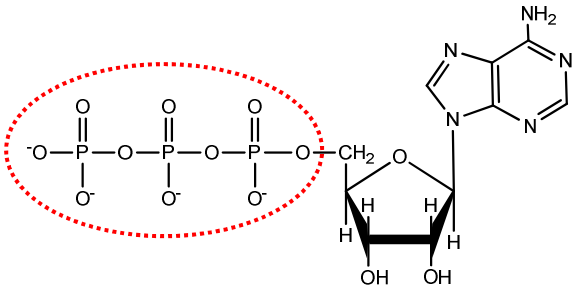
ATP – adenosine triphosphate

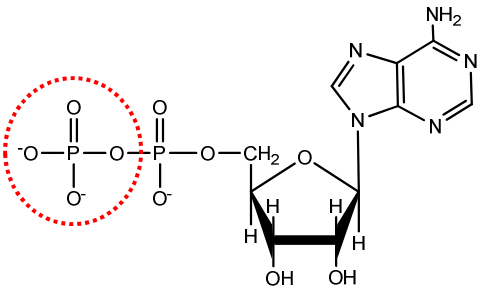
- Energy currency (ex: muscle contraction)
- Phosphoryl donor (ex: hexokinase reaction of glycolysis)
- Pyrophosphoryl donor (ex: thiamine diphosphokinase reaction)
- AMP donor (ex: amino acid activation for protein synthesis)
- Nucleotide in RNA synthesis
- Allosteric effector (ex: phosphofructokinase reaction of glycolysis)
- (See Lehninger p23, 501-503, 506-509; 178, 212, 532)



Adenosine triphosphate (ATP)

ADP – adenosine diphosphate

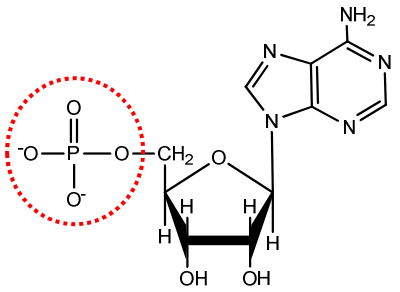
- Phosphoryl donor (ex: adenylate kinase reaction)
- Phosphoryl acceptor (ex: pyruvate kinase reaction of glycolysis)
- Allosteric effector (ex: isocitrate dehydrogenase reaction of the TCA cycle)
- (See Lehninger p23; 510, 536-537, 538)



Adenosine diphosphate (ADP)

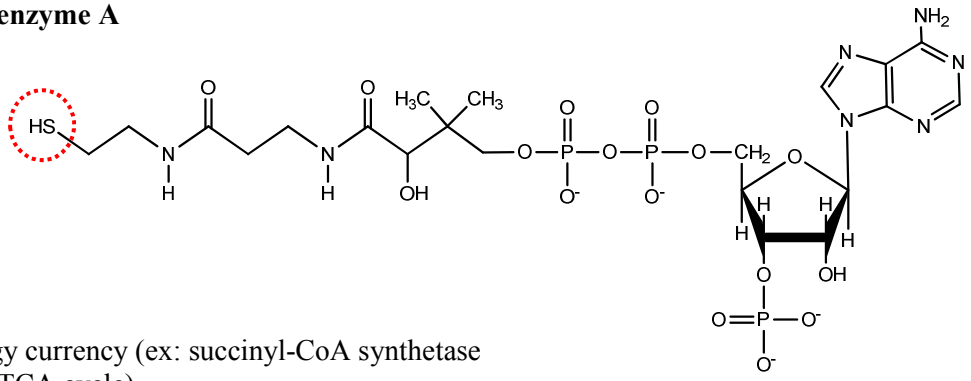
AMP – adenosine monophosphate

- Phosphoryl acceptor (ex: adenylate kinase reaction)
- Allosteric effector (ex: glycogen phosphorylase reaction of glycogen catabolism)
- (See Lehninger p 23, 273)



Adenosine monophosphate (AMP)

CoA (or CoASH) – coenzyme A

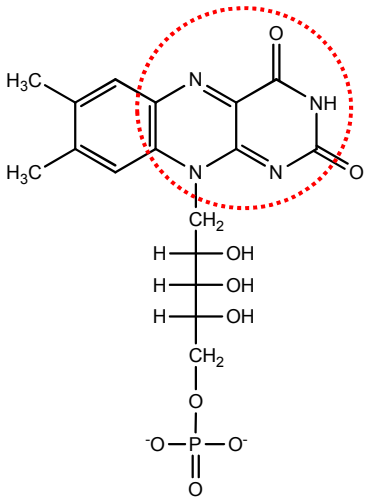


Coenzyme A (CoA)

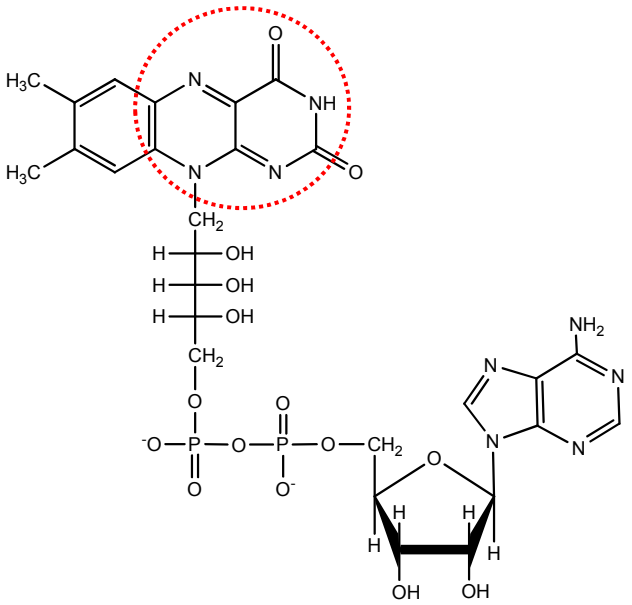
- Thioester energy currency (ex: succinyl-CoA synthetase reaction of the TCA cycle)
- Acyl carrier via thioester formation (ex: as acetyl-CoA entering the TCA cycle)
- Synthesized from pantothenic acid, essential vitamin B_5
- (See Lehninger p 617; 505, 616-619, 622-623, 626)

FMN (redox forms FMN, FMNH•, or $FMNH_2$) – flavin mononucleotide

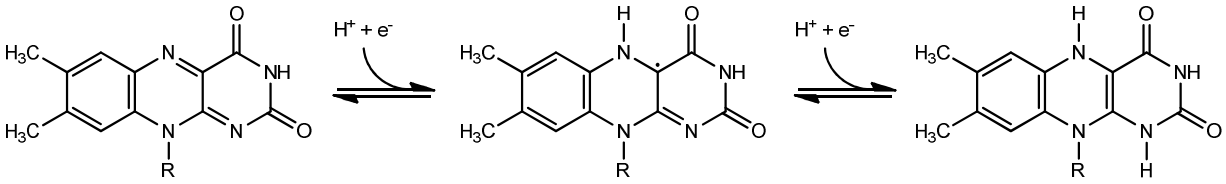
- Redox cofactor:
  - accepts/gives 2 electrons and 2 protons (= hydride ion + proton), (ex: Complex I reaction of ETC)
  - accepts/gives 1 electron and 1 proton (= hydrogen atom), (ex: Complex I reaction of ETC)
- Tightly bound in enzyme active site
- Varies in redox potential based on protein surroundings
- Synthesized from riboflavin, essential vitamin B_2
- (See Lehninger p 519-521, 709, 714)



Flavin mononucleotide (FMN)



Flavin adenine dinonucleotide (FAD)



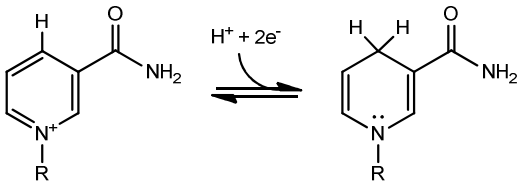
FMN or FAD **FMNH· or FADH·** **$FMNH_2$ or $FADH_2$**

FAD (redox forms FAD, FADH•, or $FADH_2$) – flavin adenine dinucleotide

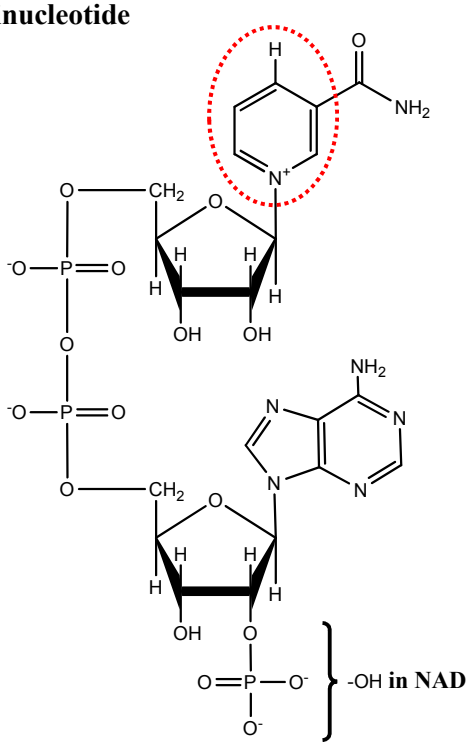
- Redox cofactor:
  - accepts/gives 2 electrons and 2 protons (= hydride ion + proton), (ex: succinate DH/Complex II reaction of the TCA cycle and ETC)
  - accepts/gives 1 electron and 1 proton (= hydrogen atom), (ex: succinate DH/Complex II reaction of the TCA cycle and ETC)
- Tightly bound in enzyme active site
- Varies in redox potential based on protein surroundings
- Synthesized from riboflavin, essential vitamin B_2
- (See Lehninger p 519-521, 628, 709, 715)

NAD (redox forms NAD^+ or NADH) – nicotinamide adenine dinucleotide

- Redox cofactor: accepts/gives 2 electrons and 1 proton (= hydride ion), (ex: GAPDH reaction of glycolysis)
- Water soluble and freely diffusing
- Used mainly in catabolic pathways
- $[NAD^+] > [NADH]$ in cells
- Synthesized from niacin or niacinamide (nicotinamide), essential vitamin B_3
- (See Lehninger p 516-519; 535-536, 616-619, 624-625, 628, 709)



NAD^+ or $NADP^+$ **NADH or NADPH**

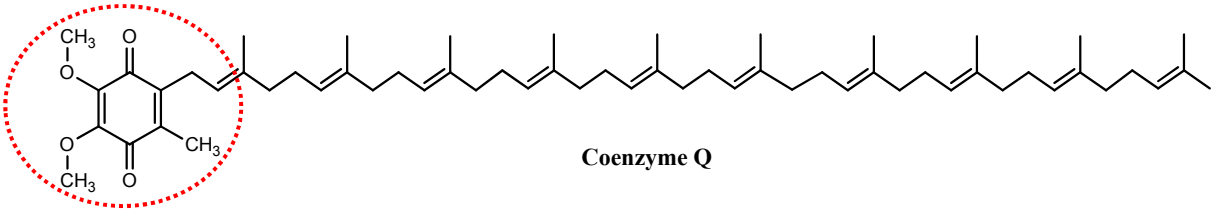


Nicotinamide adenine dinucleotide phosphate (NADP)

NADP (redox forms $NADP^+$ or NADPH) – nicotinamide adenine dinucleotide phosphate

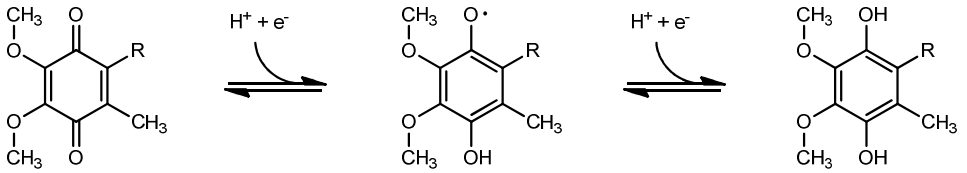
- Redox cofactor: accepts/gives 2 electrons and 1 proton (= hydride ion), (ex: G6P DH reaction of the pentose phosphate pathway)
- Water soluble and freely diffusing
- Used mainly in anabolic pathways
- $[NADP^+] < [NADPH]$ in cells
- Synthesized from niacin or niacinamide (nicotinamide), essential vitamin B_3
- (See Lehninger p 516-519; 624)

CoQ (or Q; redox forms Q, QH•, QH_2) – coenzyme Q or ubiquinone



Coenzyme Q

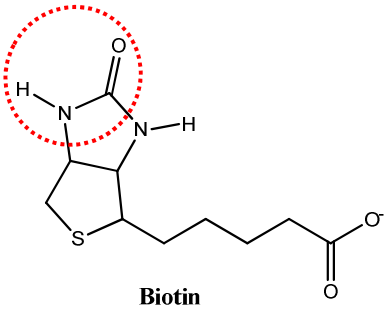
- Redox cofactor: accepts/gives 1 electron and 1 proton (= hydrogen atom) up to 2 times, (ex: Q-cycling at Complex III)
- Hydrophobic; freely diffusing in the membrane
- Length of isoprene tail varies by species
- (See Lehninger p 710, 715-717)



CoQ or Q (ubiquinone) **CoQH· or QH· (ubisemiquinone)** **$CoQH_2$ or QH_2 (ubiquinol)**

Biotin

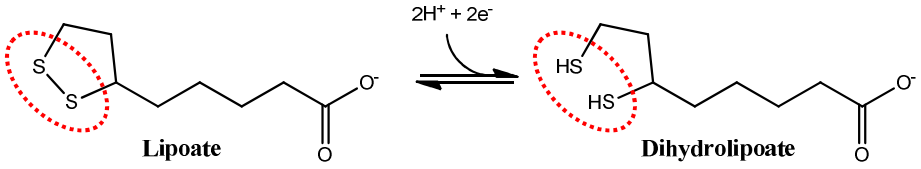
- Helps catalyze carboxylation (ex: pyruvate carboxylase reaction of gluconeogenesis)
- Covalently linked (via amide linkage) to enzyme at lysine side chain
- Essential vitamin B_7
- (See Lehninger p554, 633-635)



Biotin

Lipoic acid (redox forms 'lipoic acid' and 'dihydrolipoic acid')

- Redox cofactor; accepts 2 electrons (plus 2 protons) at disulfide, yielding sulfhydryls (ex: PDH complex reaction in aerobic metabolism)

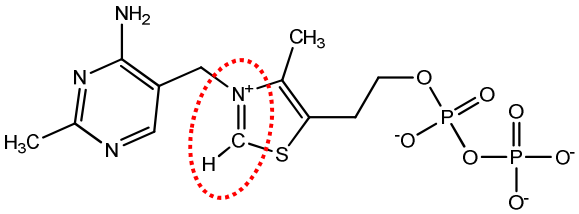


Lipoate **Dihydrolipoate**

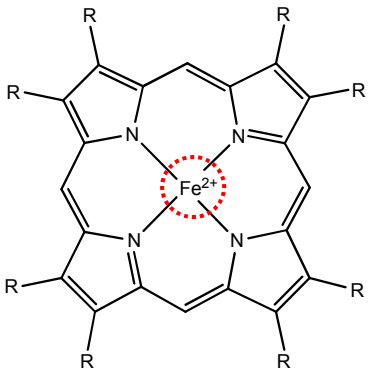
- Covalently linked (via amide linkage) to enzyme at lysine sidechain; becomes lipoamide (or dihydrolipoamide)
- Catalyzes acyl transfer via thioester formation (ex: PDH complex reaction in aerobic metabolism)
- (See Lehninger p 617, 635, 616-619)

TPP – thiamine pyrophosphate

- Catalyzes α-keto decarboxylation (ex: PDH complex reaction of aerobic metabolism)
- Ylid proton is acidic, with pKa ~ 18 (pKa may differ in enzyme)
- Bound tightly in enzyme active site
- Synthesized from thiamine, essential vitamin B_1
- (See Lehninger p 550, 616-619)



Thiamine pyrophosphate (TPP)



Heme

- O_2-binding cofactor
- Redox cofactor: accepts/gives 1 electron ($Fe^{3+} + e^- \leftrightarrow Fe^{2+}$), (ex: Complex IV reaction of ETC)
- Bound tightly in protein, either non-covalently via hydrophobic interactions, or covalently
- Varies in redox potential based on R-groups and protein surroundings
- (See Lehninger p 154, 710-711, 716-718)