Vitamins.

Definition - Organic compound required in small amounts.

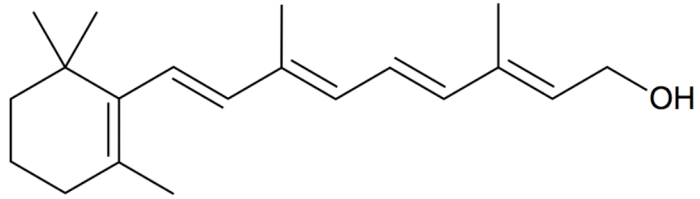
A few words about each.

Vitamin A

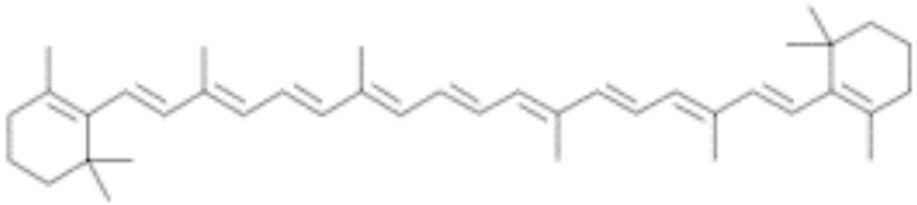
Vitamin B1, B2, B3, B5, B6, B7, B9, B12

Vitamin D
Vitamin E
Vitamin K

Vitamin A - Retinol



Retinol (vitamin A)



β-carotene (2 μg β-carotene considered equivalent to 1 μg retinol as a vitamin A source)

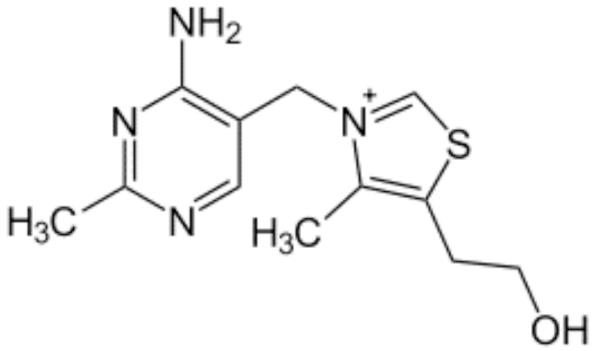
Sources in diet - Many plants (photoreceptors), also meat, especially liver. Fat soluble, so you can get too much, or too little if absorption is a problem.

Some uses:

Vision (11-cis-retinol bound to rhodopsin detects light in our eyes).

Regulating gene transcription (retinoic acid receptors on cell nuclei are part of a system for regulating transcription of mRNAs for a number of genes).

Vitamin B1 - Thiamine



Thiamine

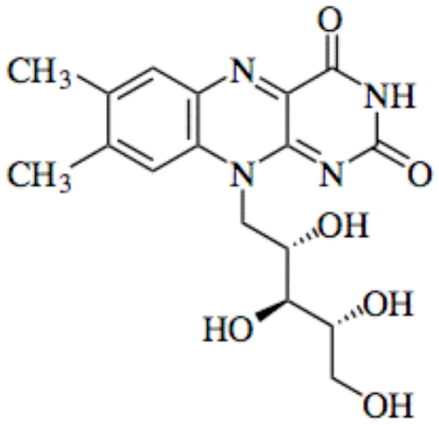
Some uses:

Cofactor for several enzymes (a precursor for thiamine pyrophosphate, one of the cofactors used by the pyruvate decarboxylase complex (PDC).

Also, a cofactor for branched chain a-keto dehydrogenase.

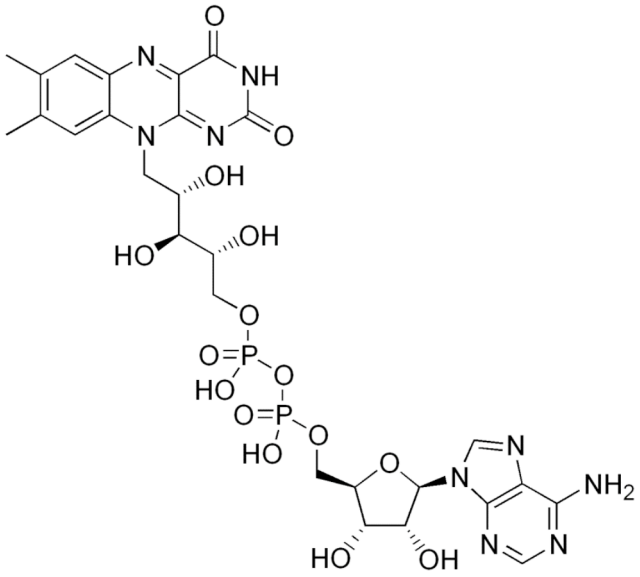
Found in a wide variety of foods, including meat, grains. Deficiency causes beriberi (muscle atrophy, neurological problems).

Vitamin B2 - riboflavin

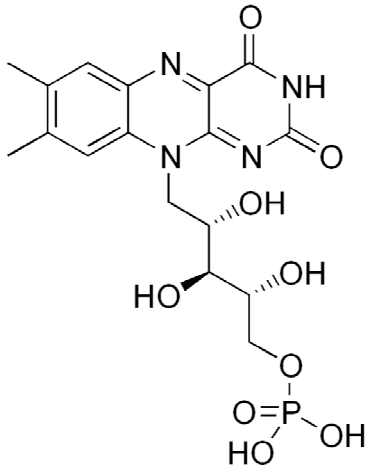


Riboflavin is a precursor for FAD and FMN.

FAD -
flavin adenine dinucleotide.



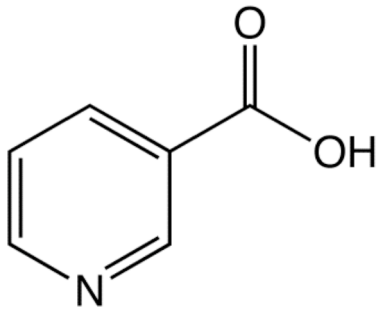
FMN - Flavin mononucleotide



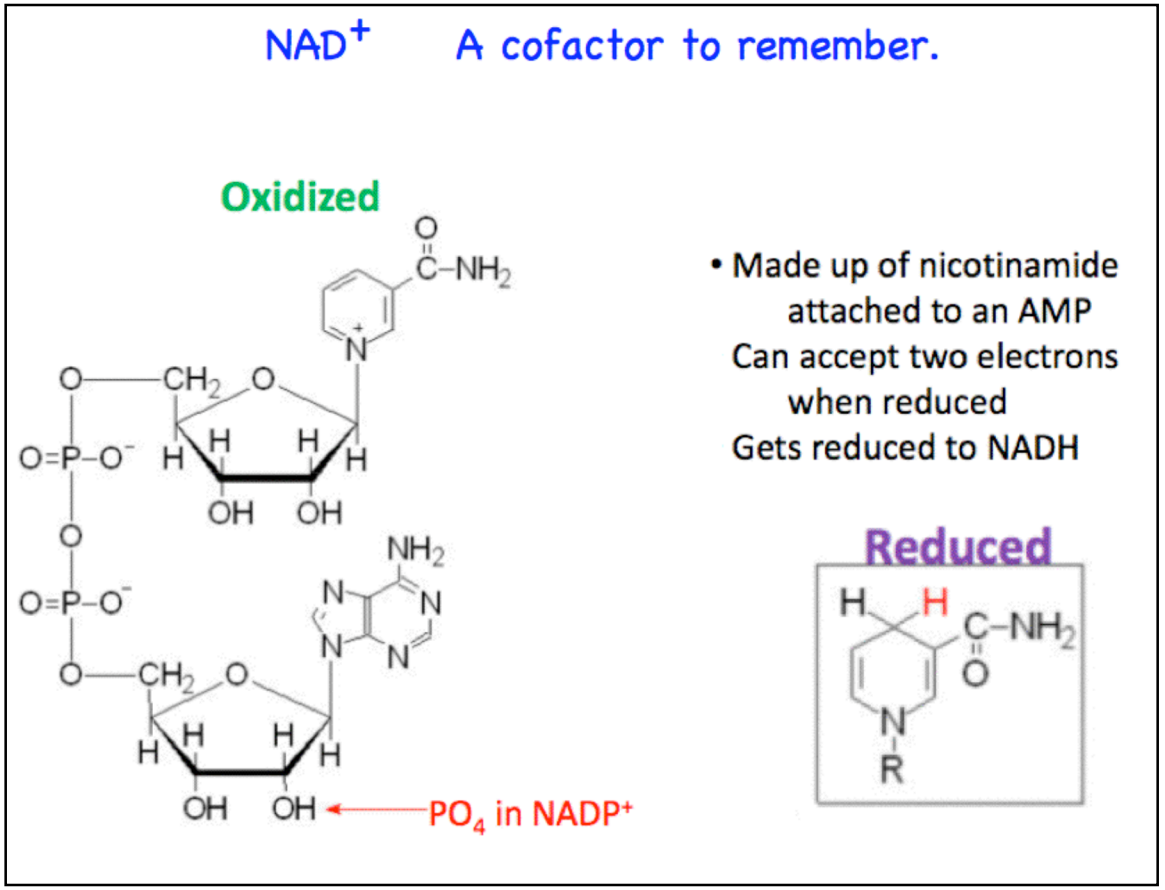
FAD is a cofactor for pyruvate decarboxylase complex (PDC), and succinate dehydrogenase in TCA cycle.

FMN is an electron carrier in the electron transport chain.

Vitamin B3 - nicotinic acid
(a precursor for NAD).
Also known as niacin.



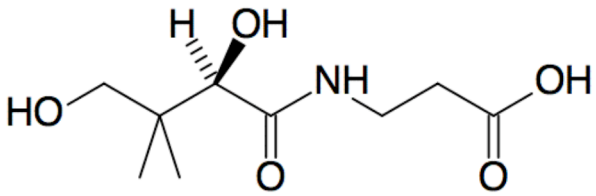
nicotinic acid



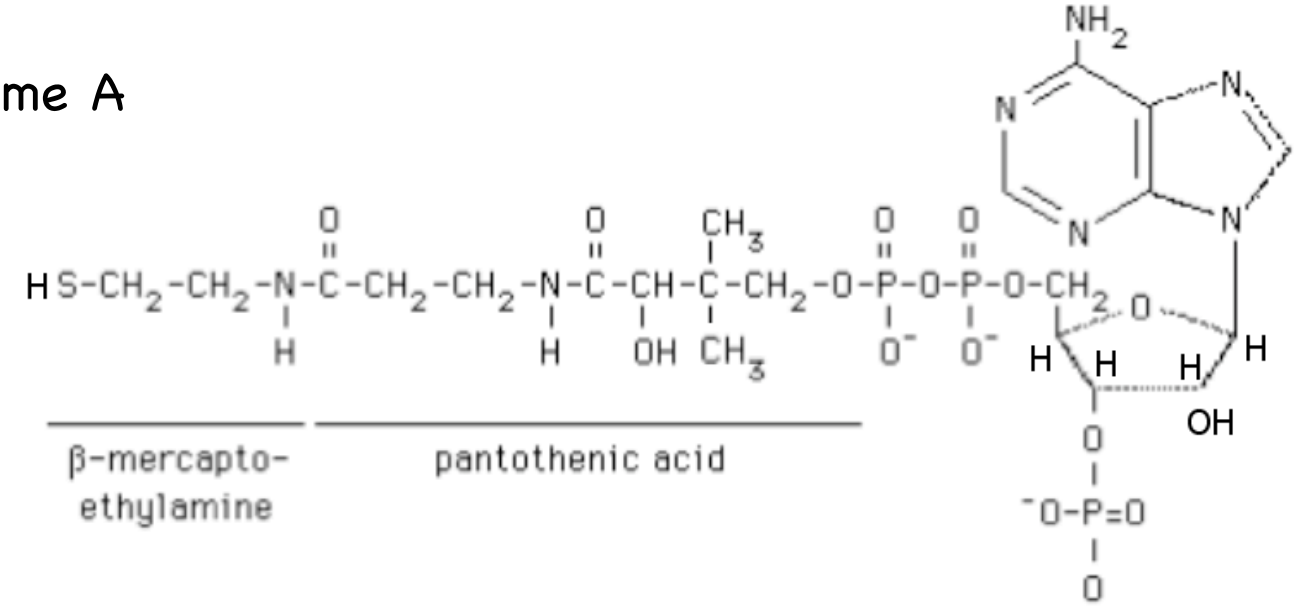
NAD^+ is needed for glycolysis, NADH gets oxidized in electron transport chain, etc.

Vitamin B5 - pantothenic acid (needed for making CoA)

pantothenic acid

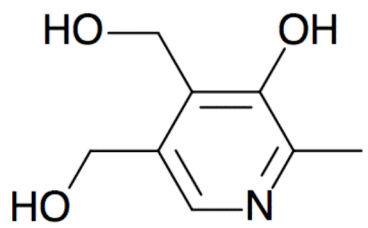


Coenzyme A



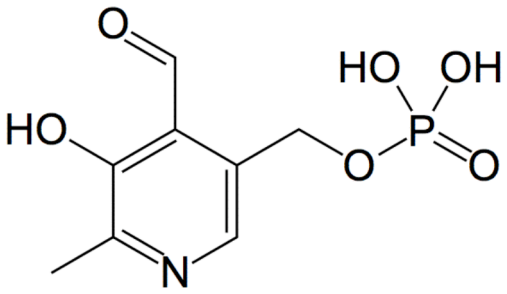
We get pantothenic acid in our diet as CoA, which must be broken down to pantothenic acid to be absorbed in intestine. We then use the pantothenic acid in making our own CoA.

Vitamin B6 - pyridoxine



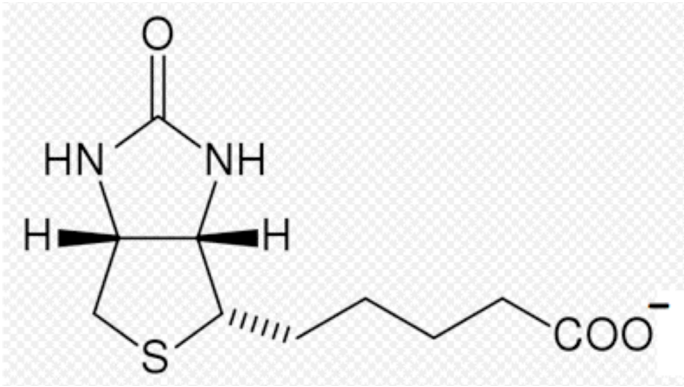
Precursor for pyridoxal phosphate (PLP).

PLP is a covalently linked cofactor to transaminases, and some decarboxylases, and glycogen phosphorylase; these are called "PLP-dependent enzymes".



PLP

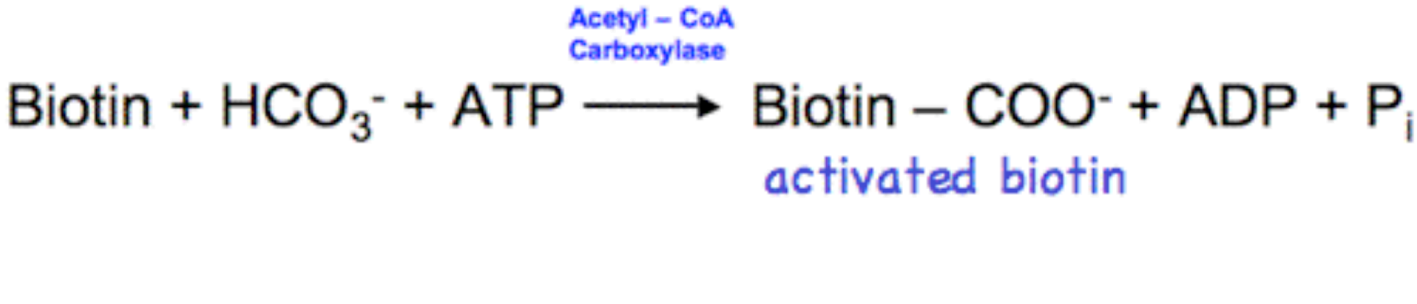
Vitamin B7 - Biotin.



Used in fatty acid synthesis, also other functions.

We saw biotin in chapter 14:

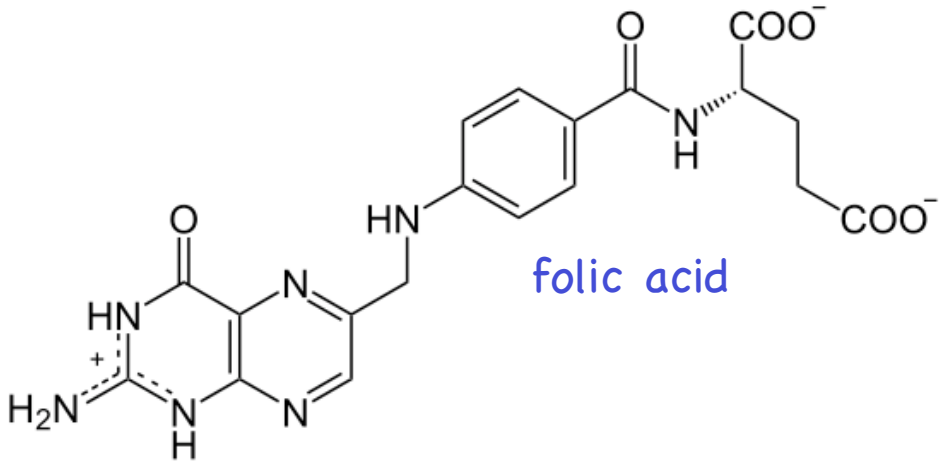
Acetyl-CoA is converted to malonyl-CoA for use in FA synthesis.



Biotin deficiency is rare.

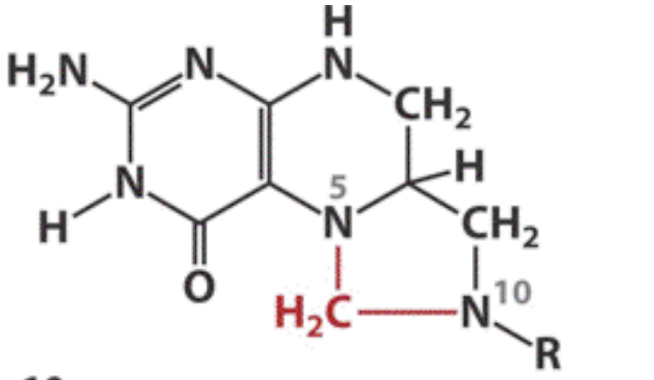
Vitamin B9 - Folic acid.

Required for synthesis of glycine, methionine, nucleotides T & U (chapter 15).



folic acid

Important for rapidly dividing cells (very important in early pregnancy).



N^5,N^{10}-Methylene-tetrahydrofolate

N^5,N^{10} methylene-tetrahydrofolate is a donor of methylene groups.

Deficiency in pregnancy causes neural tube defects.
Folic acid is now added to many grain products in the US.

Vitamin B12 - cobalamin.
(also hydroxycobalamin, adenosylcobalamin).

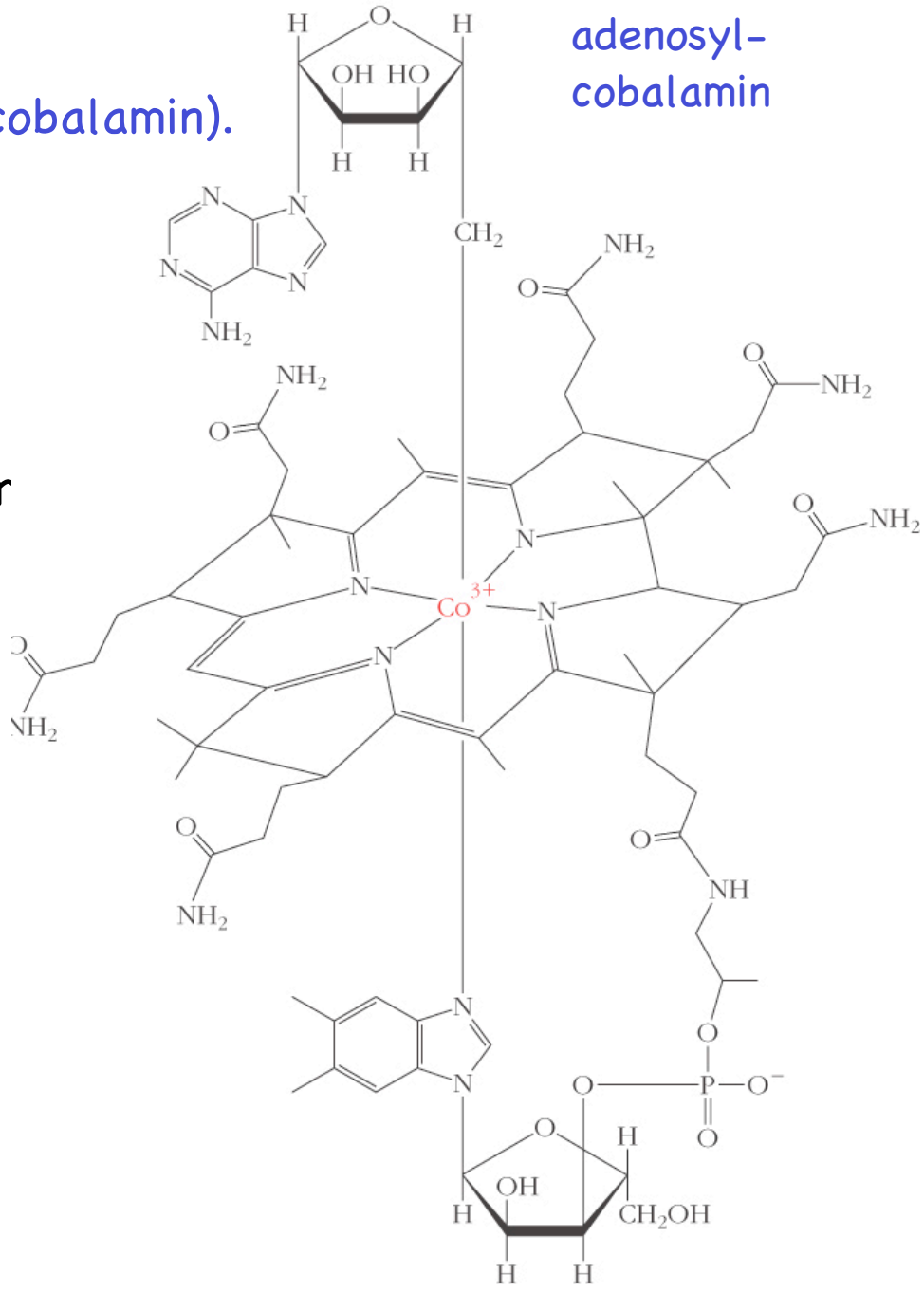
We saw cobalamine in fatty acid oxidation.

Cobalamin is needed in making adenosylcobalamin, a cofactor for "methyl malonyl mutase", which breaks down odd-chain fatty acids.

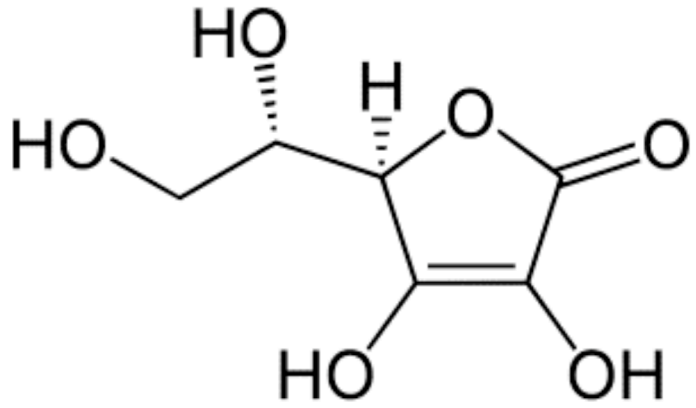
B12 is also used in regenerating folate

Sources are meat, milk and eggs.

Vegetarians who eat dairy products are OK, but non-dairy vegans may not get enough.



Vitamin C - asorbic acid



Required for collagen synthesis, and as a cofactor for several enzymes. Also scavenges oxygen radicals.

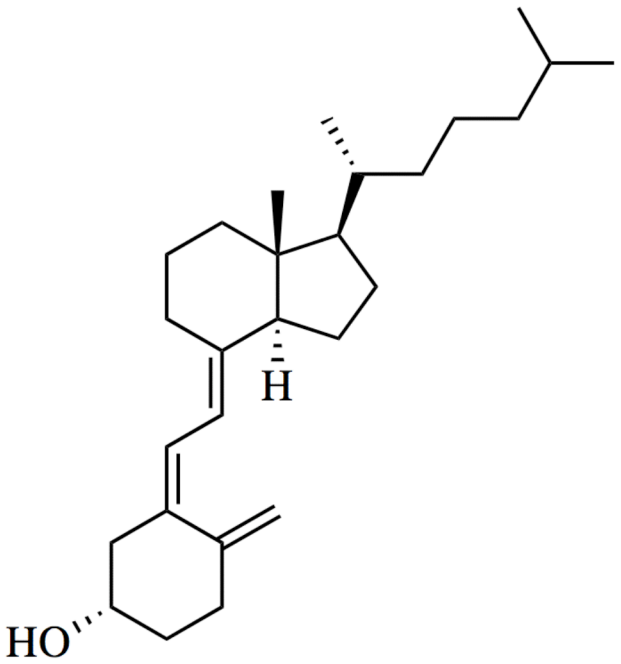
In almost all organisms, ascorbic acid is synthesized from glucose in 4 steps.

A relatively recent (40 million years ago) mutation in the ancestor of humans made us unable to make ascorbic acid. So for us, and some closely related primates, it's a vitamin.

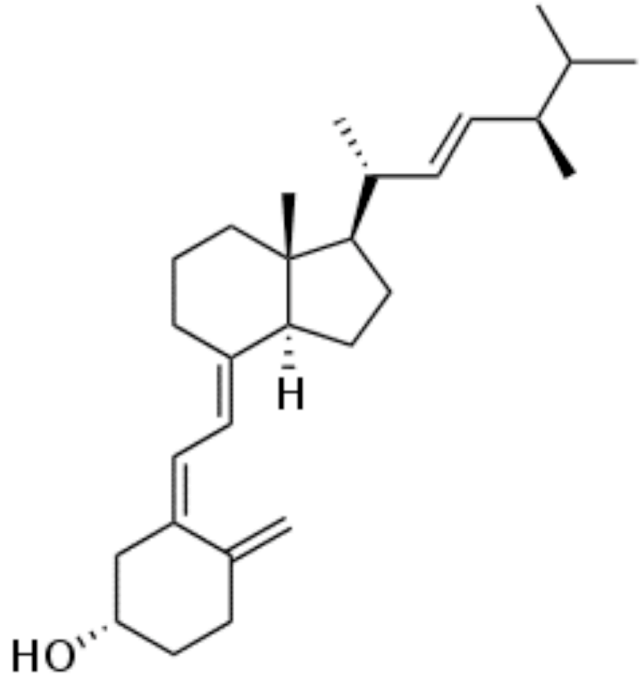
Guinea pigs can't make ascorbic acid, either.

Sources of vitamin C are fruit and fresh meat. Vitamin C deficiency causes scurvy, and in human history vitamin C deficiency may have been an impediment to spreading northward.

Vitamin D refers to a group of similar lipid-soluble molecules (major forms are D2 and D3, also D1, D4, D5).

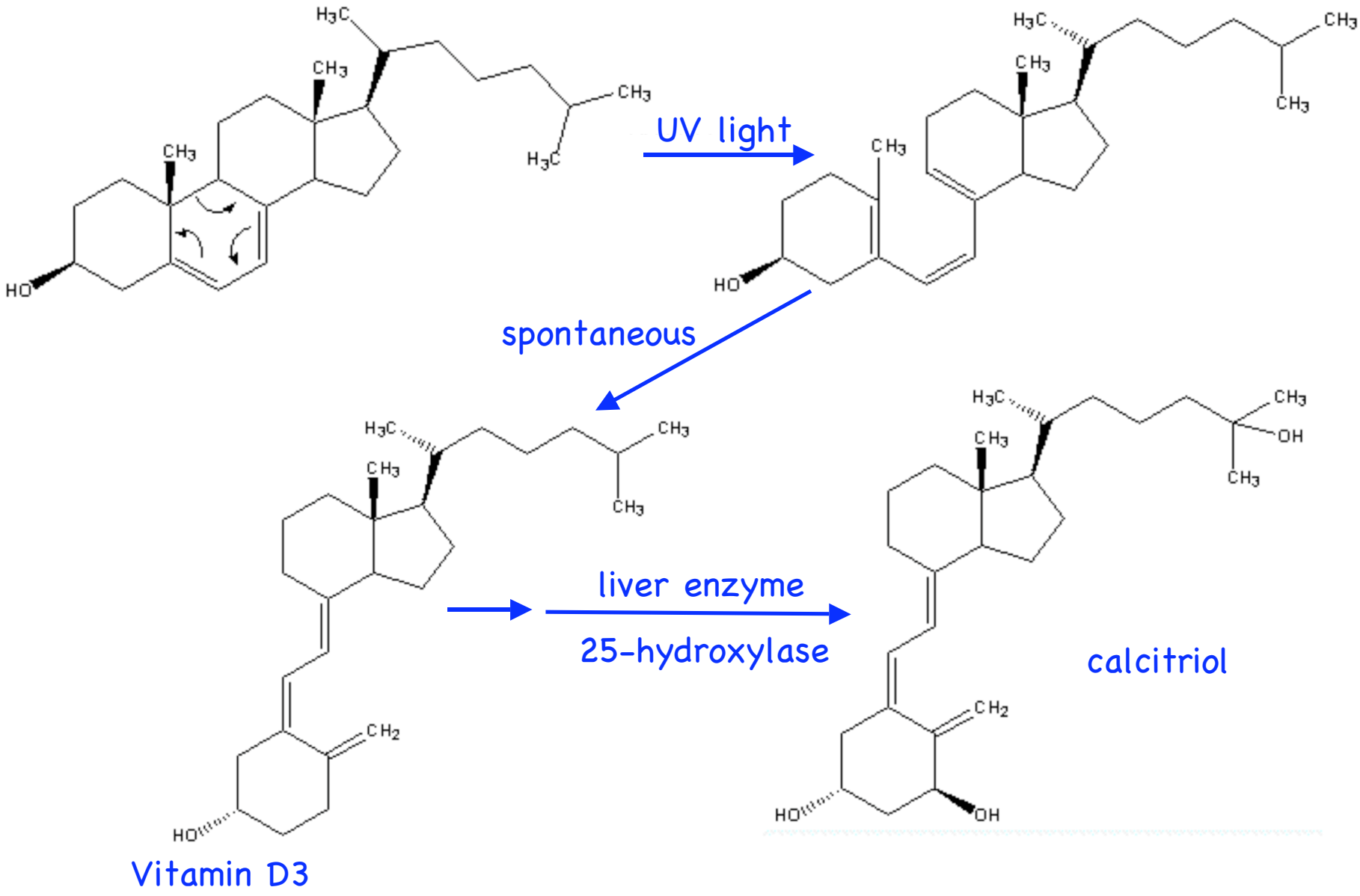


Vitamin D3 (cholecalciferol)



Vitamin D2 (ergocalciferol)

Vitamin D3 can be obtained in diet, or derived from cholesterol in a reaction that requires UV light.



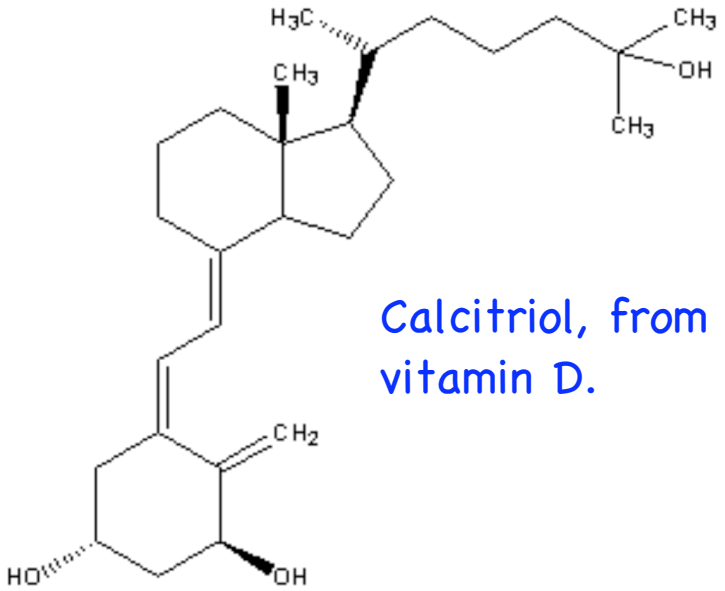
Vitamin D binds to a "vitamin D binding protein" (VDP) for transport to target organs.

Vitamin D is not active itself (it's a prohormone); it is modified to yield biologically active forms, such as calcitriol.

Calcitriol (derived from vitamin D) is a transcription factor, influencing expression of proteins involved in calcium absorption and transport.

Vitamin D is also important for immune system function.

Deficiency causes rickets, bone loss.



Calcitriol, from vitamin D.

Vitamin D production requires UV light (sunlight).

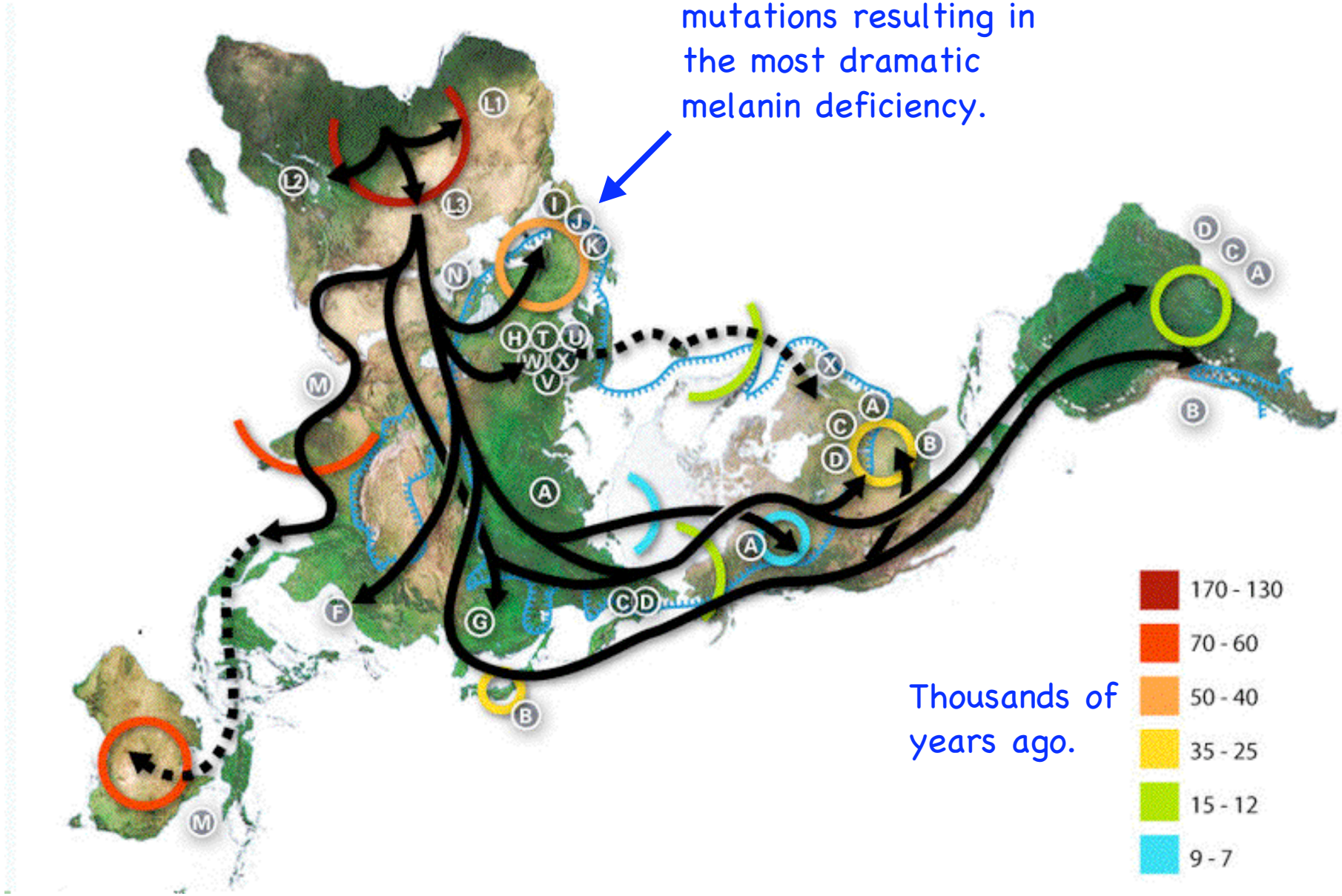
Sometime after humans migrated north out of Africa about 50,000 years ago, mutations appeared that reduced melanin (pigment) production in the skin, permitting vitamin D production with less sunlight.

Disadvantages of less melanin production are skin that is easily damaged by the sun, skin cancer risk, and loss of folic acid due to UV damage.

The melanin-reducing mutations helped early humans make vitamin D in northern europe in winter.

Human migration.

These groups have mutations resulting in the most dramatic melanin deficiency.



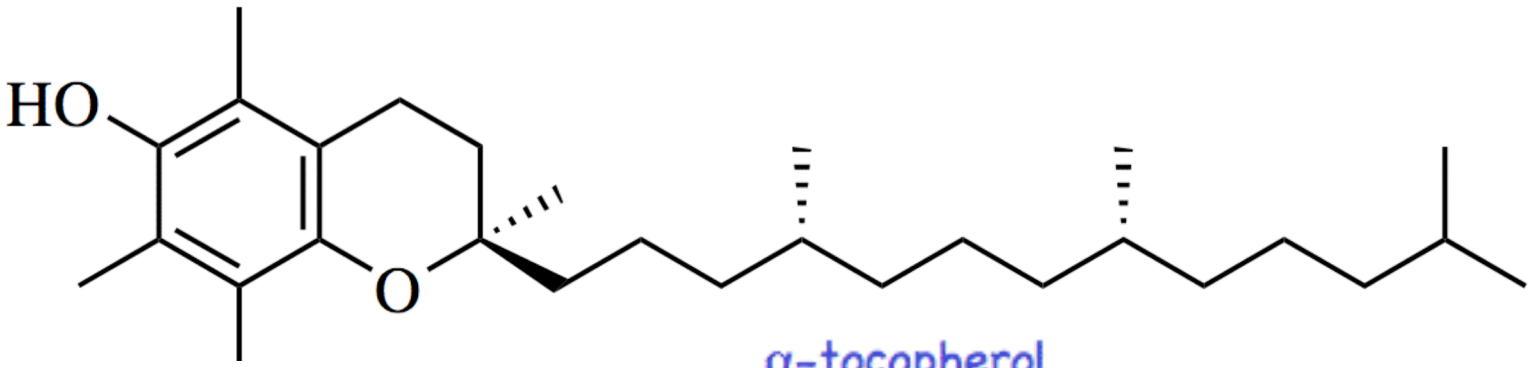
Thousands of years ago.

Map from wikipedia.

Vitamin E - Collectively refers to 8 related tocopherols.

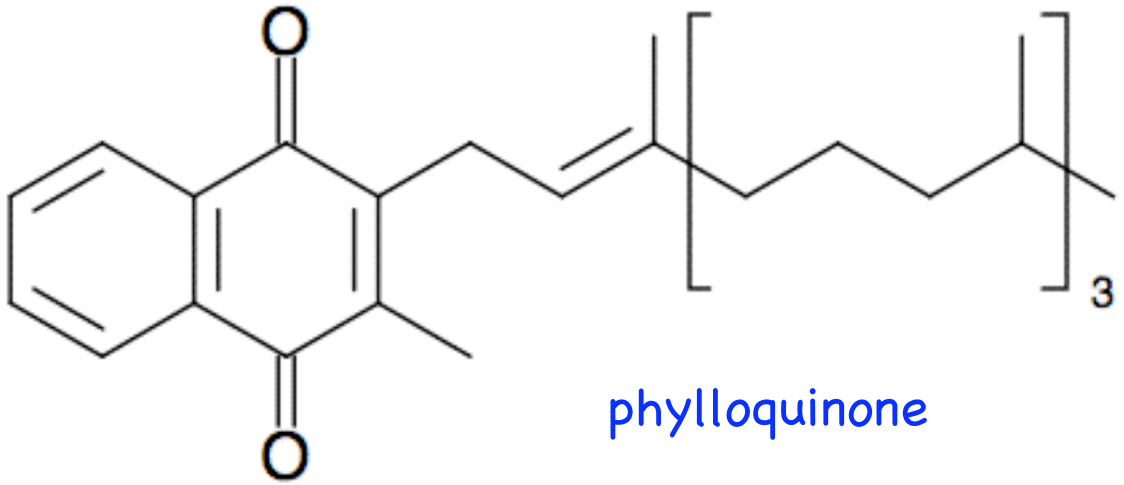
It is essential, but roles are unclear.
Suggestions include neural membrane component, antioxidant.

Obtained in diet, deficiency is rare.



α-tocopherol

Vitamin K - Refers to phylloquinonone (vitamin K-1), and several structurally similar molecules.



phylloquinone

Vitamin K is required for proper blood clotting.

It is used in synthesizing gamma carboxy glutamate, a post-translationally modified amino acid in prothrombin.

Sources are vegetables and fruits, deficiency is rare.