Amino Acids
And
Protein
DEFINITION OF AMINO ACID

Contains **N** in addition to **C**, **H**, **O**

Contains at least two functional groups -**COOH** and -**NH₂** attached to **ALPHA** –**C** atom

They are building blocks of proteins

Essential for life
GENERAL STRUCTURE OF A-AMINO ACID

H₂N

COOH

C

H

R

Reference axis

Side chain defines 20 amino acids

L-α Amino acid
STRUCTURE OF A - AMINO ACID
WHAT IS D & L FORM

L- Amino acid
D- Glyceraldehyde
D- Amino acid
TYPES OF AMINO ACIDS

α Amino acids
β – Amino acids
γ -- Amino acids

L Amino acids -
D Amino acids -
1. Components of peptides
2. Derivatives are components of lipids
3. Neurotransmitters or precursors of NT or hormones
4. Glucogenic
5. Purine and pyrimidine Nitrogen base synthesis

FUNCTIONS OF AMINO ACIDS
FUNCTIONS OF AMINO ACIDS

6. Non-proteinogenic amino acids are intermediate of metabolic reactions.
7. Forms active site in enzymes.
8. Acts as buffers at physiological pH — Histidine
9. Transport oxygen and carbon dioxide — Histidine
10. Detoxification agents — Glycine, cysteine, taurine
VARIOUS WAYS OF CLASSIFICATION

- Based on their presence in protein
- Based on R Group (side chain)
- Based on Nutritional value
- Based on metabolic fate
CLASSIFICATION
BASED ON
R GROUP (SIDE CHAIN)
BASED ON R GROUP / SIDE CHAIN

A = Aliphatic amino acids
S = Sulphur containing amino acids
H = Hydroxyl group containing amino acid
A = Aromatic amino acids
B = Basic amino acids
A = Acidic amino acids
I = Imino acids
Aliphatic amino acids
Contains open hydrocarbon side chain
Sulfur-containing amino acids
Contains sulfur atom in their side chain

### Amino Acids with Sulfur-containing Side Chains

**Cysteine (Cys, C)**

**Methionine (Met, M)**
Hydroxyl group containing amino acids:
Contains hydroxyl / alcohol group in side chain
Aromatic amino acids
Contains closed ring hydrocarbon / Phenyl ring as side chain
Basic amino acids
Contains more than 1 NH₂ groups in side chain
--- H A L
Acidic amino acids
Contains COOH group OR their amides in their side chain--- A G A G

<table>
<thead>
<tr>
<th>Amino Acids with Acidic Side Chains and Their Derivatives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aspartate</strong> (Asp, D)</td>
</tr>
<tr>
<td><img src="image1" alt="Aspartate structure" /></td>
</tr>
<tr>
<td><strong>Glutamate</strong> (Glu, E)</td>
</tr>
<tr>
<td><img src="image2" alt="Glutamate structure" /></td>
</tr>
<tr>
<td><strong>Asparagine</strong> (Asn, N)</td>
</tr>
<tr>
<td><img src="image3" alt="Asparagine structure" /></td>
</tr>
<tr>
<td><strong>Glutamine</strong> (Glu, Q)</td>
</tr>
<tr>
<td><img src="image4" alt="Glutamine structure" /></td>
</tr>
</tbody>
</table>
Imino acids
Contains secondary amino group in the molecule
Aliphatic
Sulphur containing
Hydoxyl group
Acidic
Basic
Aromatic
Imino
CLASS 2

CLASSIFICATION OF AMINO ACIDS CONTINUE...
BASED ON THEIR PRESENCE IN PROTEIN MOLECULE
BASED ON THEIR PRESENCE IN PROTEIN & DNA CODE AVAILABILITY

PROTEINOGENIC amino acids
Also called as STANDARD amino acids

NON PROTEINOGENIC amino acids
Also called as METABOLIC amino acids
The amino acids that are included in the genetic Code are described as “PROTEINOGENIC.” These amino acids can be incorporated into proteins through translation.

Ex: Glycine, Alanine, Valine, Leucine, Isoleucine, serine, Threonine, Methionine, Cysteine, Aspartic acid, Glutamic acid, Histidine, Arginine, Lysine
NON- PROTEINOGENIC amino acids

Amino acids arise during

A. metabolic reactions - Ornithine, citruline, taurine

B. As result of enzymatic modifications of amino acid residues in peptides or proteins - Cystine, Hydroxyproline

C. The “biogenic amines” synthesized from α- amino acids by decarboxylation. They don't have genetic Code
BASED ON NUTRITIONAL REQUIREMENT
CLASSIFICATION BASED ON NUTRITIONAL VALUE

Essential amino acids
or
non-dispensable amino acids

Non-Essential amino acids
or
Dispensable amino acids
They are required by the body
Can be synthesized in the body
Not required to be supplemented through diet

NON ESSENTIAL AMINO ACIDS

- A Alanine
- A Asparagine
- A Aspartate
- C Cysteine
- G Glutamate
- G Glutamine
- G Glycine
- P Proline
- S Serine
- T Tyrosine
ESSENTIAL AMINO ACIDS

- **M** Methionine
- **A** Arginine
- **T** Threonine
- **T** Tryptophan
- **V** Valine
- **I** Isoleucine
- **L** Leucine
- **P** Phenylalanine
- **H** Histidine
- **Ly** Lysine

Required by the body
Cannot be synthesized in the body
Must be supplemented through diet
Deficiency leads to improper protein synthesis and may lead to disease.
ESSENTIAL AMINO ACIDS

**Absolute essential**

Not at all synthesized in the body
100% supply through diet

**Semi essential**

Small quantity synthesized in body
Not sufficient to meet the metabolic need
Partly supplied through diet
Ex Histidine Arginine
Sources of essential amino acids

Complete proteins
Milk casein, egg albumin, animal proteins contains all EAA

Cysteine spare Methionine and Tyrosine spare phenylalanine

In PKU Tyrosine becomes essential amino acid.
Blend diet
Why EAA are required?

-proper growth
-nitrogen balance
-To synthesize new protein
-quality protein

PEM
CLASSIFICATION BASED ON METABOLIC FATE

1. Ketogenic Amino acids

2. Glycogenic Amino acids

3. Ketogenic and Glycogenic amino acids
KETOGENIC AMINO ACIDS

Leucine, Lysine
On deamination carbon skeleton forms glycogenic intermediates like Propionic acid, Succinic acid, Pyruvic acid, Oxaloacetate, α-Ketoglutarate. 

Ex: Glycine,Alanine, Threonine, Cysteine, Valine, Methionine, Aspartate, Glutamiate
On deamination carbon skeleton gives ketogenic intermediates like acetoacetate, Phe, Tyr, Trypto. Acetyl CoA, Isoleucine, and also glycogenic intermediate like fumarate, Phe & Tyr, Tryptoaphane. Pyruvate, Tryptoaphane, Isoleucine, propionate, Isoleucine.

GLYCOGENIC AND KETOGENIC AMINO ACIDS

Phenylalanine
Tyrosine
Tryptophan
Isoleucine
VARIOUS WAYS OF CLASSIFICATION

Based on their presence in protein

Based on R Group (side chain)

Based on Nutritional value

Based on metabolic fate
Class 3
Reactions of amino acids
Ionization of amino acids

Amino acid

Low pH
Acidic

High pH
Basic

Anionic form
Cationic form
What is Zwitter ion?
What is Amphoteric molecule?
What is Isoelectric pH?
Peptide bond
Different types of amino acids undergo polymerization by peptide bond formation.

Peptide bonds are an important part of protein structure. If they are broken or hydrolyzed it degrades protein.
PEPTIDE BOND FORMATION

The image depicts the formation of a peptide bond between two amino acids. The process involves the dehydration of the carboxyl group of one amino acid with the amino group of another, forming a covalent bond and releasing water (H₂O) as a byproduct. This results in the formation of a dipeptide with an amide link between the two amino acids.
Composed of small number of amino acids

Linkage is peptide bonds

Synthesized in body

Have specific function

Digestion of protein also leads
BIOLOGICALLY IMP PEPTIDES
EXAMPLES AND BIOMEDICAL IMPORTANCE

**Hormone**: Insulin, glucagon, Vasopressin, Oxytocin

**Antioxidant**: Glutathione

**Antibiotics**: Gramicidin S

**Anti-tumor drug**: Bleomycin

**Sweetening agent**: Aspartame
**Glutathione**

**Tripeptide**: Glutamic acid, Cysteine and Glycine

Reduced form as **GSH**

Oxidised form as **GS-SG**

Characterised by Gama peptide bonds, 

*not digested* by peptidase

Found in all cells except nerve cells

Biological antioxidant, Amino acid absorption
BIOLOGICALLY IMP PEPTIDES

Glutathione

Functions:

1. **Coenzyme** in oxidation reduction reaction
2. Maintains Red Cell **Membrane integrity**
3. **Protects HB** against Oxidation
4. Free radical and peroxide **scavanging**
5. **Detoxication**

Hemolytic anemia due to **G6PD deficiency**
INSULIN
from β cell of pancreas

Contains $30 + 21$ amino acids

Hypoglycemic Hormone

Glucagon

from α cell of pancreas

Contains 29 amino acids

Hyper glycemic hormone
Angiotensinogen synthesized by liver

Angiotensinogen to angiotensin I by Renin (10 AAs)

Angiotensin I to II by ACE (Angiotensin converting enzyme)

Angiotensin II active form Have 8 AAs

Vaso-constructor increase arterial pressure

Increase synthesis of Aldosteron -Na+ retention

ACE inhibitors used as antihypertensive & CCF
OXYTOCIN

Hormone of posterior pituitary
Contains 9 amino acids
Stimulates contraction of uterus

Vasopressin (ADH)

- Hormone secreted by posterior pituitary
- Contains 9 amino acids
- Decreases GFR and retains body water
- Increases Blood pressure
CORTICOTROPIN

Hormone of Anterior pituitary
Contains **39** amino acids
Stimulates adrenal cortex for secretion of steroid hormones

**TRH**
- Hypothalamic hormone
- Contains **3** amino acids
- Stimulates release of thyrotropin from anterior pituitary
GASTRIN

Local hormone from Stomach
Stimulates production of gastric juice

Secretin

- G I Peptide
- Stimulates secretion of pancreatic juice
BRADYKININ

Contains 9 amino acids

Formed in blood

Power full vasodilator

Causes contraction of smooth muscles

Stimulates pain receptors

Enkephalins

- Peptide formed in CNS

- Binds to certain receptors in brain and induces analgesia (Killing pain sensation)
Contains 10 amino acids

Power full vasodilator

Aspartame

- Di-peptide,
- Neutra sweet, artificial sweetener
- L aspartyl phenylalanyl methyl ester
- Not suitable for phenylketourics.
IMPORTANT REACTIONS OF AMINO ACIDS
Removal of amino group from amino acid by enzyme to forms keto acid

Deamination: 1. Oxidative deamination
2. Non oxidative deamination

Glutamate $\xrightarrow{\text{Amino acid deaminase}} \alpha$ keto glutarate

$\text{NH}_2$
Transfer of amino group of one amino acid to a keto acid

Result in formation of new amino acid and a keto acid

Enzymes: Transaminase or Amino transferase

Coenzymes: Pyridoxal phosphate

Advantage: Non essential amino acid synthesis

Interconversion of amino acids
General reaction

Amino acid

Amino transferase

α ketoacid

Pyridoxal phosphate

Amino acid

α ketoacid

Pyridoxal phosphate

Alanine

Alanine transaminase

Pyruvate

L- Glutamate

α ketoglutarate

Pyridoxal phosphate

Alanine

Pyruvate
Acidic amino acids react with NH$_3$ to form amide. They are part of protein structure and serve as a source of nitrogen.

**REACTION WITH AMMONIA**

\[ \text{L-Glutamate} \rightarrow \text{NH}_3 \rightarrow \alpha\text{-keto glutarate} \rightarrow \text{L-Glutamine} \]

Enzyme - Glutaminase
Sulphur containing amino acid during their catabolism oxidises sulph-hydryl group to form keto acid.
**DECARBOXYLATION**
Removal of coo group to form amines

**Enzymes**: Amino acid decarboxylase

**Coenzyme**: Pyridoxal phosphate

<table>
<thead>
<tr>
<th>Glutamate</th>
<th>GABA</th>
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</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>Neurotransmitter</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>Histamine</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>Effect on BP, Allergic cond</td>
</tr>
</tbody>
</table>

Decarboxylase

PLP

CO₂

Tyramine
Contracts uterus

Tryptamine
Serotonin, NT
## Colour Reactions of Amino Acids

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Reaction Details</th>
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<tr>
<td>Biuret reaction</td>
<td>Peptide bonds</td>
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<tr>
<td>Ninhydrine reaction</td>
<td>Free amino groups</td>
</tr>
<tr>
<td>Xanthoproteic reaction</td>
<td>Aromatic amino acids</td>
</tr>
<tr>
<td>Millon’s reaction</td>
<td>Tyrosine</td>
</tr>
<tr>
<td>Hopkins – cole reaction</td>
<td>Tryptophan – indole ring</td>
</tr>
<tr>
<td>Sakaguchi’s reaction</td>
<td>Arginine – guanidino group</td>
</tr>
<tr>
<td>Nitroprusside reaction</td>
<td>Free SH group</td>
</tr>
<tr>
<td>Pauly’s reaction</td>
<td>Histidine – imidazole group</td>
</tr>
<tr>
<td>Lead acetate reaction</td>
<td>SH group</td>
</tr>
</tbody>
</table>
# BIOLOGICALLY IMPORTANT COMPOUNDS FROM AMINO ACIDS

<table>
<thead>
<tr>
<th>Amino Acid Combination</th>
<th>Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycine</td>
<td>Heme, Purine base, Bile salt, Glutathione</td>
</tr>
<tr>
<td>Aspartic and Glutamic acid</td>
<td>Purine, pyrimidine bases</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>Thyroxine, Adrenaline, Melaniine, Tryptamine</td>
</tr>
<tr>
<td>Tryptophane</td>
<td>Niacin, Serotonin</td>
</tr>
<tr>
<td>Arginine, Methionine, Glycine</td>
<td>Creatine</td>
</tr>
</tbody>
</table>
1. Describe biomedical significance of five biologically active peptides.
2. List two examples of dipeptide and their biomedical importance.
3. List amino acids present in glutathione. Write its significance.
4. What is ADH? Write its function.
5. Define Zwiter ion and write its significance.
6. Explain amphoteric nature of amino acid.
7. List Branched chain and Aromatic amino acids.
Classification based on Nutritional Value & Shape of proteins
Organic compounds contain C, H, O, N, AND P, S.

Mixed polymer of amino acids linked together by peptide bonds.

PROTEINS

Contains C, H, O, N, AND P, S.

Mixed polymer of amino acids linked together by peptide bonds.

Polypeptide / Protein

H₂N
N terminal

COOH
C terminal

n
CLASSIFICATION OF PROTEINS

1. Based on Functions
2. Based on Nutritional value
3. Based on Shape & Structure
4. Based on Chemical composition
Nutritional value is determined by the presence of essential amino acids.

1. Complete Proteins - 1st class proteins
2. Incomplete Proteins
3. Partially Incomplete Proteins
Complete Proteins - 1\textsuperscript{st} class proteins
- All essential amino acids present in proper proportion
- Good for health and balanced growth
- Egg protein, Milk proteins, Fish, meat, cheese

Incomplete Proteins
- Lack one or more essential amino acids
- Can not support expected growth and health completely
- Proteins from plants and cereals, beans, nut, Gelatin
- Food blend is the solution
Proteins contain essential amino acids but not enough to meet the metabolic need of an organism. 

EX: Proteins from Wheat, Rice, Corn

PARTIALLY INCOMPLETE PROTEINS
Classification based on Physical Shape and Structure

Overall shape is determined on the basis of AXIAL RATIO

i.e. Length / Width ratio
Classification based on Physical Shape and Structure

Fibrous Proteins

- Fibrous Proteins
- Axial ratio more than 10
- Length : width ratio is more than 10
- Molecules are elongated
- Show helix, H bond, covalent bond
- Play structural role
- Myosin, Actin, Keratin, Fibrin, Collagen, Elastin, Tropomyosin
Classification based on Physical Shape and Structure

- **Globular Proteins**
- Axial ratio generally 3 or 4
- Length : width ratio is less than 10
- Molecule is Spherical / Oval
- Easily soluble in water, Digestible
- Play dynamic functions
- Albumin, Globulin, Protamines, Enzymes
Classification based on Physical Shape and Structure

- **Fibrous Proteins**
  - Play structural role
  - Insoluble in water, non-digestible
  - Myosin, Actin, Keratin, Fibrin, Collagen, Elastin

- **Globular Proteins**
  - Soluble in water, digestible
  - Play dynamic functions
  - Albumin, Globulin, Protamines
FUNCTIONS OF FIBROUS PROTEIN

Mechanical function

- Provide strength contractile character
- Provide net work for calcification of bone
FUNCTIONS OF GLOBULAR PROTEIN

Dynamic proteins

Enzymes
Hormones
Carrier proteins
Nutritive and oncotic pressure
NEXT CLASS
FUNCTIONAL CLASSIFICATION
OF PROTEIN
Organic compounds contain C, H, O, N, and P, S.

Mixed polymer of amino acids linked together by peptide bonds.

PROTEINS

N terminal

C terminal

H

H

2

COO

n

Polypeptide / Protein

COO

H
CLASSIFICATION OF PROTEIN BASED ON FUNCTION
Hi! Genetic Structure of cat was contractile. Hence transported for protection, but eaten up (nutritional).
Some hormones are protein in nature
They regulate metabolic pathways by fine tuning

E.g. Insulin, Glucagon, Growth hormone
Immunoglobulins and Antibodies are proteins synthesized against antigen.

They provide immunity and help in defence.

E.g. Immunoglobulins –G,A,M,D,E, Acute phase proteins.
Basic proteins, always found in association with Nucleic acid - DNA.

It provide stability to the DNA structure,
E.g. Nucleoproteins (Histones), Repressor proteins, Inducer proteins, SSBP.
This class of protein provides structural framework for cell and organs.

E.g. Keratin, Collagen, Actin, Myosin, Elastin, Fibroin,
Also called ENZYMES

Class of protein act as catalyst in metabolic reactions and speed up the reaction rate.

E.g. Amylase, Pepsin, Trypsin, Lipase.
Class of protein responsible for movement.

E.g. Actin, Myosin, Tubulin, Flegella, cilia.
Proteins which help in transport of molecules and metabolites inside the cell or across the cell.

E.g. Hemoglobin, Ceruloplasmin, Transferin, Lipoproteins, Albumin, RBP, TBPA,
Some proteins provide protection.

E.g. Fibrinogen, Prothrombin, Receptor proteins,
Some proteins provide good nutrition when consumed in proper amount.

E.g: Casein, Albumin, Lactalbumin, Gliadin, Oricin,
Any Question?

Please read and come....
Chemical Classification of Proteins
Organic compounds contain C, H, O, N, AND P, S.

Mixed polymer of amino acids
Linked together by peptide bonds

PROTEINS

Contains C, H, O, N, AND P, S

Mixed polymer of amino acids
Linked together by peptide bonds

Polypeptide / Protein
Classification based on Chemical composition
CLASSIFICATION BASED ON CHEMICAL COMPOSITION

Simple proteins
- Contains only amino acids

Conjugated proteins
- Contains amino acids and non-protein part called prosthetic part

Derived proteins
- Hydrolysed, degraded or denatured product of simple or conjugated protein
Composed of only amino acids, linked by peptide bonds

**SIMPLE PROTEINS**

- Albumins
- Globulins
- Albuminoids / Scleroprotein
- Globins
- Histones
- Prolamines
- Protamines
- Glutelins
SIMPLE PROTEINS

**Albumins**:
Soluble in water, Heat coagulated, Precipitated at full saturation
EX: Serum Albumin, Ovalbumin, Lactalbumin

**Globulins**:
Soluble in water & in dilute salt solutions
Coagulated by heat, Precipitated at half saturation
EX: Serum Globulins, Ovoglobulin, Lactoglobulin, Legumin of pea
SIMPLE PROTEINS

**Albuminoids / Scleroproteins:**
- Insoluble in water, Salt solution, Acid, Alkali
- Not coagulated by heat, not precipitated
- EX: Collagen, Keratin, Elastin,

**Globins:**
- Soluble in water, dilute acid and alkali
- Soluble in neutral salt solutions
- Not coagulated by heat, Basic proteins
- EX: Globins of Hemoglobin and Myoglobin
**SIMPLE PROTEINS**

**Histones:**
Basic proteins rich in histidine, Soluble in water, mainly found in association with nucleic acid and gives stability to the genetic material, not coagulated.

EX: Histones of nucleoproteins, Thymus

**Protamine:**
Basic protein, Soluble in water, Dilute alkali and dilute acid, Not Coagulated by heat, Relatively small proteins, rich in Arginine and Lysine.

EX: Zinc insulinate, Nucleo-protein of sperm, Salmine
SIMPLE PROTEINS

**Prolamines:**
Insoluble in water, soluble in dilute alcohol,
Not coagulated by heat
EX: Proline rich protein of plants deficient in lysine, Gliadin of wheat, Zein of maize

**Glutelins:**
Insoluble in water, Soluble in salt solutions
Coagulated by heat,
Found in plants
EX: Glutelin of wheat, Oryzenin of rice
Proteins linked to non-protein groups called prosthetic groups

CONJUGATED PROTEINS

Glycoproteins
Phosphoproteins
Lipoproteins
Nucleoproteins
Chromoproteins
Metalloproteins
Flevoproteins
CONJUGATED PROTEINS

**Glycoproteins:**
Carbohydrate as prosthetic group
EX: Ovomucin, Ovomucoid, mucoprotein,
Blood group antigen, receptors on cell membrane

**Phosphoproteins:**
Phosphate / phosphorus as prosthetic group
EX: Casein, Ovo-vitelline
**Lipoprotein:**
- Lipid in association of apo-protein
- Lipid is prosthetic group
- EX: Chylomicrone, VLDL, HDL, Membrane lipoproteins, milk protein

**Nucleoprotein:**
- Nucleic acid or nucleotide as the prosthetic group
- EX: Histones, nucleoprotein of thymus & sperm
**CONJUGATED PROTEINS**

**Chromo-proteins:**
Protein in association with coloured prosthetic group, it imparts colour to the proteins.
- EX: Hemoglobin, Visual purple,

**Metalo-proteins:**
Protein in association with metal ions.
Metal activates the protein enzymes.
- EX: Zinc insulinate, Hemoglobin, Myoglobin, Cytochrome, Carbonic anhydrase, Tyrosinase
CONJUGATED PROTEINS

Flavoproteins:
Riboflavin (Vitamin B2) in association with proteins
EX: Riboflavin yellow (yellow enzyme of whey), Flavanoids of liver and kidney
<table>
<thead>
<tr>
<th>Conjugated Proteins</th>
<th>Subunit</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hemoglobin</strong></td>
<td>Heme</td>
<td>Transport of $O_2$ $CO_2$</td>
</tr>
<tr>
<td><strong>Cytochrome</strong></td>
<td>Heme</td>
<td>Electron transport</td>
</tr>
<tr>
<td><strong>Rhodopsin</strong></td>
<td>Retinal</td>
<td>Vision</td>
</tr>
<tr>
<td><strong>Casein</strong></td>
<td>Phosphorous</td>
<td>Complete protein, High BVP</td>
</tr>
<tr>
<td><strong>Lipoprotein</strong></td>
<td>Lipid</td>
<td>Lipid transport &amp; cell membrane</td>
</tr>
<tr>
<td><strong>Ferritin</strong></td>
<td>Iron</td>
<td>Iron storage normal form</td>
</tr>
<tr>
<td><strong>Transferrin</strong></td>
<td>Iron</td>
<td>Transport Iron</td>
</tr>
<tr>
<td><strong>Ceruloplasmin</strong></td>
<td>Copper</td>
<td>Transport copper, Enzyme</td>
</tr>
</tbody>
</table>
Products obtained by hydrolysis, degradation or denaturation of simple or conjugated proteins

**DERIVED PROTEINS**

- Primary derived
  - Proteans
  - Meta-proteins
  - Coagulated proteins

- Secondary derived
  - Proteose
  - Peptones
  - Peptides
Products obtained by hydrolysis, degradation or denaturation of simple or conjugated proteins

**Primary derived**

- **Proteans**: Earliest product of protein hydrolysis, Ex. Fibrin of fibrinogen
- **Meta-proteins**: Product formed by concentrated acid or alkali, Ex. Paracaseinate, Acid metaprotein
- **Coagulated proteins**: Product of denatured protein, Ex. Coagulated Albumin
Products obtained by hydrolysis, degradation or denaturation of simple or conjugated proteins

- **DERIVED PROTEINS**
- Proteoses
- Peptones
- Peptides
- Amino acids

**Secondary derived**

- Progressive hydrolytic product of protein
Proteins

Simple
- Albumin
- Globulin
- Albuminoid
- Globin
- Histone
- Protamine
- Prolamine
- Glutelin

Conjugated
- Glycoproteins
- Phosphoproteins
- Lipoproteins
- Nucleoproteins
- Chromo-proteins
- Metalo-proteins
- Flevo-proteins

Derived
- Proteans
- Meta-proteins
- Coagulated proteins
- Proteoses
- Peptones
- Peptides

2. What is simple protein? Name subclass with examples.

3. What is conjugated proteins? Name subclass with examples.

4. What is derived proteins? Name subclass with examples.

5. Name any five conjugated proteins and write their functions.

6. Name products of protein hydrolysis.
FAILURE CAN NOT DEFEAT THE MAN WHO IS EAGER TO TRY AGAIN
When two amino acids join together they form a dipeptide.

When many amino acids are joined together a long-chain polypeptide is formed.

Organisms join amino acids in different linear sequences to form a variety of polypeptides, the proteins.

Why variety of proteins?

- two amino acids
- many amino acids
- different linear sequences
- variety
ORGANIZATION OF PROTEIN STRUCTURE

Assembly
Folding
Packing
Interaction
Primary structure of protein

- Peptide bond
- Amino acid
- Linear, ordered, 1-dimensional sequence of amino acid (AA) polymer
- By convention, written from -NH$_2$ end to -COOH end
- A perfectly linear amino acid polymer is neither functional nor energetically favorable → needs folding

Diagram:

- G - A - L - V - A - P
- NH$_2$ - COOH
- H$_2$N
- Peptide bond
- Amino acid
- Needs folding
Primary Structure

Defect

In the β chain of hemoglobin, the 6th amino acid (aa) is Glu. If replaced by Valine forms Sickel cell Anemia.
Insulin from different sources causes antibody and immunological reactions.

<table>
<thead>
<tr>
<th></th>
<th>A8</th>
<th>A9</th>
<th>A10</th>
<th>B30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>Thr</td>
<td>Ser</td>
<td>Ile</td>
<td>Thr</td>
</tr>
<tr>
<td>Pig</td>
<td>Thr</td>
<td>Ser</td>
<td>Ile</td>
<td>Ala</td>
</tr>
<tr>
<td>Cow</td>
<td>Ala</td>
<td>Ser</td>
<td>Val</td>
<td>Ala</td>
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Poly peptide chain organise itself by folding to become functional 3D molecule. This folding is stabilized by several types of bond:

- **Hydrogen bonds**: involved in all levels of structure.

- **Hydrophobic interactions**: between non-polar sections of the protein.

- **Disulfide bonds**: one of the strongest and most important type of bond in proteins. Occur between two cysteine amino acids.
SECONDARY STRUCTURE OF PROTEIN

1. The alpha-helix and
2. The beta-pleated sheet.
Secondary structure
-- Alpha-helix

Amino acid
- Each turn – 0.54 nm
- Spacing between aa – 0.15 nm
- Contains 3.6 aa residue / turn
- Right handed and left handed coil

Peptide bond

Hydrogen bond

3.6 aa

0.54 nm

0.15 nm
SECONDARY STRUCTURE
BETA PLEATED SHEET

Two peptide chains run parallel
Hydrogen bonds Hold shape together
Example Silk fibre
In secondary structure, polypeptides are held in position by hydrogen bonds. In both alpha-helices and beta-pleated sheets, the C=O of one amino acid bonds to the H-N of an adjacent amino acid to form hydrogen bonds.
Both secondary structures give additional strength to proteins. The alpha-helix helps make fibers like in your nails, e.g., Keratin. The beta pleated sheet helps to make the strength-giving protein of silk, fibroin. Proteins are made from both alpha-helix and beta-pleated sheet in combination.

SECONDARY STRUCTURES
A Protein will have both the forms of folding in their molecule

- Bend or Knick
- Glycine or Proline

The secondary structure is observed in a localised portion of a protein.
Strength of protein--
Spider web can trap small insects, worms and even bird or small animal
This is when a polypeptide is folded into a precise shape. The polypeptide is held in 'bends' and 'tucks' in a permanent shape by number of bonds including:

- Disulphide bridges [sulphur-sulphur bonds]
- Hydrogen bonds
- Ionic bonds
- Hydrophobic and hydrophilic forces.

TERTIARY STRUCTURE OF PROTEIN
TERTIARY STRUCTURE

- Non-linear, 3 dimensional, Global but restricted to the amino acid polymer.
- Formed and stabilized by
  - Hydrogen bonding,
  - Covalent (e.g. disulfide) bonding
  - Hydrophilic exposure to solvent
TERTIARY STRUCTURE OF PROTEIN

- Hydrophilic interaction to water
- Hydrogen bond
- Salt bridge
- Disulfide bonds
- Hydrogen bonds
- β-Pleated sheet
- Heme
- β polypeptide
- non-linear, 3 dimensional
- global, and Formed by distinct oligomers

- Stabilized by hydrogen bonding,
- covalent bonding,
- hydrophobic packing and
- hydrophilic exposure

- Thermodynamically favorable,
- functional structures
- occur frequently
BONDS RESPONSIBLE FOR THE STABILITY OF PROTEIN STRUCTURE.
Bonds responsible for the stability of protein structure.

1. Covalent bonds and

2. Non-covalent bonds.
Peptide bonds:

A

COVALENT BONDS
Disulfide bond:

- Formed between 2 cysteine residues.
- Links 2 portions of polypeptide chains through a cystine residue (S----S).
- Resistant to the conditions of protein denaturation.
They are weak bonds. Three major types:

1] Hydrogen bonds:

Formed by the sharing of hydrogen atom between nitrogen and carbonyl oxygen of different peptide bonds. (Intra or Inter peptide)
Hydrophobic interactions:

Non-polar side chain of neutral amino acids orient themselves so as to form an association. This tendency of large number of non-polar groups gives stability to the protein structure.
Electrostatic bonds or Salt Bridges:

**NON-COVALENT BONDS:**
Van der waal’s forces:

NON-COVALENT BONDS:
What happens if bonds other than peptide bonds of proteins are broken?
DEFINITION DENATURATION OF PROTEINS:

Disorganisation of secondary, tertiary and quaternary structure of native proteins, without any change in primary structure.
DENATURING AGENTS:

Physical agents:

Heat, UV light, mechanical shaking, Cooling

Chemical Agents:

Acids, Alkali, heavy metal, Organic Solvents and Alkaloids.
Denaturation of proteins leads to:

1. Unfolding of native protein structure
2. Rupture of ionic, hydrogen bonds hydrophobic and hydrophilic interactions.
3. Becomes more susceptible to proteolytic enzyme
4. Protein becomes insoluble in solutions.
5. Precipitated or coagulated.
6. Loses of its biological function and property.
1. Curdling of milk.

2. Preparation of egg omlet.

3. Formation of paneer.


5. Inactive / dormant enzymes.


7. Precipitation of protein by neutral salt, alcohol, acetone.
SIGNIFICANCE OF DENATURATION

1. Digestibility is increased.

2. Plasma proteins can be fractionated and purified.

3. Property used in heavy metal poisoning as anti dot technique.

4. Preservation of food items and biological samples
Ribonuclease is denatured by 8M urea solution. When urea is removed by dialysis, ribonuclease can be obtained in its active form.

Bence-Jones protein undergoes reversible denaturation.

**Reverse of Denaturation**
Native state
Catalytically active

Reversible
Denaturation of Ribonuclease

Unfolded state
Inactive, Disulphide cross links reduced to yield Cys residue

Native state
Catalytically active
Disulphide cross links reformed
1. Salting out and salting in.
2. Precipitation by organic solvents.
3. Precipitation at isoelectric point (pI)
4. Dialysis
5. Gel filtration
6. Centrifugation
7. Ion exchange and High performance, Affinity chromatography
8. Electrophoresis
Thank you