Chapter 11
Fat Soluble Vitamins
Vitamin A and Beta-Carotene
Overview
Vitamin A is found in the body in compounds known as retinoids: retinol, retinal, and retinoic acid. These have functional roles in vision, healthy epithelial cells, and growth.
Animal foods provide compounds that are easily converted to retinol.
Plant foods provide carotenoids, such as beta-carotene, some of which have vitamin A activity.
Retinol binding protein (RBP) allows vitamin A to be transported throughout the body.
Toxicity is often associated with abuse of supplements.
Vitamin A deficiency is a major health problem in the world.
Vitamin A and Beta-Carotene
Vitamin A, first fat-soluble vitamin recognized
Precursor – beta-carotene
Three different forms
Retinol, retinal, and retinoic acid
Conversion to other forms
Animal Foods- Absorbed as retinol
Plant Foods-Beta-carotene
Split to form retinol in the intestine and liver
Forms of Vitamin A
Vitamin A is found in the body in compounds known as retinoids: retinol, retinal, and retinoic acid.
Transport and Storage
Vitamin A is stored in the liver
Transported in the bloodstream by
Retinol-Binding Protein (RBP)
Each form of vitamin A has its own receptor protein within the cells.
Vitamin A and Beta-Carotene – Roles in the Body
Major roles
Vision
Protein synthesis and cell differentiation
Reproduction and growth
Vitamin A and Beta-Carotene – Roles in the Body
Retinol
Supports reproduction
Major transport and storage form
Retinal
Active in vision
Retinoic acid
Regulates cell differentiation, growth, and embryonic development
Conversion of Vitamin A Compounds
Forms of Vitamin A
The Retinoids
Vitamin A and Beta-Carotene
Roles in the Body
Vitamin A in Vision
Helps to maintain the cornea
Conversion of light energy into nerve impulses at the retina
Rhodopsin
light-sensitive pigment of the retina
contains a protein called opsin, bonded to retinal
Stimulates nerve impulse to send a message to the brain
Vitamin A’s Role in Vision
Vitamin A’s Role in Vision
Vitamin A’s Role in Vision
Vitamin A and Beta-Carotene
Roles in the Body
Vitamin A in Protein Synthesis
Vitamin A maintains integrity of epithelial cells
Epithelial tissues on the outside of the body form the skin.
Epithelial tissues on the inside of the body form the mucous membranes.
Linings of the mouth, stomach, intestines, lungs, bladder, uterus, eyelids, sinus passageways

Vitamin A and Beta-Carotene
Roles in the Body
Vitamin A in Reproduction and Growth
Sperm development in men
Normal fetal development in women
Growth in children
Bone Remodeling: Vitamin A helps break down bone to allow for new bone growth
Vitamin A and Beta-Carotene
Roles in the Body
Beta-Carotene as an Antioxidant
Beta-carotene helps protect the body from diseases, including cancer.
Vitamin A and Beta-Carotene
Vitamin A Deficiency
Deficiency disease is called Hypovitaminosis A
Because vitamin A is stored in the body, it would take a year or more to develop a deficiency in the presence of inadequate intake.
1-2 years in healthy adult; sooner in growing child
Uncommon in U.S.
250 million children worldwide are affected
Routine Vitamin A supplementation is life saving
Vitamin A and Beta-Carotene
Vitamin A Deficiency
Infectious Diseases
Impaired immunity correlates with vitamin A deficiency in children.
Severity of the illness correlates with the degree of Vitamin A
deficiency (measles, pneumonia, diarrhea)
   – The goals of worldwide health organizations include vitamin A supplementation.
Vitamin A and Beta-Carotene
Vitamin A Deficiency
Night Blindness
First detectable sign of vitamin A deficiency
Inability to see in dim light or inability to recover sight after a flash of bright light
Vitamin A Deficiency
   ▪ Blindness
   Xerophthalmia is blindness due to vitamin A deficiency.
Xerosis is the first stage where the cornea becomes dry and hard;
Lack of vitamin A at cornea
Keratomalacia is the softening of the cornea.
Vitamin A deficiency is major cause of childhood blindness in the world
More than 500,000 preschool children lose sight annually
Vitamin A Deficiency
Vitamin A Deficiency
Keratinization
Epithelial cells secrete a protein keratin
Hard, inflexible protein of hair and nails.
Changes in epithelial cells results in keratinization, rough, dry and scaly skin.
Gastrointestinal tract
Goblet cells diminish, limits mucus
Decreased absorption of nutrients
Increased infections
Vitamin A and
Beta-Carotene
Vitamin A Toxicity
Can occur with concentrated amounts of the preformed Vitamin A or beta-carotene
from animal foods, fortified foods, or supplements.
Excessive beta-carotene from foods will not cause vitamin A toxicity
However, it can cause people to turn a bright yellow due to deposition in subcutaneous fat
Vitamin A and Beta-Carotene

Vitamin A Toxicity
Toxicity disease is called Hypervitaminosis A
Chronic toxicity symptoms include liver abnormalities.
Acute toxicity symptoms include blurred vision, nausea, vomiting, vertigo, headaches, and pressure in the skull.
Upper level for adults: 3000 μg/day

Vitamin A and Beta-Carotene

Bone Defects
Increased activity of osteoclasts causes weakened bones
Increased risk of osteoporosis

Birth Defects
Abnormal fetal development and birth defects.

Vitamin A supplements are not recommended the first trimester of pregnancy.

Not for Acne
Massive doses of Vitamin A are not effective on acne.

Accutane is made from vitamin A

Vitamin A fights acne, the wrinkles of aging, and other skin disorders.

Vitamin A

Carotenoids and Diseases
Lack of dietary beta-carotene increases the risk of the most common form of untreatable age-related blindness, macular degeneration
Progressive loss of function of the part of the retina most crucial to vision

Vitamin A
(continued)

Recommendations:
Men- 900 micrograms RAE (retinal activity equivalent)
Women- 700 micrograms RAE
1 RAE = 12 mcg beta-carotene

Sources:
Vitamin A-Animal Origin:
Liver, fish, fortified milk, cheese, cream, butter, fortified margarine, and eggs.

Vitamin A and Beta-Carotene

Vitamin A in Plant Foods

Beta-carotene
Spinach and other dark green leafy vegetables (chlorophyll pigment masks the color)
Deep orange fruits like apricots and cantaloupe
Deep orange vegetables like squash, carrots, sweet potatoes, and pumpkin
White foods are typically low in beta-carotene. Vitamin A is poor in fast foods and foods with the xanthophyll pigments (beets, corn).

Vitamin A and Beta-carotene in Foods
RDA for men: 900mcg RE         RDA for women: 700mcg RE
1 RAE = 12 mcg beta-carotene

Vitamin D
Also known as calciferol, 1,25-dihydroxy vitamin D (calcitriol), vitamin D \(_3\) or cholecalciferol, vitamin D \(_2\) or ergocalciferol

Vitamin D is a nonessential nutrient that acts like a hormone in the body. The body can make vitamin D with help from sunlight. Once the vitamin enters the body it must become activated. Activation occurs through the action of the liver and the kidneys.

Vitamin D
Not an essential nutrient
Body synthesizes
Sunlight
Precursor from cholesterol
Activation of vitamin D
Two hydroxylation reactions
Liver
Kidneys

**Functions:**
Bone Growth-
Makes calcium and phosphorus available in the bloodstream for use in bone growth.
Enhances absorption from the G.I. tract
Enhances calcium reabsorption by the kidneys
Stimulates calcium mobilization from bones into the blood

Vitamin D
Roles in the Body
Vitamin D in Other Roles
Immune system
Brain and nervous system
Pancreas, skin, muscles, cartilage, and reproductive organs

Vitamin D
Vitamin D Deficiency
Factors that contribute to deficiency
Dark skin
Breastfeeding without supplementation
Lack of sunlight
Use of nonfortified milk
Vitamin D
Vitamin D Deficiency
Rickets
Affects mainly children worldwide
Deficiency symptoms
Inadequate calcification of bones
Growth retardation
Misshapen bones including bowing of the legs
Enlargement of the ends of long bones
Deformities of ribs
Delayed closing of fontanel thus rapid enlargement of the head
Lax muscles (resulting in a protruding abdomen) and muscle spasms
Vitamin D
Deficiency symptoms: rickets in children (continued)
Delayed closing of fontanel, resulting in rapid enlargement of head
Vitamin D
Vitamin D Deficiency
Osteomalacia
Affects adults
Soft, flexible, brittle, and deformed bones
Progressive weakness
Pain in pelvis, lower back, and legs
Vitamin D
Vitamin D Deficiency
Osteoporosis
Loss of calcium from the bones due to inadequate synthesis of vitamin D
Results in a reduced bone density
The Elderly
Inadequate production and activation of vitamin D
Decreased consumption of milk
Having little time in the sun.
There is an increased risk for bone loss and fractures.
Vitamin D
Vitamin D Toxicity
Upper level for adults: 50 μg/day
Toxicity disease is called Hypervitaminosis D
Raises blood calcium
Excess calcium forms stones in soft tissue such as kidney stones, blood vessels, heart
Vitamin D
Vitamin D Recommendations (1997 Adequate Intake) and Sources
AI 5 μg/day for adults 19-50 years old
AI 10 μg/day for adults 51-70 years old
AI 15 μg/day for adults if older than 70 years of age
Vitamin D
Vitamin D Recommendations
Vitamin D in Foods
Fortified milk, butter, and margarine
Cereals
Veal, beef, egg yolks, liver, fatty fish and their oils
Vegans may need fortification or supplements if they do not have adequate sun exposure.
Vitamin D
Vitamin D Recommendations
Vitamin D from the Sun
Synthesized in the body from cholesterol
SPF of 8 or above prevents the synthesis of vitamin D from sunlight.
Can be obtained from tanning beds depending on type of UV radiation.
Vitamin D
Vitamin D from the Sun
In most places, during warmer months, just being outdoors when the sun is overhead, even in lightweight clothing, promotes sufficient skin synthesis of vitamin D
Approximately 5-10 minutes, 2-3 times per week is usually adequate sun exposure
Factors affecting sun exposure and vitamin D synthesis:
Skin color, air pollution, city living, clothing, geography, indoor lifestyle, season, sunscreen, time of day
SPF of 8 or above prevents the synthesis of vitamin D from sunlight.
Vitamin D
Adolescents who consume soft drinks rather than fortified milk and who prefer indoor to outdoor activities often lack the vitamin D that is needed to prevent later in life bone loss
Vitamin E
Alpha-tocopherol
Vitamin E as an Antioxidant
Stops the chain reaction of free radicals
Protection of polyunsaturated fatty acids and vitamin A
Protects the oxidation of LDLS
Vitamin E
Vitamin E and Free Radicals
Vitamin E
Vitamin E Deficiency
Primary deficiency due to inadequate intake is rare
Erythrocyte hemolysis
Red blood cells break open
Occurs in premature infants prior to transfer of Vitamin E from Mom
Hemolytic anemia can be treated with vitamin E.
Loss of muscle coordination and reflexes
Impaired vision and speech
Nerve damage
Vitamin E
Vitamin E Toxicity
Rare and the least toxic of the fat-soluble vitamins
Upper level for adults: 1000 mg/day
May augment the effects of anticlotting medication
Vitamin E Recommendations (2000 RDA)
RDA adults: 15 mg/day
Vitamin E
Vitamin E in Foods
Polyunsaturated plant oils such as margarine, salad dressings, and shortenings
Leafy green vegetables
Wheat germ
Whole grains
Liver and egg yolks
Nuts and seeds
Easily destroyed by heat and oxygen
Antioxidant Nutrients
Beta Carotene- High intake of fruits and vegetables rich in beta carotene-
Low rate lung cancer.
Vitamin C- High intake of foods rich in C
Seems to protect against mouth, laryngeal and esophageal cancer.
Vitamin E- May protect against heart disease.
Antioxidant Nutrients
Fruits and vegetables strengthen antioxidant defenses against LDL oxidation.
Vitamin E defends against LDL oxidation, inflammations, arterial injuries and blood clotting.
Vitamin C may protect against LDL oxidation, raises HDL, lowers total cholesterol and improves blood pressure.
Vitamin K
Vitamin K is unique
half of human needs are met through intestinal bacteria that synthesize Vitamin K
Roles in the Body
Synthesis of blood-clotting proteins
Activates prothrombin, precursor of thrombin
Synthesis of bone proteins that bind calcium (osteocalcin)
Hemophilia is a hereditary disorder and is not cured with vitamin K.
Vitamin K
Chief functions in the body
Synthesis of blood-clotting proteins and bone proteins that regulate blood calcium
Vitamin K
Vitamin K Deficiency
Primary deficiency is rare
Secondary deficiency may occur-
due to fat malabsorption
Disruption of Vit K Synthesis-
antibiotics
anticoagulants
Symptoms include hemorrhaging

**Newborn infants receive a single dose of vitamin K at birth because of a sterile intestinal tract.**

Vitamin K

Vitamin K Toxicity

Uncommon

No known toxicities

High doses can decrease the effectiveness of anti-clotting medications.

Vitamin K Sources

Bacterial synthesis in the digestive tract

Significant Food Sources

Liver

Leafy green vegetables and cabbage-type vegetables

Milk

End of Chapter 11

Fat Soluble Vitamins