**OBI CHUKWUDUMEBI NNAMDI**

**18/MHS03/008**

**DEPARTMENT OF HUMAN ANATOMY**

**COLLEGE OD MEDICINE AND HEALTH SCIENCES**

**BCH 204**

**MEDICAL BIOCHEMISTRY II**

**QUESTION**

Vitamins and coenzymes

**VITAMINS**

A vitamin is an organic molecule (or related set of molecules) that is an essential micronutrient which an organism needs in small quantities for the proper functioning of its metabolism. Essential nutrients cannot be synthesized in the organism, either at all or not in sufficient quantities, and therefore must be obtained through the diet. Vitamin C can be synthesized by some species but not by others; it is not a vitamin in the first instance but is in the second. The term vitamin does not include the three other groups of essential nutrients: minerals, essential fatty acids, and essential amino acids. Most vitamins are not single molecules, but groups of related molecules called vitamins. For example, vitamin E consists of four tocopherols and four tocotrienols. The thirteen vitamins required by human metabolism are vitamin A (as all-trans-retinol, all-trans-retinyl-esters, as well as all-trans-beta-carotene and other provitamin A carotenoids), vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), vitamin B7 (biotin), vitamin B9 (folic acid or folate), vitamin B12 (cobalamins), vitamin C (ascorbic acid), vitamin D (calciferols), vitamin E (tocopherols and tocotrienols), and vitamin K (quinones).

Vitamins have diverse biochemical functions. Vitamin A acts as a regulator of cell and tissue growth and differentiation. Vitamin D provides a hormone-like function, regulating mineral metabolism for bones and other organs. The B complex vitamins function as enzyme cofactors (coenzymes) or the precursors for them. Vitamins C and E function as antioxidants. Both deficient and excess intake of a vitamin can potentially cause clinically significant illness, although excess intake of water-soluble vitamins is less likely to do so.

List

Vitamin generic

descriptor name

Vitamer chemical name(s) (list not complete)

Solubility

US Recommended dietary allowances

(male/female, age 19–70)[8]

Deficiency disease

Overdose syndrome/symptoms

Food sources

Vitamin A

all-trans-Retinol, Retinal, and

alternative provitamin A-functioning Carotenoids

including all-trans-beta-carotene

Fat

900 µg/700 µg

Night blindness, hyperkeratosis, and keratomalacia[9]

Hypervitaminosis A

from animal origin as Vitamin A / all-trans-Retinol: Fish in general, liver and dairy products;

from plant origin as provitamin A / all-trans-beta-carotene: orange, ripe yellow fruits, leafy vegetables, carrots, pumpkin, squash, spinach;

Vitamin B1

Thiamine

Water

1.2 mg/1.1 mg

Beriberi, Wernicke-Korsakoff syndrome

Drowsiness and muscle relaxation[10]

Pork, wholemeal grains, brown rice, vegetables, potatoes, liver, eggs

Vitamin B2

Riboflavin

Water

1.3 mg/1.1 mg

Ariboflavinosis, glossitis, angular stomatitis

Dairy products, bananas, green beans, asparagus

Vitamin B3

Niacin, Niacin amide, Nicotinamide riboside

Water

16 mg/14 mg

Pellagra

Liver damage (doses > 2g/day)[11] and other problems

Meat, fish, eggs, many vegetables, mushrooms, tree nuts

Vitamin B5

Pantothenic acid

Water

5 mg/5 mg

Paraesthesia

Diarrhoea; possibly nausea and heartburn.[12]

Meat, broccoli, avocados

Vitamin B6

Pyridoxine, Pyroxamine, Pyridoxal

Water

1.3–1.7 mg/1.2–1.5 mg

Anaemia,[13] Peripheral neuropathy

Impairment of proprioception, nerve damage (doses > 100 mg/day)

Meat, vegetables, tree nuts, bananas

Vitamin B7

Biotin

Water

AI: 30 µg/30 µg

Dermatitis, enteritis

Raw egg yolk, liver, peanuts, leafy green vegetables

Vitamin B9

Folates, Folic acid

Water

400 µg/400 µg

Megaloblastic anaemia and deficiency during pregnancy is associated with birth defects, such as neural tube defects

May mask symptoms of vitamin B12 deficiency; other effects.

Leafy vegetables, pasta, bread, cereal, liver

Vitamin B12

Cyanocobalamin, Hydroxocobalamin, Methylcobalamin, Adenosylcobalamin

Water

2.4 µg/2.4 µg

Vitamin B12 deficiency anaemia

None proven

Meat, poultry, fish, eggs, milk

Vitamin C

Ascorbic acid

Water

90 mg/75 mg

Scurvy

None known

Many fruits and vegetables, liver

Vitamin D

Cholecalciferol (D3), Ergocalciferol (D2)6

Fat

15 µg/15 µg

Rickets and osteomalacia

Hypervitaminosis D

Lichen, eggs, liver, certain fish species such as sardines, certain mushroom species such as shiitake

Vitamin E

Tocopherols, Tocotrienols

Fat

15 mg/15 mg

Deficiency is very rare; mild haemolytic anaemia in new-born infants[15]

Possible increased incidence of congestive heart failure.[16][17]

Many fruits and vegetables, nuts and seeds, and seed oils

Vitamin K

Phyllo Quinone, Menaquinones

Fat

AI: 110 µg/120 µg

Bleeding diathesis

Decreased anticoagulation effect of warfarin.[18]

Leafy green vegetables such as spinach; egg yolks; liver

CLASSIFICATION

Vitamins are classified as either water-soluble or fat-soluble. In humans there are 13 vitamins: 4 fat-soluble (A, D, E, and K) and 9 water-soluble (8 B vitamins and vitamin C). Water-soluble vitamins dissolve easily in water and, in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption. Because they are not as readily stored, more consistent intake is important. Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Vitamins A and D can accumulate in the body, which can result in dangerous hypervitaminosis. Fat-soluble vitamin deficiency due to malabsorption is of particular significance in cystic fibrosis.

ANTI VITAMINS

Anti-vitamins are chemical compounds that inhibit the absorption or actions of vitamins. For example, avidin is a protein in raw egg whites that inhibits the absorption of biotin; it is deactivated by cooking. Pyrithiamine, a synthetic compound, has a molecular structure similar to thiamine, vitamin B1, and inhibits the enzymes that use thiamine.

**COENZYME**

Coenzyme A (CoA, SHCoA, CoASH) is a coenzyme, notable for its role in the synthesis and oxidation of fatty acids, and the oxidation of pyruvate in the citric acid cycle. All genomes sequenced to date encode enzymes that use coenzyme A as a substrate, and around 4% of cellular enzymes use it (or a thioester) as a substrate. In humans, CoA biosynthesis requires cysteine, pantothenate (vitamin B5), and adenosine triphosphate (ATP)

DISCOVERY OF COENZYMES

Coenzyme A was identified by Fritz Lipmann in 1946, who also later gave it its name. Its structure was determined during the early 1950s at the Lister Institute, London, together by Lipmann and other workers at Harvard Medical School and Massachusetts General Hospital. Lipmann initially intended to study acetyl transfer in animals, and from these experiments he noticed a unique factor that was not present in enzyme extracts but was evident in all organs of the animals. He was able to isolate and purify the factor from pig liver and discovered that its function was related to a coenzyme that was active in choline acetylation. The coenzyme was named coenzyme A to stand for "activation of acetate". In 1953, Fritz Lipmann won the Nobel Prize in Physiology or Medicine "for his discovery of co-enzyme A and its importance for intermediary metabolism"

BIO SYNTHESIS

Coenzyme A is naturally synthesized from pantothenate (vitamin B5), which is found in food such as meat, vegetables, cereal grains, legumes, eggs, and milk. In humans and most living organisms, pantothenate is an essential vitamin that has a variety of functions. In some plants and bacteria, including Escherichia coli, pantothenate can be synthesised de novo and is therefore not considered essential. These bacteria synthesize pantothenate from the amino acid aspartate and a metabolite in valine biosynthesis

Details of the biosynthetic pathway of CoA synthesis from pantothenic acid.

Pantothenate (vitamin B5) is phosphorylated to 4′-phosphopantothenate by the enzyme pantothenate kinase (PanK; CoaA; CoaX). This is the committed step in CoA biosynthesis and requires ATP.[10]

A cysteine is added to 4′-phosphopantothenate by the enzyme phosphopantothenoylcysteine synthase (PPCS; CoaB) to form 4'-phospho-N-pantothenoylcysteine (PPC). This step is coupled with ATP hydrolysis.

PPC is decarboxylated to 4′-phosphopantetheine by phosphopantothenoylcysteine decarboxylase (PPC-DC; CoaC)

4′-Phosphopantetheine is adenylated (or more properly, AMPylated) to form dephospho-CoA by the enzyme phosphopantetheine adenylyl transferase (PPAT; CoaD)

Finally, dephospho-CoA is phosphorylated to coenzyme A by the enzyme dephosphocoenzyme A kinase (DPCK; CoaE). This final step requires ATP.

USE IN BIOLOGICAL RESEARCH

Coenzyme A is available from various chemical suppliers as the free acid and lithium or sodium salts. The free acid of coenzyme A is detectably unstable, with around 5% degradation observed after 6 months when stored at −20 °C, and near complete degradation after 1 month at 37 °C. The lithium and sodium salts of CoA are more stable, with negligible degradation noted over several months at various temperatures. Aqueous solutions of coenzyme A are unstable above pH 8, with 31% of activity lost after 24 hours at 25 °C and pH 8. CoA stock solutions are relatively stable when frozen at pH 2–6. The major route of CoA activity loss is likely the air oxidation of CoA to CoA disulfides. CoA mixed disulfides, such as CoA-S–S-glutathione, are commonly noted contaminants in commercial preparations of CoA. Free CoA can be regenerated from CoA disulfide and mixed CoA disulfides with reducing agents such as dithiothreitol or 2-mercaptoethanol.