SBCH322: UNIT 4

Prof Khajamohiddin Syed

Room no. 247, Department of Biochemistry & Microbiology,

University of Zululand

SyedK@unizulu.ac.za

Important notice

The questions and answers provided in this file are only for students' practice purposes. The intention of providing this information is purely to educate and make students aware of the correct way of answering the questions. All the sources used in the preparation of this material are properly cited at the end of this document. Students are requested not to regard this material as a reference, but as guidance on how to answer questions. However, ultimately the onus rests on the student to work hard and to read the books and other material on the topics listed in the module.

NOTE: BROWESE ONLINE VITAMINS AND MINERAL CHAPTERS AND PRACTICE MULTIPLE CHOICE QUESTIONS.

Micronutrients

Vitamins

A vitamin is an organic molecule (or related set of molecules) which is an essential micronutrient, meaning a substance which an organism needs in small quantities for the proper functioning of its metabolism but cannot synthesize, either at all or in sufficient quantities, and therefore must obtain through its diet.

Vitamins are organic compounds that are essential in the diet in small amounts to promote and regulate the processes necessary for growth, reproduction, and the maintenance of health. When a vitamin is lacking in the diet, deficiency symptoms occur. When the vitamin is restored to the diet the symptoms resolve. There are 15 known vitamins, and they have traditionally been grouped based on their solubility in water or fat. This chemical characteristic allows generalization to be made about how they are absorbed, transported, excreted, and stored in the body. The water-soluble vitamins include the B vitamin and vitamin C. The fat-soluble vitamins include vitamins A, D, E, and K (Table 1). The vitamins were initially named alphabetically in approximately the order in which they were identified: A, B, C, D, and E. The B vitamins were first thought to be one chemical substance but were later found to be many different substances, so the alphabetical name was broken down by numbers; thiamin, riboflavin and niacin were originally referred to as vitamin B1, B2, and B3, respectively. Vitamins B6, and B12 are the only ones that are still commonly referred to by their numbers. Some people consider choline and carnitine to be conditionally essential, water-soluble, vitamin-like compounds and thus these two molecules were also included under water-soluble vitamins.

Table 1. Vitamins.

Water-soluble		Fat-soluble
B vitamins		Vitamin A
B1	Thiamine	Vitamin D
B2	Riboflavin	Vitamin E
B3	Niacin	Vitamin K
B5	Pantothenic acid	
B6	pyridoxine	
B7	Biotin	
B9	Folic acid	
B12	Cobalamin	
Vitamin C		
Choline		
Carnitine		

Water-soluble vitamins function primarily as coenzymes in energy metabolism, the fat-soluble vitamins are needed for cell growth, reproduction, and gene regulation.

Properties of water-soluble vitamins

One attribute that all water-soluble vitamins share is that they dissolve in water (as opposed to lipids). Second, although there are exceptions, the body generally digests, absorbs, and transports the water-soluble vitamins in similar ways. For example, they are absorbed mostly in the small intestines and, to lesser extent, the stomach. Further, many water-soluble vitamins found in foods are bound to proteins that enzymes must remove before the vitamins can be absorbed. In addition, their bioavailability (i.e. absorption) can be influenced by many factors, including nutritional status, other nutrients and substances in foods, medications, age, and illness. And, except for choline which is circulated away from the gastrointestinal tract in the lymph, all of the water-soluble compounds are circulated directly to the liver in the blood. Finally, because the body does not actively store water-soluble vitamins, they generally do not have toxic effects when consumed in large amounts.

General characteristic of fat-soluble vitamins

Although each of the fat-soluble vitamins is chemically unique, this group of nutrients shares certain general characteristics in terms of how they are absorbed and circulated (Table 2). For example, like the water-soluble vitamins, fat-soluble vitamins are absorbed mostly in the small intestine. Unlike their water-soluble counterparts, however, absorption requires the presence of dietary lipids as well as the action of bile. In other words, if you were to eat a very low-fat diet, you might have difficulty absorbing the fat-soluble vitamins. Unlike water-soluble vitamins, which are circulated in the blood, fat-soluble vitamins are circulated away from the small intestine in the lymph via chylomicrons before eventually entering the blood either as components of lipoproteins or bound to transport properties.

Like water-soluble vitamins, each fat-soluble vitamin has several forms, some of which are more biologically active than others. Because the body can store most of the fat-soluble vitamins, consuming large amounts of them (especially in supplement form) can results in toxicities, sometimes which serious consequences. Once absorbed and circulated to cells in the body, the fat-soluble vitamins are involved in many processes such as vision, blood coagulations, regulation of gene expression, cell maturation, and stabilization of free radicals.

Table 2. General characteristics of the fat-soluble vitamins.

Water-soluble	Fat-soluble
Soluble in water	Soluble in fat
Attached to proteins in the food	Typically found in fatty portions of the food
Need digestion	Very little digestion

<table>
<tr><td>Mostly absorbed in the small intestines and, to
lesser extent, the stomach</td><td>Absorption requires the presence of dietary lipids as well as the action of bile.
Occurs mostly in small intestines
Requires incorporation into micelles and the action of bile
Once transported into the intestinal cell, vitamins and packaged with other lipids into chylomicrons</td></tr>
<tr><td>Circulated directly to the
liver in the blood</td><td>Circulated away from the small intestine in the lymph via chylomicrons before eventually entering the blood either as components of lipoproteins or bound to transport properties.</td></tr>
<tr><td>Body does not actively store water-soluble vitamins. No toxicity.</td><td>Body can store most of the fat-soluble vitamins. Consuming large amounts of them (especially in supplement form) can results in toxicities.</td></tr>
</table>

Table 3. Information on water-soluble vitamins including their functions, disorders caused by their deficiency and toxicity.

Vitamin	Name	Functions	Deficiency	Toxicity
Vitamin C	ascorbic acid and L-ascorbic acid	• Vitamin C is a powerful reducing agent that participates in several important hydroxylation reactions. • Vitamin C is needed for collagen, carnitine, catecholamine, and bile acid biosynthesis. • Vitamin C uses Fe++ and Cu++ as cofactors, and enhances intestinal Fe++ absorption. • Vitamin C is a natural preservative added to pet food products.	Vitamin C deficiency can result in "scurvy." swollen legs blotched with capillary hemorrhages, decaying peeling gums with loose teeth, decreased capacity to heal wounds, depression, anemia, and fatigue. Infantile scurvy (also known as Barlow's syndrome or disease), is associated with similar symptoms.	None
B1	Thamine	• Thiamin diphosphate is used to facilitate oxidative decarboxylation and transketolase reactions. • Thiamin is activated to its coenzyme form in brain and liver tissue.	Thiamin deficiency, which limits aerobic metabolism, can be fatal. **Beriberi:** Symptoms of beriberi include weight loss, emotional disturbances, impaired sensory perception, weakness and pain in the limbs, and periods of irregular heart rate. Edema (swelling of bodily tissues) is common. It may increase the amount of lactic acid and pyruvic acid within the blood. In advanced cases, the disease may cause high-output cardiac failure and death.	None
B2	Riboflavin	• Riboflavin is used to produce FMN and FAD, and stored forms of this vitamin tend to decompose in the presence of light. • FAD and FMN are coenzymes containing iron or molybdenum.	Riboflavin deficiency (also called ariboflavinosis) results in stomatitis including painful red tongue with sore throat, chapped and fissured lips (cheilosis), and inflammation of the corners of the mouth (angular stomatitis). There can be oily scaly skin rashes on the scrotum, vulva, philtrum of the lip, or the nasolabial folds. The eyes can become	None

			itchy, watery, bloodshot and sensitive to light.	
B3	Niacin	• Niacin is a component of NAD+ and NADP+. • Coenzymes generated from niacin are best associated with dehydrogenase reactions.	Severe deficiency of niacin in the diet causes the disease pellagra, which is characterized by diarrhea, dermatitis, and dementia, as well as Casal's necklace lesions on the lower neck, hyperpigmentation, thickening of the skin, inflammation of the mouth and tongue, digestive disturbances, amnesia, delirium, and eventually death, if left untreated	Skin inflammation and flushin
B5	Panthothenic acid	• Pantothenic acid gives rise to two coenzymes, 4-phosphopantetheine and coenzyme A (i.e., CoA.SH). • 4-Phosphopantetheine is a prosthetic group for acyl carrier protein, which participates in fatty acid biosynthesis. • The reactive thiol (-SH) group of CoA.SH serves as a carrier (and activator) of acylgroups, most notably in degradative energy-yielding pathways.	Burning feet syndrome (possibly)	None
B6	Pyridoxine	• Vitamin B6 (pyridoxine) is used in muscle glycogenolysis, and in erythrocytes it is bound to hemoglobin. Pyridoxal phosphate is used in transamination reactions.	Although rare in animals, a vitamin B6 deficiency can result in increased amounts of amino acid metabolites appearing in urine, and it can reduce conversion of Trp to NAD+.	
B7	Biotin	• Biotin participates in carboxylation reactions. • Biotin, pantothenate (B5), and cobalamin (B12) are needed by herbivores to move propionate into hepatic gluconeogenesis.	Depression, loss of muscle control, and skin irritations	
B9	Folate	• Folate acts as a cofactor for enzymes involved in DNA and RNA biosynthesis. • Folate is also involved in the supply of methyl groups to the so-called methylation cycle, which uses methionine and makes homocysteine. The folate cofactor, N5-	The cell's ability to methylate important compounds such as proteins, lipids and myelin will be compromised by deficiency of folate or vitamin B12, resulting in impaired cellular function.	Neurological problems

		methyltetrahydrofolate, donates its methyl group to a vitamin B12-dependent enzyme, methionine synthase, which recycles homocysteine back to methionine.		
B12	Cobalamin	• Vitamin B12 is an antipernicious anemia factor. • The association of Co+++ with B12 is the primary recognized action of this trace element in mammalian metabolism. • Entry of propionate into hepatic gluconeogenesis requires 5'deoxyadenosylcobalamin. • Involved in the metabolism of every cell of the human body: it is a cofactor in DNA synthesis, and in both fatty acid and amino acid metabolism	Common symptoms of vitamin B12 deficiency include homocystinuria and methylmalonuria. A secondary intestinal dysfunction may develop from persistent cobalamin deficiency.	Vitamin B12 is generally absent from plant and vegetable foods unless they are contaminated by microbes. Liver is a good source of the three endogenous forms of vitamin B12 (methylcobalamin, 5'-deoxyadenosylcobalamin, and hydroxocobalamin).

Fat-soluble vitamins – Please go through presentation slides for information

Minerals

Minerals are inorganic elements needed by the body as structural components and regulators of body processes. Because the body requires them in very small amounts, dietary minerals are considered micronutrients. All minerals needed for health are essential nutrients because the body cannot make them from other compounds. Thus, we rely on the foods we eat to provide us with these important substances. Minerals can be neither created nor destroyed; even if you completely combust (burn) a food, the minerals will remain in the ash. This is true of the minerals in our bodies as well.

Minerals have traditionally been categorized based on the amounts needed in the diet or present in the body. Essential minerals are divided up into major minerals (macrominerals) and trace minerals (microminerals). The major minerals include those needed in the diet in amounts greater than 100 mg per day or present in the body in amounts greater than 0.01% of body weight. These two groups of minerals are equally important, but trace minerals are needed in smaller amounts than major minerals. The amounts needed in the body are not an indication of their importance.

The body requires seven major minerals (calcium, phosphorus, magnesium, sodium, chloride, sulfur and potassium) and nine trace minerals (iron, copper, iodine, selenium, chromium, fluoride, manganese, molybdenum, and zinc).

IRON:

Iron is the most abundant trace element in mammalian organisms. The principal function of iron in the body involves oxygen transport. Only 3-6% of the iron present in the diet is normally absorbed by the intestine. Iron absorption is an active process, with most absorption occurring in the upper part of the small intestine. Cobalt, zinc, copper, and manganese compete, somewhat, with iron for intestinal absorption. Unless bleeding occurs, iron is not easily excreted from the body. Iron, which is continually interconverted between the ferric and ferrous state, can cause free radical formation. Iron toxicity results in pancreatic and liver damage, which is exacerbated in vitamin E deficiency. Young, fast-growing animals are vulnerable to iron deficiency. Most metalloflavoproteins contain iron.

Food sources rich in iron:

The body absorbs two to three times more iron from animal sources than from plants. Some of the best animal sources of iron are:

Lean beef, Oysters, Chicken, Turkey

Although you absorb less of the iron in plants, every bite counts, and adding a source of vitamin C to vegetarian sources of iron will enhance absorption. Some of the best plant sources of iron are:

Beans and lentils, Tofu, Baked potatoes, Cashews, Dark green leafy vegetables such as spinach, Fortified breakfast cereals and Whole-grain and enriched breads

ZINC:

Zinc is an active component of several important enzymes (including collagenase), and it is widely distributed in animal tissues. Zinc affects the metabolism of the pancreas, skin, and male reproductive organs. Zinc toxicity affects several different organ systems. Zinc is normally absorbed from the intestine at approximate 20-30% efficiency, and competes with Cu^{++}, Fe^{++}, and Ca^{++} for absorption. Zinc deficiency results in growth retardation, delayed wound healing, photophobia, scaly dermatitis, and sometimes loss of taste and smell. Vitamin A metabolism is partially Zn^{++}-dependent.

Food sources rich in Zinc: Here are 5 of the best foods that are high zinc.

1. Meat particularly red meat is an excellent source of zinc. A 100-gram serving of raw ground beef provides 44% of the DV.

2. Shellfish - Shellfish like oysters, crab, mussels and shrimp can all contribute to your daily zinc needs.

3. Legumes- Legumes contain high amounts of zinc. However, they also contain phytates, which reduce its absorption. Processing methods like heating, sprouting, soaking or fermenting can help improve its bioavailability.

4. Seeds - Some seeds like hemp, pumpkin, squash and sesame seeds contain significant amounts of zinc. They are also a good source of fiber, healthy fats and vitamins, making them a healthy addition to your diet.

5. Nuts - Nuts are a healthy and convenient snack that can boost your intake of zinc and many other healthy nutrients.

COPPER:

Intestinal Cu^{++} absorption appears to be enhanced by dietary protein. Ceruloplasmin carries Cu^{++} in plasma, and also assists circulating transferrin in the reception of hepatic iron. Superoxide dismutase is the most abundant Cu^{++}-containing enzyme. Copper is a component of the mitochondrial electron transport chain. Copper is required for both catecholamine synthesis and degradation. Lysyl oxidase is a Cu^{++}-containing enzyme that aids in the crosslinking of elastin and collagen. Copper toxicity causes hepatic necrosis, methemoglobinemia, and hemolysis. Copper deficiency is associated with anemia, skin and hair depigmentation, CNS disturbances, and vascular degeneration. Wilson's-like disease is prevalent in Bedlington terriers.

Food sources rich in copper:

1. Liver is an extremely nutritious meat. Just one slice of calf liver boasts over 11 times the RDI for copper, as well as good amounts of other important nutrients.

2. Per 3.5 ounces (100 grams), oysters contain 8.5 times the RDI for copper. This low-calorie shellfish is also high in zinc, selenium and vitamin B12.

3. Spirulina, a dried supplement made from blue-green algae, is extremely nutritious — a single tablespoon (7 grams) gives nearly half of your daily copper needs.

4. A handful of dried shiitake mushrooms packs nearly all of your daily needs for copper. They're also rich in other important nutrients.

5. Nuts and seeds — particularly almonds, cashews and sesame seeds — are good sources of copper. What's more, they're high in fiber, protein and healthy fats.

MANGANESE:

Mn++ is associated with a wide variety of mammalian enzymes, including carboxylases, dehydrogenases, and transferases. Mn++ is best associated with mucopolysaccharide and lipopolysaccharide metabolism. Mn++ is absorbed from the small intestine at a rather low 3-4% efficiency, and is generally an abundant plant element. Mn++ is an additive in many pet food products. Mn++ is needed for normal bone metabolism.

Food sources rich in manganese:

Some examples of foods that are good sources of manganese include:

1. Nuts, such as almonds and pecans

2. Beans and legumes, such as lima and pinto beans

3. oatmeal and bran cereals

4. Whole wheat bread

5. Brown rice

SELENIUM:

Selenium is an essential component of glutathione peroxidase, and is normally absorbed from the digestive tract at a rather high (50-90%) efficiency. The chemistry of Se appears to resemble that of sulfur. Some soils are Se-deficient, while others grow plants that when consumed can cause Se-toxicity. Se toxicity is associated with "blind staggers" and "alkali disease" in farm animals. Both vitamin E deficiency and Se deficiency lead to nutritional muscular degeneration, as well as other symptoms.

Food sources rich in selenium: Selenium occurs in proteins as analogs of amino acids, in plants as selenomethoinine and in animals as selenocysteine.

1. Brazil nuts - Brazil nuts are one of the best sources of selenium. One ounce, or about six to eight nuts, contains about 544 mcg. Make sure you only eat a serving of Brazil nuts a few times a week to avoid selenium toxicity.

2. Fish - Yellowfin tuna contains about 92 mcg of selenium per 3 ounces (oz), making it an excellent source of selenium. This is followed by sardines, oysters, clams, halibut, shrimp, salmon, and crab, which contain amounts between 40 and 65 mcg.

3. Ham - Many health-conscious eaters avoid ham due to its high salt content. However, it provides about 42 mcg of selenium per 3 oz serving, or 60 percent of the recommended daily intake for adults.

4. Enriched foods - Some products, including pastas, whole wheat breads, and whole grain cereals, are enriched or fortified with selenium and other minerals. The amount of selenium in these products will vary, but you can typically get up to 40 mcg per 1 cup serving of noodles or cereal, and about 16 mcg from 2 slices of whole grain toast. Just make sure you balance enriched foods with plenty of whole, plant-based foods for optimal nutrition.

5. Pork - Three ounces of lean pork contain about 33 mcg of selenium.

IODINE:

Dietary iodine is largely converted to iodide in the digestive tract, where it is normally absorbed at >95% efficiency. Iodide is required for thyroid hormone biosynthesis, and is extensively recycled within the organism. The thiocarbamide group of plant-derived goitrogens possesses antithyroid activity. 131I is sometimes used to treat animals with hyperthyroidism.

Food sources rich in Iodine:

The diet is the primary method of achieving adequate iodine nutrition, with dairy products, some breads, seaweed and other seafood, and iodized salt as the most common iodine-containing foods.

COBALT:

Cobalt is an important constituent of vitamin B12. Cobalt deficiency in ruminant animals results in an inability to metabolize propionate, as well as an inability to reform tetrahydrofolate from N^5-methyl-H_4 folate. Several physiologic processes require inorganic cobalt. Cobalt and iron may share the same transport system for intestinal absorption. Iron deficiency enhances intestinal Co absorption.

Food sources: Good food sources of cobalt include fish, nuts, leafy green vegetables, such as broccoli and spinach, and cereals, including oats.

Antinutrients

Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients. Examples include the following:

• Protease inhibitors (e.g., Bowman–Birk trypsin inhibitor in soybeans), which inhibit trypsin, pepsin, and other proteases in the gut, preventing digestion and absorption of proteins and amino acids

• Lipase inhibitors (e.g., tetrahydrolipstatin), which interfere with enzymes, such as lipases, which catalyze hydrolysis of some lipids and fats

• Amylase inhibitors in beans, which prevent the action of enzymes that break the glycosidic bonds of starches and other complex carbohydrates, preventing the release of simple sugars and absorption by the body

• Phytic acid in the hulls of nuts, seeds, and grains, which has a strong binding affinity for calcium, magnesium, iron, copper, and zinc, preventing their absorption

• Oxalic acid and oxalates, which are present in many plants, particularly members of the spinach family, bind calcium to prevent its absorption

Many traditional preparation methods (e.g., fermentation) reduce antinutrients, such as phytic acid, increase the nutritional quality of plant foods, and are widely used in societies where cereals and legumes are a significant part of the diet. For example, cassava is fermented to reduce levels of both toxins and antinutrients. Glucosinolates (e.g., broccoli, Brussels sprouts, cabbage, and cauliflower), although widely recognized for their putative health benefits, also interfere with the uptake of iodine and flavonoids, and chelate metals (e.g., iron and zinc) thus reducing their absorption.

Alternative sweeteners

Alternative sweeteners are chemical substances used as a sweet alternative to replace sucrose. Many have been developed to provide zero-calorie or low calorie sweetening for foods and drinks. Based on their sweetness level compared to sucrose, the sweeteners are divided into two classes: intense and bulk sweeteners. The synthetic sweeteners because of their intense sweetness are called high potency sweeteners (HPS). The need for HPS sweeteners arises due to health reasons for persons who cannot have sugar in their meal. Further, the economic reasons also add for the development of HPS.

The intense sweeteners are generally produced by chemical synthesis and broadly used in processed foods, including baked foods, carbonated beverages, powdered drink, candy, puddings, canned foods, and jelly. The intense sweeteners are also called alternative sweeteners. They do not contribute significantly to the energy values of the food but can increase appetite. Several of the intense sweeteners have been commonly used in food additives including potassium acesulfame, aspartame, cyclamate, neohesperidin, saccharin, sucralose, and thaumatin. They were believed to cause health problems, including cancer, dental caries, obesity, and cardiovascular disease. The alternative sweeteners can rapidly increase the blood sugar level and cause deleterious effects in diabetic patients.

The other group of sweeteners, i.e., bulk sweeteners, are less sweet than sucrose. Bulk sweeteners are allowed to be used as filler in several food products, including desserts, ice cream, jam, preserves, marmalade, sweets, baked foods, breakfast cereals, and mustard. The bulk sweeteners cannot reduce the energy content of the food. The most popular bulk sweeteners are erythritol, sorbitol, xylitol, maltitol, isomalt, lactitol, and mannitol.

Table 13.1 Relative sweetness of natural sweeteners [27]

Sugar	Relative sweetness
Sucrose	1.0
Glucose	0.6
Fructose	2.0
Maltose	0.6
Lactose	0.25
Steviol glycosides	40–300

Table 13.2 Relative sweetness of artificial sweeteners [27]

Sweetener	Relative sweetness*
Saccharine	300–500
Acesulfame-K	150–300
Cyclamate	30
Sucralose	600
Aspartame	150–200
Neotame	7000–13000
Alitame	2000
Talin	2500

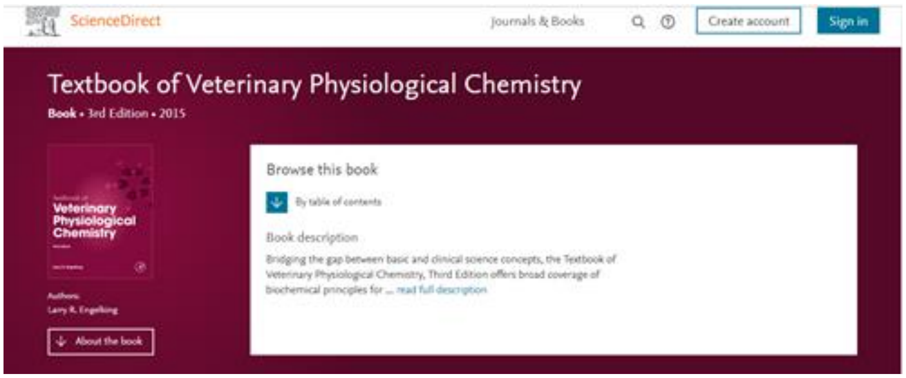
*With reference to sucrose

Sources

Textbook of veterinary physiological chemistry. 3rd edition. Authors: Larry R Engelking. ISBN: 978-0-12-391909-0

DOI: https://doi.org/10.1016/C2010-0-66047-0. 2015 Elsevier Inc. All rights reserved.

https://www.sciencedirect.com/book/9780123919090/textbook-of-veterinary-physiological-chemistry#book-info



SiânAstleyPaulFinglas. 2016. Nutrition and Health. Reference Module in Food Science. https://doi.org/10.1016/B978-0-08-100596-5.03425-9.

https://www.sciencedirect.com/science/article/pii/B9780081005965034259

LindsayJolly. 2004. Alternative sweetners. Sugar Trading Manual. Pages 5a, 5b, 1-47. https://doi.org/10.1016/B978-1-85573-457-9.50011-1

https://www.sciencedirect.com/science/article/pii/B9781855734579500111

https://courses.lumenlearning.com/suny-nutrition/chapter/2-13-alternative-sweeteners/