysis of proteins - reverse of peptide bond formation:
- Results in the generation of an amine and a carboxylic acid functional groups.
- Digestion of ingested protein is enzyme-catalyzed hydrolysis
- Free amino acids produced are absorbed into the bloodstream and transported to the liver for the synthesis of new proteins.
- Hydrolysis of cellular proteins and their resynthesis is a continuous process.



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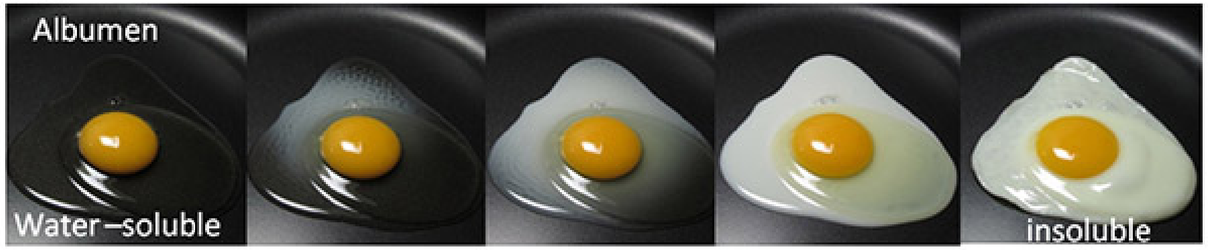
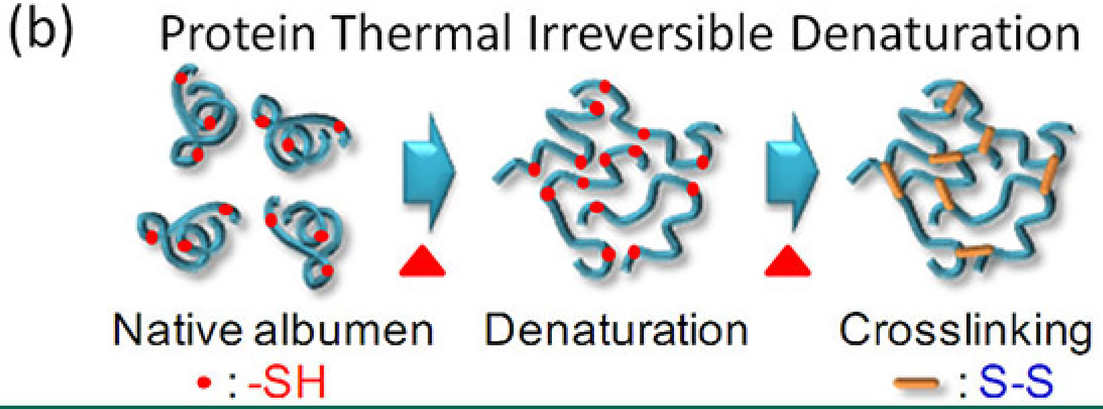
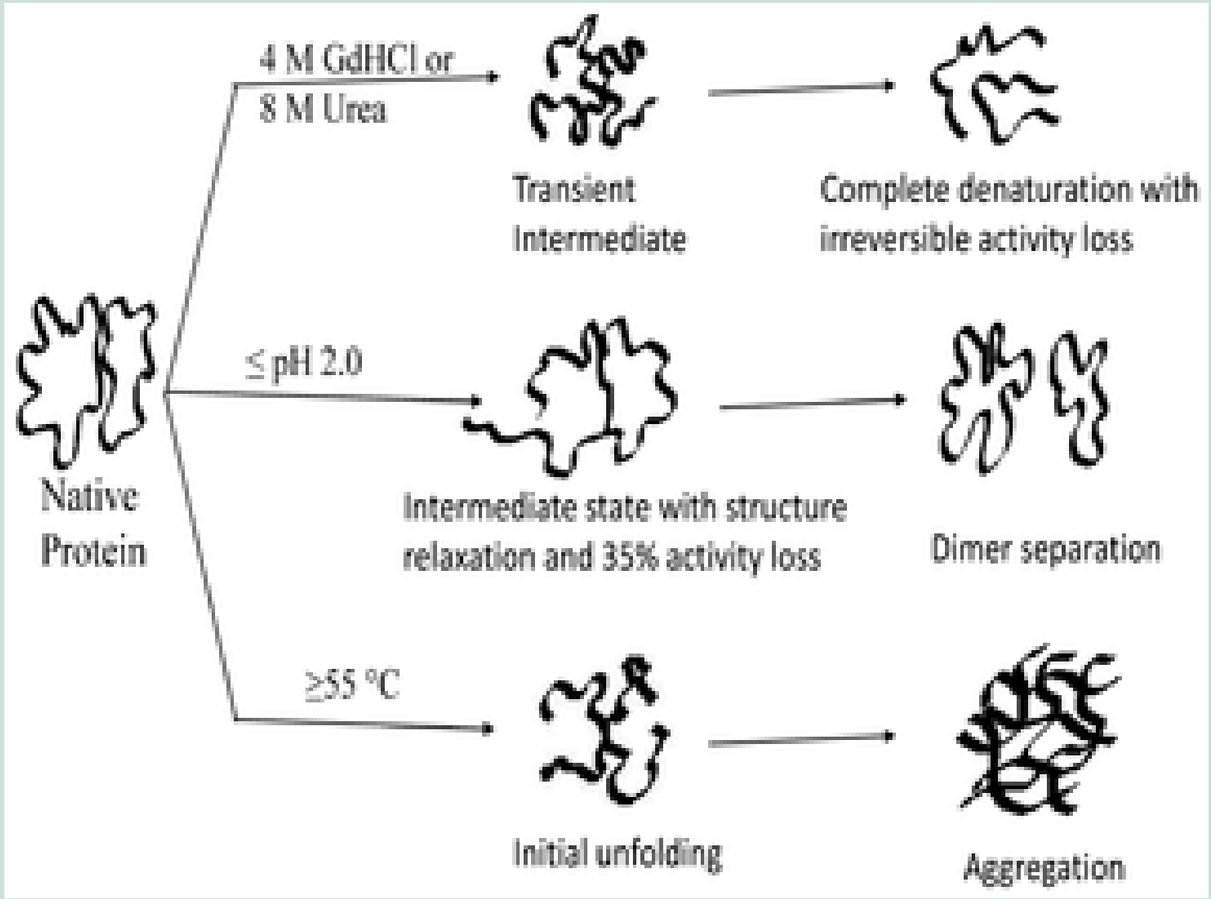


(b)



Protein Denaturation

- Partial or complete disorganization of protein's tertiary structure
- Cooking food denatures the protein but does not change protein nutritional value
- Coagulation: Precipitation (denaturation of proteins)
- Egg white - a concentrated solution of protein albumin - forms a jelly when heated because the albumin is denatured



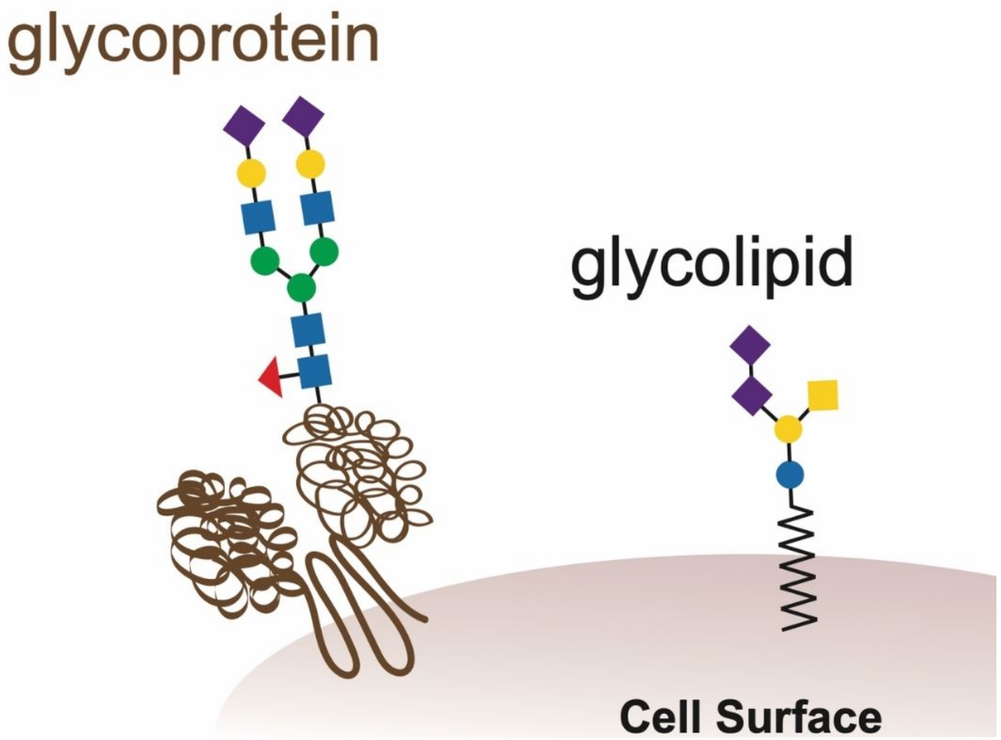
Protein Denaturation

- Cooking:
- Denatures proteins – Makes it easy for enzymes in our body to hydrolyze/digest protein
- Kills microorganisms by denaturation of proteins
- Fever: >104°F – the critical enzymes of the body start getting denatured

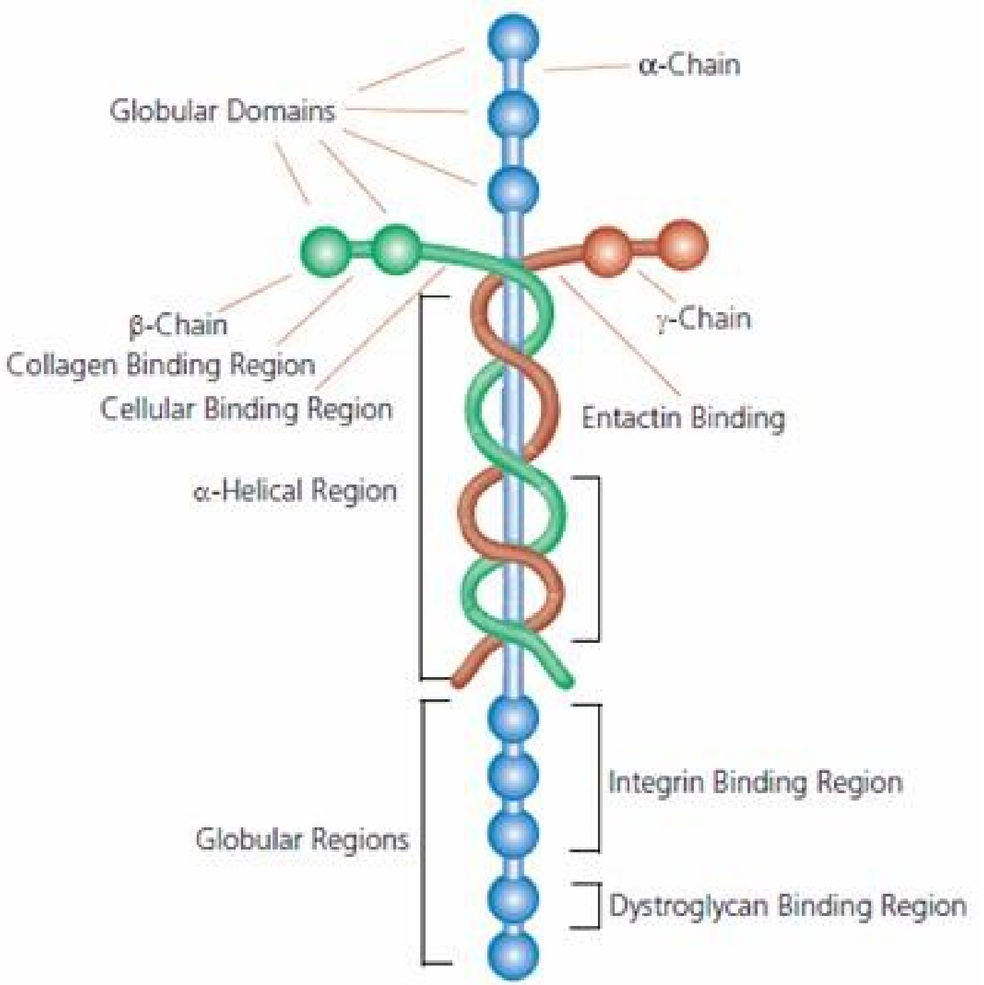
Glycoprotein

Conjugated proteins with carbohydrates linked to them:
Many of plasma membrane proteins are glycoproteins
Blood group markers of the ABO system are also glycoproteins

- *Collagen and Immunoglobulins are glycoproteins*



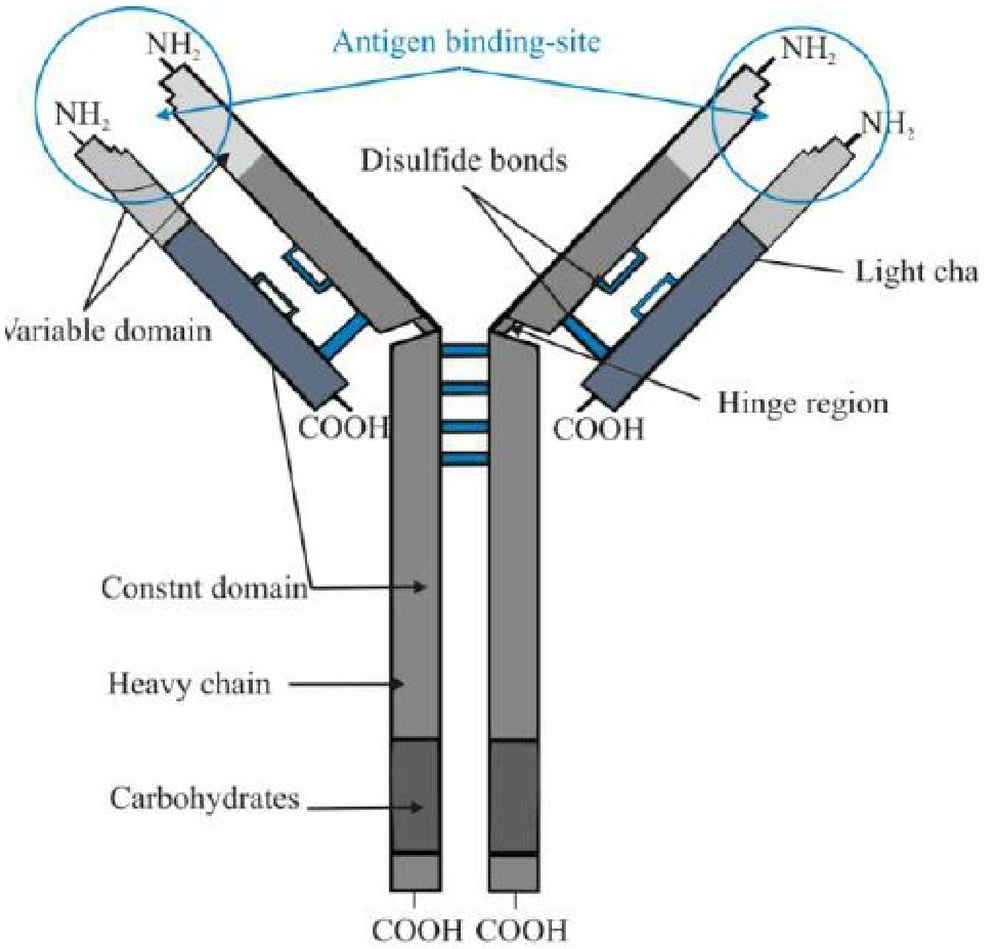
Glycoproteins



Collagen

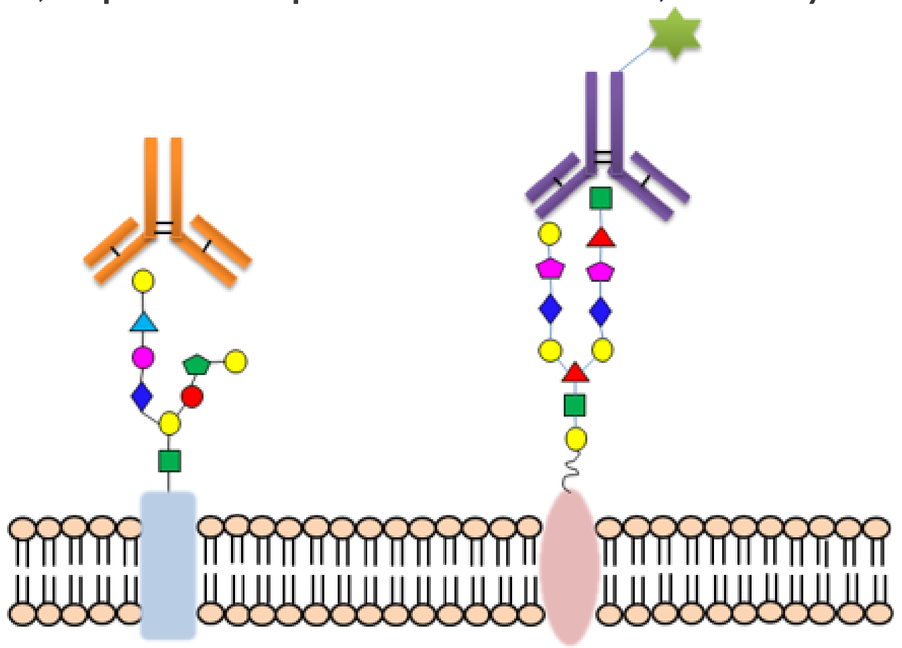
- Most abundant protein in human body (30% of total body protein)
- Triple helix structure
- Rich in 4-hydroxyproline (5%) and 5-hydroxylysine (1%) — derivatives
- Some hydroxylysines are linked to glucose, galactose, and their disaccharides – help in aggregation of collagen fibrils.

Glycoproteins



Immunoglobulins

- Glycoproteins produced as a protective response to the invasion of microorganisms or foreign molecules - antibodies against antigens.
- Immunoglobulin bonding to an antigen via variable region of an immunoglobulin occurs through hydrophobic interactions, dipole – dipole interactions, and hydrogen bonds.



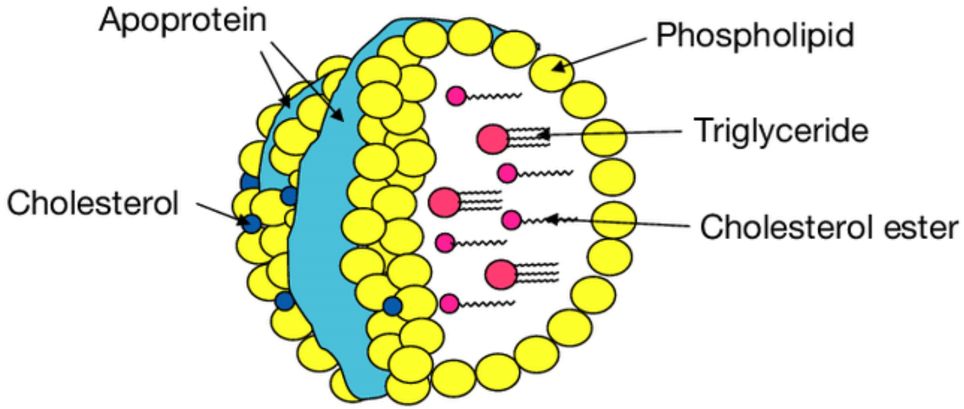
Lipoproteins

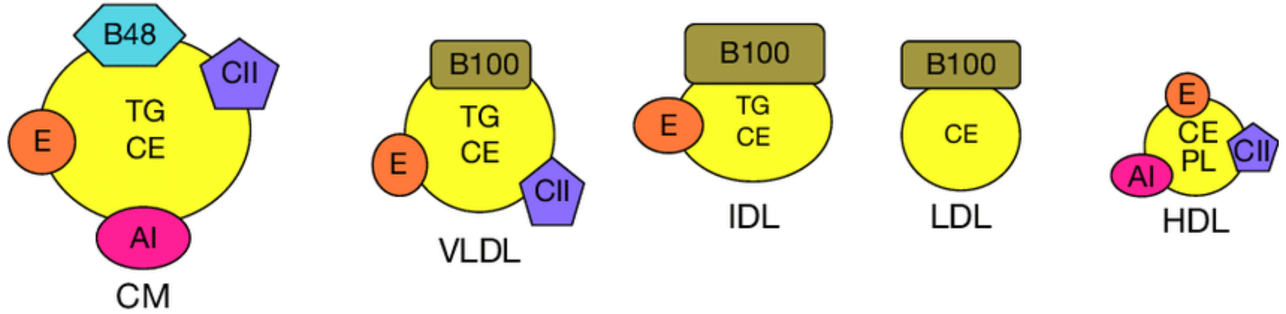
Lipoprotein: a conjugated protein that contains lipids in addition to amino acids
Major function - help suspend lipids and transport them through the bloodstream

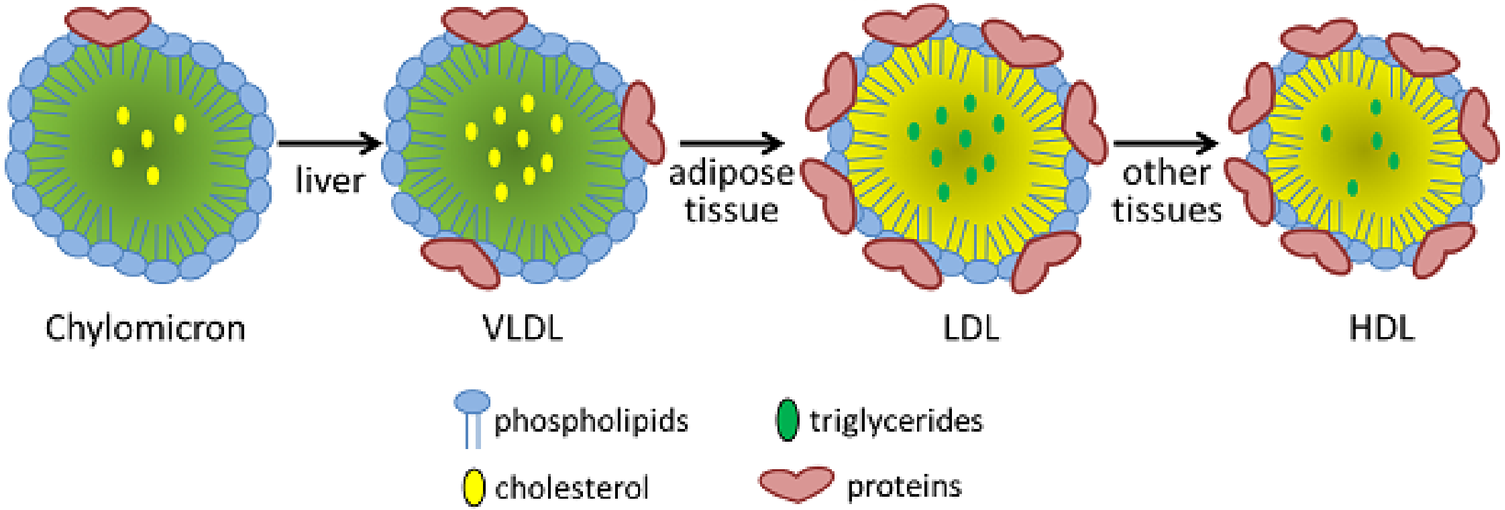
Four major classes of plasma lipoproteins:

- *Chylomicrons: Transport dietary triacylglycerols from intestine to liver and to adipose tissue.*
- *Very-low-density lipoproteins (VLDL): Transport triacylglycerols synthesized in the liver to adipose tissue.*
- *Low-density lipoproteins (LDL): Transport cholesterol synthesized in the liver to cells throughout the body.*
- *High-density lipoproteins (HDL): Collect excess cholesterol from body tissues and transport it back to the liver for degradation to bile acids.*

Lipoproteins







“There are no secrets to success. It is the result of preparation, hard work, and learning from failure.”

Colin Powell

Thank you!!!