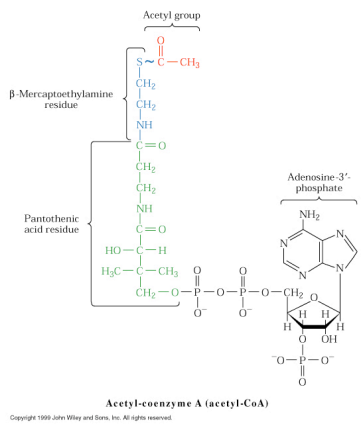


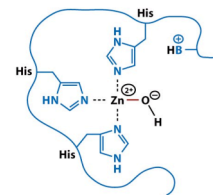
- Transfer of acyl (carbon chains) require an activation step
- These reactions involved a thioester high energy bond.
- Use the compound Coenzyme A (derived from pantoic acid, vitamin B₅)
- The hydrolysis of thioesters is as energetically favorable as ATP hydrolysis
- Used in fatty acid synthesis, lipid production, lipid modification of proteins and others



Cofactors

Required by inactive apoenzymes to convert them into active holoenzymes

- Essential ions - mostly metal ions
- Coenzymes - organic compounds



Carbonic anhydrase active site

Many enzymes require trace metals for activity

Metal-activated enzymes (eg. K⁺, Ca²⁺, Mg²⁺)
Metalloenzymes (eg. iron, zinc)

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIIIB	IB	IIA	IVA	VA	VIA	VIIA	0													
1 H 1.008	2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18	11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95										
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80										
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 106.4	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3										
55 Cs 132.9	56 Ba 137.3	57* La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 209.0	85 At (210)	86 Rn (222)										
87 Fr (223)	88 Ra (226)	89** Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (266)	110 Ds (267)	111 Rg (268)	112 Cn (269)	113 Nh (270)	114 Fl (271)	115 Lv (272)	116 Ts (273)	117 Og (274)	118 Lr (277)										
89** Ce 140.1	90 Pr 140.9	91 Nd 144.2	92 Pm (145)	93 Sm 150.4	94 Eu 152.0	95 Gd 157.3	96 Tb 158.9	97 Dy 162.5	98 Ho 164.9	99 Er 167.3	100 Tm 168.9	101 Yb 173.0	102 Lu 175.0	103 Th 232.0	104 Pa 231	105 U 238.0	106 Np (237)	107 Pu (244)	108 Am (243)	109 Cm (247)	110 Bk (247)	111 Cf (251)	112 Es (252)	113 Fm (257)	114 Md (258)	115 No (259)	116 Lr (262)

Coenzymes: a closer look

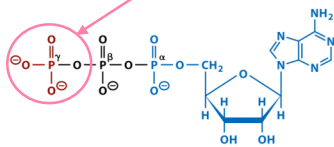
- Altered during the course of the reaction
- Provide reactive groups not found in amino acid side chains
- Two classes
 - **Co-substrates** freely dissociate from enzymes - regenerated by another enzyme (eg. NADH)
 - **Prosthetic groups** remain bound (sometimes covalently) to its apoenzyme - regenerated during each full catalytic event (eg. FAD)

Metabolite coenzymes

synthesized from common metabolites

ATP
S-Adenosylmethionine
UDP-glucose

Phosphoryl transfer
Methyl transfer
Glycosyl transfer

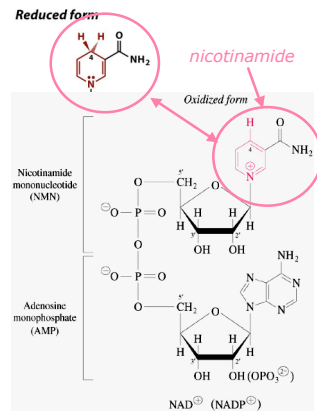


Vitamin-derived coenzymes

- vitamins are precursors obtained as nutrients in small amounts.
- Most vitamins must be enzymatically transformed to their corresponding coenzyme
- Vitamin deficiency can lead to disease

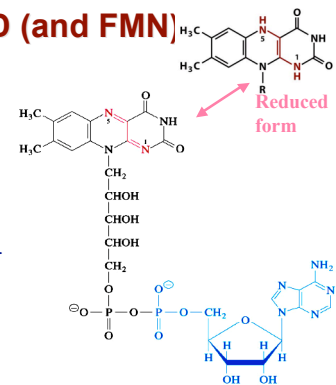
NADH (and NADPH)

- Full name
 - Nicotinamide adenine dinucleotide
- Vitamin precursor
 - nicotinic acid (niacin)
- Vitamin deficiency
 - Pellagra
- Metabolic role
 - Oxidation-reduction involving two-electron transfers
- Cosubstrate for
 - dehydrogenases



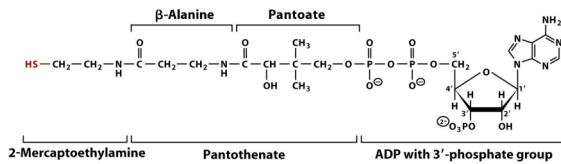
FAD (and FMN)

- Full name
 - flavin adenine dinucleotide
- Vitamin precursor
 - Riboflavin (B₂)
- Vitamin deficiency
 - Growth retardation
- Metabolic role
 - Oxidation-reduction involving one- and two-electron transfers
- Prosthetic group for
 - flavoenzymes



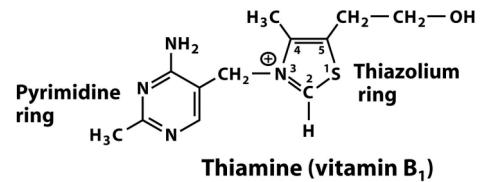
CoA

- Full name: Coenzyme A
- Vitamin precursor: Pantothenate (B₅)
- Vitamin deficiency: Dermatitis in chicks
- Metabolic role: Acyl transfer
- Cosubstrate for: Hundreds of enzymes



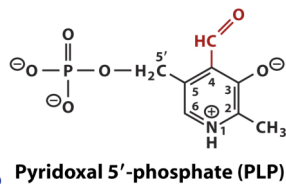
TPP

- Full name: Thiamine pyrophosphate
- Vitamin precursor: Thiamine (B₁)
- Vitamin deficiency: beriberi
- Metabolic role: Transfer of 2-carbon fragments containing carbonyl
- Prosthetic group for: Some carboxylases



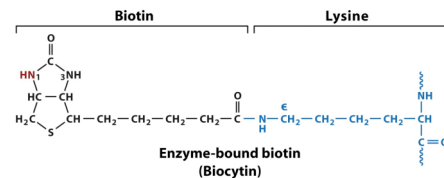
PLP

- Full name
 - Pyridoxal phosphate
- Vitamin precursor
 - Pyridoxine, pyridoxal, pyridoxamine (B₆)
- Vitamin deficiency
 - Dermatitis in rats
- Metabolic role
 - Transfer of groups to and from amino acids
- Prosthetic group for
 - transaminases



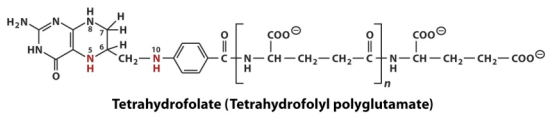
Biotin

- Full name: biotin
- Vitamin precursor: Biotin
- Vitamin deficiency: Dermatitis - humans
- Metabolic role: Carboxyl group transfer and ATP-dependent carboxylation
- Prosthetic group for: Some carboxylases



Tetrahydrofolate

- Full name: tetrahydrofolate
- Vitamin precursor: Folic acid
- Vitamin deficiency: anemia, spina bifida
- Metabolic role: One-carbon transfer (formyl, hydroxymethyl)
- Cosubstrate for: Dihydrofolate reductase and others



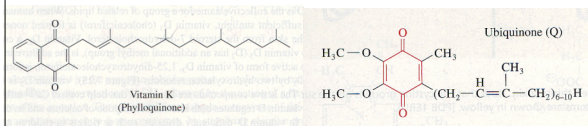
Other coenzymes

Vitamin K

- Deficiency
 - Blood clotting disorder
- Metabolic role
 - carboxylation of Glu
- Prosthetic group for
 - Vit. K-dep. carboxylase

Ubiquinone

- Alternate name
 - Coenzyme Q
- Metabolic role
 - Electron transfer
- cosubstrate for
 - Mitochondrial enzymes



Other essential vitamins

Vitamin	Role	Deficiency	solubility
A	Vision	Night blindness	Lipid
C	Antioxidant	Scurvy	Water
D	Gene expression	Rickets	Lipid
E	Antioxidant	Fragile blood cells	lipid

Heme

- Metabolic role
 - electron transfer
- Prosthetic group for
 - cytochromes

