Vitamins and minerals

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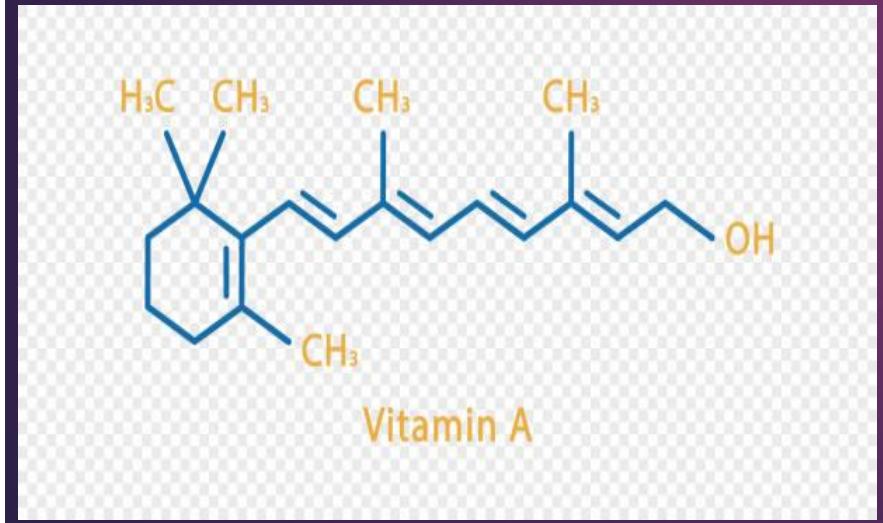
Vitamins

- **Organic compounds are essential and needed in minimal amounts (not synthesized in the body) and must be supplied in the diet.**
- **needed for normal health and growth and their deficiency results in a disease.**
- **They act as coenzymes, do not enter tissue structure, and are not used for energy production as carbohydrates, fats, and proteins.**

Classification:

- **I- Fat-soluble vitamins**
  - Vit. A -Vit. D - Vit. E - Vit. K
- **II- water-soluble vitamins**
  -Vit. B complex - Vit. C

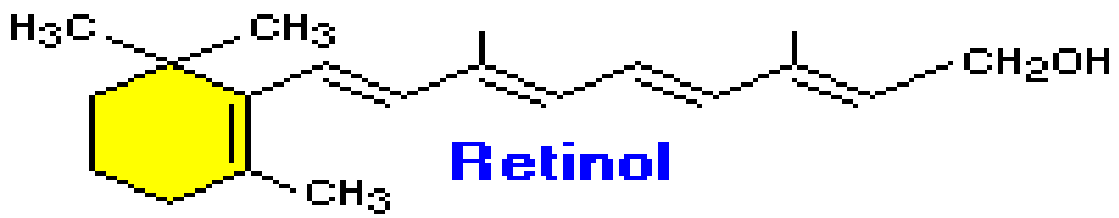
Vitamin A



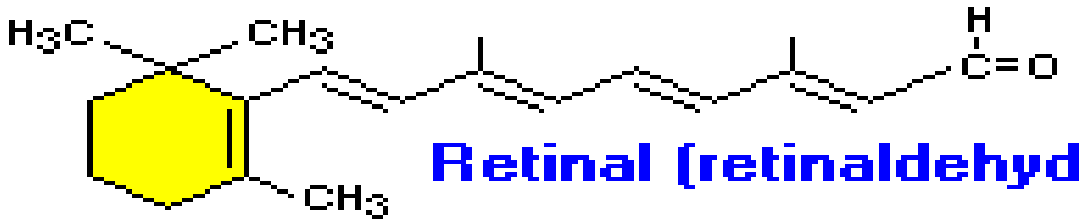
- The biologically active forms of vitamin A are called **retinoids.** The principal retinoids are **retinol (CH_2OH), retinal (CHO),** and **retinoic acid (COOH)**. These molecules can be acquired in the diet performed only from foods of **animal origin**.
- Vitamin A can also be derived from a family of compounds called the **carotenoids** (α-, β-, and γ-carotene) that are found in **plants**.

Metabolism:

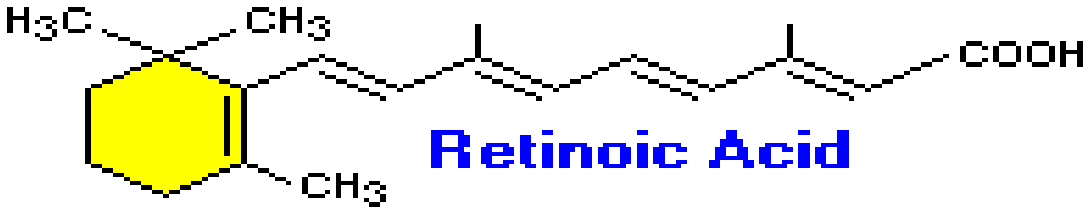
- Vegetables contain no retinol. They have **yellow pigments** called **carotenes**, chemically related to vitamin A. Carotenes can be converted to retinol in the wall of the small intestine during absorption. Several carotenes are known; but the most important is **beta-carotene**, often called '**provitamin A**'. The beta-carotene molecule is almost twice as big as that of vitamin A.



Retinol



Retinal (retinaldehyde)



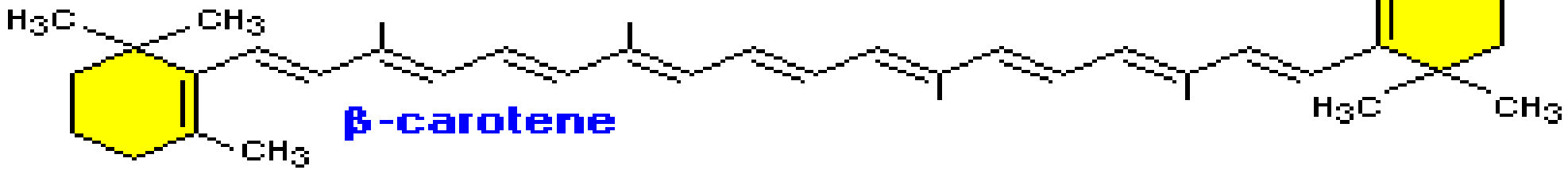
Retinoic Acid

Retinoids

Animal origin

Carotenes

Plant origin



β-carotene

Sources:

Plant origin: All yellow-pigmented vegetables and fruits supply carotenes such as carrots, tomatoes, and potatoes.

Animal origin: meat, liver, milk, butter, and egg yolk. Colostrum is rich with carotenes.

In fish liver oils

Functions:

1. Retinol has an important function in the visual process; necessary for vision in dim light.

2. It is necessary for maintaining the integrity of healthy epithelium, especially the membrane line of the eyes, mouth, gastrointestinal, respiratory, and genitourinary tract.

3. It is required for normal skeletal growth, tooth development, and normal reproductive function.

4. Vitamin A also facilitates iron metabolism.

5. Beta-carotene is a powerful antioxidant. It helps to protect the easily oxidized nutrients, such as PUFAs, from oxidation. It is also able to protect the body from the harmful effects of the free radicals in the body.

Deficiency:

- Night blindness (impaired dark adaptation).
- Xerophthalmia cornea becomes yellow, dry, and rough. (Xero=dryness)
- keratomalacia (corneal fissuring).
- Bitot's spot (white area in the conjunctiva).
- goose skin (rough skin), xeroderma (hyper keratinized skin)
- Roughness of mucous membrane of the urinary tract, genital tract, gastrointestinal tract, and respiratory tract leading to repeated infection.
- Growth retardation and increased liability to cancer and anemia.


Deficiency
of
Vitamin A
Leads to Dry Skin
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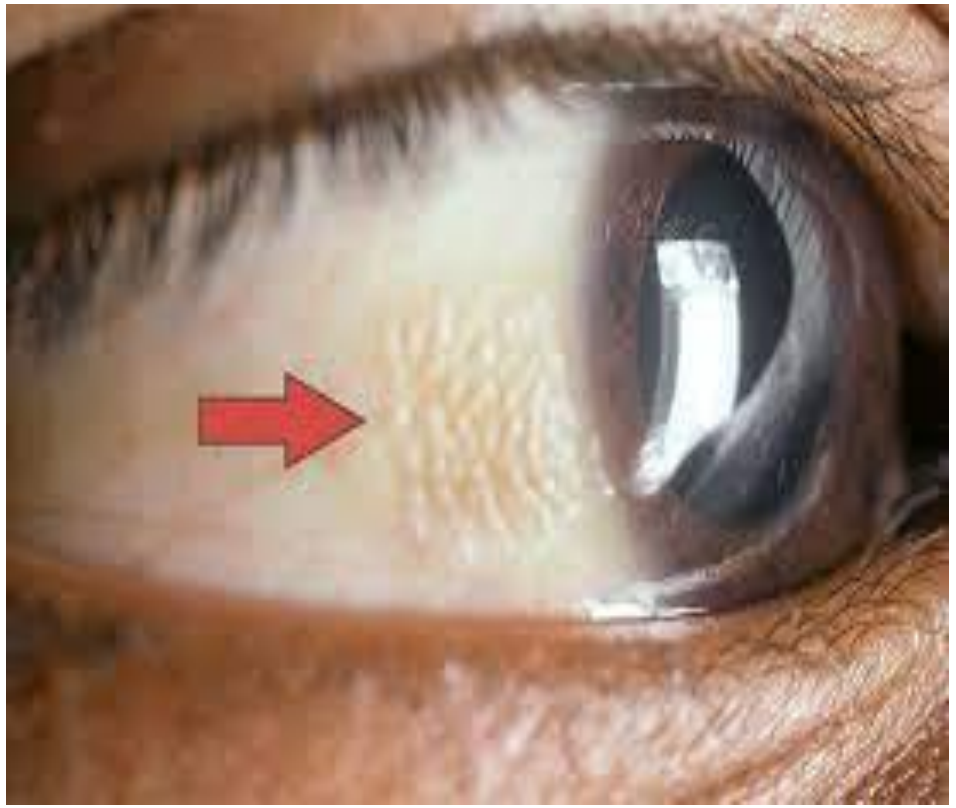


Vitamin K

Sources:

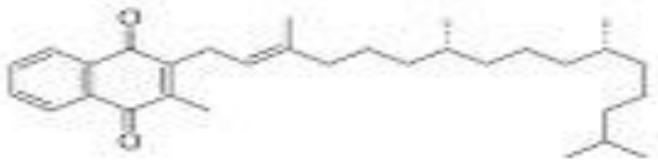
- Vitamin K1 (phylloquinone) is present in green leafy vegetables; spinach, cauliflower, and cabbage.
- Vitamin K2 (menaquinone) is synthesized by intestinal bacteria.
- K3 is synthetic and it is water soluble.

Function:

- The main function is in the formation of several coagulation factors like prothrombin factor II, VII, IX, and X.
- Has a role on bone density.

Deficiency:

- **The dietary deficiency is usually unlikely, but the deficiency may occur due to fat malabsorption diseases.**
- **Since the vitamin K2 form is synthesized by intestinal bacteria, deficiency of the vitamin in adults is rare.**
- **However, long-term antibiotic treatment can lead to deficiency in adults.**
- **The intestine of newborn infants is sterile, therefore, vitamin K deficiency in infants is possible. The primary symptom of a deficiency in infants is hemorrhagic syndrome.**



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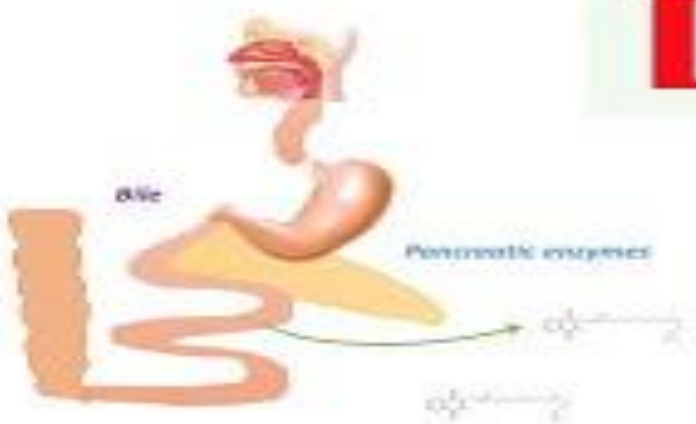
Vitamin K Deficiency



Vitamin E

- **Vitamin E is a term used for tocopherols. It is a light-yellow oil.**
- **Sources:**

- **Vegetable oils, e.g., wheat germ, cotton seed, olive, and coconut oils.**
- **Small amounts are present in the liver, egg yolk, milk, and colostrum.**

Function:

The principal role of vitamin E is as an antioxidant. Various other functions are as follows:

- **Regulation of immune response through cell-mediated immunity.**
- **Protects from various diseases like cancer, arthritis, and ischemic heart disease by preventing peroxidation and maintaining the integrity of cellular membranes.**
- **Prevents oxidation of beta carotene, vitamin A, and vitamin C.**
- **Prevents lipid peroxidation of polyunsaturated fatty acids (PUFA) in cells.**
- **They are used in the food industry as antioxidants and food additives.**

Deficiency:

- It is rarely observed in humans.

It may be observed in subjects with either fat malabsorption or subjects on total parenteral nutrition (TPN) or in premature infants fed on formula feeds. The major symptom of vitamin E deficiency in humans is an increase in red blood cell fragility.

Vitamin D

Sources:

I- Provitamins (vitamers):

- **7-dehydrocholesterol** in animals and man only. It is formed in intestinal mucosa from cholesterol and then passes to the skin, whereby ultraviolet rays of the sun convert it into cholecalciferol (Vitamin D3).
- **Ergosterol** is widely distributed in plants, especially yeast and mushrooms (Vitamin D2).

II- Vitamin D: Fish liver oils, fatty fish, milk, cheese, egg yolk, liver.

Function:

- **Vitamin D is needed for health and to maintain strong bones. It does so by helping the body absorb calcium from food and supplements.**
- **Vitamin D is important for Muscles to move, for example, nerves need it to carry messages between the brain and every body part.**
- **Vitamin D is important to the immune system to fight off invading bacteria and viruses.**
- **Some studies suggest that vitamin D may protect against colon, prostate, and breast cancers.**

Deficiency:

- **Rickets in young children and**
- **Osteomalacia in adults**

Water-soluble B-group Vitamins

- These groups of vitamins are important and act as coenzymes in the metabolism of carbohydrates, proteins, and fats.

- All are present in the same sources (in whole grains, cereals, liver, egg, milk, and yeast).

Thiamine /Vitamin B1

Function:

- The active form is thiamin pyrophosphate (TPP). It acts as a co-enzyme in carbohydrate, protein, and fat metabolism.
- It is essential for pyruvate dehydrogenase (PDH) and a-ketoglutarate dehydrogenase (a-KGDH). Both enzymes are critical to the functioning of the TCA (tricarboxylic acid) cycle.
- The enzymes, PDH & a-KGDH are known as the Tender Loving Care For Nancy (TLCFN) enzymes reflective of their requirement for thiamin, lipoic acid, coenzyme A, FAD, and NAD
- It affects the function of nerve cell membranes.

Deficiency:

The earliest symptoms of thiamin deficiency include constipation, appetite suppression, nausea as well as mental depression, peripheral neuropathy, and fatigue.

Chronic thiamin deficiency leads to more severe neurological symptoms including ataxia, mental confusion, and loss of eye coordination resulting in nystagmus (Dry Beriberi).

Other clinical symptoms of prolonged thiamin deficiency are related to cardiovascular and musculature defects (Wet Beriberi) and are the result of a diet that is carbohydrate-rich and thiamin-deficient.

An additional thiamin deficiency–related disease is known as Wernicke encephalopathy. This disease is most found in chronic alcoholics due to their poor diet and has symptoms like those of beriberi.

Wernicke-Korsakoff syndrome is an extreme manifestation of chronic deficiency of thiamin. It is characterized by acute encephalopathy followed by chronic impairment of short-term memory and mild-to-severe psychosis.

Riboflavin/ Vitamin B2

- **Riboflavin is the precursor for the coenzymes flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD).**
- **The enzymes that require FMN or FAD as cofactors are termed flavoproteins.**

Deficiency:

Riboflavin deficiency is often seen in chronic alcoholics due to their poor dietary habits. Symptoms associated with riboflavin deficiency include:

- **Itching and burning eyes, bloodshot eyes.**
- **Angular stomatitis and cheilosis (cracks and sores in the mouth and lips).**
- **Glossitis (inflammation of the tongue leading to purplish discoloration).**
- **Seborrhea (dandruff, flaking skin on scalp and face).**
- **Trembling, sluggishness, and photophobia (excessive light sensitivity).**

▶ **Riboflavin decomposes when exposed to visible light. This characteristic can lead to riboflavin deficiencies in newborns treated for hyperbilirubinemia by phototherapy.**

Niacin/ vitamin B3

Niacin (nicotinic acid and nicotinamide)

- **Function:** Niacin is required for the synthesis of the active forms of vitamin B3, Coenzyme I (NAD), Coenzyme II (NADP) and Coenzyme III (NMN).
- Niacin is **not a true vitamin** in the strictest definition since it can be derived from the amino acid **tryptophan**. However, the ability to utilize tryptophan for niacin synthesis is inefficient (60 mg of tryptophan is required to synthesize 1 mg of niacin). Also, synthesis of niacin from tryptophan requires vitamins **B1**, **B2**, and **B6** which would be limiting on a marginal diet.

▶ **Deficiency**: A diet deficient in niacin (as well as tryptophan) leads to **pellagra (3D)** which is characterized by; Dermatitis, Diarrhea, and Dementia.

Pantothenic acid/ vitamin B5

- **Function:** It is part of two important coenzymes- Co A (coenzymes A) and ACP (Acyl carrier protein) which are part of the carbohydrate, fat, and protein metabolism.

- **Deficiency:** Deficiency of pantothenic acid is extremely rare due to its widespread distribution in whole grain cereals, legumes, and meat.
- Symptoms of pantothenate deficiency resemble those of other vitamin B deficiencies including loss of appetite, abdominal pain, peripheral neuritis, fatigue, weakness, insomnia, and respiratory infections.

Pyridoxine (Vitamins B6)

- **Pyridoxal phosphate (PLP) is the active form of vitamin B6.**

- **Function:**

Pyridoxal phosphate functions as a coenzyme in:

- **Catalyzes the conversion of tryptophan to niacin,**
- **Required for glycogen breakdown (Glycogenolysis).**
- **Required for the formation of antibodies (Ig),**
- **Synthesis of hemoglobin molecule (Heme synthesis).**
- **Synthesis of the inhibitory neurotransmitter γ-aminobutyric acid (GABA).**

Deficiency:

- **Pellagra may develop in tuberculosis patients receiving isoniazid medication as this depletes the coenzyme (PLP) required for the conversion of tryptophan to NAD.**
- **Anemia and reduced antibody production.**

Biotin/ Vitamin H

- **Biotin is found in numerous foods and is also synthesized by intestinal bacteria and as such deficiencies of the vitamin are rare.**
- **Function: biotin is the cofactor required for enzymes that are involved in carboxylation (carbon dioxide fixation) reactions.**
- **Deficiency:**
  - **Deficiencies are generally seen only after long antibiotic therapies, which deplete the intestinal microbiota or following excessive consumption of raw eggs. The latter is due to the affinity of the egg white protein, avidin, for biotin, preventing intestinal absorption of the vitamin.**
  - **Symptoms that may appear if biotin is deficient are extreme exhaustion, drowsiness, muscle pain, loss of appetite, depression, hair loss, and dry skin.**

Cobalamin/ Vitamin B12

- **Source:**

- **Vitamin B12 is present only in animal foods (e.g., liver, meat, fish, kidney, brain & egg) and is not present in foods of vegetable origin.**
- **Bacteria in the gastrointestinal tract also synthesize Vitamin B12.**
- **vitamin B12 requires an intrinsic factor, a protein secreted by parietal cells of the stomach, to be absorbed by the ileum.**

Functions:

Vit B12 is a coenzyme for some important metabolic reactions like synthesis of DNA.

Vit B12 along with folate and iron, is required for the formation of red blood cells.

Vit B12 is required for the maturation of cells.

Vit B12 is involved in the formation of myelin sheath surrounding the nerve fiber.

Deficiency:

Dietary deficiency is usually observed in persons who do not consume any animal food. In addition, the deficiency is also seen in persons lacking intrinsic factor, which is required for absorption. This is observed in cases of malabsorption syndrome and cases of surgical removal of part of the stomach.

The deficiency results in a condition called pernicious anemia which is a megaloblastic anemia resulting from impaired DNA synthesis due to a block in purine and thymidine biosynthesis.

Neurological complications also are associated with vitamin B12 deficiency and result from a progressive demyelination of nerve cells.

Folic acid/ Folacin

Function

- **Folic acid with vitamin B12 is essential for DNA synthesis and the formation of RBCs.**
- **Folic acid supplement decreases neural tube defects in pregnant women.**

Deficiency:

Causes of folate deficiency: **Folate deficiencies are rare due to the adequate presence of folate in food.**

- **Poor dietary habits as those of chronic alcoholics can lead to folate deficiency.**
- **Or secondary to malabsorption syndromes**
- **Or an increased demand for the vitamin during pregnancy. This is due to an increased number of rapidly proliferating cells present in the blood. The need for folate will nearly double by the third trimester of pregnancy.**
- **Certain drugs such as anticonvulsants and oral contraceptives can impair the absorption of folate.**

Symptoms of deficiency:

- **The deficiency of folic acid causes megaloblastic (macrocytic) anemia, the symptoms of this anemia are a reduction in the number of RBCs, immature large, nucleated cells, low hemoglobin, and low leukocyte and platelet levels.**

Ascorbic Acid or Vitamin C

- **It is a good antioxidant.**
- **It is one of the unstable nutrients and is easily destroyed by atmospheric oxidation and exposure to light or high temperatures.**
- **As humans lack the enzyme required for its synthesis, it must be provided in the diet.**

Functions

Ascorbic acid is an antioxidant; that protects other substances from oxidation.

Ascorbic acid protects the body from free radicals so prevents diseases caused by free radicals.

It helps in the absorption of dietary iron.

Is involved in collagen (intercellular connecting protein) synthesis, formation of bone and teeth calcification & many other reactions.

Deficiency: Vitamin deficiency results in scurvy a condition characterized by easily bruised skin, muscle fatigue, soft swollen gums, decreased wound healing and hemorrhage, osteoporosis, and anemia.

Minerals

According to the body's needs, minerals may be divided into two groups:

A. Macro-minerals:

- They are required in amounts greater than **100 mg/day**.
- They include seven elements: **calcium**, **phosphorus**, **magnesium**, **sodium**, **potassium**, **chloride**, and **sulfur**.

B. Micro-minerals (trace elements):

- They are required in amounts less than **100mg/day**.
- Trace elements: Elements present in the body in very low amounts (**micrograms or less**).
- Some are essential trace elements e.g., **chromium**, **cobalt**, **copper**, **fluorine**, **iodine**, **iron**, **manganese**, **molybdenum**, **selenium**, and **zinc**.

You are tending to a patient in the emergency room (ER) who presents with the following symptoms: nystagmus, organic toxic psychosis, and ataxia. You notice that the patient is dirty and appears not to have bathed for several days or weeks. There is an odor of vomit and alcohol on his clothing. Given the outward appearance and observed symptoms, your diagnosis is indicative of a deficiency in which of the following vitamins?

- A. biotin
- B. folate
- C. pantothenate
- D. riboflavin
- E. thiamin

Wernicke encephalopathy results from a deficiency of vitamin B1. Which of the following represents classical symptoms associated with this disorder?

- A. megaloblastic anemia
- B. nausea, peripheral neuropathy, mental depression, ophthalmoplegia
- C. numbness, tingling, weakness, sore smooth tongue, anorexia, diarrhea, pallor of the skin and mucous membranes
- D. seizure disorders
- E. weight loss, diarrhea, dementia, and dermatitis

A 60-year-old chronic smoker and alcoholic man suffering from odynophagia, insomnia, epigastric discomfort, and recurrent diarrhea presented to the outpatient department. Clinical examination revealed memory disorientation, stomatitis, glossitis, esophagitis, and exfoliative dermatitis with some vesicles on erythematous bases on photoexposed sites. These signs and symptoms are most likely the result of a deficiency in which of the following vitamins?

- A. biotin
- B. cobalamin
- C. niacin
- D. riboflavin
- E. thiamin

A 45-year-old man, a known alcoholic for at least the past 10 years, reported to a physician for consultation. He complained of burning of eyes, a sore tongue, reduced appetite, and mild abdominal discomfort. Physical examination revealed cracks on the lips and in the corners of the mouth; a red, fissured, and inflamed tongue; dull hair, oily skin, and split nails. A deficiency in which of the following vitamins would best explain the observed symptoms?

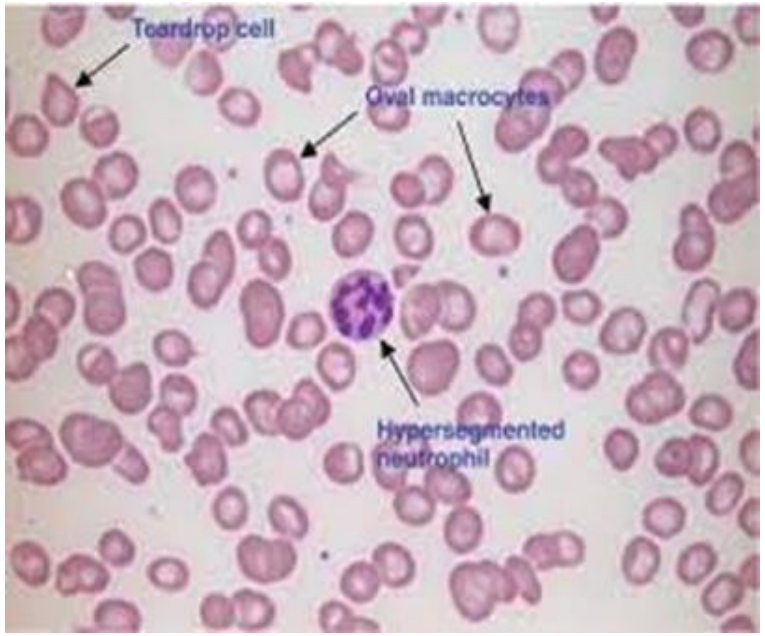
- A. biotin
- B. niacin
- C. pantothenate
- D. riboflavin
- E. thiamin

Not all water-soluble vitamins are strictly required in the diet since the human body can synthesize at least one of this class of vitamins. However, the ability to do so is limited and not of sufficient capacity to provide all the necessary coenzymes required for normal metabolic processes. Which of the following is this vitamin?

- A. α-lipoic acid
- B. folate
- C. niacin
- D. riboflavin
- E. thiamin

The terminal ileum was removed from a 50-year-old woman during the excision of a tumor. About 3 years later, the patient was admitted to the hospital. She is very pale. Hemoglobin is 9 g/dL, and MCV (mean corpuscular volume) has increased to 110 mm3 (110 fL). The provisional diagnosis is a vitamin deficiency. Which of the following vitamins is the most likely one causing the symptoms?

- A. vitamin A
- B. vitamin B1
- C. vitamin B6
- D. vitamin B12
- E. vitamin K



A 14-month-old baby boy is brought to your office by his mother because he seems to be in pain whenever he tries to move. During your physical examination, you note the bowing of his legs, depression of the sternum with outward projection of the ends of the ribs, reluctance to move his limbs, and numerous bruises on his legs as well as gingival hemorrhages. These findings lead you to suspect that this child suffers from a dietary deficiency of which of the following vitamins?

- A. vitamin A
- B. vitamin B1 (thiamine)
- C. vitamin B12 (cyanocobalamin)
- D. vitamin C (ascorbate)
- E. vitamin D (calciferol)

A 50-year-old woman was diagnosed 2 years ago with primary biliary cirrhosis. Given her diagnosis, she is at greatest risk for becoming deficient in which of the following?

- A. vitamin B1 (thiamin)
- B. vitamin B12 (cobalamin)
- C. vitamin C
- D. vitamin A
- E. niacin

As an essential component of the nucleotide analog, FAD, which of the following vitamins plays a major role in the transfer of reducing equivalents?

- A. folate
- B. vitamin B1
- C. vitamin B2
- D. vitamin B6
- E. vitamin B12


Thank you