قسم الكيمياء الحيوية
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جامعة الملك سعود
King Saud University
1957
كلية العلوم

BCH 580
Biochemistry of human nutrition

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Fat-Soluble Vitamins

- **The fat-soluble vitamins A, D, E, and K insoluble in the watery juices of the GI tract, the fat-soluble vitamins require bile for their digestion and absorption.**
- **Upon absorption, fat-soluble vitamins travel through the lymphatic system within chylomicrons before entering the bloodstream, where many of them require protein carriers for transport.**

- **The fat-soluble vitamins participate in numerous activities throughout the body, but excesses are stored primarily in the liver and adipose tissue. The body maintains blood concentrations by retrieving these vitamins from storage as needed; thus people can eat less than their daily need for days, weeks, or even months or years without ill effects. They need only ensure that, over time, average daily intakes approximate recommendations.**

- **Because fat-soluble vitamins are not readily excreted, the risk of toxicity is greater than it is for the water-soluble vitamins.**

Vitamin A and Beta-Carotene

- **Three different forms of vitamin A are active in the body: retinol, retinal, and retinoic acid (retinoids).**
- **Foods derived from animals provide compounds (retinyl esters) that are readily digested and absorbed as retinol in the intestine. Foods derived from plants provide carotenoids, some of which can be converted to vitamin A.**
- **The most studied of the carotenoids with vitamin A activity is beta-carotene, which can be split to form retinol in the intestine and liver**

- **Beta-carotene's absorption and conversion are significantly less efficient than those of the retinoids.**
- **The cells can convert retinol and retinal to the other active forms of vitamin A as needed.**
- **The conversion of retinol to retinal is reversible, but the further conversion of retinal to retinoic acid is irreversible.**
- **Several proteins participate in the digestion and absorption of vitamin A. After absorption via the lymph system, vitamin A eventually arrives at the liver, where it is stored.**

- **There, a special transport protein, retinol-binding protein (RBP), picks up vitamin A from the liver and carries it in the blood.**
- **Cells that use vitamin A have special protein receptors for it, and its action within each cell may differ depending on the receptor. For example, retinoic acid can stimulate cell growth in the skin and inhibit cell growth in tumors**

Roles in the Body

Vitamin A is a versatile vitamin, known to regulate the expression of several hundred genes. Its major roles include:

- **Promoting vision**
- **Participating in protein synthesis and cell differentiation, thereby maintaining the health of epithelial tissues and skin**
- **Supporting reproduction and regulating growth**

Each form of vitamin A performs specific tasks.

- **Retinol supports reproduction and is the major transport and storage form of the vitamin.**

- **Retinal is active in vision and is also an intermediate in the conversion of retinol to retinoic acid.**
- **Retinoic acid acts like a hormone, regulating cell differentiation, growth, and embryonic development.**
- **Animals raised on retinoic acid as their sole source of vitamin A can grow normally, but they become blind because retinoic acid cannot be converted to retinal**

Thiamin Food Sources

- **Thiamin occurs in small quantities in many nutritious foods.**
- **Meats in the pork family are rich in thiamin.**
- **Grains; whole grains or enriched are a reliable source of thiamin.**
- **prolonged cooking can destroy thiamin, thiamin leaches into water when foods are boiled or blanched.**
- **Cooking methods that require little or no water such as steaming and microwave heating conserve thiamin and other water-soluble vitamins.**

Vitamin A in Vision

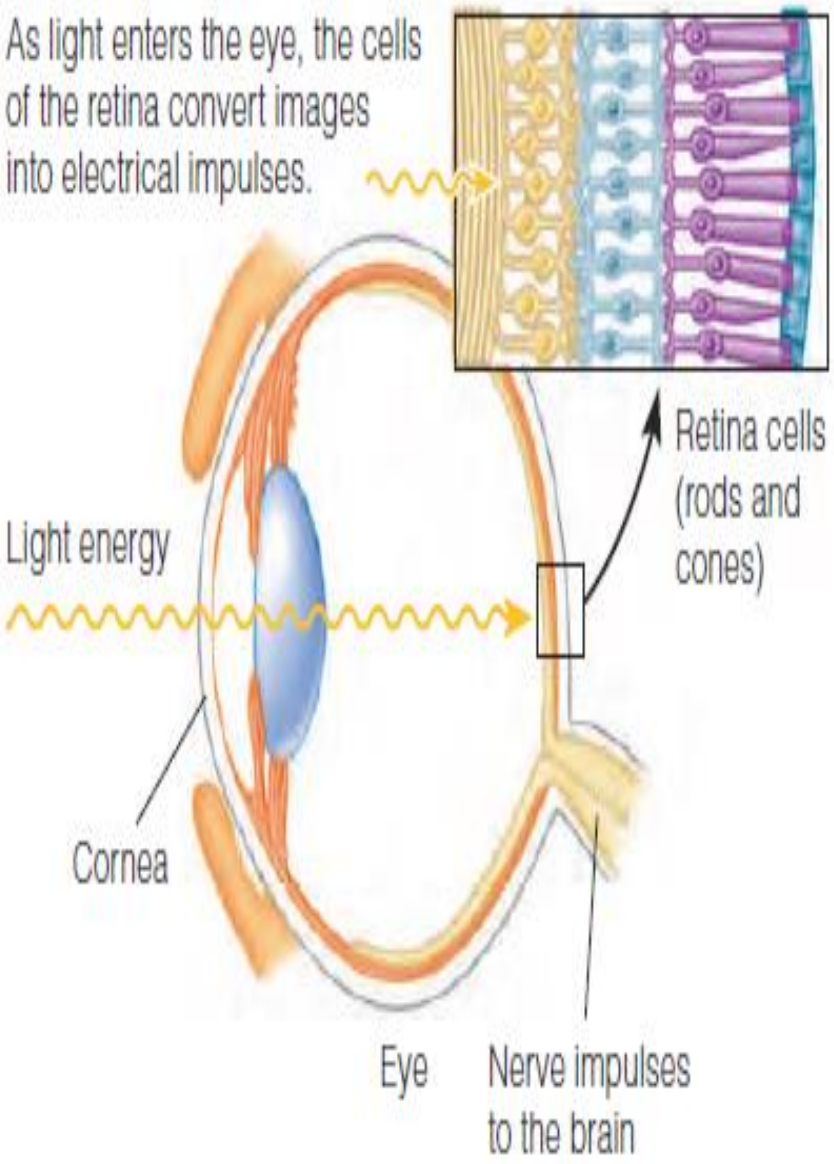
Vitamin A plays two indispensable roles in the eye:

- **It helps maintain a crystal-clear outer window, the cornea.**
- **it participates in the conversion of light energy into nerve impulses at the retina.**

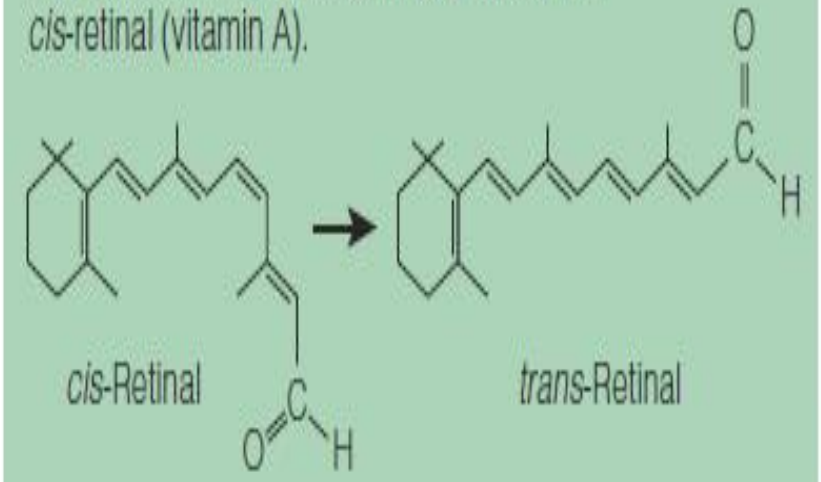
Some of the photosensitive cells of the retina contain pigment molecules called rhodopsin; each rhodopsin molecule is composed of a protein called opsin bonded to a molecule of retinal.

When light passes through the cornea of the eye and strikes the retina, rhodopsin responds by changing shape and becoming bleached. As it does, the retinal shifts from a cis to a trans configuration, just as fatty acids do during hydrogenation. The bleached trans-retinal cannot remain bonded to opsin. When retinal is released, opsin changes shape, thereby disturbing the membrane of the cell and generating an electrical impulse that travels along the cell's length. At the other end of the cell, the impulse is transmitted to a nerve cell, which conveys the message to the brain.

Much of the retinal is then converted back to its active cis form and combined with the opsin protein to regenerate the pigment rhodopsin. Some retinal, however, may be oxidized to retinoic acid, a biochemical dead end for the visual process. Visual activity leads to repeated small losses of retinal, necessitating its constant replenishment either directly from foods or indirectly from retinol stores.



The cells of the retina contain rhodopsin, a molecule composed of opsin (a protein) and *cis*-retinal (vitamin A).



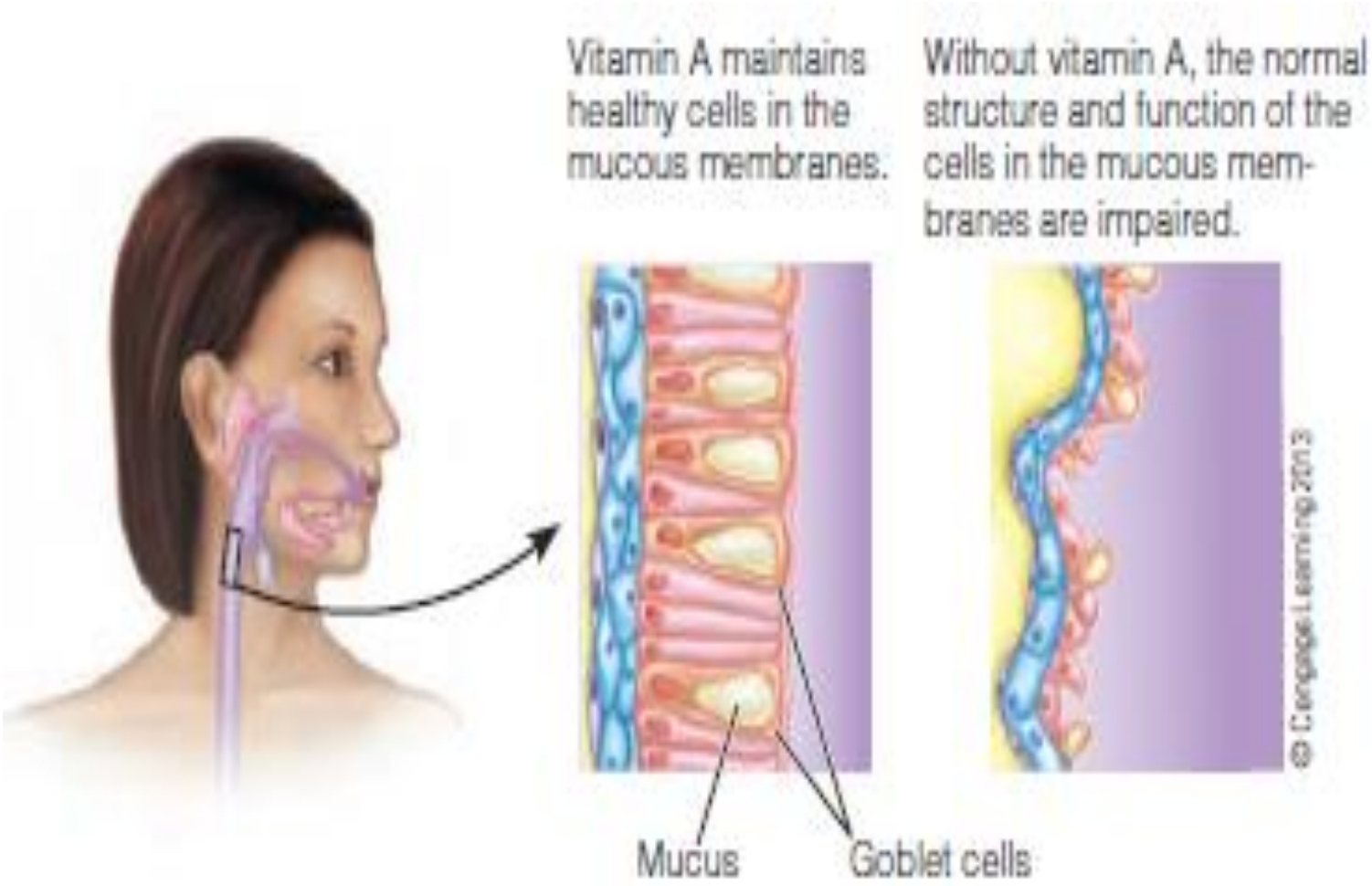
As rhodopsin absorbs light, retinal changes from *cis* to *trans*, which triggers an electrical impulse that carries visual information to the brain through the optic nerve.

Vitamin A in Protein Synthesis and Cell Differentiation

- **The vitamin participates in protein synthesis and cell differentiation, a process by which each type of cell develops to perform a specific function.**
- **All body surfaces, both inside and out, are covered by layers of cells known as epithelial cells. The epithelial tissue on the outside of the body is the skin—and vitamin A helps to protect against skin damage from sunlight.**

- **The epithelial tissues that line the inside of the body are the mucous membranes: the linings of the mouth, stomach, and intestines; the linings of the lungs and the passages leading to them; the linings of the urinary bladder and urethra; the linings of the uterus; and the linings of the eyelids and sinus passageways. Within the body, the mucous membranes of the GI tract alone line an area larger than a quarter of a football field, and vitamin A helps to maintain their integrity.**

- **Vitamin A promotes differentiation of epithelial cells and goblet cells, one celled glands that synthesize and secrete mucus. Mucus coats and protects the epithelial cells from invasive microorganisms and other potentially damaging substances, such as gastric juices.**


Vitamin A maintains healthy cells in the mucous membranes.
Without vitamin A, the normal structure and function of the cells in the mucous membranes are impaired.
Mucus
Goblet cells

Vitamin A in Reproduction and Growth

- **Vitamin A also supports reproduction and regulates growth. In men, retinol participates in sperm development, and in women, vitamin A supports normal fetal development during pregnancy.**
- **Children lacking vitamin A fail to grow; given vitamin A supplements, these children gain weight and grow taller.**

- **The growth of bones illustrates that growth is a complex phenomenon of remodeling. To convert a small bone into a large bone, the bone-remodeling cells must "undo" some parts of the bone as they go, and vitamin A participates in the dismantling.**
- **The cells that break down bone contain sacs of degradative enzymes. With the help of vitamin A, these enzymes destroy selected sites in the bone, removing the parts that are not needed.**

Beta-Carotene as an Antioxidant

- **In the body, beta-carotene serves primarily as a vitamin A precursor.**
- **Not all dietary beta-carotene is converted to active vitamin A, however. Some beta-carotene may act as an antioxidant capable of protecting the body against disease.**

Vitamin A Deficiency

- **Vitamin A status depends mostly on the adequacy of vitamin A stores, 90 percent of which are in the liver.**
- **Vitamin A status also depends on a person's protein status because retinol-binding protein serves as the vitamin's transport carrier inside the body.**
- **If a person were to stop eating vitamin A–containing foods, deficiency symptoms would not begin to appear until after stores were depleted 1 to 2 years for a healthy adult but much sooner for a growing child. Then the consequences would be profound and severe.**

- **An estimated 250 million children worldwide have some degree of vitamin A deficiency and thus are vulnerable to infectious diseases and blindness.**
- **About 1 to 2 percent of them become blind every year, half of them dying within a year of losing their sight. Routine vitamin A supplementation and food fortification can be a life-saving intervention.**

Infectious Diseases

- **Vitamin A supports immune function and inhibits replication of the measles virus.**
- **The severity of the illness often correlates with the degree of vitamin A deficiency; deaths are usually due to related infections such as pneumonia and severe diarrhea. Providing large doses of vitamin A reduces the risk of dying from these infections by half.**

- **Vitamin A supplements protect against blindness and the complications of other life-threatening infections, including malaria, lung diseases, and HIV (human immunodeficiency virus, the virus that causes AIDS).**

Night Blindness

- **Night blindness is one of the first detectable signs of vitamin A deficiency and permits early diagnosis.**
- **In night blindness, the retina does not receive enough retinal to regenerate the visual pigments bleached by light.**
- **The person loses the ability to recover promptly from the temporary blinding that follows a flash of bright light at night or to see after dark.**

Blindness (Xerophthalmia)

- **Beyond night blindness is total blindness—failure to**
- **see at all. Night blindness is caused by a lack of vitamin A at the back of the eye, the retina; total blindness is caused by a lack of vitamin A at the front of the eye, the cornea.**
- **Severe vitamin A deficiency is the leading cause of preventable blindness.**

- **Blindness due to vitamin A deficiency, known as xerophthalmia, develops in stages. At first, the cornea becomes dry and hard because of inadequate mucous production—a condition known as xerosis. Then xerosis quickly progresses to keratomalacia, the softening of the cornea that leads to irreversible blindness.**

Keratinization

- **Vitamin A deficiency affects other surfaces of the body.**
- **On the body's outer surface, the epithelial cells change shape and begin to secrete the protein keratin—the hard, inflexible protein of hair and nails. shows, the skin becomes dry, rough, and scaly as lumps of keratin accumulate (keratinization). Without vitamin A, the goblet cells in the GI tract diminish in number and activity, limiting the secretion of mucus.**

With less mucus, normal digestion and absorption of nutrients falter, and this, in turn, worsens malnutrition by limiting the absorption of whatever nutrients the diet may deliver. Similar changes in the cells of other epithelial tissues weaken defenses, making infections of the respiratory tract, the GI tract, the urinary tract, and inner ear likely.

Vitamin A Toxicity

- **Toxicity is a real possibility when concentrated amounts of preformed vitamin A in foods derived from animals, fortified foods, or supplements is consumed.**
- **Children are most vulnerable to toxicity because they need less vitamin A and are more sensitive to overdoses.**
- **An Upper Level (UL) has been set for preformed vitamin A.**
- **Even multivitamin supplements provide more vitamin A than most people need.**

- **Beta-carotene, which is found in a wide variety of fruits and vegetables, is not converted efficiently enough in the body to cause vitamin A toxicity; instead, it is stored in the fat just under the skin.**
- **Although overconsumption of beta-carotene from foods may turn the skin yellow, this is not harmful. In contrast, overconsumption of beta-carotene from supplements may be quite harmful.**

- **In excess, this antioxidant may act as a prooxidant. Adverse effects of beta-carotene supplements are most evident in people who drink alcohol and smoke cigarettes.**

Bone Defects

- **Excessive intake of vitamin A over the years may weaken the bones and contribute to fractures and osteoporosis.**
- **Vitamin A suppresses bone-building activity, stimulates bone-dismantling activity, and interferes with vitamin D's ability to maintain normal blood calcium.**

Birth Defects

- **Excessive vitamin A during pregnancy leads to abnormal cell death in the spinal cord, which increases the risk of birth defects. In such cases, vitamin A is considered a teratogen.**
- **High intakes (10,000 IU of supplemental vitamin A daily) before the seventh week of pregnancy appear to be the most damaging. For this reason, vitamin A is not given as a supplement in the first trimester of pregnancy without specific evidence of deficiency, which is rare.**

Not for Acne

- **Adolescents need to know that massive doses of vitamin A have no beneficial effect on acne. The prescription medicine Accutane is made from vitamin A but is chemically different.**
- **Taken orally, Accutane is effective against the deep lesions of cystic acne. It is highly toxic, however, especially during growth, and has caused birth defects in infants when women have taken it during their pregnancies.**

- **For this reason, women taking Accutane must agree to pregnancy testing and to using contraception from at least 1 month before taking the drug through at least 1 month after discontinuing its use. Should they become pregnant, they need to stop taking Accutane immediately and notify their physician.**
- **Another vitamin A relative, Retin-A, fights acne, the wrinkles of aging, and other skin disorders. Applied topically, this ointment smooths and softens skin; it also lightens skin that has become darkly pigmented after inflammation. During treatment, the skin becomes red and tender and peels.**

Vitamin A in Foods

- **The richest sources of the retinoids are foods derived from animals liver, fish liver oils, milk and milk products, butter, and eggs.**
- **Because vitamin A is fat soluble, it is lost when milk is skimmed. To compensate, reduced-fat, low-fat, and fat-free milks are often fortified so as to supply 6 to 10 percent of the Daily Value per cup. Margarine is usually fortified to provide the same amount of vitamin A as butter.**

- **Plants contain no retinoids, but many vegetables and some fruits contain vitamin A precursors—the carotenoids.**
- **Only a few carotenoids have vitamin A activity; the carotenoid with the greatest vitamin A activity is beta-carotene. Beta-carotene is a rich, deep yellow, almost orange compound. The beta-carotene in dark green, leafy vegetables is abundant, but masked by large amounts of the green pigment chlorophyll. Attractive meals that include colorful fruits and vegetables are likely to provide vitamin A.**

The Colors of Vitamin A Foods

- **Dark leafy greens like spinach and rich yellow or deep orange vegetables and fruits (such as cantaloupe, carrots, and sweet potatoes) help people meet their vitamin A needs.**
- **A diet including several servings of such carotene-rich sources helps to ensure a sufficient intake.**
- **Bright color is not always a sign of vitamin A activity, however. Beets and corn, for example, derive their colors from the red and yellow xanthophylls, which have no vitamin A activity.**
- **White plant foods such as potatoes, cauliflower, pasta, and rice, they also offer little or no vitamin A. Similarly, fast foods often lack vitamin A.**

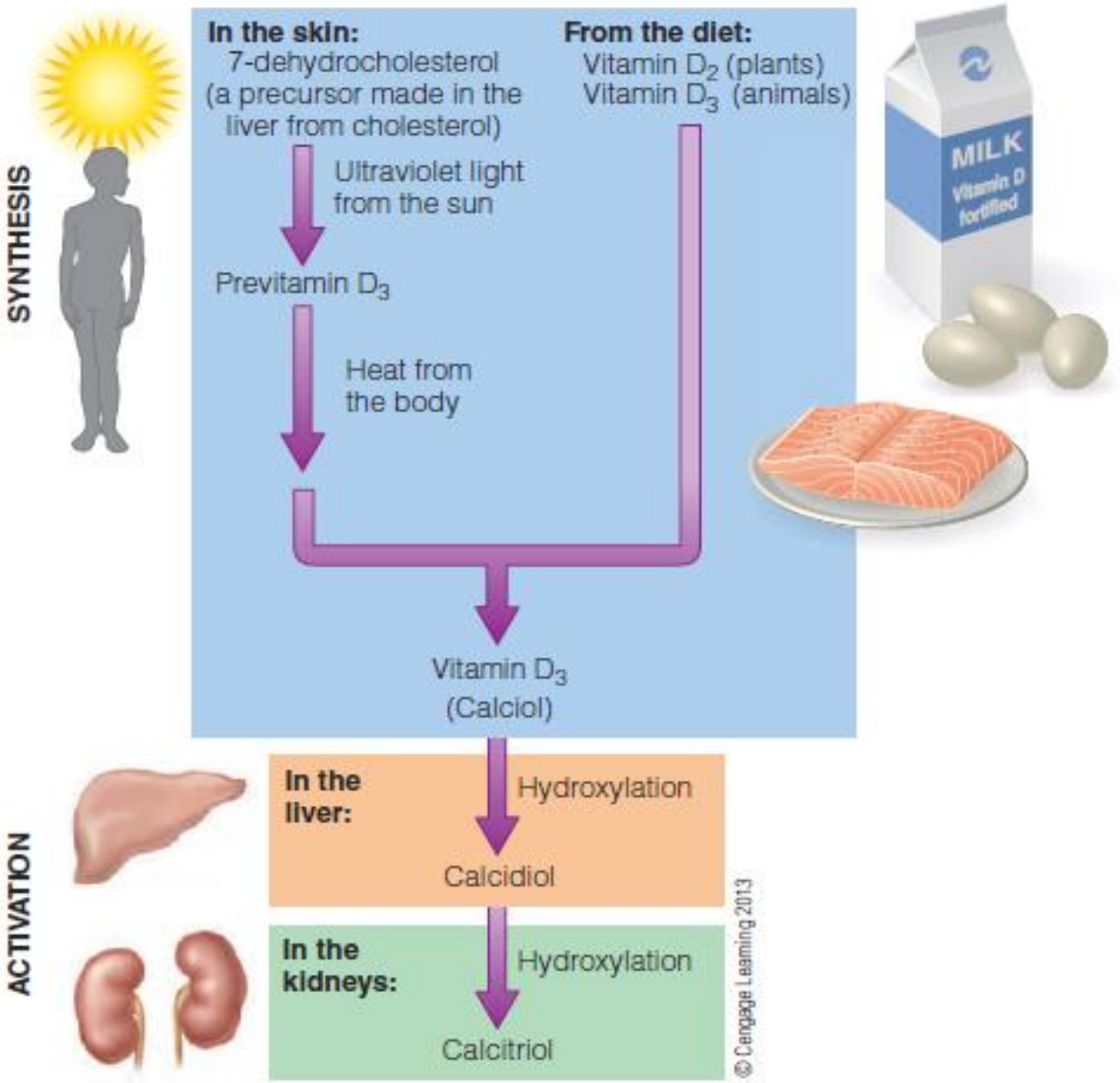
Vitamin A–Rich Liver

- **People sometimes wonder if eating liver too frequently can cause vitamin A toxicity.**
- **Liver is a rich source because vitamin A is stored in the livers of animals, just as in humans.**
- **Arctic explorers who have eaten large quantities of polar bear liver have become ill with symptoms suggesting vitamin A toxicity. Liver offers many nutrients, and eating it periodically may improve a person's nutrition status, but caution is warranted not to eat too much too often, especially for pregnant women.**

Vitamin D

- **Vitamin D differs from the other nutrients in that the body can synthesize it, with the help of sunlight, from a precursor that the body makes from cholesterol. Therefore, vitamin D is not an essential nutrient.**
- **Also known as calciferol, vitamin D comes in two major forms. Vitamin D2 (or ergocalciferol) derives primarily from plant foods in the diet. Vitamin D3 (or cholecalciferol) derives from animal foods in the diet and from synthesis in the skin. These two forms of vitamin D are similar and both must be activated before they can fully function.**

- **To make vitamin D, ultraviolet rays from the sun hit a precursor in the skin and convert it to previtamin D3, which is converted to vitamin D3 with the help of the body's heat. To activate vitamin D—whether made in the body or consumed from the diet**
- **Two hydroxylation reactions must occur. First, the liver adds an OH group, and then the kidneys add another OH group to produce the active vitamin. As you might expect, diseases affecting either the liver or the kidneys can interfere with the activation of vitamin D and produce symptoms of deficiency.**


SYNTHESIS
In the skin:
7-dehydrocholesterol
(a precursor made in the liver from cholesterol)
Ultraviolet light from the sun
Previtamin D_3
Heat from the body
From the diet:
Vitamin D_2 (plants)
Vitamin D_3 (animals)
MILK
Vitamin D fortified
Vitamin D_3
(Calciol)
ACTIVATION
In the liver:
Hydroxylation
Calcidiol
In the kidneys:
Hydroxylation
Calcitriol
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Roles in the Body

- **Though called a vitamin, the active form of vitamin D is actually a hormone a compound manufactured by one part of the body that travels through the blood and causes another body part to respond.**
- **Like vitamin A, vitamin D has a binding protein that carries it to the target organs most notably, the intestines, the kidneys, and the bones. All respond to vitamin D by making the minerals needed for bone growth and maintenance available.**

- **Vitamin D in Bone Growth Vitamin D is a member of a large and cooperative bone-making and maintenance team composed of nutrients and other compounds, including vitamins A and K; the hormones parathyroid hormone and calcitonin; the protein collagen; and the minerals calcium, phosphorus, magnesium, and fluoride.**
- **Vitamin D's special role in bone health is to assist in the absorption of calcium and phosphorus, thus helping to maintain blood concentrations of these minerals. The bones grow denser and stronger as they absorb and deposit these minerals.**

- **Vitamin D raises blood concentrations of bone minerals in three ways.**
- **When the diet is sufficient, vitamin D enhances their absorption from the GI tract.**
- **When the diet is insufficient, vitamin D provides the needed minerals from other sources: reabsorption by the kidneys and mobilization from the bones into the blood. The vitamin may work alone, as it does in the GI tract, or in combination with parathyroid hormone, as it does in the bones and kidneys.**

Vitamin D in Other Roles

- **Scientists have discovered many other tissues that respond to vitamin D, including cells of the immune system, brain and nervous system, pancreas, skin, muscles and cartilage, and reproductive organs.**
- **In many cases, vitamin D enhances or suppresses the activity of genes that regulate cell growth.**
- **Recent research suggests that vitamin D may protect against tuberculosis, inflammation, multiple sclerosis, macular degeneration, hypertension, and some cancers.**

Vitamin D Deficiency

- **Overt signs of vitamin D deficiency are relatively rare, but vitamin D insufficiency is remarkably common.**
- **Factors that contribute to vitamin D deficiency include dark skin, breastfeeding without supplementation, lack of sunlight, and not using fortified milk.**
- **In vitamin D deficiency, production of calbindin, a protein that binds calcium in the intestinal cells, slows.**

- **Thus, even when calcium in the diet is adequate, it passes through the GI tract unabsorbed, leaving the bones undersupplied.**
- **Consequently, a vitamin D deficiency creates a calcium deficiency and increases the risks of several chronic diseases and osteoporosis. Vitamin D–deficient adolescents do not reach their peak bone mass.**

Rickets

- **Worldwide, the prevalence of the vitamin D–deficiency disease rickets is extremely high, affecting more than half of the children in countries.**
- **To prevent rickets, the American Academy of Pediatrics recommends a supplement for all infants, children, and adolescents who do not receive enough vitamin D.**
- **In rickets, the bones fail to calcify normally, causing growth retardation and skeletal abnormalities.**

- **The bones become so weak that they bend when they have to support the body's weight. A child with rickets who is old enough to walk characteristically develops bowed legs, often the most obvious sign of the disease.**
- **Another sign is the beaded ribs that result from the poorly formed attachments of the bones to the cartilage.**

Osteomalacia

- **In adults, the poor mineralization of bone results in the painful bone disease osteomalacia. The bones become increasingly soft, flexible, brittle, and deformed.**

Osteoporosis (reduced bone density)

- **Any failure to synthesize adequate vitamin D or obtain enough from foods sets the stage for a loss of calcium from the bones, which can result in fractures. describes the many factors that lead to osteoporosis.**

The Elderly

- **Vitamin D deficiency is especially likely in older adults for several reasons. For one, the skin, liver, and kidneys lose their capacity to make and activate vitamin D with advancing age. For another, older adults typically drink little or no milk the main dietary source of vitamin D. And finally, older adults typically spend much of the day indoors, and when they do venture outside, many of them cautiously wear protective clothing or apply sunscreen to all sun-exposed areas of their skin.**

- **All of these factors increase the likelihood of vitamin D deficiency and its consequences: bone losses and fractures. Vitamin D supplementation helps to raise blood levels, reduce bone loss, improve muscle performance, and lower the risks of falls and fractures in elderly persons.**

Vitamin D Toxicity

- **Vitamin D clearly illustrates how nutrients in optimal amounts support health, but both inadequacies and excesses create harm. Vitamin D is among the most likely of the vitamins to have toxic effects when consumed in excessive amounts.**
- **The amounts of vitamin D made by the skin and found in foods are well within the safe limits set by the UL, but supplements containing the vitamin in concentrated form should be kept out of the reach of children and used cautiously, if at all, by adults.**

- **Excess vitamin D raises the concentration of blood calcium. Excess blood calcium tends to precipitate in the soft tissue, forming stones, especially in the kidneys where calcium is concentrated in an effort to excrete it.**
- **Calcification may also harden the blood vessels and is especially dangerous in the major arteries of the brain, heart, and lungs, where it can cause death.**

Vitamin D Recommendations and Sources

- **Only a few foods contain vitamin D naturally. Fortunately, the body can make vitamin D with the help of a little sunshine. In setting dietary recommendations, however, the DRI Committee assumed that no vitamin D was available from skin synthesis.**
- **In order to reach sufficient levels of vitamin D in the blood without contributions from the sun, dietary recommendations were recently increased. Some research suggests that vitamin D recommendations should be higher still.**

Vitamin D in Foods

- **Most adults, especially in sunny regions, need not make special efforts to obtain vitamin D from food. People who are not outdoors much or who live in northern or predominantly cloudy or smoggy areas are advised to drink at least 2 cups of vitamin D–fortified milk a day.**
- **The fortification of milk and other foods with vitamin D is the best guarantee that people will meet their needs.**
- **Egg yolks and oily fish such as salmon, mackerel, and sardines are the best natural sources of vitamin D.**

- **Meeting vitamin D needs is difficult without adequate sunshine, fortification, or supplementation.**
- **Vegetarians who do not include milk in their diets may use vitamin D–fortified soy milk and cereals.**
- **Importantly, feeding infants and young children nonfortified "health beverages" instead of milk or infant formula can create severe nutrient deficiencies, including rickets.**

Vitamin D from Supplements

- **Some people may benefit from taking vitamin D supplements. Vitamin D can be found in multivitamin mineral supplements as well as a high-dose single supplement.**
- **As a single supplement, vitamin D3 is less expensive, more commonly available, and more potent than vitamin D2.**
- **Taking vitamin D supplements with the largest meal of the day improves absorption, resulting in a 50 percent increase in blood levels.**

Vitamin E

- **A component of vegetable oils necessary for reproduction in rats.**
- **Anti-sterility factor tocopherol.**
- **All tocopherols (Alpha, beta, gamma, and delta) consist of a complex ring structure and a long saturated side chain.**
- **The positions of methyl groups (CH3) on the side chain and their chemical rotations distinguish one tocopherol from another.**
- **Alpha-tocopherol is currently the only one recognized as having vitamin E activity in the human body**

Vitamin E as an Antioxidant

- **Vitamin E is a fat-soluble antioxidant and one of the body's primary defenders against the adverse effects of free radicals. Its main action is to stop the chain reaction of free radicals from producing more free radicals.**
- **Vitamin E protects the vulnerable components of the cells and their membranes from destruction.**

- **Vitamin E prevents the oxidation of the polyunsaturated fatty acids, but it protects other lipids and related compounds (for example, vitamin A) as well.**
- **Vitamin E may reduce the risk of heart disease by protecting low-density lipoproteins (LDL) against oxidation and reducing inflammation.**

Vitamin E Deficiency

- **A primary deficiency of vitamin E (from poor dietary intake) is rare; deficiency is usually associated with diseases of fat malabsorption such as cystic fibrosis.**
- **Without vitamin E, the red blood cells break and spill their contents, probably due to oxidation of the polyunsaturated fatty acids in their membranes (erythrocyte hemolysis),**
- **Erythrocyte hemolysis is seen in premature infants born before the transfer of vitamin E from the mother to the infant that takes place in the last weeks of pregnancy.**

- **Vitamin E treatment corrects hemolytic anemia.**
- **Prolonged vitamin E deficiency also causes neuromuscular dysfunction involving the spinal cord and retina of the eye. Common symptoms include loss of muscle coordination and reflexes and impaired vision and speech.**
- **Vitamin E treatment corrects these neurological symptoms of vitamin E deficiency.**

- **Two other conditions seem to respond to vitamin E treatment, although results are inconsistent. One is fibrocystic breast disease, a nonmalignant breast disease. The other is intermittent claudication, an abnormality of blood flow that causes cramping in the legs.**

Vitamin E Toxicity

- **Liver carefully regulates vitamin E concentrations. Toxicity is rare, and vitamin E appears safe across a broad range of intakes.**
- **The UL for vitamin E (1000 milligrams) is more than 65 times greater than the recommended intake for adults (15 milligrams).**

Vitamin E Recommendations

- **The RDA for vitamin E is based on the alpha-tocopherol form only.**
- **A person who consumes large quantities of polyunsaturated fatty acids needs more vitamin E. Fortunately, vitamin E and polyunsaturated fatty acids tend to occur together in the same foods.**

Vitamin E in Foods Vitamin

- **E is widespread in foods. Much of the vitamin E in the diet comes from vegetable oils and products made from them, such as margarine and salad dressings. Wheat germ oil is especially rich in vitamin E.**
- **Because vitamin E is readily destroyed by heat processing (such as deep-fat frying) and oxidation, fresh or lightly processed foods are preferable sources.**
- **Most processed and convenience foods do not contribute enough vitamin E to ensure an adequate intake.**

Vitamin K

- **Vitamin K can be obtained both from foods and from a nonfood source. Bacteria in the GI tract synthesize vitamin K that the body can absorb. Vitamin**
- **K appropriately gets its name from the Danish word koagulation ("coagulation" or "clotting"). Its primary action is blood clotting, where its presence can make the difference between life and death.**
- **Blood has a remarkable ability to remain liquid, but it can clot within seconds when the integrity of that system is disturbed.**

Roles in the Body

- **More than a dozen different proteins and the mineral calcium are involved in making a blood clot.**
- **Vitamin K is essential for the activation of several of these proteins, among them prothrombin, made by the liver as a precursor of the protein thrombin.**
- **When any of the blood-clotting factors is lacking, hemorrhagic disease results.**

- **If an artery or vein is cut or broken, bleeding goes unchecked.**
- **Hemorrhaging is not always caused by vitamin K deficiency. Another cause is the genetic disorder hemophilia.**

- **Vitamin K also participates in the metabolism of bone proteins, most notably osteocalcin.**
- **Without vitamin K, osteocalcin cannot bind to the minerals that normally form bones, resulting in low bone density.**
- **An adequate intake of vitamin K helps to decrease bone turnover and protect against fractures. The effectiveness of vitamin K supplements on bone health is inconclusive.**
- **Vitamin K is historically known for its role in blood clotting, and more recently for its participation in bone building, but researchers continue to discover proteins needing vitamin K's assistance. These proteins have been identified in the plaques of atherosclerosis, the kidneys, and the nervous system.**

Vitamin K Deficiency

- **A primary deficiency of vitamin K is rare, but a secondary deficiency may occur in two circumstances. First, whenever fat absorption falters, as occurs when bile production fails, vitamin K absorption diminishes. Second, some drugs disrupt vitaminK's synthesis and action in the body: antibiotics kill the vitamin K–producing bacteria in the intestine, and anticoagulant drugs interfere with vitamin K metabolism and activity.**

- **Excessive bleeding due to a vitamin K deficiency can be fatal.**
- **Newborn infants present a unique case of vitamin K nutrition because they are born with a sterile intestinal tract, and the vitamin K–producing bacteria take weeks to establish themselves. At the same time, plasma prothrombin concentrations are low. This reduces the likelihood of fatal blood clotting during the stress of birth.**
- **To prevent hemorrhagic disease in the newborn, a single dose of vitamin K is given at birth by intramuscular injection.**

Vitamin K Toxicity

- **Toxicity is not common, and no adverse effects have been reported with high intakes of vitamin K. Therefore, a UL has not been established. High doses of vitamin K can, however reduce the effectiveness of anticoagulant drugs used to prevent blood clotting.**
- **People taking these drugs can continue eating their usual diets. Their blood clotting times should be monitored closely and drug dosages adjusted accordingly**

Vitamin K Recommendations and Sources

- **Vitamin K is made in the GI tract by the billions of bacteria that normally reside there. Once synthesized, vitamin K is absorbed and stored in the liver. This source provides only about half of a person's needs.**
- **Vitamin K–rich foods such as green vegetables and vegetable oils can easily supply the rest.**