

C5720 Biochemie

13-Koenzymy a vitaminy

Obsah

- Koenzymy a vitaminy. Koenzymy oxidoreduktáz (nikotinamid a NAD, flaviny, chinony, hemy, železosírné proteiny, lipoát,) transferáz (ATP, UDP, CDP, biotin, thiamin, koenzym A, THF, pyridoxalfosfát, vit B12) Vitamin C, lipofilní vitaminy (A, D3, K).

Typy kofaktorů

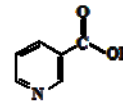
- Rozdělení podle reakcí – tříd
 - Někdy spadají do více skupin (THF)
- Jako prekurzory slouží vitaminy
 - Většinou, někdy jiné esenciální složky potravy
 - Možnost syntézy z neesenciálních prekurzorů - hem
- Relativita pojmu
 - Kofaktor – koenzym x druhý substrát (ATP, ...)
 - Vazba kovů
 - Produkty přeměny aminoacylů (PQQ, ...)

Kofaktory oxidoreduktas

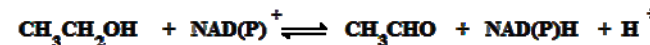
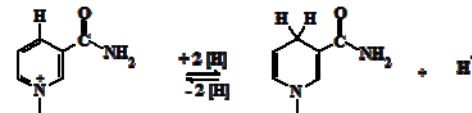
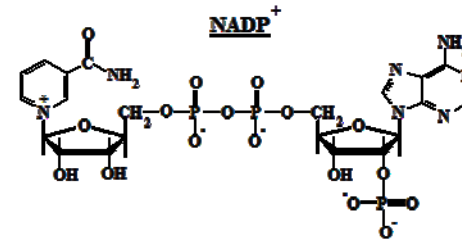
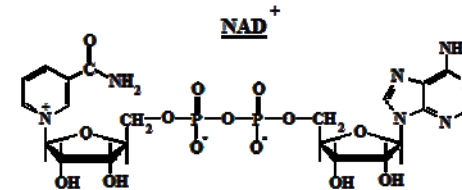
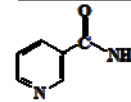
- Nikotinamidové
- Koenzymy
- Prekurzor niacin
- Disociabilní
- $2e^-$ redukce
- Přenos H^-
- NAD^+ - respirace
- $NADP^+$ - redukce
- Změna spektra
- $A_{340} = f(c)$

NIKOTINAMIDOVÉ KOENZYMY

k. nikotinová

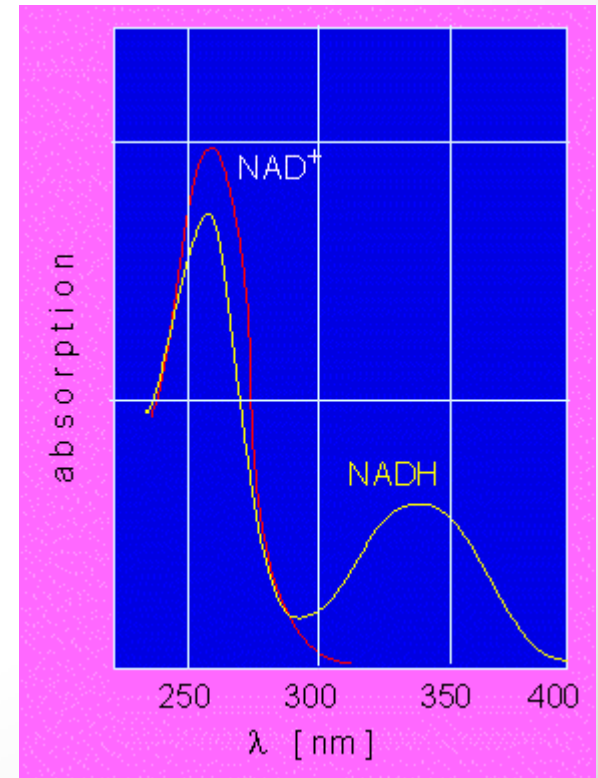
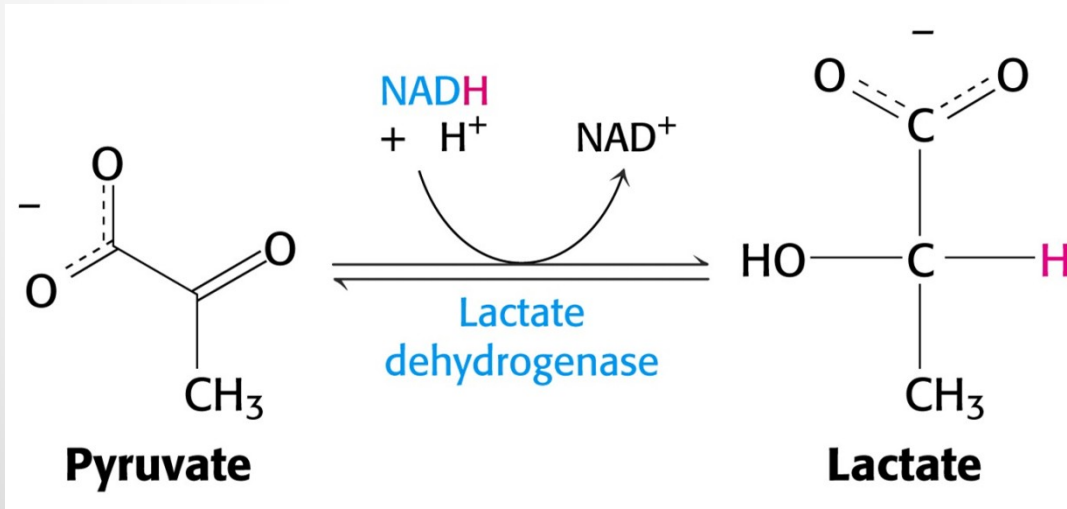


nikotinamid



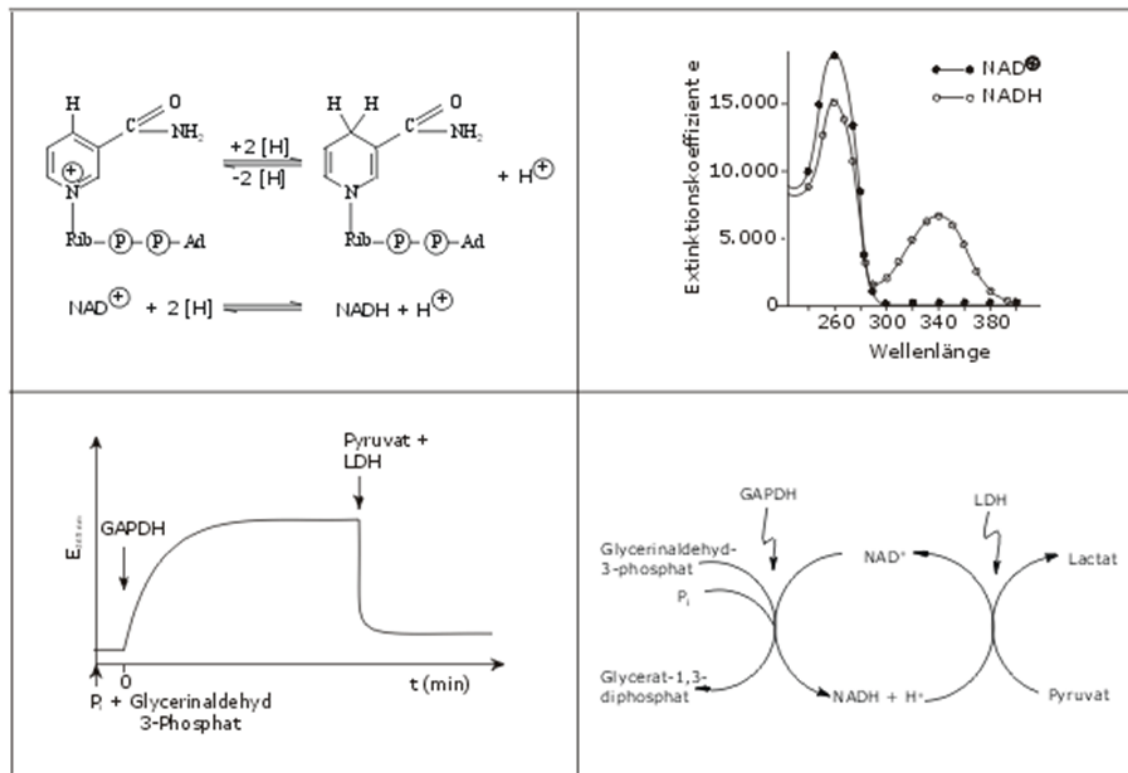
Kofaktory oxidoreduktas

- Warburgův optický test



Warburgův optický test

Prinzip des Optischen Tests nach WARBURG



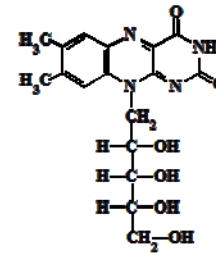
Folie 7.11

Kofaktory oxidoreduktas

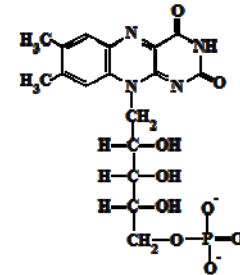
- Flavinové kofaktory
- Prekurzor riboflavin
- Prostetické skupiny
- 2 $1e^-$ kroky
- Semichinony, radikály
- Změna A nevýrazná
- Žlutá (ox) x leukoforma (red)

FLAVINOVÉ KOENZYMY

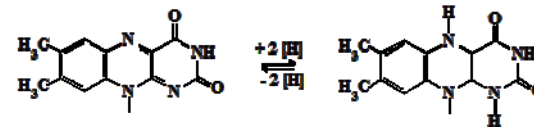
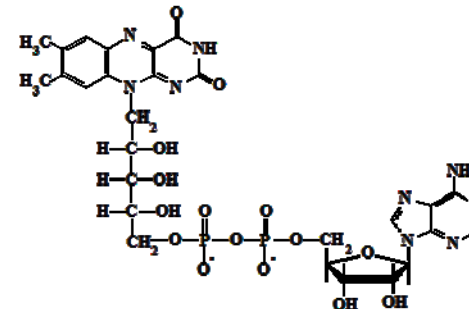
riboflavin



FMN

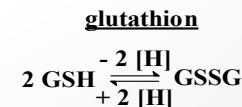
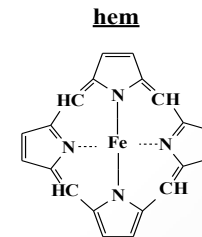
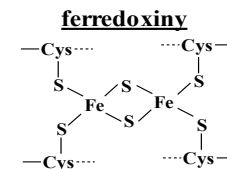
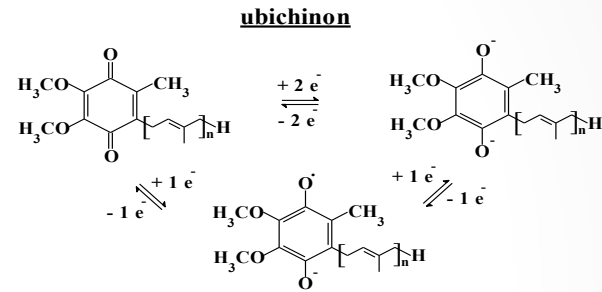
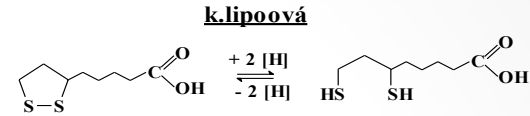


FAD



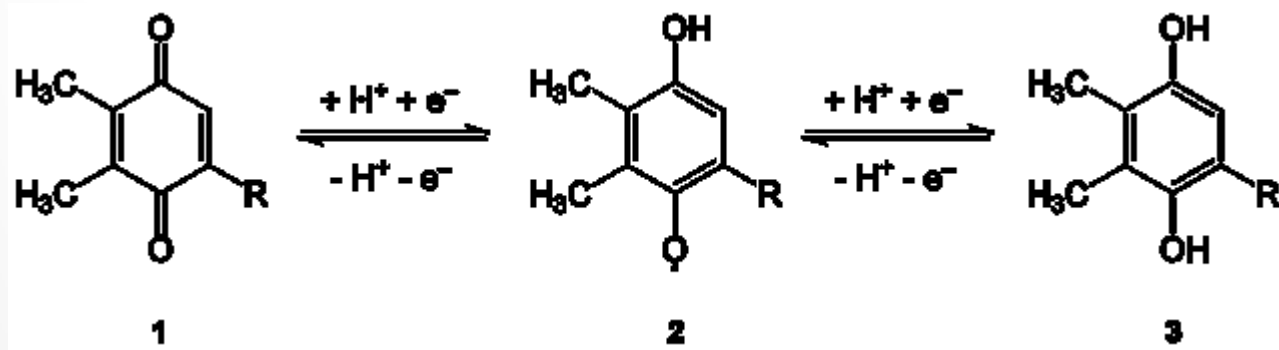
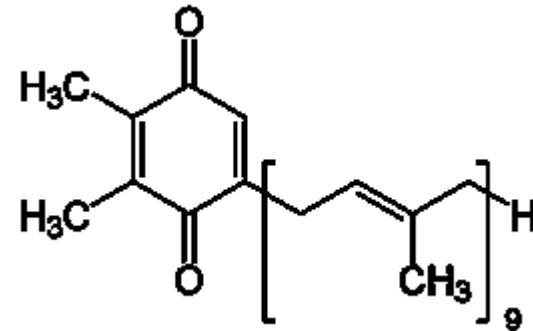
Kofaktory oxidoreduktas

- Kys. lipoová (thioktová)
 - Vitamin
 - Vázán amidicky na apoprotein
 - Odtud lipoamid
- Ubichinon, CoQ
 - Volná interakce
 - UQ-5n, CoQ_n, n = 6 – 10
 - Semichinony, radikály, ROS
- Ferredoxinové typy
 - Nehemově vázané Fe, FeS proteiny
 - Klastry Fe-S různé struktury
- Hemově vázané Fe
 - Různé substituenty, též lipofilní
 - Různý způsob vazeb
- GSH
 - Detoxikace, GSH peroxidasa x reduktasa
 - Též přenos skupin, xenobiotika



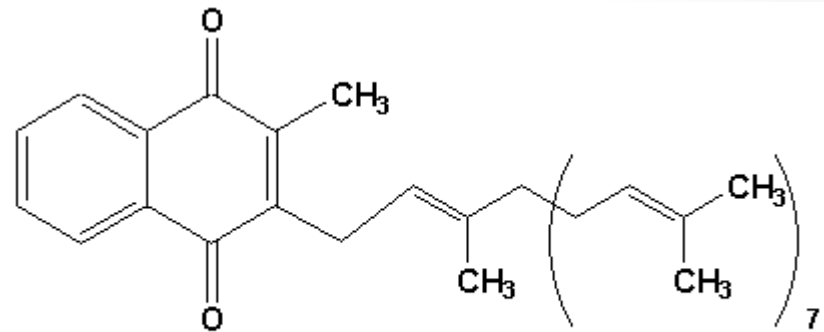
Kofaktory oxidoreduktas

- Plastochinon
 - Obdoba UQ u fotosyntézy
 - Redukce 2 x $1e^-$



Kofaktory oxidoreduktas

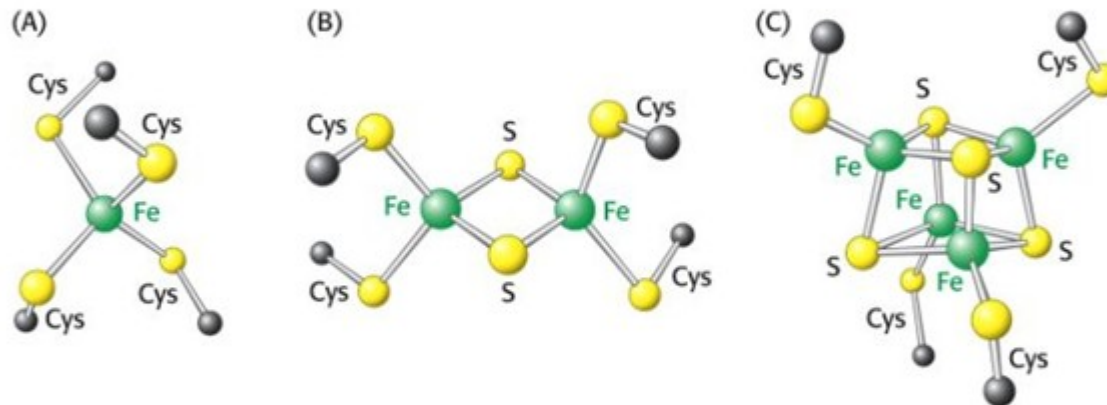
- Naftochinony
 - Vitaminy K
 - Speciální funkce
 - Tvroba karboxyGlu
 - Srážení krve



Menaquinone (vitamin K2)

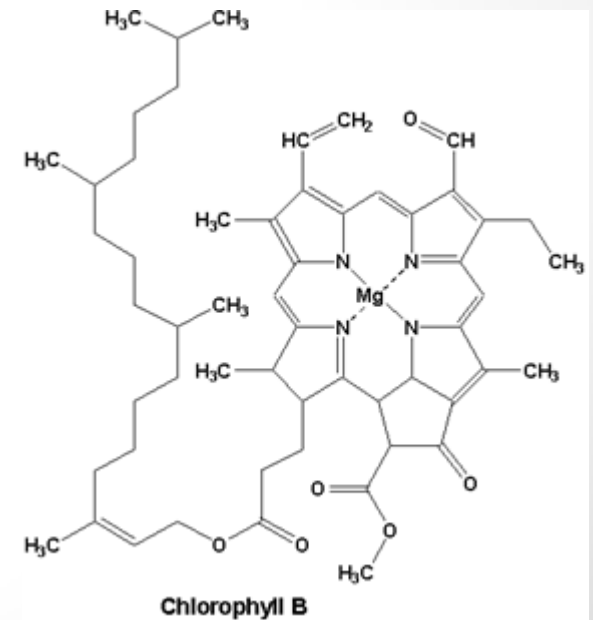
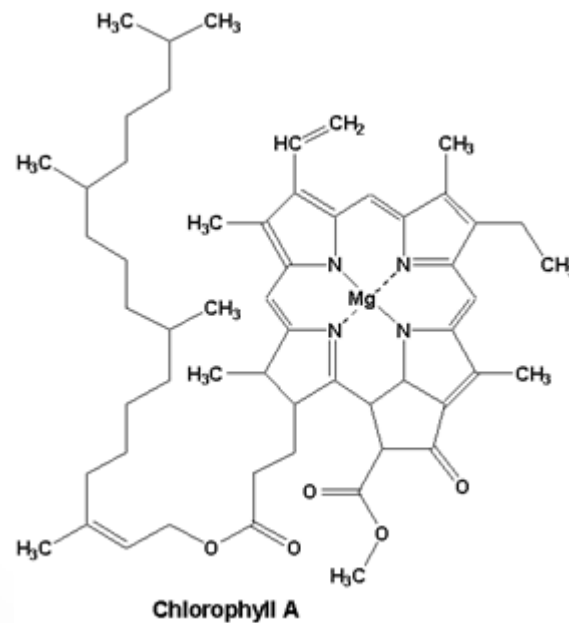
Kofaktory oxidoreduktas

- Fe-S klastry, příklady prostetických skupin bílkovin feredoxinového typu



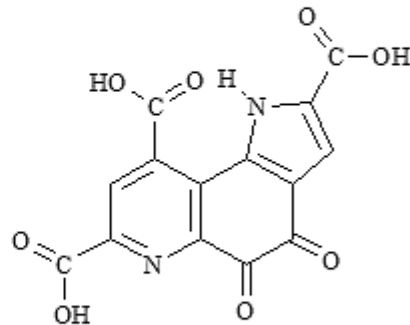
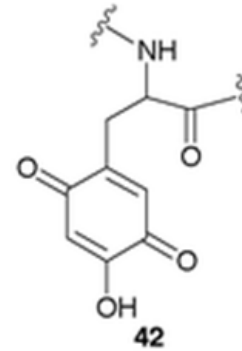
Kofaktory oxidoreduktas

- Chlorofyly
 - Porfyrinová struktura, lipofilní substituent
 - Mg^{2+}
 - Fotosyntéza – transport e^-

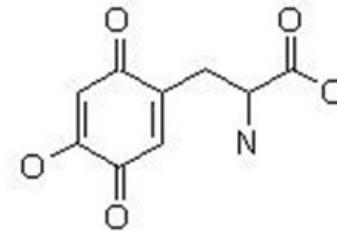


Kofaktory oxidoreduktas

- Přeměněné AK
 - Prostetické skupiny
 - Bílkovinný původ



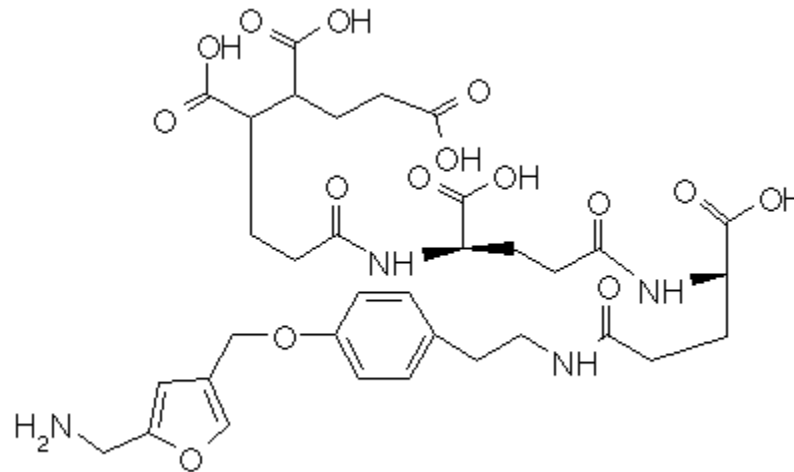
Pyrolochinolichinon
PQQ



TOPAchinon
TrihydrOxyPhenylAlanin

Kofaktory oxidoreduktas

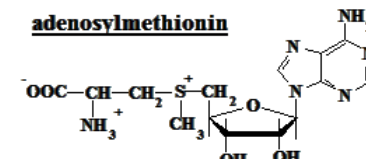
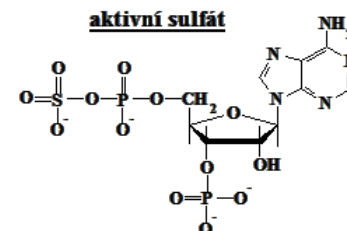
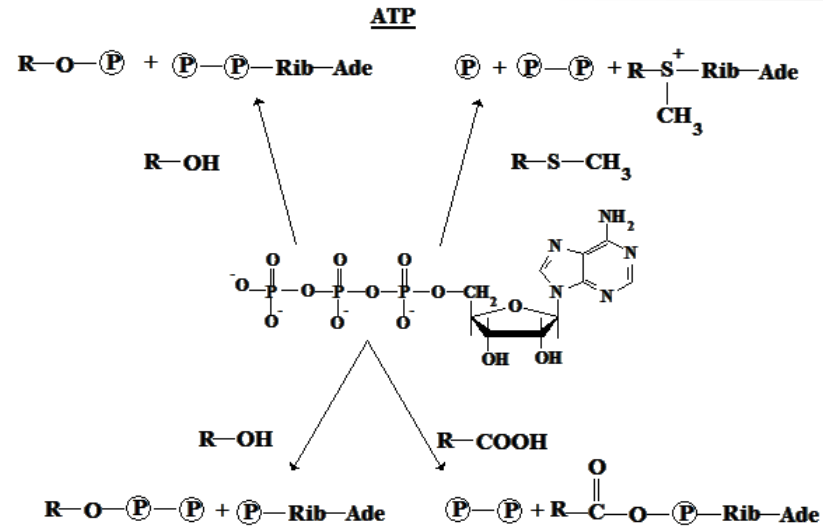
- Kofaktory metanogeneze



Metanofuran

Koenzymy transferas

- ATP
 - Přenos aktivních skupin
 - Aktivace metabolitů
- Reakce s R-OH
 - Voda – hydrolýza
 - sacharidy bílkoviny
 - kinasy
- Reakce s Met
 - Aktivní metyl
- Reakce s R-OH
 - Přenos PP, Rib-5P na P-Rib-PP
- Reakce s R-COOH
 - Aktivace acylů, aminoacylů
- Reakce se síranem
 - Aktivní kys. sírová



Koenzymy transferas

- Biotin

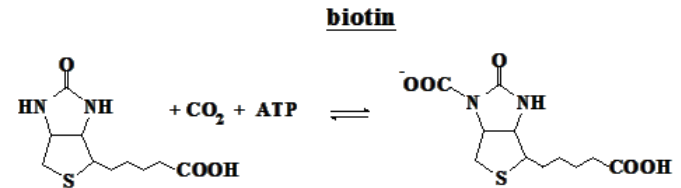
- Vitamin B
- Vázán na Lys enzymu
- Aktivní karboxyl

- THF – tetrahydrofolát

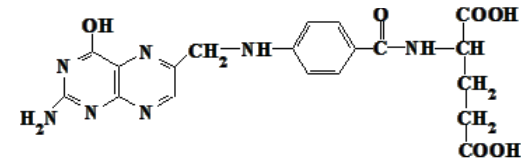
- Z folátu
- Disociabilní
- Aktivní 1C metabolity
- Syntézy nukleotidů - bází

- TPP – thiamindifosfát

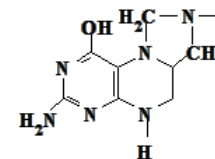
- Aktivní aldehydy (2C)
- Prostetická skupina



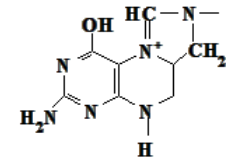
~~tetrahydrofolátová k.~~
Kys. listová



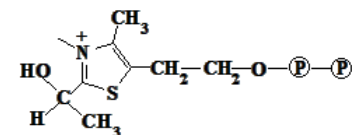
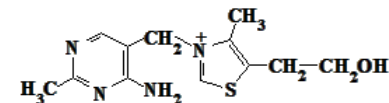
methyltetrahydrolistová k.



methenyltetrahydrolistová k.



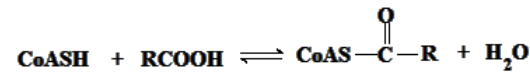
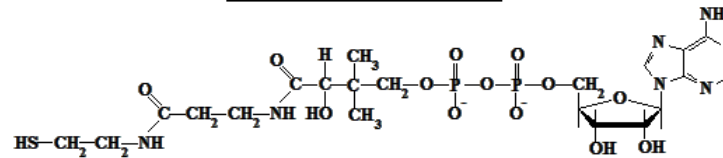
thiamin



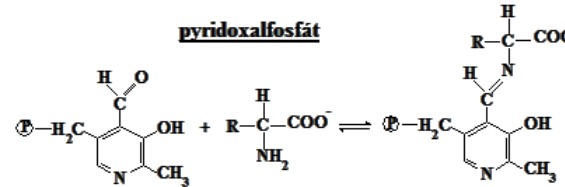
Koenzymy transferas

- Koenzym A
 - Z pantotenátu
 - Aktivní acyly
 - Spřaženo ATP = AMP + PP
- PALPO
 - Z pyridoxinu
 - Metabolismus aminů, AK
 - Tvorba Schiffovy báze
- CDP – netřeba vitamin
 - Aktivní báze PL
- UDP - dtto
 - Aktivní monosacharidy
 - UTP + Glc-1-P = UDP-Glc + PP

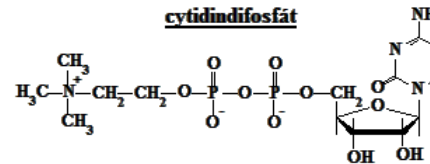
koenzym A - CoA - CoASH



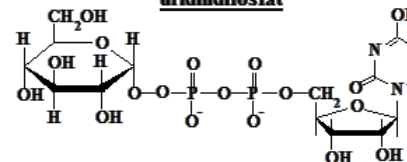
pyridoxalfosfát



cytidindifosfát

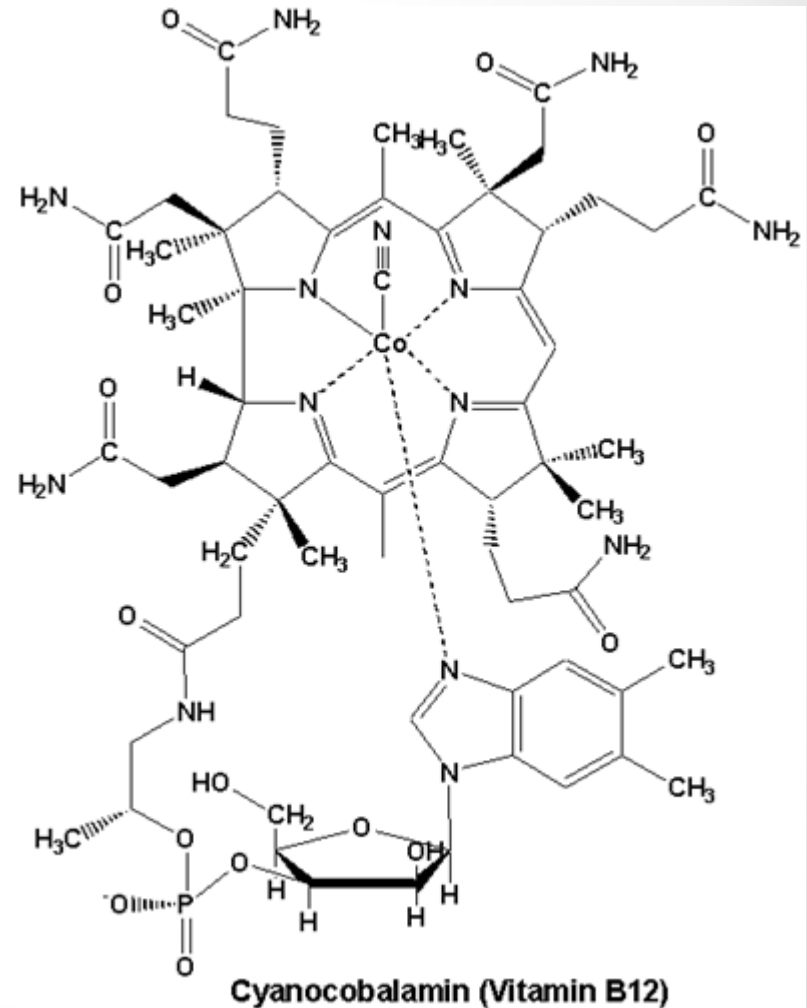


uridindifosfát



Koenzymy isomeras

- Vitamin B₁₂
 - Kobalamin
 - Korinoid + nukleotid
 - Ligandy
 - CN neúčinnější
 - Transkarboxylace
 - Krvetvorba
 - Perniciosní anemie
 - Aplikace
 - Perorální nespolehlivá
 - Vnitřní faktor pro vstřebávání
 - Biotechnologická produkce
 - Výkaly přežvýkavců
 - Aktivovaný kal



Vitaminy

- Vitaminy jako prekurzory kofaktorů
 - Většinou, některé nepotřebují
 - Některé jsou spíše metabolity (askorbát)
- Fyziologická role – zde druhořadé
- Výskyt – vlastnosti (polarita)
 - Rozpustné ve vodě – polární
 - Rozpustné v tucích – nepolární
 - Hledisko dietetické
- Následující přehled
 - Korelace struktur s kofaktory

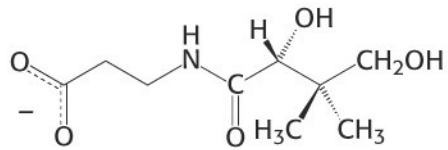
TABLE 8.9 Water-Soluble Vitamins

Vitamin	Coenzyme	Typical reaction type	Consequences of deficiency
Thiamine (B ₁)	Thiamine pyrophosphate	Aldehyde transfer	Beriberi (weight loss, heart problems, neurological dysfunction)
Riboflavin (B ₂)	Flavin adenine dinucleotide (FAD)	Oxidation–reduction	Cheliosis and angular stomatitis (lesions of the mouth), dermatitis
Pyridoxine (B ₆)	Pyridoxal phosphate	Group transfer to or from amino acids	Depression, confusion, convulsions
Nicotinic acid (niacin)	Nicotinamide adenine dinucleotide (NAD ⁺)	Oxidation–reduction	Pellagra (dermatitis, depression, diarrhea)
Pantothenic acid	Coenzyme A	Acyl–group transfer	Hypertension
Biotin	Biotin–lysine complexes (biocytin)	ATP-dependent carboxylation and carboxyl-group transfer	Rash about the eyebrows, muscle pain, fatigue (rare)
Folic acid	Tetrahydrofolate	Transfer of one-carbon components; thymine synthesis	Anemia, neural-tube defects in development
B ₁₂	5'-Deoxyadenosyl cobalamin	Transfer of methyl groups; intramolecular rearrangements	Anemia, pernicious anemia, methylmalonic acidosis
C (ascorbic acid)		Antioxidant	Scurvy (swollen and bleeding gums, subdermal hemorrhages)

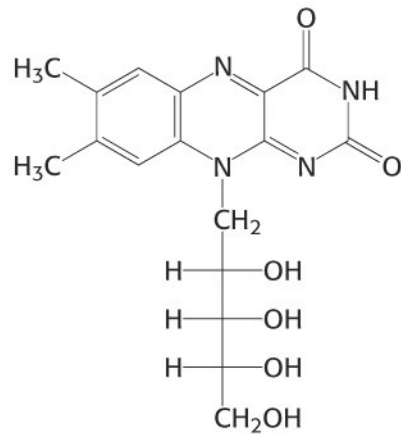
Přehozeny A a E!

TABLE 8.10 Fat-soluble vitamins

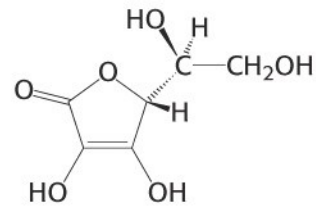
Vitamin	Function	Deficiency
A	Antioxidant	Inhibition of sperm production; lesions in muscles and nerves (rare)
D	Regulation of calcium and phosphate metabolism	Rickets (children): skeletal deformities, impaired growth Osteomalacia (adults): soft, bending bones
E	Roles in vision, growth, reproduction	Night blindness, cornea damage, damage to respiratory and gastrointestinal tract
K	Blood coagulation	Subdermal hemorrhaging



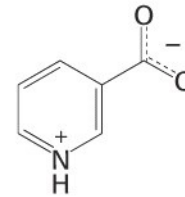
Vitamin B₅
(Pantothenate)



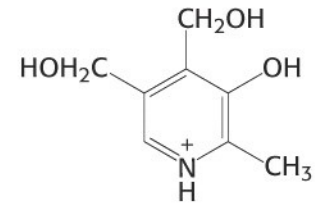
Vitamin B₂
(Riboflavin)



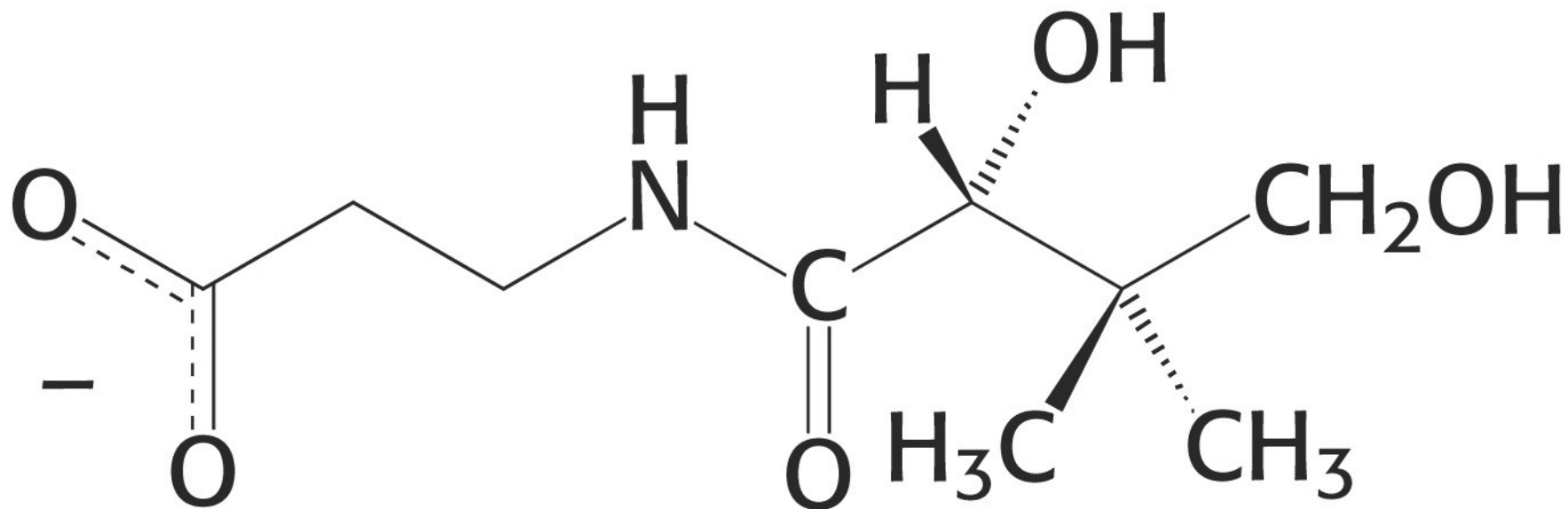
Vitamin C
(Ascorbic acid)



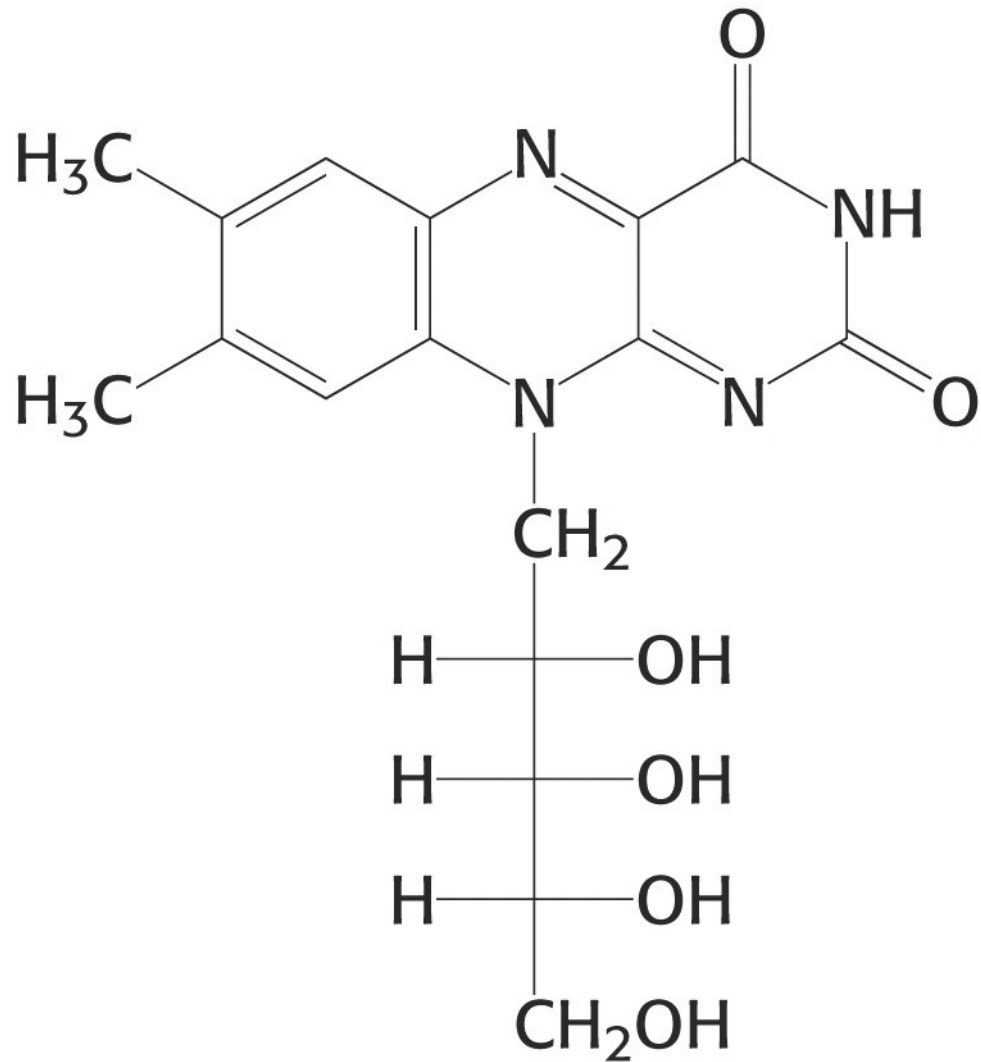
Vitamin B₃
(Niacin)



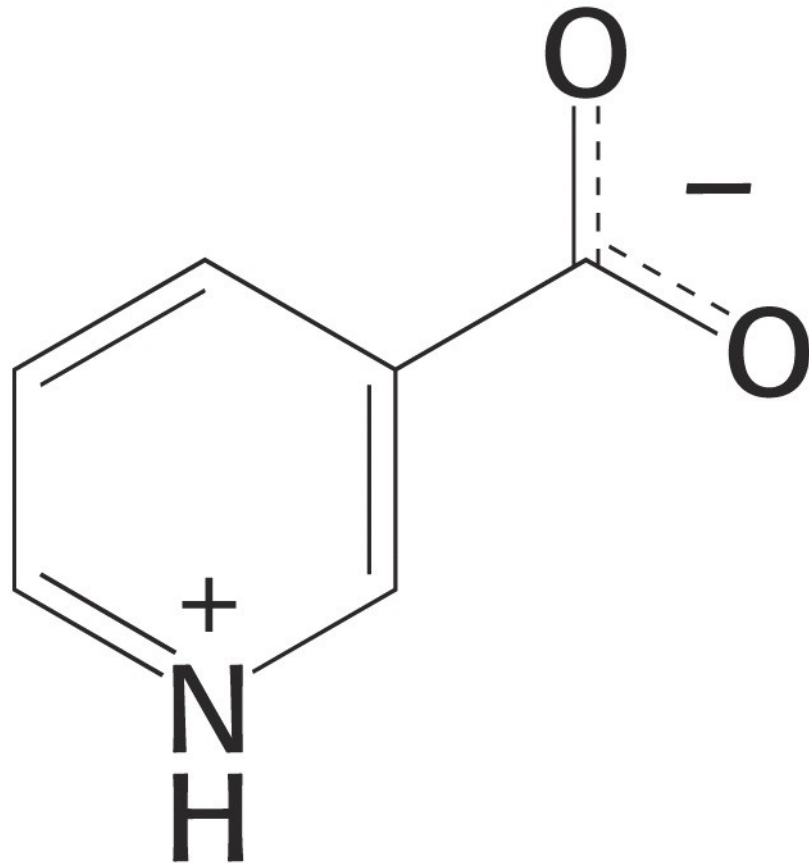
Vitamin B₆
(Pyridoxine)



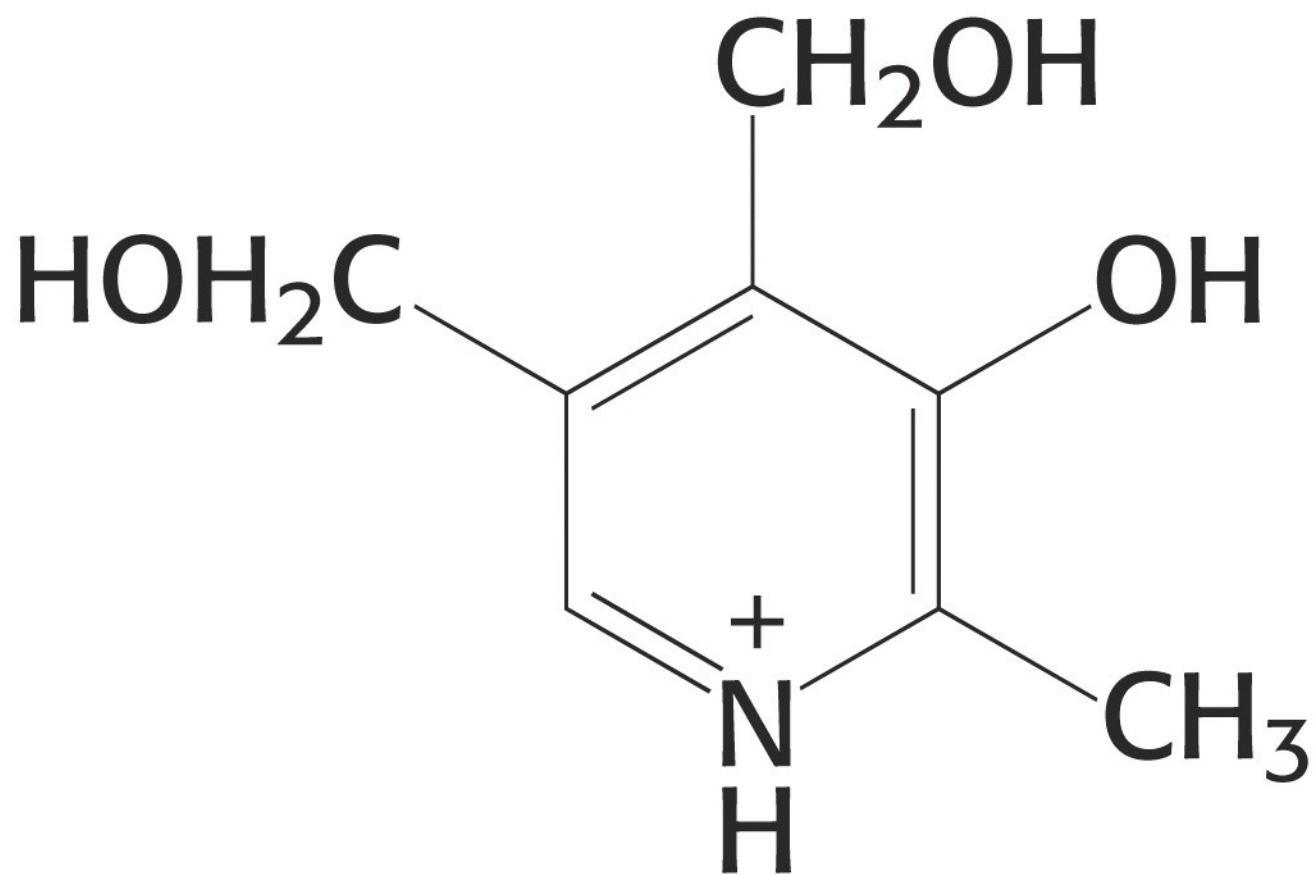
Vitamin B₅
(Pantothenate)



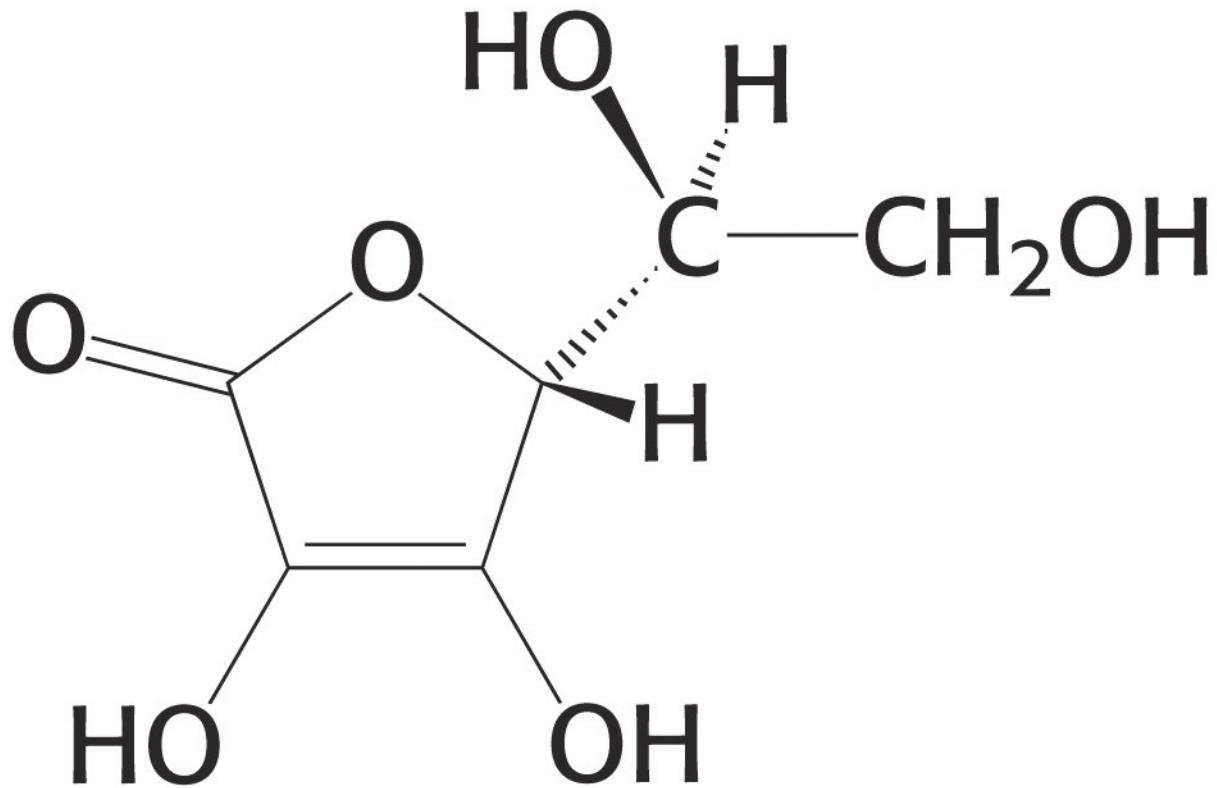
Vitamin B₂
(Riboflavin)



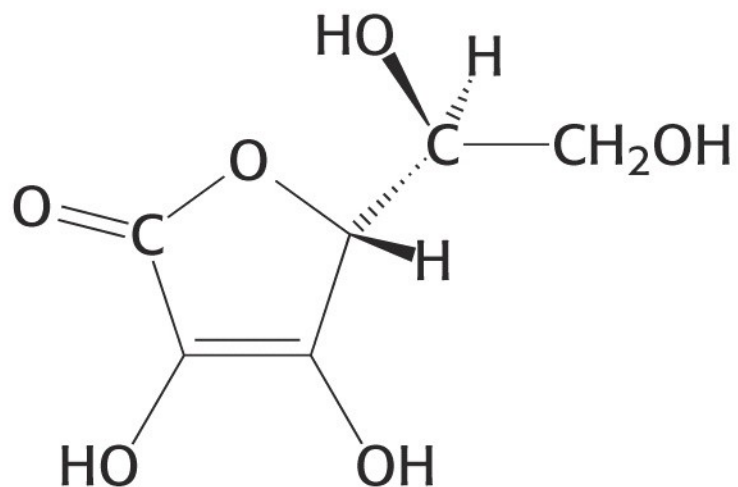
Vitamin B₃
(Niacin)



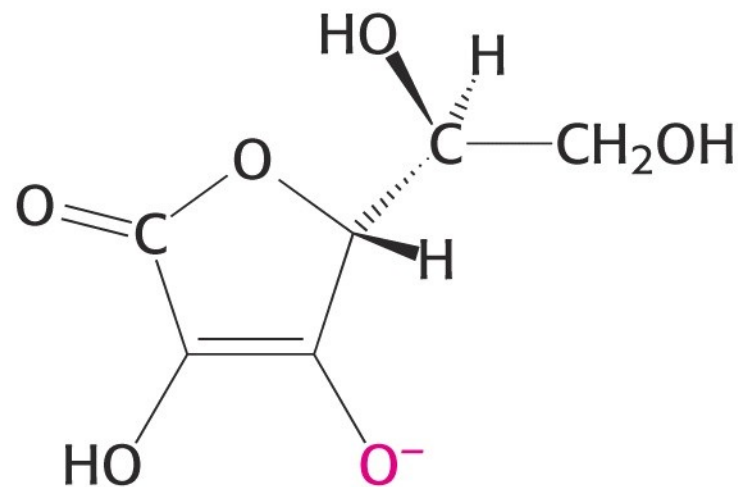
Vitamin B₆
(Pyridoxine)



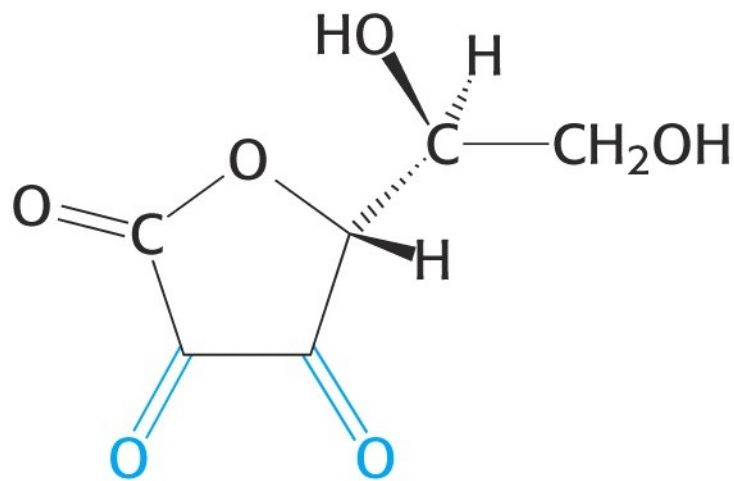
Vitamin C
(Ascorbic acid)



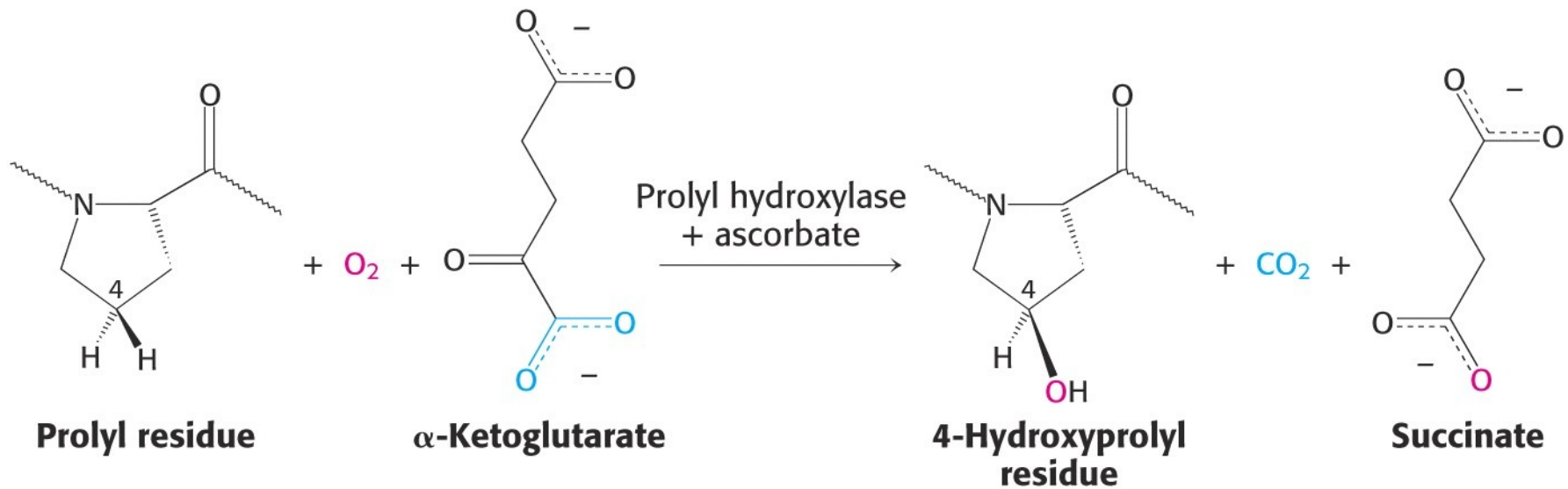
Ascorbic acid

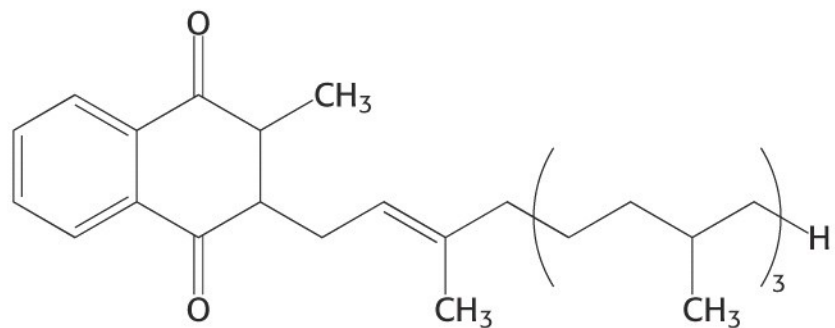


Ascorbate

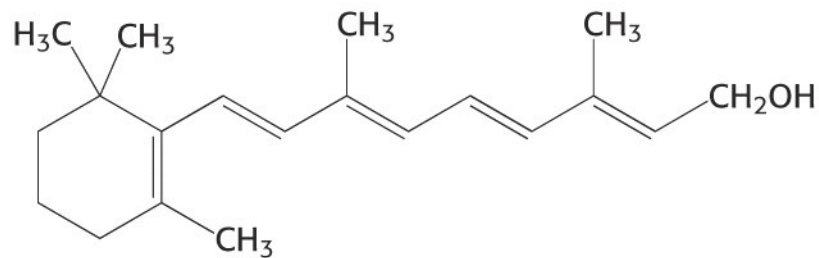


Dehydroascorbic acid

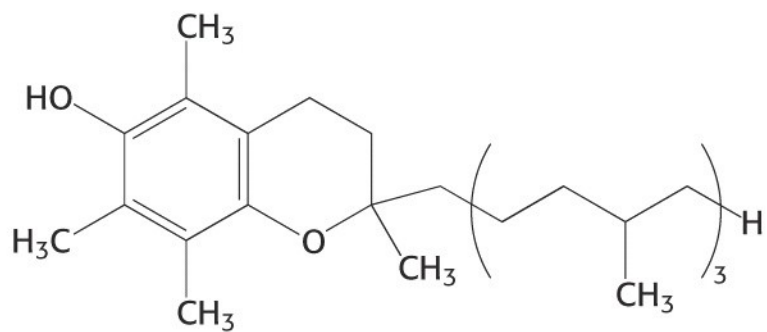




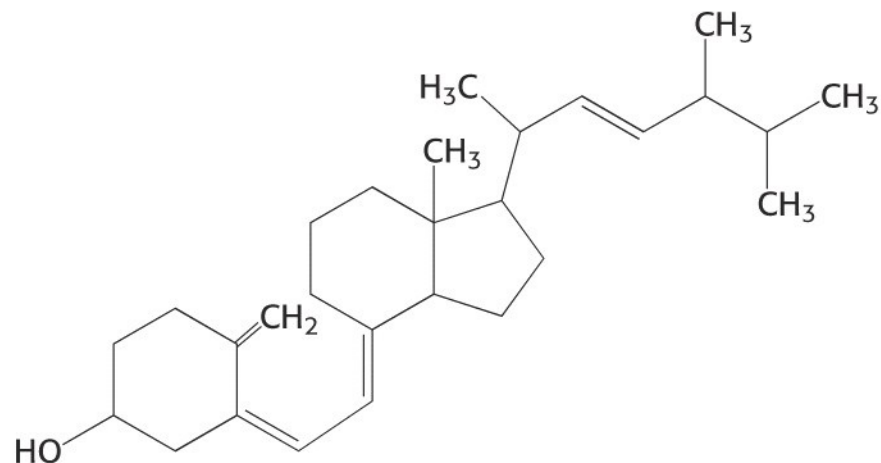
Vitamin K₁



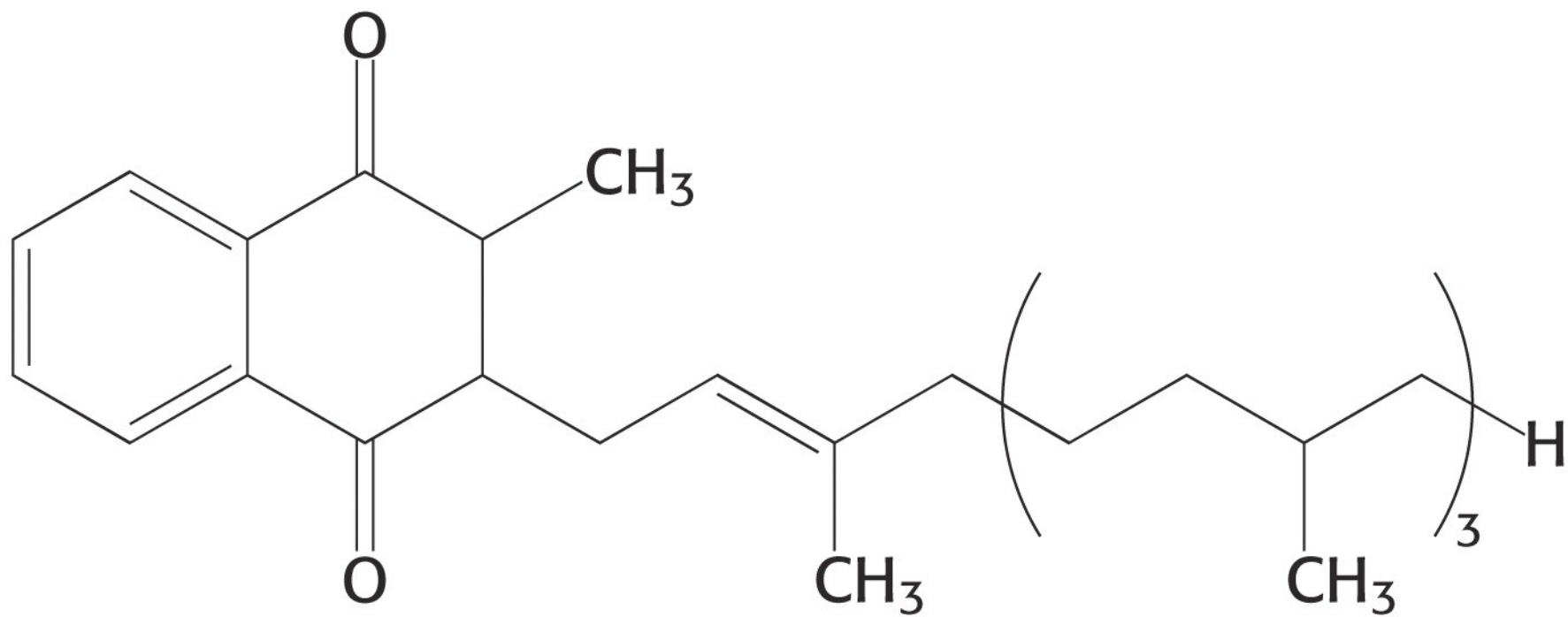
Vitamin A (Retinol)



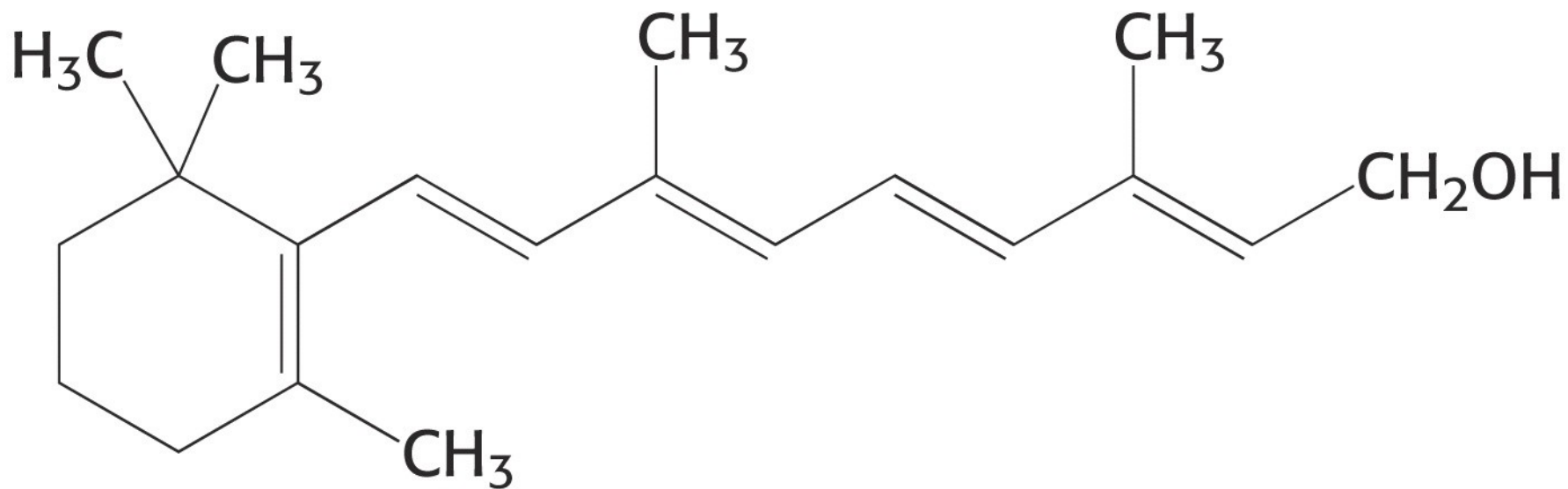
Vitamin E (α -Tocopherol)



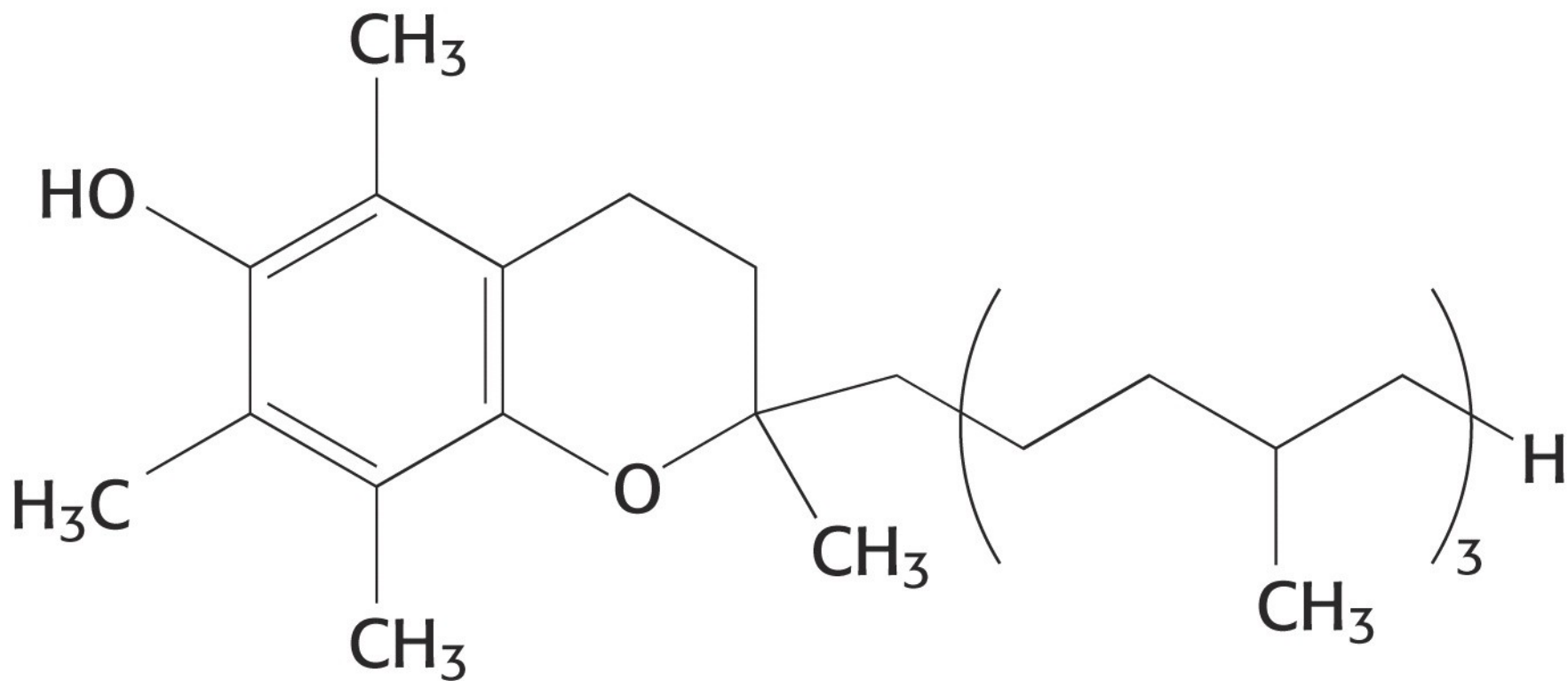
Vitamin D₂ (Calciferol)



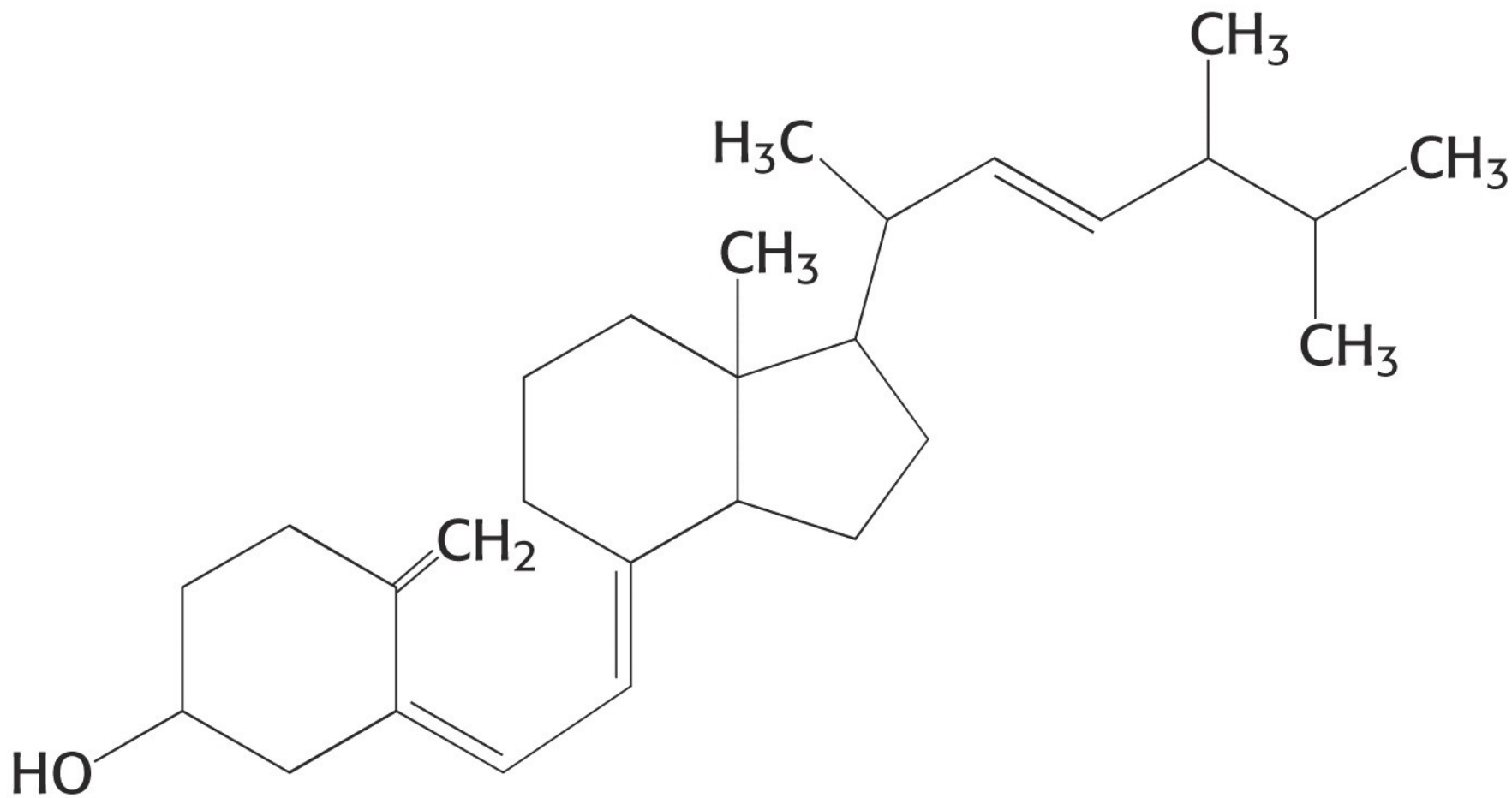
Vitamin K₁



Vitamin A (Retinol)



Vitamin E (α-Tocopherol)



Vitamin D₂ (Calciferol)