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Food Proteins and Enzymes

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- Introduction to Food Proteins and Enzymes
- Biological Importance of Protein
- Biological Functions of Protein
- Functions of Food Proteins
- Sources of Food Proteins
- Amino Acids (AA)
- Classification of Amino Acids

Introduction to Food Proteins and Enzymes

Introduction to Food Proteins and Enzymes

- Proteins play a central role in biological systems.
- -Enzymes perform the biochemical processes that sustain the life of a cell/organism.
- -Proteins (such as collagen and keratin) also function as structural components of cells and complex organisms.
- -The functional diversity of proteins arises from their chemical makeup. Proteins are highly complex polymers, made up of 20 different amino acids.
- -The constituents are linked via substituted amide bonds. The amide linkage in proteins is a partial double bond, which further underscores the structural complexity of protein polymers.
- -Complicated protein structure gives rise to a multitude of three-dimensional structural forms with different biological functions.

Introduction to Food Proteins and Enzymes

- At the elemental level, proteins contain 50–55% carbon, 6–7% hydrogen, 20–23% oxygen, 12–19% nitrogen, and 0.2–3.0% sulfur.
- Protein synthesis occurs in ribosomes. After the synthesis, some amino acids are modified by cytoplasmic enzymes which changes the composition of some proteins.
- Proteins that are not enzymatically modified in cells are called homoproteins, and those that are modified or complexed with nonprotein components are called conjugated proteins or heteroproteins.
- The nonprotein components are referred to as prosthetic groups. - Examples of conjugated proteins include nucleoproteins (ribosomes), glycoproteins (casein), phosphoproteins (kinases, phosphorylases), lipoproteins (proteins of egg yolk, plasma proteins), and metalloproteins (hemoglobin, and several enzymes).

Introduction to Food Proteins and Enzymes

- Proteins can be classified according to their structural organization.
- Globular proteins are exist in spherical shapes, resulting from folding of the polypeptide chain(s) on itself.
- Fibrous proteins are exist in rod-shapes containing twisted linear polypeptide chains (e.g., collagen, keratin, and elastin). Fibrous proteins also can be formed as a result of linear aggregation of small globular proteins, such as actin and fibrin.
- A majority of enzymes are globular proteins, and fibrous proteins function as structural proteins.

Introduction to Food Proteins and Enzymes

- Biological functions of proteins can be classified as
- Enzyme catalysts,
- Structural proteins,
- Hormones (insulin and growth hormone),
- Transfer proteins (serum albumin and hemoglobin),
- Antibodies (immuno-globulins),
- Storage proteins (egg albumen and seed proteins), and
- Protective proteins (toxins and allergens).
- Storage proteins are found in eggs and seeds. These proteins act as sources of nitrogen and amino acids for germinating seeds and embryos.
- Protective proteins are a part of the defense mechanism for the survival of certain microorganisms and animals.

Introduction to Food Proteins and Enzymes

- All biologically produced proteins can be used as food proteins. However, for practical purposes, food proteins may be defined as those that are easily digestible, nontoxic, nutritionally adequate, functionally useable in food products, and available in abundance.
- Traditionally, milk, meats (including fish and poultry), eggs, cereals, and oilseeds have been the major sources of food proteins. However, because of the increase in world population, nontraditional sources of proteins for human nutrition need to be developed to meet the future demand.
- The suitability of such new protein sources for use in foods, however, depends on their cost and their ability to fulfill the normal role of protein ingredients in processed and home-cooked foods.

Introduction to Food Proteins and Enzymes

- The functional properties of proteins in foods are related to their structural and physicochemical characteristics.
- A fundamental understanding of the physical, chemical, nutritional, and functional properties of proteins and the changes these properties undergo during processing is essential if the performance of proteins in foods is to be improved, and if new or less costly sources of proteins are to compete with traditional food proteins.

Introduction to Food Proteins and Enzymes

- Enzymes are proteins with catalytic activity due to their power of specific activation and conversion of substrates to products:
- Substrate(s) Product(s)
- Some of enzymes are composed only of amino acids linked via peptide bonds to give proteins that range in size from about 12,000 MW to 1,000,000 MW. -Other enzymes contain additional components, such as carbohydrate, phosphate, and cofactor groups. Enzymes have all the chemical and physical characteristics of other proteins. -Composition-wise, enzymes are not different from other proteins found in nature and they comprise a small part of our daily protein intake in our foods. However, unlike other groups of proteins, they are highly specific catalysis for many chemical reactions required by living organisms.

Introduction to Food Proteins and Enzymes

- Enzymes are synthesized in vivo by living organisms, based on expression (translation) of specific genes.
- Enzymes are found in all living systems and make life possible, whether the organisms are adapted to growing near 0°C, or at 37°C (humans), or near 100°C (microorganisms found in hot springs).
- Enzymes accelerate reactions by factors of thousand times.
- Enzymes are highly selective for a limited number of substrates, since the substrate(s) must bind correctly into the active site before any catalysis occurs.
- Enzymes control the direction of reactions, leading to specific product(s) that can be very valuable by-products for foods, nutrition, and health.

Proteins

- Proteins are complex organic nitrogenous compounds of high molecular weight. Proteins are the most complex materials produced in nature.
- They are consisting of α-amino acids linked together by peptide linkages.

Proteins

- The name protein is derived from the Greek word proteios “of prime importance or the first kind” this is because proteins are the basis of the cytoplasm of cells and are present in all living organisms.
- Proteins are the most abundant macromolecules in living cells and constitute 50% or more of their dry weight.

Proteins

- Proteins are polymers of α-ami
- Proteins are synthesized from only 20 amino acids, known as the common amino acids.
- Amino acids are formed mainly of carbon, hydrogen, oxygen and nitrogen.
- Nitrogen is a characteristic component of proteins forming about 16% of their weight (i.e. 100 g of protein contains 16 g of nitrogen)

Biological Importance of Protein

- Plasma membrane proteins (channel, carrier, pump proteins) regulate the transfer of many substances across the cell membrane
- All receptors are protein in nature
- All enzymes are proteins in nature
- All antibodies (immuno-gobulins) are proteins in nature
- Some hormones are proteins in nature (e.g. insulin and growth hormone).

Biological Importance of Protein (cont.)

- Some proteins are protective

e.g. Keratins (skin, hair and nails) make the skin resistant to chemicals

- Some proteins are supportive

e.g. Collagen; the most abundant protein in animals.

- Hemoglobin is a protein carries O2 in blood.
- Actin and myosin are contractile proteins found in muscle cells and responsible for muscular contraction.
- Amino acids (AA) are converted to other nitrogenous substances of great physiological importance (e.g. creatine, histamine, heme, purines and pyrimidines).

Biological Functions of Protein

1. Catalytic function:

Nearly all chemical reactions in biological systems are catalyzed by specific enzymes.

2. Transport and storage:

For example;

- Hemoglobin transports oxygen in blood.
- Myoglobin carries and stores oxygen in muscle.
- Albumin transports free fatty acids in blood.
- Transferrin transports iron in blood.

- 3. Coordinated motion:
- Actin and myosin are contractile proteins in muscle.

Biological Functions of Protein (cont.)

- Structural and mechanical support:
- Collagen (a fibrous protein in skin and bone).
- Defense function:
- Clotting factors (prevent loss of blood).
- Immuno-globulins (protect against infection).
- Generation and transmission of nerve impulses:
- Receptor proteins (neuro-transmitters, e.g. acetyl choline), are responsible for transmitting nerve impulses.
- Control of growth and differentiation:
- The activities of different cells are coordinated by hormones. Many hormones are polypeptides and proteins, such as insulin and thyroid-stimulating hormone.

Functions of Food Proteins

Functions of Food Proteins

- Amino acids, peptides and proteins are important constituents of food. -They supply the required building blocks for protein biosynthesis. -They contribute to the flavor of food and are precursors for aroma compounds.
- They contribute, with other food compounds such as carbohydrates, to colors formed during thermal or enzymatic reactions in production, processing and storage of food.
- Proteins contribute to food physical properties through their ability to build or stabilize gels, foams, emulsions and fibrillar structures. -The nutritional energy value of proteins (17 kJ/g or 4 kcal/g) is as high as that of carbohydrates.

Sources of Food Proteins

- The most important sources of protein are grain, oilseeds and legumes, followed by meat and milk.
- In addition to plants and animals, protein producers include algae (Chlorella, Spirulina spp.), yeasts and bacteria (single-cell proteins [SCP]).
- Bacteria of the species Pseudomonas in aqueous methanol produce about 0.3 ton of protein per ton of alcohol.
- Some products rich in protein also result from other processes, e. g., in oil and starch production.
- Protein concentrates and protein isolates serve to enhance the nutritional value and to enhance of the physical properties of foods. They are added to traditional foods, such as meat and cereal products, but they are also used in the production of novel food items such as meat and milk substitutes.

Sources of Food Proteins (cont.)

- Raw materials in which protein enrichment takes place include:
- Legumes such as soybeans,
- Wheat, which provide gluten as a by-product of starch production,
- Potatoes; after starch production, protein isolated by thermal coagulation,
- Eggs, which are processed into different products (e.g., whole egg, egg white and egg yolk products),
- Milk, which supplies casein and whey protein,
- Fish, which supplies protein concentrates after fat extraction,
- Blood from slaughter animals, which is processed into blood meal, blood plasma concentrate and globin isolate,
- Green plants grown for animal fodder, such as alfalfa, which are processed into leaf protein concentrates through the thermal coagulation of proteins.

Proteins

are polymer of amino acids

AMINO ACIDS

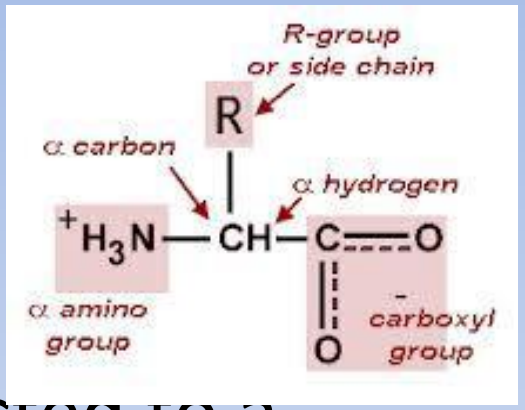
are the basic building blocks of

PROTEINS

Amino Acids (AA)

- There are about 200 amino acids found in nature.
- There are about 20 amino acids in a protein hydrolysate. -With a few exceptions, their general in the simplest case, R=H (aminoacetic acid or glycine). -In other amino acids, R is an aliphatic, aromatic or heterocyclic residue and may incorporate other functional groups.

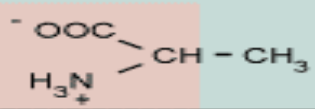
- α-Amino acids are the building units of proteins.
- Each α-amino acid consists of
- an amino group (-NH2),
- a carboxylic acid group (-COOH),
- a hydrogen atom (-H) and
- a side chain group (-R), all connected to a carbon atom called α- carbon atom. The α-carbon is the first carbon next to the –COOH group. -The side chain group (R) is specific and unique for each amino acid. -The R may be a hydrogen, a straight or branched-chain aliphatic group, an aromatic ring or a heterocyclic ring.



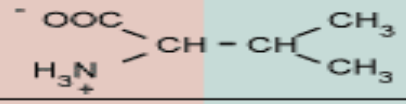
R GROUPS

NONPOLAR, HYDROPHOBIC

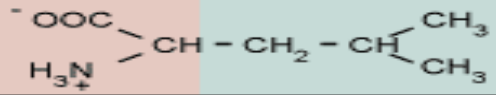
Alanine
Ala
A
MW = 89



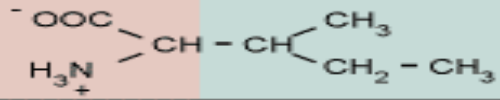
Valine
Val
V
MW = 117



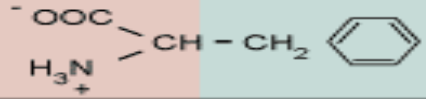
Leucine
Leu
L
MW = 131



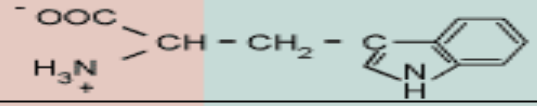
Isoleucine
Ile
I
MW = 131



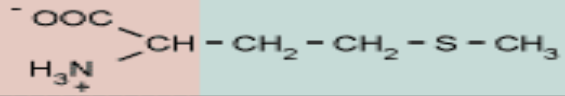
Phenylalanine
Phe
F
MW = 131



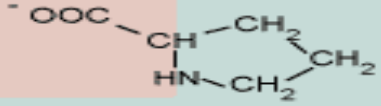
Tryptophan
Trp
W
MW = 204



Methionine
Met
M
MW = 149

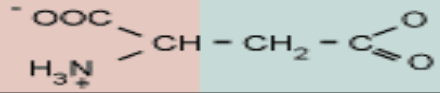


Proline
Pro
P
MW = 115

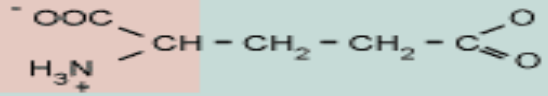


POLAR ACIDIC

Aspartic acid
Asp
D
MW = 133

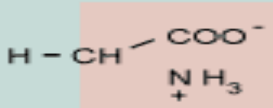


Glutamine acid
Glu
E
MW = 147

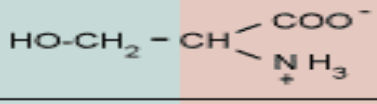


POLAR, UNCHARGED

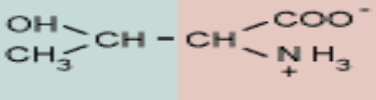
Glycine
Gly
G
MW = 75



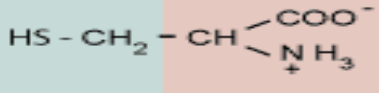
Serine
Ser
S
MW = 105



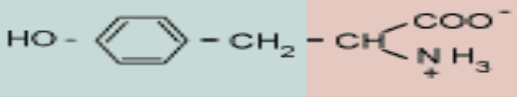
Threonine
Thr
T
MW = 119



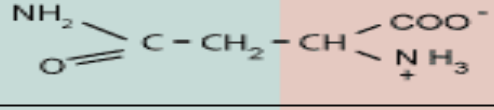
Cysteine
Cys
C
MW = 121



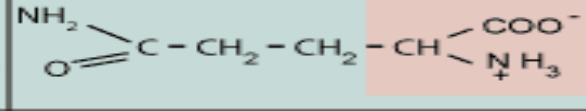
Tyrosine
Tyr
Y
MW = 181



Asparagine
Asn
N
MW = 132

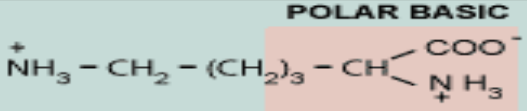


Glutamine
Gln
Q
MW = 146

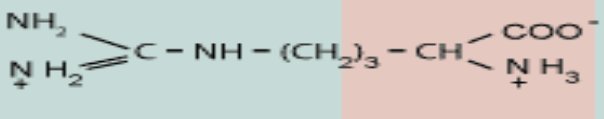


POLAR BASIC

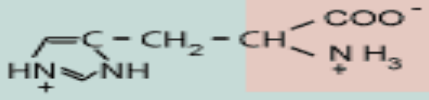
Lysine
Lys
K
MW = 146



Arginine
Arg
R
MW = 174



Histidine
His
H
MW = 155



The R group determines the amino acid

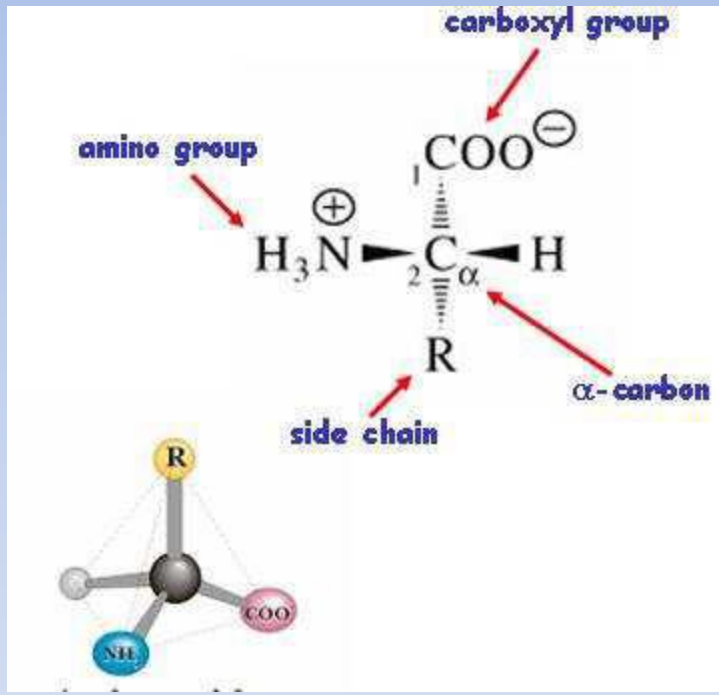
R group	Amino acid	Side chain
- H	Glycine	Non-polar
- CH_3	Alanine	Non-polar
- CH_2OH	Serine	Uncharged polar
- CH_2SH	Cysteine	Uncharged polar
- CH_2COOH	Aspartic acid	Acidic (-ve) Charged polar
$-CH_2CH_2CH_2CH_2NH_2$	Lysine	Basic (+ve) Charged polar

Abbreviation for the 20 amino acids

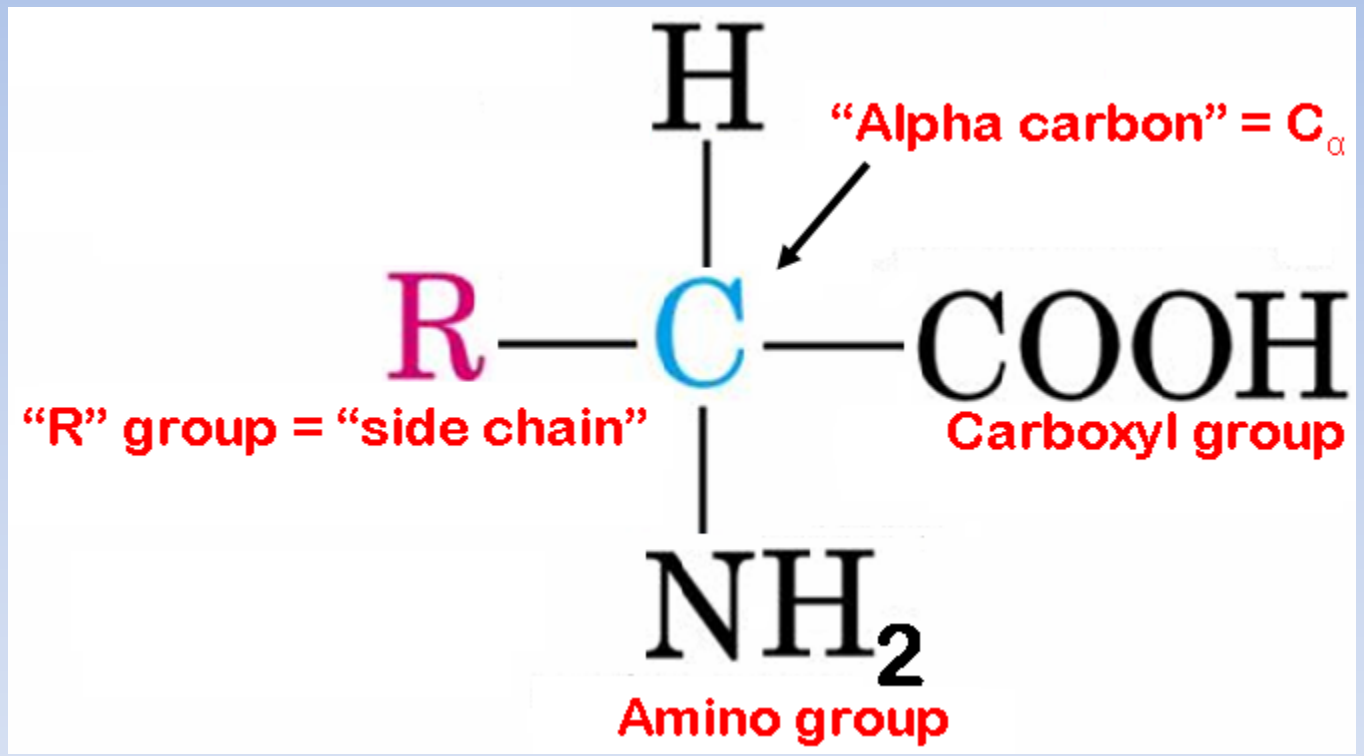
Amino Acid	Abbreviation		Amino Acid	Abbreviation	
	Three letter	One letter		Three letter	One letter
Alanine	Ala	A	Leucine	Leu	L
Arginine	Arg	R	Lysine	Lys	K
Asparagine	Asn	N	Methionine	Met	M
Aspartic acid	Asp	D	Phenylalanine	Phe	F
Cysteine	Cys	C	Proline	Pro	P
Glycine	Gly	G	Serine	Ser	S
Glutamine	Gln	Q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

Basic amino acid structure

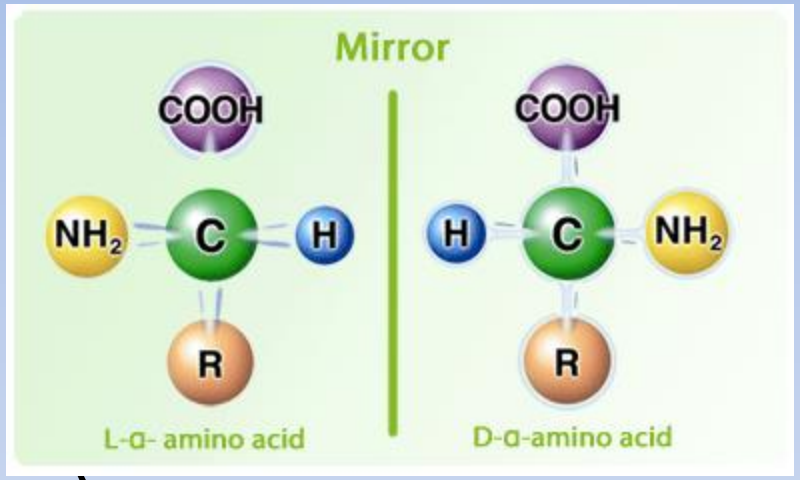
- α-Carbon is chiral (Asymmetric carbon) in all amino acids except for glycine.
- At pH 7 amino acids have both +ve and -ve charges so called dipolar ion or zwitterions.

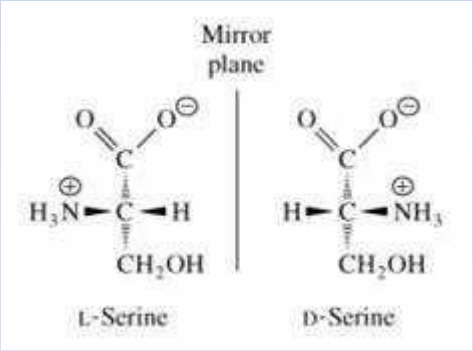


- Amino acids have a tetrahedral structure (3D shape).

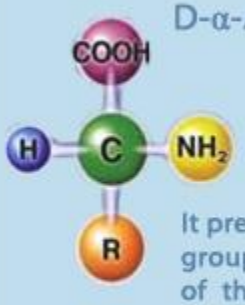

H
"Alpha carbon" = C_α
R—C—COOH
"R" group = "side chain"
Carboxyl group
NH_2
Amino group

- Natural amino acids are inthe L-configuration
- L and D forms are called Optical isomers (Stereoisomers = Enantiomers)
- Biological system in all organisms synthesize and use only L-amino-acids





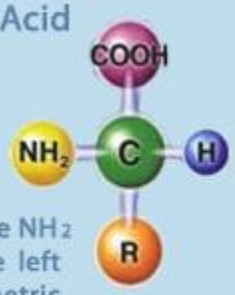
D-α-Amino Acid



It presents the NH_2 group on the right of the asymmetric carbon

L-α-Amino Acid

the only biologically active one.



It presents the NH_2 group on the left of the asymmetric carbon.

There are
20 amino acids
that make up
the proteins, each with
different side chain.

Side chains

vary in

Size, Shape, Charge,

Hydrogen-bonding capacity, and

Chemical reactivity

Classification of Amino Acids

- Side chain (R group) classification.
- Biological classification.
- Metabolic classification.

1-Side Chain (R group) Classification

- CHEMICAL CLASSIFICATION -The amino acids are classified according to the chemical structure of the side chain (R) into:

✓ Aliphatic
✓ Hydroxy
✓ Sulfur containing
✓ Aromatic
✓ Acidic
✓ Basic
✓ Imino acids

Side Chain Classification
Glycine

1- Hydrophobic (non-polar) R-group

- Glycine (Gly-G)
- Alanine (Ala-A)
- Valine (Val-V)
- Leucine (Leu-L)
- Isoleucine (Ile– I)
- Methionine (Met– M)
- Proline (Pro– P)
- Phenylalanine (Phe– F)
- Tryptophan (Trp–W)

2- Hydrophilic (polar) R-group

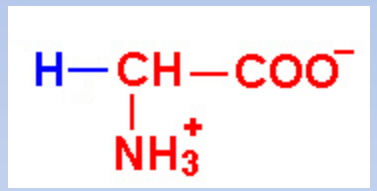
Uncharged	Positively charged	Negatively charged
•Aspargine (Asn – N)	•Lysine (Lys – K)	•Aspartic acid (Asp – D)
•Glutamine (Gln – Q)	•Arginine (Arg – R)	•Glutamic acid (Glu – E)
• Serine (Ser – S)	•Histidine (His – H)	
•Threonine (Thr – T)		
•Tyrosine (Tyr – Y)		
• Cysteine (Cys – C)		

Non Polar (hydrophobic) Amino Acids

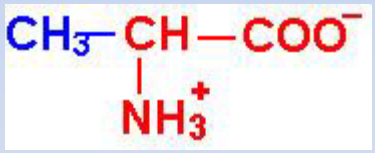
- Side chains of non polar (hydrophobic) amino acids can not participate in hydrogen or ionic bonds, but they form hydrophobic interactions.
- In aqueous environment, non polar amino acids tend to be present in the interior of proteins.
- Non polar (hydrophobic) amino acids include: -Amino acids with aliphatic R group (glycine, alanine). -Amino acids with aliphatic branched R group (valine, leucine and isoleucine). -Amino acids with aromatic R group (phenylalanine, tryptophan). -Amino acids with sulfur containing R group (methionine). -Imino acid (proline).

Amino acids with non polar side chains (Aliphatic)

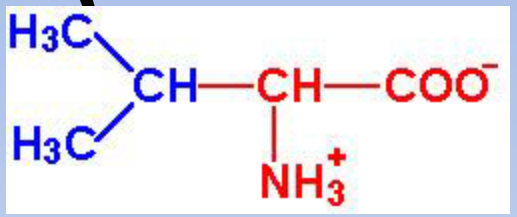
Glycine(Gly - G)



Alanine (Ala – A)

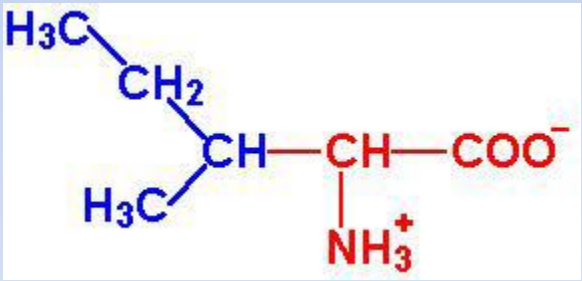


Amino acids with non polar side chains (branched chains, aliphatic)



Valine (Val – V)

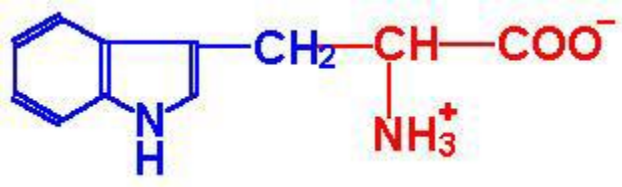
Leucine (Leu – L)



Isoleucine (Ile – I)

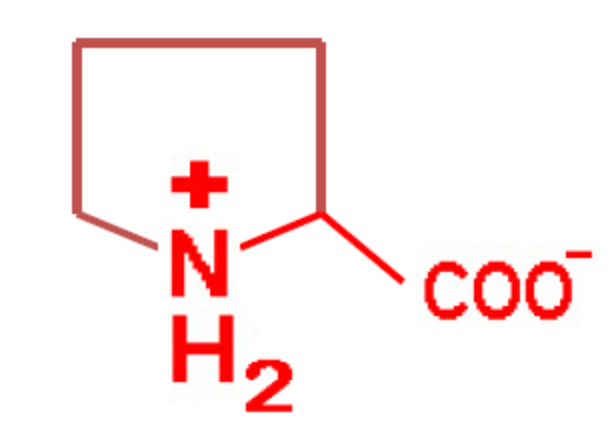
Amino acids with non polar side chains (Aromatic)

Phenylalanine (Phe – F)



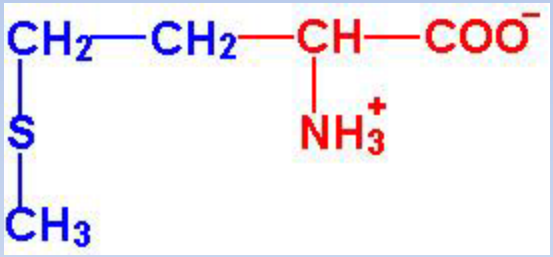
Tryptophan (Trp – W)

Amino acids with non polar side chains (imino)



Proline (Pro – P)

Amino acids with non polar side chains (sulfur containing)



Methionine (Met – M)

Polar (hydrophilic) Amino Acids

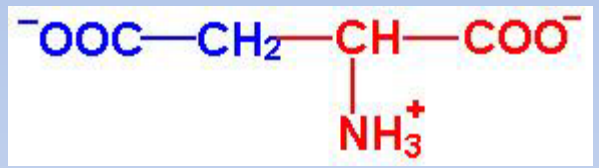
- Side chains of polar (hydrophilic) amino acids can participate in hydrogen or ionic bonds.

- Therefore, in aqueous environment polar amino acids tend to be present on the surface of proteins.
- Polar (hydrophilic) amino acids are classified into:
  1. Polar charged amino acids:
    - ✓ Acidic amino acids (aspartic & glutamic acids) and
      Basic amino acids (arginine, lysine, histidine)
- **2.Polar uncharged amino acids:**

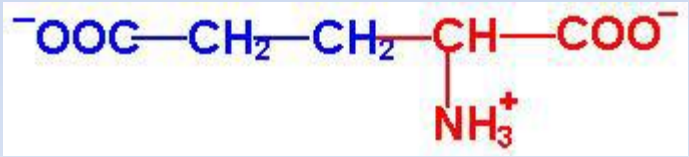
  - ✓ Amino acids with OH group (serine, threonine, tyrosine)
    Amino acids with SH group (cysteine)
  - ✓ Amino acids with amide group (glutamine, asparagine)

Amino acids with polar charged side chains (acidic group)

Aspartic acid (Asp – D)

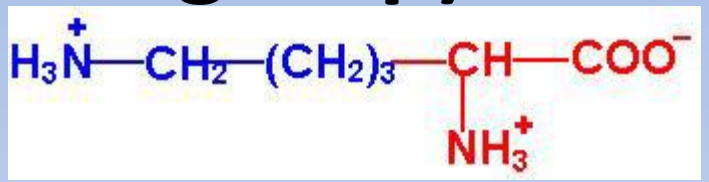


Glutamic acid (Glu – E)

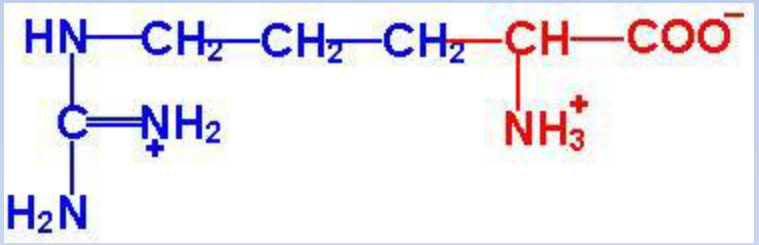


Amino acids with polar charged side chains (basic group)

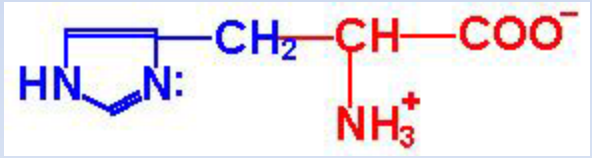
Lysine (Lys – K)



Arginine (Arg – R)

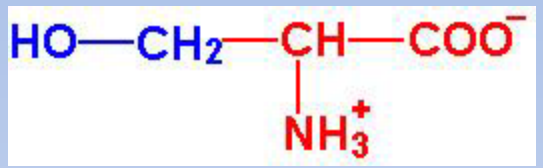


Histidine (His – H)

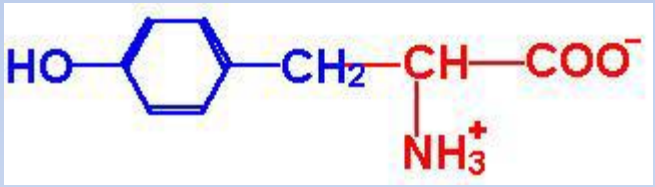


Amino acids with polar uncharged side chains (with OH group)

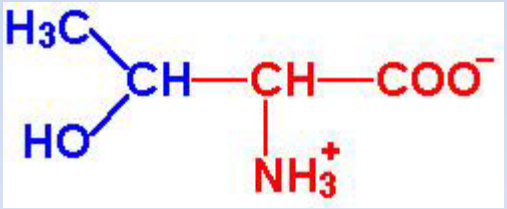
Serine (Ser – S)



Tyrosine (Tyr – Y)



Threonine (Thr – T)



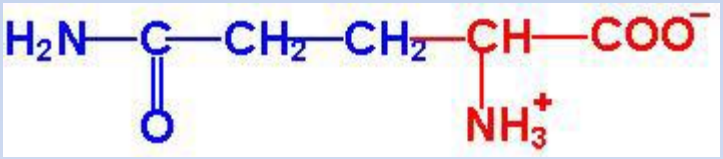
Amino acids with polar uncharged side chains (with SH group)

Cysteine (Cys – C)

Amino acids with polar uncharged side chains (with amide group)

Asparagine (Asn – N)

Glutamine (Gln – Q)



2-Biological (Nutritional) classification

On nutritional basis AA are classified into essential or non-essential AA.

1- Non essential amino acids:

Amino acids that could be synthesized in the body, so they are not needed in the diet. They are 10 AA.

2- Essential amino acids:

- ✓ Amino acids that could not be synthesized in the body, so they have to be taken in the diet, and their deficiency results in diseases.
- ✓ The essential amino acids are not more important to our body than the non-essential amino acids.
- ✓ Both (all 20 AA) are equally needed and equally essential for the normal growth and good health.

Biological classification

1- Non-essential amino acids

- Glycine
- Alanine
- Serine
- Tyrosine
- Cysteine
- Asparagine
- Aspartic
- Glutamic acid
- Glutamine
- Proline

2- Essential amino acids

- Valine
- Leucine
- Isoleucine
- Threonine
- Methionine
- Arginine
- Lysine
- Histidine
- Phenylalanine
- Tryptophan

3-Metabolic classification (According to their metabolic fate in the body)

- **Glucogenic amino acids:**

Amino acids that can give glucose.

- **Ketogenic amino acids:**

Amino acids that can give ketone bodies.

- **Glucogenic/Ketogenic (mixed) amino acids:**

Amino acids that can give both ketone bodies and glucose.

Metabolic and biological classification

	Glucogenic	Glucogenic and Ketogenic	Ketogenic
Nonessential	Alanine Arginine Asparagine aspartate Cysteine Glutamate Glutamine Glycine Histidine proline Serine	Tyrosine	
Essential	Methionine Threonine Valine	Isoleucine Phenylalanine Tryptophan	Leucine Lysine

Amino Acid deficiency in selected Vegetables and Grains

Food Source	Amino Acid Missing
Eggs, Milk, Meat, Fish, Poultry	None
Wheat, Rice, Oats	Lysine
Corn	Lysine, Tryptophan
Beans	Methionine, Tryptophan
Peas	Methionine
Almonds, Walnuts	Lysine, Tryptophan
Soy	Low in Methionine

Related Journals of Journal of Food Processing & Technology

- Nutritional Disorders & Therapy
- Vitamins & Minerals
- Nutrition & Food Sciences

Journal of Food Processing & Technology
Related Conferences

- **4th International Conference and Exhibition on Food Processing & Technology**

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