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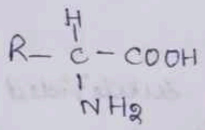
Part III (Major)

Plant Biochemistry

UNIT IV:-

Classification of Amino acids :-

Amino acids are the building blocks of proteins. The general chemical formula of an amino acid is —



The structure depicts a primary amino acid in which the amino acid group ($-NH_2$) is attached to the α-carbon adjacent to the carboxyl group ($-COOH$). Individual difference between the primary amino acids are found in the R-group, which may be quite different from one amino acid to the next.

20 different amino acids found in proteins are — glycine, alanine, valine, leucine, isoleucine, serine, threonine, phenyl alanine, tyrosine, tryptophan, cysteine, methionine, proline, hydroxyproline, aspartic acid, glutamic acid, histidine, arginine and lysine ; Aspargine.

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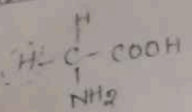
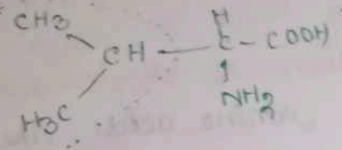
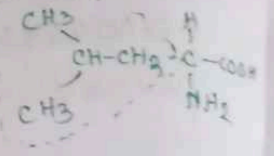


Glycine



valine



leucine

Classification:—

Amino acids can be subdivided into smaller groupings on the basis of properties of their side chains or R-groups. They display different physicochemical properties depending on the nature of their side chain. Accordingly the groupings of classification are as below.—

1. Hydrophobic aliphatic amino acids:—

For example

Glycine
Alanine
Leucine
Isoleucine
Metheonine
} Hydrophobic and chemically unreactive
S.T : GALIM (HP and UR)

Proline ⟶ hydrophobic and conformationally rigid (H.P and C.Rigid)

Cysteine ⟶ hydrophobic and highly reactive (H.P and H.R)

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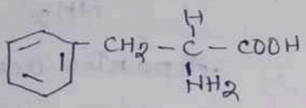
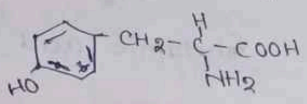
2. Hydrophobic, aromatic amino acids :— Eg: phenylalanine, tyrosine and tryptophan.



Phenyl alanine



Tyrosine

S.T : Ph Ty Tr (H.P and Aro)

3. Polar, charged aminoacids :— This types of amino acids have polar, hydrophilic sidechains, some of which are charged at neutral pH. They may be of two kinds —

a) Basic :— The amino grops on the side chains are protonated and thus positively charged at neutral pH. Eg :- Arginine, Lysine, Histidine.

$$NH_2-\overset{NH_2^+}{\overset{\|}{C}}-NH-CH_2-CH_2-CH_2-\underset{NH_2}{\overset{H}{C}}-COOH$$

Arginine

Basic (Ar, Ly, H)

$$NH_3^+-CH_2-CH_2-CH_2-CH_2-\underset{NH_2}{\overset{H}{C}}-COOH$$

Lysine

b) Acidic :— The carboxyl groups on the side chains are deprotonated and possess a negative charge, at neutral pH. Eg: Asapartic acid and glutamic acid.

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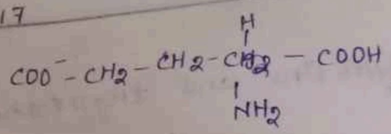
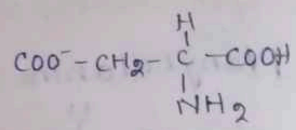


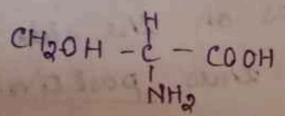
Glutamic acid



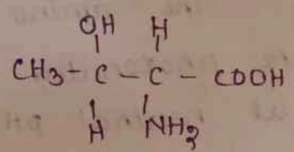
Aspartic acid.

4. Polar, uncharged amino acids :- They are uncharged but can participate in hydrogen bonding

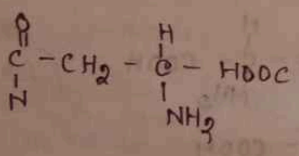
Eg : Serine, Threonine (reactive hydroxyl groups in side chains) ; Asparagine, Glutamine (Amide derivatives of aspartate and glutamate)



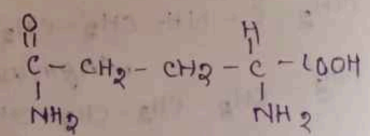
Serine



Threonine.



Asparagine



Glutamine

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Amino acid Biosynthesis :—

Amino acids are generally considered to be the initial product of nitrogen assimilation. There are two major ways for biosynthesis of amino acids. They are — Reductive amination and Transamination.

1. Reductive amination :—

Experiments with isotypically labelled nitrogen has revealed that in most cases the initial receipients of inorganic ammonia nitrogen are the free α-Keto acids in the cytoplasm. There are four pathways by which the incorporation of ammonia nitrogen into organic compounds i.e, organic acids occur to form amino acids. The four pathways are as below —

i) α-Ketoglutarate + NH_3 ⇌ glutamate.

ii) Oxaloacetate + NH_3 ⇌ aspartate.

iii) Fumarate + NH_3 ⇌ aspartate

iv) Pyruvate + NH_3 ⇌ alanine.

Of these four pathways, the amination of α-ketoglutarate appears to be the major reaction in the biosynthesis of amino acid. The reaction is reversible and proceeds as follows —

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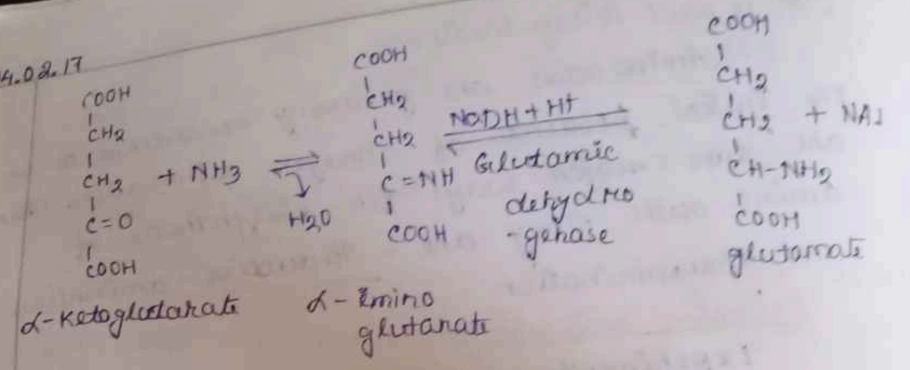

The first reaction probably proceeds spontaneously, but the second reaction is catalyzed by the enzyme glutamic dehydrogenase and requires the presence of reduced nicotinamide-adenine-dinucleotide (NADH+).

2. Transmination :— Transamination involves the transfer of an amino group of an amino acid to the carbonyl group of a keto acid. After inorganic ammonia nitrogen has gained entry primarily through the amination of α-Keto-glutarate, the product glutamate, is available for transamination reactions with Keto acids to form the corresponding amino acids. Although about 17 different amino acids are synthesized through transmination reaction. With

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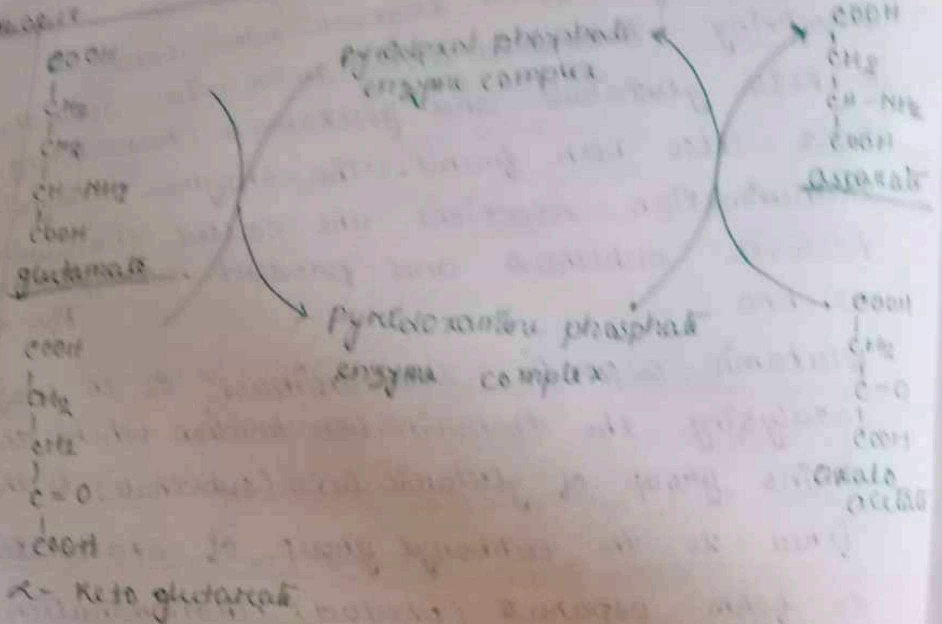
glutamate, yet other transamination reactions involving keto acids and amino acids other than α- keto glutarate and glutamate, respectively have also been found. The enzymes catalyzing transmination reactions are called transaminases, however substrate and product names are used as bro For eg.

Glutamic - aspartic transaminase' is th enzyme catalyzing the transmination reaction where the amino group of glutamic acid (substrate) is transfered to the carbonyl group of oxaloacetate to form asparate (product). Transmination reach also involves the participation of pyrodoxal phosphate or pyridoxamine phosphate as a co enzyme. Apparantly, pyridoxal phosphate, which is tightly bound to the enzyme accepts an amino group from the substrate amino acid to form pyridoxamine phosphate, thereby releasing the corresponding keto acid product. Pyridoxamine then passes the amino acid (the product) and regenerating pyridoxal phosphate. The reaction proceeds as the following ex:-



Peptide Bond

Proteins are the linear sequence of amino acids and the bonds by which the amino acids are linked together are called peptide bonds. The peptide bond is a chemical, covalent bond formed between the α amino group of one amino acid and the α-carboxyl group of another. Each area within the dotted box in the following diagram include four atoms of the peptide bond:

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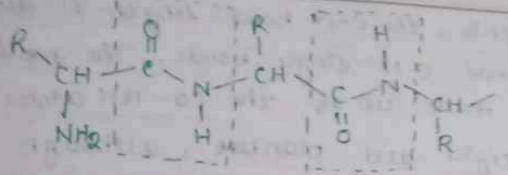
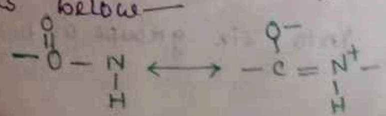


A compound composed of two amino acids linked together by one peptide bond is called a dipeptide of three amino acids, a tripeptide, and so on. Long, unbranched chains of amino acids can be linked with (together) by peptide bonds to form oligopeptides (upto 25 amino acid residues). Conventionally peptide chains are written down with the free α-amino group on the left and 11 free α-carboxyl group on the right and a hyphen between the amino acids to indicate the peptide bonds. For ex, the tripeptide $^{+}H_3N$- serine - leucine - phenylamine - COO^- would be written simply as Ser-Leu-Phe or S-L-P.

The peptide bond between carbon and nitrogen exhibits partial double bond characteristic due to the closeness of the carbonyl carbon-oxygen double bond allowing the resonance structure as below—



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Because of this, the C-N bond length is also shorter than normal C-N single bonds. The peptide unit which is made up of the CO-NH atoms is thus relatively rigid and planare, although free rotation can take place about the C_α-N and C_α-C bonds; i.e, the bonds either side of the peptide bond, permitting adjacent peptide units to be different angles. The hydrogen of the amino group is nearly always on the opposite side (trans) of the double bond to the oxygen of the carboxyl group, rather than on the same side (cis).

Classification of Proteins:—

Depending on solubility properties and on known chemical and physical differences, proteins are classified into two major groups — single proteins and conjugated proteins.

1. Simple proteins:— They are compounds that on hydrolysis, yield only amino acids. On the basis of solubility properties simple proteins can be further divided into six groups as below—