

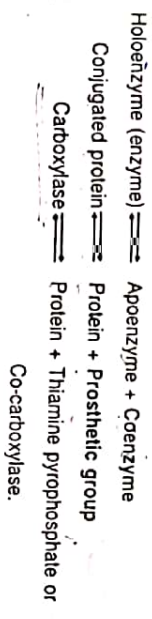
# 5

## Co-Enzyme Chemistry

enzyme → protein (polypeptide chain) + prosthetic group → active site

### CO-FACTORS AS DERIVED FROM VITAMINS, CO-ENZYMES, PROSTHETIC GROUPS & APOENZYMES

We know enzymes are protein molecules. Some enzymes are simple proteins, i.e., their molecules consist of only amino acids, whereas others are conjugated proteins. The non-protein part (non-amino acid) of a conjugated protein or enzyme is known as prosthetic group. The two fragments (protein + prosthetic group) of some conjugated proteins (enzymes) can be separated by dialysis and it was seen that dialysis of such enzymes resulted in the loss of catalytic activity of that enzyme; but the activity can be regained by mixing the two separated components. This fact clearly indicates that the dialyzable component is necessary for the protein to act as an enzyme & hence this dialyzable material (prosthetic group) is termed as co-enzyme, the protein part of conjugated protein is known as apoenzyme and the intact molecule or conjugated protein as holoenzyme.



Thus Co-enzyme part is necessary for the activity of the enzyme. But, now-a-days term cofactor is used in general way & coenzyme specifies for those co-factors which are organic molecules & participate in the catalytic process. For example, in metalloprotein enzyme, the metallic ion is not the co-enzyme but only organic prosthetic group constitutes the co-enzyme. Thus every coenzyme is a nucleotide and are composed of vitamins. Co-enzymes may be classified according to their function into hydrogen-carrying & group-carrying co-enzymes & co-factor group:

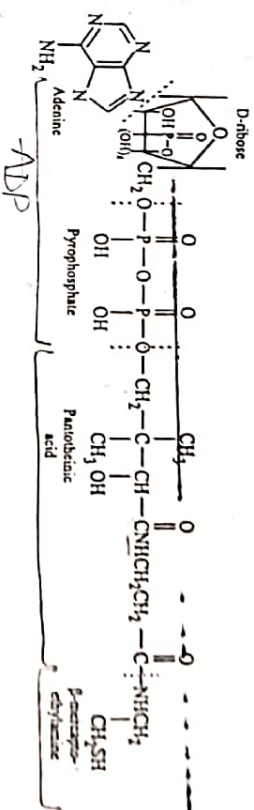
- (1) Hydrogen Carrying Coenzyme:
  - Pyridine nucleotide
  - Flavin nucleotide
  - Lipoic acid
- (2) Co-factor:
  - Biotin
  - Vitamin B12
  - Ascorbic acid
  - Choline
  - Inositol
  - Glutathione
  - Vitamin K
- (3) Group-Carrying Coenzymes:
  - Adenosine phosphate
  - Uridine phosphate
  - Cytidine phosphate
  - Guanosine phosphate
  - Sugar phosphate
  - Thiamine pyrophosphate
  - Coenzyme A
  - Pyridoxal phosphate
  - Folic acid family

### CO-ENZYME CHEMISTRY

#### STRUCTURE & BIOLOGICAL FUNCTIONS OF SOME COENZYMES

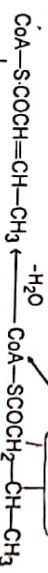
##### 1. CO-ENZYME A (COA-SH)

It is a part of enzyme which catalyses biological acylation reactions, i.e., it helps in transferring the acetyl group from one compound to another. Its structure was established by a series of selective enzymatic degradations.



It participates in all biosynthetic processes which proceed by way of two carbon units, thus coenzyme A is involved in carbohydrate metabolism, in the biosynthesis of fatty acids, terpenoids and steroids in plants and animals.

**Biosynthesis of fatty acids:** Acetyl coenzyme A, CoA-SCOCH<sub>3</sub>, undergoes self-condensation to form acetoacetyl coenzyme A which is converted into butyryl coenzyme by various reactions.



We see that two carbon atoms are added in acetyl-CoA to form butyryl-CoA; butyryl-CoA now again condenses with acetyl-CoA and in a similar manner forms butyryl-CoA; repetition of these sequences finally leads to the formation of a long chain fatty acids.

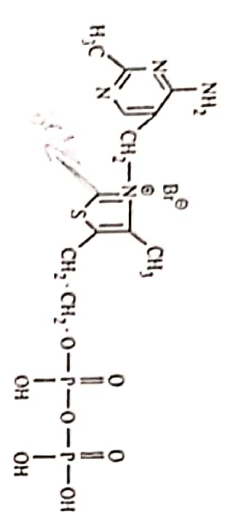


- (i) Reduction
- (ii) -H<sub>2</sub>O
- (iii) Reduction

**Biosynthesis of Terpenoids & Steroids:** Isopentenyl pyrophosphate and β:β-dimethylallyl pyrophosphate which are the precursors of terpenoids & steroids biosynthesis are synthesised with the help of CoA. An example is given below:



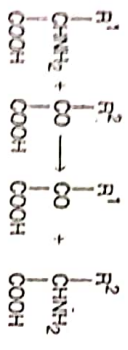
The structure of co-carboxylase is:



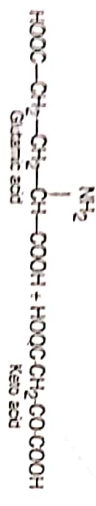
(III) Pyridoxal Phosphate [Codecarboxylase or Co-transaminase]

Pyridoxal phosphate is obtained by phosphorylation of pyridoxal. It is involved in a number of important metabolic reactions of the α-amino acids, e.g., transamination, racemization, decarboxylation and elimination reactions.

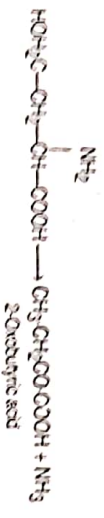
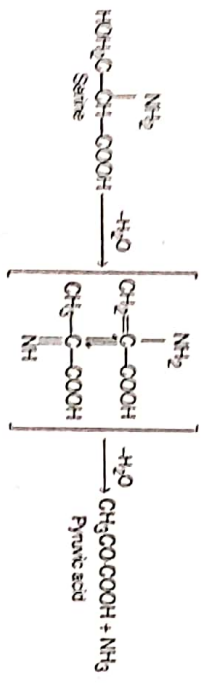
In transamination the amino acid is converted into keto acid and vice-versa.



e.g., the interconversion of glutamic acid into its keto acid & of a keto acid to amino acid

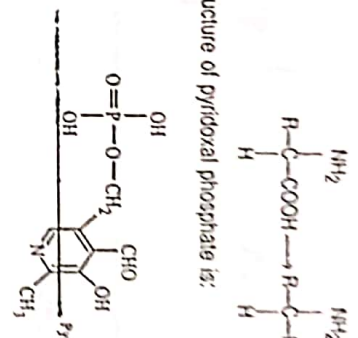


Elimination reactions are also catalysed by an enzyme having pyridoxal unit in its structure, e.g., conversion of serine into pyruvic acid with the elimination of one molecule of ammonia.



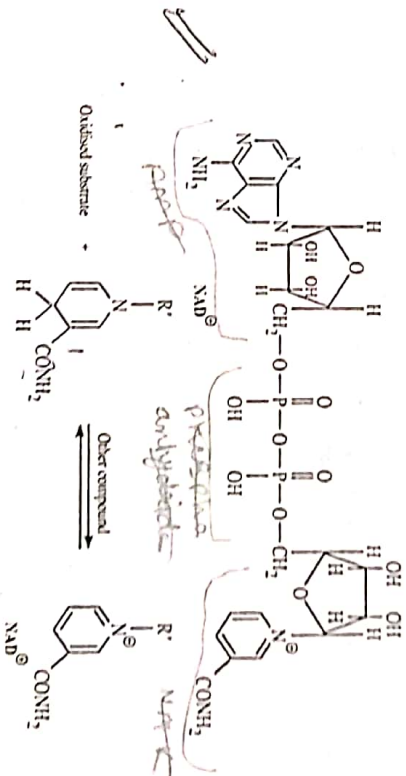
The enzymes which decarboxylate amino acids also require pyridoxal phosphate as a coenzyme, e.g., formation of histamine from histidine. The general reaction is:

The structure of pyridoxal phosphate is:



(IV) NAD<sup>+</sup>

It is also known as DPN (diphosphopyridine nucleotide) or Codehydrogenase I or Coenzyme I or Cozymase. NAD<sup>+</sup> stands for nicotinamide adenine dinucleotide. This is hydrogen transfer co-enzyme & its activity is due to nicotinamide. It accepts hydrogen from substrate (which is oxidised) and then transfers step by step to other compounds such as flavoprotein, cytochrome b, cytochrome c, cytochrome n and cytochrome oxidase. The last compound gives its hydrogen to oxygen, forming water. The overall result is oxidation of substrate. Transference of hydrogen is reversible and stereospecific.



One important use of NAD<sup>+</sup> is its use during the alcoholic fermentation where CH<sub>3</sub>CHO is reduced to CH<sub>3</sub>CH<sub>2</sub>OH by means of NADH.

(V) NADP<sup>+</sup> [Nicotinamide Adenine Dinucleotide Phosphate]

It is also known as Coenzyme II or phosphocoenzyme or TPN (Triphosphopyridine nucleotide) or codehydrogenase-II. It has one additional phosphate group apart from DPN molecule in position 2' of ribose molecule of adenosine. It also helps in dehydrogenation.

Structure: NADP<sup>+</sup> on hydrolysis by a nucleotide phosphatase gives