Chapter 7: Vitamins
Objectives for Chapter 7

- Explain what vitamins are, their functions, and how to preserve them in food.
- Describe the storage of the fat-soluble vitamins.
- Describe the role water-soluble vitamins play as coenzymes.
- Name the functions, sources, and deficiency/toxicity of:
  - vitamin A
  - vitamin E
  - vitamin K
  - vitamin D
  - thiamin
  - riboflavin
  - niacin
  - vitamin B₆
  - folate
  - vitamin B₁₂
  - vitamin C
  - pantothenic acid and biotin
- Name other vitamin-like substances the body needs.
- Explain the role of vitamin supplements and fortified foods in your diet.
What Are Vitamins?

- Vitamins are essential nutrients
  - Tasteless, organic compounds needed in small amounts
  - A deficiency will cause physiological symptoms
  - Consuming too much of some vitamins will cause adverse effects
<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Fruit</th>
<th>Grains</th>
<th>Protein</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folate</td>
<td>Folate</td>
<td>Folic acid</td>
<td>Niacin</td>
<td>Riboflavin</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Vitamin C</td>
<td>Niacin</td>
<td>Thiamin</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Vitamin A</td>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</td>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</td>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
</tr>
<tr>
<td>Vitamin E</td>
<td></td>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
<td>Vitamin D</td>
<td></td>
</tr>
<tr>
<td>Vitamin K</td>
<td></td>
<td>(if fortified)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Riboflavin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiamin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.1
What Are Vitamins?, Continued

• Vitamins are either fat-soluble or water-soluble
  • Fat-soluble vitamins (A, D, E, and K) are absorbed with dietary fat and can be stored in body
  • Water-soluble vitamins (B vitamins and C) are absorbed with water and enter the bloodstream directly
    • Not stored in body, but excesses can still be harmful
Categorizing the Vitamins: Fat-Soluble and Water-Soluble

Figure 7.2
Absorbing Vitamins

Figure 7.3
# Table 7.1 Fat-Soluble vs Water-Soluble Vitamins

<table>
<thead>
<tr>
<th></th>
<th>Fat Soluble: A, D, E, K</th>
<th>Water Soluble: Bs and C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>Needed in small amounts</td>
<td>Needed in small amounts</td>
</tr>
<tr>
<td>Absorption</td>
<td>Need fat to be absorbed</td>
<td>Absorbed with water</td>
</tr>
<tr>
<td></td>
<td>Absorbed in upper part of small intestine</td>
<td>Most absorbed in upper part of the small intestine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vitamin $B_{12}$ absorbed in the lower part of the small intestine</td>
</tr>
<tr>
<td>Transport through Body</td>
<td>Packed in micelles and chylomicrons in lymph</td>
<td>Enter bloodstream directly</td>
</tr>
<tr>
<td>Storage in Body</td>
<td>Stored in liver, fat, and muscle tissue</td>
<td>Not stored in body</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excess amounts excreted in the urine</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Can be toxic in high doses</td>
<td>Low risk of toxicity, <em>but</em> excesses can be harmful</td>
</tr>
<tr>
<td>Major Food Sources</td>
<td>Fortified milk, oils</td>
<td>Fortified grains, whole fruits, vegetables, and some animal food sources</td>
</tr>
</tbody>
</table>
Some vitamins function as **antioxidants**, which counteract **oxidation** by neutralizing substances called free radicals.

- Vitamins A, C, and E, and beta-carotene are antioxidants
- **Free radicals** are unstable oxygen-containing molecules that can damage the cells of the body and possibly contribute to increased risk of chronic diseases
Free Radicals and Antioxidants

Free radicals are the by-products of:
- Normal reactions in the body
- Chemicals in the environment
- Smoking
- Ultraviolet light

Oxidative stress

Free radicals (unstable molecules that damage cells)

Which can accelerate the process of aging and increase risk of:
- Heart disease
- Cancer
- Diabetes
- Arthritis
- Macular degeneration
- Parkinson’s disease
- Alzheimer’s disease

Antioxidants help neutralize free radicals, limiting the damage that free radicals cause and helping to reduce the risk of many chronic diseases.

Antioxidants

“Neutralized” free radicals

Figure 7.4
Free Radical Formation
Normal and Impaired Vision

a. Normal vision and the ability to clearly see the world around you is often taken for granted.

b. People with age-related macular degeneration (AMD) have difficulty seeing things directly in front of them.

c. Cataracts cause vision to become cloudy.
Vitamins differ in **bioavailability**: the degree to which a nutrient is absorbed from foods and used in the body

- Vitamins can be destroyed by air, water, or heat
- Don't expose your produce to air
- A little water is enough for cooking
- Reduce cooking time
- Keep your food cool

- Overconsumption of some vitamins can be toxic
- **Provitamins** can be converted to vitamins by the body
Table 7.2 The Phytochemical Color Guide

The National Cancer Institute recommends eating a variety of colorful fruits and vegetables daily to provide your body with valuable vitamins, minerals, fiber, and disease-fighting phytochemicals. Whole grains also have phytochemicals and have been added to this list.

<table>
<thead>
<tr>
<th>Color</th>
<th>Phytochemical</th>
<th>Found In</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Anthocyanins</td>
<td>Apples, beets, cabbage, cherries, cranberries, red cabbage, red onion, red beans, peppers</td>
</tr>
<tr>
<td></td>
<td>Lycopene</td>
<td>Tomatoes, watermelon, pink grapefruit</td>
</tr>
<tr>
<td>Yellow/Orange</td>
<td>Beta-carotene</td>
<td>Apricots, butternut squash, cantaloupe, carrots, mangoes, peaches, pumpkin, sweet potatoes</td>
</tr>
<tr>
<td></td>
<td>Flavonoids</td>
<td>Apricots, clementines, grapefruits, lemons, papaya, pears, pineapple, yellow raisins</td>
</tr>
<tr>
<td>White</td>
<td>Alliums/allicin</td>
<td>Chives, garlic, leeks, onions, scallions</td>
</tr>
<tr>
<td>Green</td>
<td>Lutein, zeaxanthin</td>
<td>Broccoli, collard greens, honeydew melon, kale, kiwi, lettuce, mustard greens, peas, spinach</td>
</tr>
<tr>
<td></td>
<td>Indoles</td>
<td>Arugula, broccoli, bok choy, brussels sprouts, cabbage, cauliflower, kale, Swiss chard, turnips</td>
</tr>
<tr>
<td>Blue/Purple</td>
<td>Anthocyanins</td>
<td>Blackberries, black currants, elderberries, purple grapes</td>
</tr>
<tr>
<td></td>
<td>Phenolics</td>
<td>Eggplant, plums, prunes, raisins</td>
</tr>
<tr>
<td>Brown</td>
<td>Beta-glucan, lignans, phenols, plant sterols, phytoestrogens, saponins, tocotrienols</td>
<td>Barley, brown rice, oats, oatmeal, whole grains, whole-grain cereals</td>
</tr>
</tbody>
</table>
Vitamins Can Be Destroyed by Air, Water, or Heat

- Air exposure can destroy water-soluble vitamins and fat-soluble vitamins A, E, and K.
  - Store in airtight, covered containers and use soon after purchase
- To reduce vitamin loss, cook vegetables in a minimal amount of liquid
  - Steaming or microwaving with minimal water may help preserve some vitamins in vegetables
- Heat will also destroy water soluble vitamins, especially vitamin C
  - Microwaving, steaming, or stir-frying can preserve more vitamins than boiling
- Cooler temperatures help preserve vitamins, so store produce in the refrigerator rather than pantry
Overconsumption of Some Vitamins Can Be Toxic

- Vitamin toxicity, or hypervitaminosis, is very rare
- Vitamin toxicity does not occur by eating a normal balanced diet
- Can result when individuals consume megadose levels of vitamin supplements, usually in the mistaken belief that more is better
- To prevent excessive intake, the Dietary Reference Intakes include a tolerable upper intake level for most vitamins
Provitamins Can Be Converted to Vitamins by the Body

• **Provitamins** are substances found in foods that are not in a form directly usable by the body, but that can be converted into an active form once they are absorbed
  • Example: beta-carotene, which is split into two molecules of vitamin A in the small intestinal cell wall or in the liver cells
• Vitamins found in foods that are already in the active form, called **preformed** vitamins, do not undergo conversion in the body.
• **Vitamin A:** retinoids (retinol, retinal, retinoic acid)
  - Preformed vitamin A only found in animal foods: liver, eggs, fortified milk and cheese
  - Some plants contain provitamin A carotenoids, which are converted to retinol in your body
    - Carotenoids, including beta-carotene, are pigments that give color to carrots, cantaloupe, sweet potatoes, spinach, broccoli
      - Like fat-soluble vitamins, are absorbed more efficiently if fat is present in intestinal tract
Vitamin A, Continued

• Functions:
  • Essential for healthy eyes
    • Component of rhodopsin and iodopsin, light-sensitive proteins needed for vision
  • Involved in cell differentiation, reproduction, and immunity by promoting gene expression for:
    • Healthy skin, mucuos membranes
    • Bone growth
    • Fetal development
    • White blood cells to fight harmful bacteria
Vitamin A and Epithelial Tissue
Retinal and Its Role in Vision

Vitamin A is a component of two light-sensitive proteins, rhodopsin and iodopsin, that are essential for vision. Here we examine rhodopsin’s role in vision. Although the breakdown of iodopsin is similar, rhodopsin is more sensitive to light than iodopsin and is more likely to become bleached.

**EYE STRUCTURE**

1. After light enters your eye through the cornea, it travels to the back of your eye to the macula, which is located in the retina. The macula allows you to see fine details and things that are straight in front of you.

2. Inside the retina are two types of light-absorbing cells, rods and cones. Rods contain the protein rhodopsin, while cones contain the protein iodopsin.

**EFFECT OF LIGHT ON RHODOPSIN**

1. As rhodopsin absorbs incoming light, the shape of vitamin A is altered, and it detaches from the rhodopsin.

2. This process, called bleaching, causes a cascade of events that transmit visual messages through your optic nerve to your brain. After bleaching, some vitamin A is lost.

3. Vitamin A from the blood is brought in to replenish what is lost. The vitamin A returns to its original shape and becomes part of rhodopsin again, regenerating the eye’s light-absorbing capabilities. This regeneration can take a few moments.
Vitamin A and the Visual Cycle
Vitamin A, Continued

- Daily needs:
  - Adult males: 900 micrograms (µg) retinol activity equivalents (RAE)
  - Adult females: 700 µg RAE
- Food sources: organ meats (liver), milk, eggs, carrots, spinach, sweet potatoes, pumpkin
Vitamin A Content in Selected Foods

Figure 7.7

[Diagram showing vitamin A content in selected foods]
Too much or too little:

- Excessive amounts of preformed vitamin A can accumulate to toxic levels
  - Upper limit for adults: 3,000 µg
- Carotenoids in food are not toxic
  - Excess carotenoids in diet cause nonthreatening condition: carotenodermia
- Chronic vitamin A deficiency causes night blindness
- Prolonged vitamin A deficiency leads to xerophthalmia (permanent damage to the cornea)
  - Main cause of preventable blindness in children
- Vitamin A deficiency also associated with stunting of bones
Vitamin E

• Alpha-tocopherol is most active form in body

Functions:

• Acts as a powerful antioxidant
  • Protects cell membranes, prevents oxidation of LDL cholesterol
• Acts as an anticoagulant, inhibiting formation of harmful clots inside bloodstream

• Daily needs: Adults need 15 mg of alpha-tocopherol equivalents
Vitamin E as an Antioxidant

Free radicals damage phospholipids, essential components of the cell membrane.

Vitamin E in cell membranes can neutralize free radicals, preventing them from damaging phospholipids.
Vitamin E, Continued

- Food sources: vegetable oils, nuts, seeds, fortified cereals, some green leafy vegetables
- Too much or too little:
  - No known risk of consuming too much vitamin E from natural food sources
  - Overconsumption of synthetic form in dietary supplements and fortified foods can increase risk of a hemorrhage: upper limit is 1,000 mg/day
  - Although rare, chronic deficiency of vitamin E can cause nerve problems, muscle weakness, and free radical damage to cell membranes
Vitamin E Content in Selected Foods

Figure 7.9
Vitamin K

• Two forms of vitamin K
  • Menaquinone synthesized by intestinal bacteria
  • Phylloquinone found in green plants

• Functions:
  • Essential for blood clotting
    • Involved in synthesizing four blood clotting factors
  • Important to bone health
    • Enables bone protein osteocalcin to bind with calcium
Vitamin K, Continued

- Daily needs: based on current consumption, since amount contributed by intestinal synthesis is unknown
  - Men need 120 µg/day
  - Women need 90 µg/day
- Food sources: green vegetables such as broccoli, asparagus, spinach, salad greens, brussels sprouts, cabbage; also vegetable oils and margarine
Vitamin K Content in Selected Foods

Figure 7.10
Vitamin K, Continued - 1

• Too much or too little:
  • No known problems of consuming too much vitamin K from foods or supplements
  • People taking anticoagulant medications such as warfarin (Coumadin) need to keep vitamin K intake consistent
    • Changes in intake can increase or decrease drug effectiveness
  • Vitamin K deficiency that is severe enough to affect blood clotting is extremely rare
    • At risk: people with problems absorbing fat
Vitamin D

• Called "sunshine vitamin" because it is made in the body with help of sunlight (UV)
  • Cholesterol-containing compound in skin is converted to inactive form of vitamin D
  • People with insufficient sunlight exposure must meet needs through diet; vitamin D in foods is also an inactive form
  • Inactive form converted to circulating form in liver, then to active form in kidneys
Vitamin D, Continued

- Functions: active form acts as a hormone
  - Regulates two important bone minerals: calcium (Ca) and phosphorus (P)
    - Stimulates intestinal absorption of Ca and P to maintain healthy blood levels and build and maintain bones
    - When dietary calcium is inadequate, vitamin D and parathyroid hormone cause calcium to leave bones to maintain necessary blood levels
- May aid prevention of some cancers, diabetes, heart disease, and other conditions
Vitamin D, Continued

- Daily needs:
  - Sun exposure cannot meet everyone's vitamin D needs
    - Skin pigment melanin and use of sunscreen reduce vitamin D production
    - Sunlight intensity during winter in northern and southern latitudes not sufficient to make vitamin D
  - Therefore, vitamin D needs are based on dietary sources
  - Adults: 15 to 20 µg (600 to 800 IU) per day, depending on age
  - Food sources: fortified milk and yogurt, fortified cereals, fatty fish (examples: sardines, salmon)
Vitamin D Content in Selected Foods

Figure 7.11
Vitamin D, Continued

• Too much or too little:
  • Overuse of supplements may lead to hypervitaminosis D, which causes hypercalcemia
    • Damaging calcium deposited in kidneys, lungs, blood vessels, heart
    • UL: 4,000 IU (100 µg)
  • **Rickets:** vitamin D deficiency disease in children
    • On the rise in United States due to decreased milk consumption, other factors
    • Bones inadequately mineralized with calcium and phosphorus, causing them to weaken and leading to bowed legs
  • **Osteomalacia:** adult equivalent of rickets
Activation of Vitamin D
The B Vitamins and Vitamin C Are Water-Soluble

- Water-soluble vitamins are not stored in body
  - Excess is excreted in urine
  - However, routine intakes of excessive amounts can be harmful.
- B vitamins share common role as *coenzymes*
  - Help many enzymes produce chemical reactions in cells
How B Vitamins Function as Coenzymes

- **a** Two compounds approach the enzyme, but a coenzyme is needed for the reaction to occur.
- **b** Once the coenzyme is present, the compounds can interact with the enzyme.
- **c** The enzyme changes shape.
- **d** The reaction occurs, and the product is released.

Figure 7.12
Thiamin (B<sub>1</sub>)

- First B vitamin discovered
- Functions:
  - Transmission of nerve impulses
  - Metabolism of carbohydrates and certain amino acids
  - Plays role in breakdown of alcohol in body
- Daily needs: men: 1.2 mg/day; women: 1.1 mg/day
- Food sources: enriched and whole grain products, pork
Thiamin Content in Selected Foods

Figure 7.13

Thiamin

Milligrams (mg) of Thiamin

Vegetables
- Peas, boiled, 1 cup: 0.4 mg
- Oatmeal, cooked, 1/2 cup: 0.09 mg
- Rice, brown, cooked, 1/2 cup: 0.14 mg
- Wheat bread, 1 slice: 0.19 mg
- Wheat crackers, 1 oz: 0.19 mg
- Bagel, medium, whole wheat, 1/2 cup: 0.3 mg
- Pecans, dry roasted, 1/2 oz: 0.32 mg
- Beans, black, cooked, 1 cup: 0.38 mg
- Ham, extra lean, 2 oz: 0.33 mg
- Pork, center loin, lean, broiled, 3 oz: 0.42 mg
- Men 19 to 50 years: 0.43 mg
- Women 19 to 50 years: 0.53 mg

Grains
- Daily Needs: 1.2 mg

Protein
- Daily Needs: 1.1 mg

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Thiamin \((B_1)\), Continued

- Too much or too little:
  - No known toxicity, no UL set
  - **Beriberi**: thiamin deficiency disease
    - Symptoms can include rapid heartbeat, edema, confusion, loss of coordination
    - Rare in United States due to enrichment of grains
    - Chronic alcohol abuse can lead to advanced form, **Wernicke-Korsakoff syndrome**: progressively damaging brain disorder
      - Due to thiamin-deficient diet, and alcohol interfering with thiamin absorption
Riboflavin (B₂)

- Light-sensitive vitamin, abundant in milk
  - Opaque containers preserve riboflavin content
- Functions:
  - Important for energy metabolism
  - Keeps cells healthy
  - Enhances functions of other B vitamins, such as niacin and B₁₂
- Daily needs:
  - Men: 1.3 mg/day; women: 1.1 mg/day
- Food sources: milk, yogurt, enriched cereals, grains
Riboflavin Content in Selected Foods

Figure 7.14
• Too much or too little:
  • Excess riboflavin excreted in urine: bright yellow color
  • No UL set
  • Deficiency symptoms rarely seen in healthy individuals eating a balanced diet:
    • Sore throat, swelling inside mouth, inflamed and purplish-red tongue (glossitis), dry and scaly lips
Niacin ($B_3$)

- **Active forms:** nicotinic acid and nicotinamide
- **Functions:**
  - Energy metabolism
  - Synthesize fat and cholesterol
  - Keep skin cells and digestive system healthy
- **Sometimes prescribed in high doses (50 times UL) by physicians to decrease blood LDL cholesterol and triglycerides, increase HDL**
- **Daily needs:** men: 16 mg/day; women: 14 mg/day
  - Can also be made in the body from the amino acid tryptophan: daily needs expressed in niacin equivalents (NE)
Niacin ($B_3$), Continued

- Food sources: meat, fish, poultry, enriched whole-grain breads, fortified cereals
  - Protein-rich foods are good sources of tryptophan
- Too much or too little:
  - Overconsumption of niacin supplements can cause flushing, nausea, vomiting; be toxic to liver; raise blood glucose levels: UL is 35 mg/day to prevent flushing
- **Pellagra**: niacin deficiency disease
  - Four Ds: dermatitis, diarrhea, dementia, death
  - Once common in South, due to corn-based diet
Niacin Content in Selected Foods

Figure 7.15

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Vitamin B₆

- Active forms: pyridoxine, pyridoxal, and pyridoxamine
- Functions: as coenzyme with over 100 enzymes in protein metabolism, needed to:
  - Make nonessential amino acids, convert tryptophan to niacin and hemoglobin in red blood cells
  - Keep immune and nervous systems healthy
  - Metabolize fats and carbohydrates and break down glycogen
- Daily needs: men: 1.3 to 1.7 mg/day; women: 1.3 to 1.5 mg/day, depending on age
Vitamin B₆, Continued

• Food sources
  • Meat, fish, poultry, fortified cereals, nuts, legumes, peanut butter, many fruits and vegetables
• Too much or too little:
  • UL is 100 mg/day to prevent nerve damage
  • Deficiency symptoms:
    • Sore tongue, skin inflammation, depression, confusion, anemia
  • Those with alcoholism are at risk for deficiency due to poor diet, and because alcohol causes body to lose B₆
Vitamin B<sub>6</sub> Content in Selected Foods

**Figure 7.16**

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Milligrams (mg) of Vitamin B&lt;sub&gt;6&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baked potato, with skin, 1 small</td>
<td>0.29</td>
</tr>
<tr>
<td>Broccoli, cooked, 1 cup</td>
<td>0.31</td>
</tr>
<tr>
<td>Winter squash, baked, 1 cup</td>
<td>0.33</td>
</tr>
<tr>
<td>Sweet red pepper, raw, 1 cup</td>
<td>0.43</td>
</tr>
<tr>
<td>Spinach, cooked, 1 cup</td>
<td>0.44</td>
</tr>
<tr>
<td>Prunes (dried plums), 1/2 cup</td>
<td>0.27</td>
</tr>
<tr>
<td>Banana, medium</td>
<td>0.43</td>
</tr>
<tr>
<td>Barley, cooked, 1/2 cup</td>
<td>0.1</td>
</tr>
<tr>
<td>Lentils, cooked, 1/2 cup</td>
<td>0.1</td>
</tr>
<tr>
<td>Kidney beans, cooked, 1 cup</td>
<td>0.1</td>
</tr>
<tr>
<td>Pinto beans, cooked, 1/2 cup</td>
<td>0.1</td>
</tr>
<tr>
<td>Flounder, cooked, 1/4 cup</td>
<td>0.1</td>
</tr>
<tr>
<td>Peanut butter, 1 tbs</td>
<td>0.52</td>
</tr>
<tr>
<td>Hamburger, lean, 3 oz</td>
<td>1.1</td>
</tr>
<tr>
<td>Chicken breast, skinned, roast, 3 oz</td>
<td>1.3</td>
</tr>
<tr>
<td>Chickpeas, canned, 1 cup</td>
<td>0.35</td>
</tr>
<tr>
<td>Adults, 19 to 50 years</td>
<td>1.3</td>
</tr>
</tbody>
</table>

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Folate

• Naturally occurring form in foods
• **Folic acid:** synthetic form of folate added to foods and supplements
• Functions: vital for DNA synthesis
  • To create and maintain new cells, including red blood cells
  • To help body use amino acids
  • Folate deficiency during pregnancy can result in neural tube birth defects (examples: spina bifida, anencephaly)
  • Reduces risks of some cancers
Folate, Continued

• Daily needs:
  • Adults need 400 µg of dietary folate equivalents (DFE)
  • Folic acid is absorbed 1.7 times more efficiently than folate found naturally in foods
  • Women who might become pregnant need 400 µg extra from fortified foods/supplements

• Food sources:
  • Enriched grains (rice, pasta, breads, cereals), legumes, broccoli, asparagus, leafy greens such as spinach
Folate Content in Selected Foods

Figure 7.17
• Too much or too little:
  • UL = 1,000 µg/day of folic acid from enriched/fortified foods and supplements
    • Too much folic acid (not naturally occurring folate in foods) masks vitamin \( B_{12} \) deficiency anemia
  • Folate deficiency can lead to macrocytic anemia
Altered Red Blood Cells with Folate Deficiency

- **Folate adequate**
  - Normal cell division
  - Healthy red blood cells

- **Folate deficient**
  - Immature megaloblast
  - Macrocote

* A vitamin B₁₂ deficiency can also cause the formation of macrocytes.
Vitamin B$_{12}$

- Also called cobalamin because it contains the element cobalt
- Requires intrinsic factor, protein made in stomach, in order to be absorbed in small intestine
  - Pernicious anemia results in people who cannot make intrinsic factor; treatment requires B$_{12}$ injection to bypass intestine
  - Symptoms may take years to appear since B$_{12}$ is stored in the liver
Vitamin $B_{12}$, Continued

• Functions:
  • To make DNA
  • To use certain fatty acids and amino acids
  • For healthy nerves and cells, especially red blood cells

• Daily needs:
  • Adults: 2.4 $\mu g$/day
  • Ability to absorb naturally occurring $B_{12}$ from foods declines with age
Vitamin B\textsubscript{12}, Continued-1

- Food sources:
  - Naturally occurring B\textsubscript{12} only found in animal foods (meat, fish, poultry, dairy)
  - Synthetic B\textsubscript{12} found in fortified foods such as soy milk and some cereals

- Too much or too little:
  - No upper level set since no known risk from consuming too much B\textsubscript{12} natural or synthetic
  - Deficiency can cause macrocytic anemia (because folate can't be utilized properly)
    - Lack of intrinsic factor causes pernicious anemia, involves nerve damage
Vitamin B₁₂ Content in Selected Foods
Vitamin B$_{12}$ Absorption
Vitamin C

• Also known as ascorbic acid
• Function: coenzyme to synthesize and use certain amino acids
  • Needed to make collagen, most abundant protein in body, present in connective tissue
    • Important for healthy bones, skin, blood vessels, teeth
  • Also acts as an antioxidant
• Helps absorb iron from plant foods
• Breaks down histamine, cause of inflammation
• Helps to maintain a strong immune system
Vitamin C, Continued

- Daily needs:
  - Men: 90 mg/day
  - Women: 75 mg/day
  - Smokers: 35+ mg/day
- Food sources: fruits and vegetables (tomatoes, peppers, broccoli, oranges, cantaloupe)
Practical Nutrition Tips Video: Vitamin C Needs

Do You Need a Supplement to Meet Your Vitamin C Needs?
Vitamin C Content in Selected Foods

Figure 7.20

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Vitamin C, Continued-1

• Too much or too little:
  • UL = 2,000 mg/day to avoid nausea, stomach cramps, diarrhea
    • People with a history of kidney stones or hemochromatosis (body stores too much iron) should avoid excess
  • Deficiency disease: scurvy
Pantothenic Acid and Biotin

• Functions: assist in energy metabolism of carbohydrates, fats, protein
• Daily needs for adults:
  • Pantothenic acid: 5 mg/day
  • Biotin: 30 µg/day
• Food sources:
  • Widespread in foods such as whole grains and cereals, nuts, legumes, peanut butter, meat, milk, eggs
  • Biotin also synthesized by intestinal bacteria
Pantothenic Acid and Biotin, Continued

- Too much or too little:
  - No UL, no known adverse effects from consuming too much of either vitamin
  - Deficiencies of these vitamins are rare
    - "Burning feet" syndrome seen in WWII prisoners of war in Asia due to pantothenic acid-deficient diet of polished rice
    - Biotin deficiency: hair loss, skin rash, fatigue, nausea, depression
      - *Avidin* protein in raw egg whites binds biotin, preventing absorption
Are There Other Important Nutrients?

- **Choline**: essential nutrient needed for healthy cells and nerves
  - Not classified as a vitamin; body can synthesize it, but dietary sources may be needed
  - Daily needs: men: 550 mg; women: 425 mg
  - Widely available in foods: milk, eggs, peanuts, liver
  - UL of 3,500 mg/day to prevent hypotension, sweating, vomiting, fishy odor
- Carnitine, lipoic acid, inositol are not essential because body can synthesize adequate amounts
<table>
<thead>
<tr>
<th>Major Functions</th>
<th>Adult DRI, Age 19 to 50 Years</th>
<th>Food Sources</th>
<th>Toxicity Symptoms/UL</th>
<th>Deficiency Symptoms/Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fat-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vitamin A</strong></td>
<td>Vision, cell differentiation, reproduction, bone health, immune function</td>
<td>700-900 µg RAE/day</td>
<td>Beef liver, fortified dairy products</td>
<td>Compromised bone health, birth defects during pregnancy UL: 3,000 µg RAE/day of preformed vitamin A</td>
</tr>
<tr>
<td><strong>Beta-carotene</strong></td>
<td>Provitamin A carotenoid, antioxidant</td>
<td></td>
<td>Sweet potatoes, carrots, winter squash, cantaloupe</td>
<td>Carotenodermia</td>
</tr>
<tr>
<td><strong>Vitamin D</strong></td>
<td>Calcium balance, bone health, cell differentiation, immune system</td>
<td>15 µg (600 IU)/day</td>
<td>Fatty fish (salmon, tuna, sardines) Fortified foods (dairy products, orange juice, cereals)</td>
<td>Hypercalcemia UL: 100 µg (4,000 IU)/day</td>
</tr>
<tr>
<td><strong>Vitamin E</strong></td>
<td>Antioxidant, health of cell membranes, heart health</td>
<td>15 mg alphatocopherol/day</td>
<td>Vegetable and seed oils, nuts, seeds, fortified cereals, green leafy vegetables</td>
<td>Interference with blood clotting and increased risk of hemorrhage UL: 1,000 mg AT/day from supplements and/or fortified foods</td>
</tr>
</tbody>
</table>
Table 7.3 Vitamins at a Glance

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Major Functions</th>
<th>Adult DRI, Age 19 to 50 Years</th>
<th>Food Sources</th>
<th>Toxicity Symptoms/UL</th>
<th>Deficiency Symptoms/Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin K</td>
<td>Blood clotting, bone Health</td>
<td>90-120 µg/day</td>
<td>Green leafy vegetables, soybeans, canola and soybean oils, beef liver</td>
<td>None known</td>
<td>Excessive bleeding</td>
</tr>
<tr>
<td>Thiamin (B₁)</td>
<td>Coenzyme, needed for nerve function and energy metabolism</td>
<td>1.1-1.2 mg/day</td>
<td>Pork, enriched and fortified foods, whole grains</td>
<td>None known</td>
<td>Beriberi, Wernicke-Korsakoff syndrome</td>
</tr>
<tr>
<td>Riboflavin (B₂)</td>
<td>Coenzyme in energy metabolism, enhances function of other B vitamins</td>
<td>1.1-1.3 mg/day</td>
<td>Milk, enriched and fortified grains, whole grains</td>
<td>Can turn urine bright yellow</td>
<td>Sore throat, inflammation of the mouth, tongue, and lips</td>
</tr>
<tr>
<td>Niacin (B₃)</td>
<td>Coenzyme in energy metabolism, needed to synthesize fat and cholesterol</td>
<td>14-16 mg/day</td>
<td>Lean meats, fish, poultry, enriched and fortified grains and cereals, whole grains, corn, sweet potatoes</td>
<td>Flushing, nausea, vomiting, toxic to liver, may raise blood glucose levels UL: 35 mg/day</td>
<td>Pellagra, characterized by dermatitis, diarrhea, and dementia</td>
</tr>
</tbody>
</table>
Table 7.3 Vitamins at a Glance

<table>
<thead>
<tr>
<th>Major Functions</th>
<th>Adult DRI, Age 19 to 50 Years</th>
<th>Food Sources</th>
<th>Toxicity Symptoms/UL</th>
<th>Deficiency Symptoms/Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water-Soluble Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</strong></td>
<td>Coenzyme in energy metabolism, hemoglobin, healthy immune and nervous systems, homocysteine metabolism</td>
<td>1.3-1.7 mg/day</td>
<td>Fortified cereals, meat, fish, poultry, many vegetables and fruits, nuts, peanut butter, and other legumes</td>
<td>Nerve damage, tingling in hands and feet&lt;br&gt;UL: 100 mg/day</td>
</tr>
<tr>
<td><strong>Folate</strong></td>
<td>DNA and red blood cell formation, prevention of specific birth defects, homocysteine metabolism</td>
<td>400 µg DFE/day</td>
<td>Dark green leafy vegetables, enriched pasta, rice, breads and cereals, legumes, orange juice, asparagus, spinach</td>
<td>Masks vitamin B&lt;sub&gt;12&lt;/sub&gt; deficiency&lt;br&gt;UL: 1,000 µg/day from supplements and/or fortified foods</td>
</tr>
</tbody>
</table>
## Table 7.3 Vitamins at a Glance

<table>
<thead>
<tr>
<th>Water-Soluble Vitamins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitamin B₁₂</strong></td>
</tr>
<tr>
<td><strong>Major Functions</strong></td>
</tr>
<tr>
<td>Synthesis of new cells, especially red blood cells, healthy nerves and tissues</td>
</tr>
<tr>
<td>Activates folate</td>
</tr>
<tr>
<td><strong>Adult DRI, Age 19 to 50 Years</strong></td>
</tr>
<tr>
<td>2.4 µg/day</td>
</tr>
<tr>
<td><strong>Food Sources</strong></td>
</tr>
<tr>
<td>Animal products, including lean meats, fish, poultry, eggs, cheese, fortified foods</td>
</tr>
<tr>
<td><strong>Toxicity Symptoms/UL</strong></td>
</tr>
<tr>
<td>None known</td>
</tr>
<tr>
<td><strong>Deficiency Symptoms/Conditions</strong></td>
</tr>
<tr>
<td>Pernicious anemia, macrocytic anemia, nerve damage as indicated by tingling and numbness in the hands and feet</td>
</tr>
</tbody>
</table>

| **Vitamin C**         |
| **Major Functions**   |
| Collagen formation, antioxidant, enhanced iron absorption, healthy immune system |
| **Adult DRI, Age 19 to 50 Years** |
| 75–90 mg/day (an additional 35 mg if a smoker) |
| **Food Sources**      |
| Citrus fruit, tomatoes, peppers, potatoes, broccoli, cantaloupe |
| **Toxicity Symptoms/UL** |
| Nausea, diarrhea, stomach cramps |
| UL: 2,000 mg/day |
| **Deficiency Symptoms/Conditions** |
| Scurvy; characterized by bleeding gums, skin hemorrhages, coiled or curly arm hairs |

| **Biotin and Pantothenic Acid** |
| **Major Functions** |
| Aid in the metabolism of the energy nutrients |
| **Adult DRI, Age 19 to 50 Years** |
| Pantothenic acid: 5 mg/day |
| Biotin: 30 µg/day |
| **Food Sources** |
| Both are widespread in foods |
| **Toxicity Symptoms/UL** |
| No known adverse effects |
| UL has not been set |
| **Deficiency Symptoms/Conditions** |
| For pantothenic acid: fatigue, nausea, vomiting, numbness, muscle cramps, and difficulty walking |
| For biotin: hair loss, skin rash, depression, fatigue, nausea |
Myths and Facts about the Common Cold

• The truth about catching a cold:
  • Direct or indirect contact with cold virus
• Vitamin C and the common cold
  • Research shows vitamin C to be ineffective in preventing colds, but may reduce severity in some people
  • Other cold remedies (echinacea, zinc): jury is still out
    • Zinc may have some benefits
• What you can do: wash hands frequently in soap and water to reduce risk of cold
How Should You Get Your Vitamins?

• Food is still the best way to meet your vitamin needs
  • Dietary Guidelines recommend a variety of foods and increased amounts of fruits, vegetables, whole grains, lean dairy to meet needs
• Fortified foods can provide additional nutrients but should not displace vitamin-/mineral-rich foods
  • Excessive use of fortified foods can increase risk of overconsumption of some nutrients
What We Eat in America

Percent of Daily Needs Met (Shown as Range)

- Vitamin B₁₂
- Selenium
- Riboflavin
- Protein
- Manganese
- Folate
- Niacin
- Vitamin K
- Thiamin
- Copper
- Zinc
- Phosphorus
- Vitamin C
- Fiber
- Vitamin A
- Carbohydrate
- Calcium
- Iron
- Magnesium
- Choline
- Vitamin E
- Potassium
- Vitamin D

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What Are You Pouring in Your Glass?

Figure 7.22

**a** Pure orange juice is an excellent source of the mineral potassium and doesn’t contain any added sugar.

**b** Orange drink is basically sugar water with vitamin C added to it. A glass will contain the equivalent of 7 teaspoons of added sugar.

= 1 tsp of added sugar
How Should You Get Your Vitamins?, Continued

• Vitamin supplements are not a substitute for healthy eating
  • Cannot provide all missing substances of a healthy diet

• Who might benefit from a supplement?
  • People who cannot meet their needs through a regular, varied diet, such as pregnant or lactating women; older people; strict vegetarians; people with food allergies, with medical conditions, or on low-calorie diets
ABC News Video: Liquid Vitamins Via IV Drip Gain Popularity in Hollywood

Liquid vitamins delivered with an IV drip.
How Should You Get Your Vitamins?, Continued-1

• FDA approval not required for ingredients in use prior to 1994; FDA cannot remove supplement from marketplace until shown to be harmful

• Consult health professional before taking vitamin/mineral supplements
  • Read supplement label carefully
    • U.S. Pharmacopoeia (USP) seal of approval ensures quality and safety, but does not endorse or validate health claims
### Foods, Fortified Foods, and Supplements

<table>
<thead>
<tr>
<th>Foods</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sources of other nutrients and energy; can supply phytochemicals,</td>
<td>Need to shop for and prepare meals; need to plan for in diet</td>
</tr>
<tr>
<td></td>
<td>antioxidants, and fiber; delicious and satisfying</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fortified Foods</td>
<td>Easy to obtain a specific nutrient; can be delicious and satisfying</td>
<td>Often more expensive than regular variety; risk of overconsumption of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nutrients; can displace a more nutrient-dense food</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplements</td>
<td>Easy to obtain; no planning or preparation involved</td>
<td>Can be expensive; risk of overconsumption of nutrients; lack of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>antioxidants, phytochemicals, and fiber found naturally in foods;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>not satisfying</td>
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<td></td>
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</tbody>
</table>
Practical Nutrition Tips Video: Fruit Smoothie

When is a Fruit Smoothie not a Healthy Smoothie?

with Joan Salge Blake
Supplement Smarts

a. The FDA allows the term "high potency" to be used as long as at least two-thirds of the nutrients contain at least 100 percent of the Daily Value.

b. All supplements must clearly identify what is in the bottle.

c. Always look for the USP seal of approval for quality and purity. Choose the cheapest supplement with the seal to save a few dollars.

d. The FDA disclaimer is a reminder that this product doesn’t have the FDA seal of approval for effectiveness.

e. The net quantity of contents must be listed. The Supplement Facts panel lists the serving size, the vitamins in the supplement, and the amount of the vitamin in each capsule.

f. The structure/function claim explains that vitamin C is beneficial for your immune system.

g. The amount of each nutrient is also given as a percentage of the Daily Value. Remember, the Daily Value may be higher than you actually need.

h. All the ingredients must be listed in descending order by weight.

i. The name and address of the manufacturer or distributor must be provided.

---

When you need to perform your best, take vitamin C. It’s a smart choice to help your immune system.

DIRECTIONS FOR USE: Take one capsule daily.

**Supplement Facts**

<table>
<thead>
<tr>
<th>Serving Size 1 Capsule</th>
<th>%DV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Capsule</td>
<td></td>
</tr>
<tr>
<td>Vitamin C</td>
<td></td>
</tr>
<tr>
<td>60mg</td>
<td>100%</td>
</tr>
</tbody>
</table>

Other ingredients: Gelatin, water, and ascorbic acid.

XYZ Company
Some Place, NJ 00001

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