Chapter 7: The Vitamins

PowerPoint Lectures for
Nutrition: Concepts and Controversies, eleventh edition
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Lectures by Judy Kaufman, Ph.D.

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Introduction

Vitamins were discovered at the beginning of the twentieth century.

**Definition**: An essential, noncaloric, organic nutrient needed in tiny amounts in the diet.
The role of vitamins is to help make possible the processes by which other nutrients are digested, absorbed, and metabolized or built into body structures.

The only disease a vitamin can cure is the one caused by a deficiency of that vitamin.
# Definition and Classification of Vitamins

<table>
<thead>
<tr>
<th>TABLE 7-1 Vitamin Names&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fat-Soluble Vitamins</strong></td>
</tr>
<tr>
<td>Vitamin A</td>
</tr>
<tr>
<td>Vitamin D</td>
</tr>
<tr>
<td>Vitamin E</td>
</tr>
<tr>
<td>Vitamin K</td>
</tr>
<tr>
<td><strong>Water-Soluble Vitamins</strong></td>
</tr>
<tr>
<td>B vitamins</td>
</tr>
<tr>
<td>Thiamin (B&lt;sub&gt;1&lt;/sub&gt;)</td>
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<tr>
<td>Riboflavin (B&lt;sub&gt;2&lt;/sub&gt;)</td>
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<tr>
<td>Niacin (B&lt;sub&gt;3&lt;/sub&gt;)</td>
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<tr>
<td>Folate</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;12&lt;/sub&gt;</td>
</tr>
<tr>
<td>Vitamin B&lt;sub&gt;6&lt;/sub&gt;</td>
</tr>
<tr>
<td>Biotin</td>
</tr>
<tr>
<td>Pantothenic acid</td>
</tr>
<tr>
<td>Vitamin C</td>
</tr>
</tbody>
</table>

<sup>a</sup>Vitamin names established by the International Union of Nutritional Sciences Committee on Nomenclature. Other names are listed in Tables 7-5 and 7-6 (pp. 252, 254).
Definition and Classification of Vitamins

Vitamins fall into 2 classes, fat soluble and water soluble
Some vitamins exist as **precursors**, or provitamins
Fat-Soluble and Water-Soluble Vitamins

Table 7.2 Characteristics of the Fat-Soluble and Water-Soluble Vitamins

While each of the vitamins have unique functions and features, a few generalizations about the fat-soluble and water-soluble vitamins can aid understanding.

<table>
<thead>
<tr>
<th>FAT-SOLUBLE VITAMINS: VITAMINS A, D, E, AND K</th>
<th>WATER-SOLUBLE VITAMINS: B VITAMINS AND VITAMIN C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Absorption</strong></td>
<td>Absorbed directly into the blood.</td>
</tr>
<tr>
<td>Absorbed like fats, first into the lymph, then the blood.</td>
<td>Travel freely in watery fluids; most are not stored in the body.</td>
</tr>
<tr>
<td><strong>Transport and Storage</strong></td>
<td></td>
</tr>
<tr>
<td>Must travel with protein carriers in watery body fluids; stored in the liver or fatty tissues.</td>
<td></td>
</tr>
<tr>
<td><strong>Excretion</strong></td>
<td>Readily excreted in the urine.</td>
</tr>
<tr>
<td>Not readily excreted; tend to build up in the tissues.</td>
<td>Toxicities are unlikely but possible with high doses from supplements.</td>
</tr>
<tr>
<td><strong>Toxicity</strong></td>
<td></td>
</tr>
<tr>
<td>Toxicities are likely from supplements, but occur rarely from food.</td>
<td>Needed in frequent doses (perhaps 1 to 3 days) because the body does not store most of them to any extent.</td>
</tr>
<tr>
<td><strong>Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>Needed in periodic doses (perhaps weeks or even months) because the body can draw on its stores.</td>
<td></td>
</tr>
</tbody>
</table>
The Fat-Soluble Vitamins

A, D, E, K

- Found in fats and oils of foods
- Require bile for absorption
- Stored in liver and fatty tissues until needed
- Not needed in the diet daily
- Can reach toxic levels if too much is consumed
- Deficiencies can occur when people eat diets that are extraordinarily low in fat
Vitamin A

- Beta-carotene – plant-derived precursor
- Retinol – active form stored in the liver
  - Converted by cells into its other two active forms, retinal and retinoic acid, as needed
Vitamin A plays a role in

- Gene expression
- Vision
- Maintenance of body linings and skin
- Immune defenses
- Growth of bones and of the body
- Normal development of cells
- Reproduction
Vitamin A exerts influence on body functions through its regulation of genes.

Hundreds of genes are regulated by the retinoic acid form of vitamin A.
Vitamin A plays two roles:

- Process of light perception at the retina
- Maintenance of a healthy cornea
Vitamin A is part of the \textit{rhodopsin} molecule, a pigment within the cells of the retina.

When light falls on the eye, it bleaches rhodopsin, which breaks off the vitamin A, initiating a signal that conveys the sensation of sight to the optic center of the brain.
The vitamin then reunites with the pigment, but a little vitamin A is destroyed each time this reaction takes place, and fresh vitamin A must replenish the supply.

If the vitamin A supply runs low, **night blindness** can result – a lag before the eye can see again after a flash of bright light at night.
A more serious deficiency of vitamin A occurs when the protein **keratin** accumulates and clouds the eye’s outer vitamin A-dependent part, the cornea.

**Keratinization** of the cornea can lead to **xerosis** (drying) and then progress to thickening and permanent blindness, **xerophthalmia**.

500,000 of the world’s vitamin A-deprived children become blind each year due to **xerophthalmia**.
Vitamin A is needed by all epithelial tissue which includes the protective linings of the lungs, intestines, vagina, urinary tract, and bladder.

If vitamin A is deficient, cells fail to make mucus and secrete keratin, the same protein found in hair and nails.

**Keratinization** makes the tissues dry, hard and cracked which makes they are more susceptible to infection.
The skin in vitamin A deficiency
Vitamin A has a reputation as an “anti-infective” vitamin.

Body’s defenses depend on an adequate supply.
Vitamin A assists in growth of bone (and teeth).

In children, failure to grow is one of the first signs of poor vitamin A status.
Between 3 and 10 million of the world’s children suffer from a severe vitamin A deficiency including

- Xerophthalmia
- Diarrhea
- Appetite loss
- Reduced food intake

275 million more children have impaired immunity, leaving them open to infections
Vitamin A Toxicity

- Can occur when excess vitamin A is taken as supplements or fortified foods.
- Chronic use of vitamin supplements providing three to four times the recommended dose for pregnancy has caused birth defects.
With the exception of liver, it is not easy to ingest toxic amounts of vitamin A.

- 1 oz of beef liver contains 3 times the DRI.
### Vitamin A Toxicity

<table>
<thead>
<tr>
<th>Source</th>
<th>Vitamin A (μg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-potency vitamin pill</td>
<td>3,000 μg</td>
</tr>
<tr>
<td>Calf’s liver, 1 oz. cooked</td>
<td>2,300 μg</td>
</tr>
<tr>
<td>Regular multivitamin pill</td>
<td>1,500 μg</td>
</tr>
<tr>
<td>Vitamin gumball, 1</td>
<td>1,500 μg</td>
</tr>
<tr>
<td>Chicken liver, 1 oz cooked</td>
<td>1,400 μg</td>
</tr>
<tr>
<td>“Complete” liquid supplement drink, 1 serving</td>
<td>350–1,500 μg</td>
</tr>
<tr>
<td>Instant breakfast drink, 1 serving</td>
<td>600–700 μg</td>
</tr>
<tr>
<td>“Diet” low-carbohydrate drink, 1 serving</td>
<td>500–700 μg</td>
</tr>
<tr>
<td>Cereal breakfast bar, 1</td>
<td>350–400 μg</td>
</tr>
<tr>
<td>“Energy” candy bar, 1</td>
<td>350 μg</td>
</tr>
<tr>
<td>Milk, 1 c</td>
<td>150 μg</td>
</tr>
<tr>
<td>Vitamin-fortified cereal, 1 serving</td>
<td>150 μg</td>
</tr>
<tr>
<td>Margarine, 1 tsp</td>
<td>55 μg</td>
</tr>
</tbody>
</table>
Vitamin A Recommendations

- Vitamin A is not needed every day. Why?
- DRI for man is 900 micrograms
- DRI for woman is 700 micrograms
- Tolerable Upper Intake Level is 3,000 micrograms
Food Sources of Vitamin A

- Beta-carotene is found in vegetables and fruits
  - Orange or muddy green colored

- Active vitamin A is found in foods of animal origin
  - Liver, fish oil, milk, fortified cereals, eggs, butter
Food Sources of Vitamin A

**SNAPSHOT 7-1**

**VITAMIN A AND BETA-CAROTENE**

**DRI RECOMMENDED INTAKES:**
- Men: 900 μg/day
- Women: 700 μg/day

**TOLERABLE UPPER INTAKE LEVEL:**
Adults: 3,000 μg vitamin A/day

**CHIEF FUNCTIONS:**
- Vision; maintenance of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; regulation of gene expression; reproduction; immunity

**DEFICIENCY:**
- Night blindness, corneal drying (xerosis), and blindness (xerophthalmia); impaired bone growth and easily decayed teeth; keratin lumps on the skin; impaired immunity

**TOXICITY:**
- Vitamin A: Increased activity of bone-dismantling cells causing reduced bone density and pain; liver abnormalities; birth defects
- Beta-carotene: Harmless yellowing of skin

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**GOOD SOURCES**

- **FORTIFIED MILK**:
  - 1 c = 150 μg

- **CARROTS** (cooked):
  - 1/2 c = 671 μg

- **SWEET POTATO** (baked):
  - 1/2 c = 961 μg

- **SPINACH** (cooked):
  - 1/2 c = 472 μg

- **BEET LIVER** (cooked):
  - 3 oz = 6,582 μg

- **BOK CHOY** (cooked):
  - 1/2 c = 180 μg

- **APRICOTS**:
  - 3 apricots = 100 μg

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*These foods provide 10 percent or more of the vitamin A Daily Value in a serving. For a 2,000-calorie diet, the DV is 900 μg/day.

*Vitamin A recommendations are expressed in retinol activity equivalents (RAE).

*This food contains preformed vitamin A.

*This food contains the vitamin A precursor, beta-carotene.
Colorful foods are often rich in vitamins.
In plants, vitamin A only exists in its precursor form.

Beta-carotene, the most abundant of these carotenoid precursors, has the highest vitamin A activity.

- 12 micrograms of beta carotene from food supplies the equivalent of 1 microgram of retinol in the body.
Beta-carotene from food is not converted to retinol efficiently enough to cause vitamin A toxicity. Excess beta-carotene is stored in the fat under the skin, imparting a yellow cast.

Do you think this is harmful?

Answer: NO
Yes, eating carrots and other rich sources of beta-carotene promotes good vision.

- Dark green vegetables
  - Spinach, broccoli, collard greens
- Orange fruits and vegetables
  - Carrots, sweet potatoes, pumpkins, mango, cantaloupe, apricots
People with low intakes of beta-carotene have a high incidence of **macular degeneration**.

Beta-carotene is an antioxidant along with vitamin E, vitamin C, selenium, and many phytochemicals.
Can be self-synthesized with the help of sunlight.

Whether made with the help of sunlight or obtained from food, vitamin D undergoes chemical transformations in the liver and kidneys to activate it.
The sunshine 
Vitamin: D
Roles of Vitamin D

Vitamin D functions as a hormone to:

- Regulate blood calcium and phosphorus levels, thereby maintaining bone integrity

- To replenish blood calcium, vitamin D acts at three body locations to raise blood calcium levels:
  - Skeleton
  - Digestive tract
  - Kidneys
Vitamin D stimulates maturation of cells, including immune cells that defend against disease.

Vitamin D acts on genes, affecting how cells grow, multiply, and specialize.

- Deficiencies may include:
  - High blood pressure
  - Some common cancers
  - Rheumatoid arthritis
  - Multiple sclerosis
  - Psoriasis
Rickets leads to bowed legs to unmineralized bone and also beaded ribs as calcium is deposited on the ribs, rather than in the ribs.
In adults, the poor mineralization of bone results in **osteomalacia**.

- Brittle, soft, and deformed bones
Too Much Vitamin D – A Danger to Soft Tissues

- Vitamin D is the most potentially toxic of all vitamins
- More likely if supplements are taken
  - Toxic to bones, kidneys, brain, nerves, heart, and arteries
How Can People Make a Vitamin from Sunlight?

When ultraviolet light from the sun shines on a cholesterol compound in human skin, the compound is transformed into a vitamin D precursor and is absorbed directly into the blood.

Over the next day, the liver and kidneys finish converting the precursor to active vitamin D.

Sunlight presents no risk of vitamin D toxicity; sun breaks down excess vitamin D in the skin.
At the end of winter, many otherwise healthy northern U.S. adults, even those drinking milk fortified with vitamin D, may test low for blood vitamin D.

Dark-skinned people need up to three hours of direct sun for several days to make enough vitamin D.

Light-skinned people need much less time – 10 or 15 minutes.
## Intake Recommendations and Food Sources

- **5 micrograms/day for adults 19 to 50 years**
- **UL 50 micrograms/day (2,000 IU on supplement labels)**

### Snapshot 7-2: Vitamin D

#### DRI RECOMMENDED INTAKES:
- Adults: 5 μg/day (19–50 yr)
- 10 μg/day (51–70 yr)
- 15 μg/day (>70 yr)

#### TOLERABLE UPPER INTAKE LEVEL:
- Adults: 50 μg/day

#### CHIEF FUNCTIONS:
- Mineralization of bones and teeth (raises blood calcium and phosphorus by increasing absorption from digestive tract, withdrawing calcium from bones, stimulating retention by kidneys)

#### DEFICIENCY:
- Abnormal bone growth resulting in rickets in children, osteomalacia in adults; malformed teeth; muscle spasms

#### TOXICITY:
- Elevated blood calcium; calcification of soft tissues (blood vessels, kidneys, heart, lungs, tissues of joints), excessive thirst, headache, nausea, weakness

*These foods provide 10 percent or more of the Vitamin D Daily Value in a serving. For a 2,000-calorie diet, the DV is 10 μg/day.

1 Avoid prolonged exposure to sun.
Vitamin E, a.k.a. tocopherol
Vitamin E is an antioxidant.

Oxidative damage occurs when highly unstable molecules known as free radicals, formed normally during cell metabolism, run amok and disrupt cellular structures.
The Extraordinary Bodyguard

Free radicals cause chain reactions that damage cellular structures.

1. A chemically reactive oxygen free radical attacks fatty acid, DNA, protein, or cholesterol molecules, which form other free radicals in turn.

2. This initiates a rapid, destructive chain reaction.

3. The result is disabling injury to lipids of cell membranes and cellular proteins, damage to DNA, or oxidation of cholesterol. These changes may initiate steps leading to diseases such as heart disease, cancer, macular degeneration, and others.

Antioxidants quench free radicals and protect cellular structures.

4. Antioxidants, such as vitamin E, stop the chain reaction by changing the nature of the free radical.
Deficiencies are almost never seen in healthy humans.

A classic vitamin E deficiency occurs in premature babies born before the transfer of the vitamin from mother to the infant, which takes place in the last weeks of pregnancy.

- Infant’s RBC lyse and infant becomes anemic
Heart disease and cancer may arise in part through tissue oxidation and inflammation.

People with low blood vitamin E concentrations die more often from these and other causes than do people with higher blood levels.
Toxicity of Vitamin E

- No adverse effects arise from consuming foods that naturally provide vitamin E.

- Vitamin E supplements appear safe at lower doses.

- An increase in brain hemorrhages, a form of stroke, among smokers taking just 50 mg of vitamin E per day has also been noted.

- Supplements may also increase the effects of anticoagulant medication.
Vitamin E Requirements

- 15 milligrams a day for adults
- On average, U.S. intakes of vitamin E fall substantially below the recommendation.
**Food Sources of Vitamin E**

**SNAPSHOT 7-3  VITAMIN E**

**DRI RECOMMENDED INTAKE:**
Adults:  15 mg/day

**TOLERABLE UPPER INTAKE LEVEL:**
Adults:  1,000 mg/day

**CHIEF FUNCTIONS:**
Antioxidant (protects cell membranes, regulates oxidation reactions, protects polyunsaturated fatty acids)

**DEFICIENCY:**
Red blood cell breakage, nerve damage

**TOXICITY:**
Augments the effects of anticlotting medication

*These foods provide 10 percent or more of the vitamin E Daily Value in a serving. For a 2,000-calorie diet, the DV is 30 IU or 20 mg/day.*

**GOOD SOURCES**

- **MAYONNAISE**
  (safflower oil)
  1 tbs = 3.0 mg

- **SAFFLOWER OIL** (cooked)
  1 tbs = 4.7 mg

- **CANOLA OIL**
  1 tbs = 2.4 mg

- **WHEAT GERM**
  1 oz = 6.0 mg

- **SUNFLOWER SEEDS** (shelled)
  2 tbs = 9.0 mg
Raw vegetable oils contain substantial vitamin E, but high temperatures destroy it.
Vitamin K

Have you ever thought about how remarkable it is that blood can clot?

What would happen if it didn’t?
Roles of Vitamin K

- Main function of vitamin K is to help synthesize proteins that help blood clot.
- Also necessary for the synthesis of key bone proteins.
Vitamin K can be made by intestinal bacteria.

Newborns are given a dose of vitamin K at birth.
Sources of Vitamin K

DRI RECOMMENDED INTAKES:
Men: 120 µg/day
Women: 90 µg/day

CHIEF FUNCTIONS:
Synthesis of blood-clotting proteins and bone proteins

DEFICIENCY:
Hemorrhage; abnormal bone formation

TOXICITY:
Opposes the effects of anti-clotting medication

GOOD SOURCES*

- CAULIFLOWER (steamed)
  ½ c = 20 µg

- CABBAGE (steamed)
  ½ c = 102 µg

- SPINACH (steamed)
  ½ c = 360 µg

- CANOLA OIL
  1 tbs = 19 µg

- SALAD GREENS
  1 c = 60 µg

- SOYBEANS (dry roasted)
  ½ c = 20 µg

*These foods provide 10 percent or more of the vitamin K Daily Value in a serving. For a 2,000-calorie diet, the DV is 80 µg/day.

Vitamin K Toxicity

- Toxicity is rare and there is no Tolerable Upper Intake Level.
- Toxicity causes jaundice and may occur if supplements of a synthetic version are given too enthusiastically.
The Water-Soluble Vitamins

Vitamin C and the B vitamins

- Cooking and washing cut foods with water can leach these vitamins out of the food.
- Absorbed easily and excreted easily in urine.
- Foods never deliver a toxic dose of them but large doses concentrated in some vitamin supplements can reach toxic levels.
- “The most expensive urine in town”
More than 200 years ago, any man who joined the crew of a seagoing ship knew he might contract scurvy, which would end up killing as many as 2/3 of the crew.

Long voyages without fresh fruits and veggies spelled death by scurvy for the crew.
The first nutrition experiment was done nearly 250 years ago to find a cure for scurvy:

- **4 Experimental Groups**
  
  1. Vinegar
  2. Sulfuric acid
  3. Seawater
  4. Lemons

Which group do you think was cured?

Answer: group 4
Those receiving the citrus fruits were cured

It took 50 years for the British navy to make use of the information and require all its ships to provide lime juice to every sailor daily

Nicknamed them “limeys”

The name given to the vitamin that the fruit provided, ascorbic acid, literally means “no scurvy acid”

Today called vitamin C
Functions of vitamin C

- Assists enzymes involved in the formation and maintenance of **collagen**
- Acts as an antioxidant, especially protecting the immune system cells from free radicals generated during their assault on invaders
Deficiency Symptoms

Most scurvy symptoms are due to collagen breakdown

- Loss of appetite
- Growth cessation
- Tenderness to touch
- Bleeding gums
- Swollen ankles and wrists
- Anemia
- Red spots on skin
- Weakness
- Loose teeth
Deficiency Symptoms
Consumer Corner: Vitamin C and the Common Cold

Do you think vitamin C relieves colds?

a. Yes
b. No
c. I have no opinion
Consumer Corner: Vitamin C and the Common Cold

More than 30 years ago, Linus Pauling, a Nobel Prize Winner, became a vocal supporter of vitamin C supplements.

The scientific community all but discounts his claims because research fails to support Pauling’s theories.
One review of the literature did reveal a modest benefit – a difference in duration of less than one day per cold in favor of those taking a daily dose of at least 1 gram of vitamin C.

The effect may be greater in children than in adults (adults may need doses near the UL of 2 grams a day).
Consumer Corner: Vitamin C and the Common Cold

In drug-like doses, vitamin C may act like a weak antihistamine.

Can vitamin C ease the suffering of a person with a cold?
Possible adverse effects of taking 2 grams a day:

- Alteration of the insulin response to carbohydrate
- Interference with blood clotting medications
- Kidney stones
- Gout
- Digestive upsets
SNAPSHOT 7-5  

VITAMIN C

**DRI RECOMMENDED INTAKES:**
- Men: 90 mg/day
- Women: 75 mg/day
- Smokers: +35 mg/day

**TOLERABLE UPPER INTAKE LEVEL:**
- Adults: 2,000 mg/day

**CHIEF FUNCTIONS:**
Collagen synthesis (strengthens blood vessel walls, forms scar tissue, provides matrix for bone growth), antioxidant, restores vitamin E to active form, supports immune system, boosts iron absorption

**DEFICIENCY:**
Scurvy, with pinpoint hemmorhages, fatigue, bleeding gums, bruises; bone fragility, joint pain; poor wound healing, frequent infections

**TOXICITY:**
Nausea, abdominal cramps, diarrhea; rashes; interference with medical tests and drug therapies; in susceptible people, aggravation of gout or kidney stones.

*These foods provide 10 percent or more of the vitamin C Daily Value in a serving. For a 2,000-calorie diet, the DV is 60 mg/day.

**GOOD SOURCES**

- ORANGE JUICE: 1/2 c = 62 mg
- SWEET RED PEPPER (raw): 1/2 C = 142 mg
- GREEN PEPPERS (raw): 1/2 c = 60 mg
- BRUSSELS SPROUTS (cooked): 1/2 c = 48 mg
- BROCCOLI (cooked): 1/2 c = 51 mg
- GRAPEFRUIT: 1/2 grapefruit = 36 mg
- STRAWBERRIES: 1/2 c = 43 mg
- SWEET POTATO: 1/2 c = 20 mg
- BOK CHOIY (cooked): 1/2 c = 22 mg
The Need for Vitamin C
The Need for Vitamin C

Table 7-4  Minimizing Nutrient Losses

Each of these tactics saves a small percentage of the vitamins in foods, but repeated each day this can add up to significant amounts in a year’s time.

*Prevent enzymatic destruction:*
- Refrigerate most fruits, vegetables, and juices to slow breakdown of vitamins.

*Protect from light and air:*
- Store milk and enriched grain products in opaque containers to protect riboflavin.
- Store cut fruits and vegetables in the refrigerator in airtight wrappers; reseal opened juice containers before refrigerating.

*Prevent heat destruction or losses in water:*
- Wash intact fruits and vegetables before cutting or peeling to prevent vitamin losses during washing.
- Cook fruits and vegetables in a microwave oven, or quickly stir fry, or steam them over a small amount of water to preserve heat-sensitive vitamins and to prevent vitamin loss in cooking water. Recapture dissolved vitamins by using cooking water for soups, stews, or gravies.
- Avoid high temperatures and long cooking times.
DRI RECOMMENDED INTAKES:
Men: 90 mg/day
Women: 75 mg/day
Smokers: +35 mg/day

TOLERABLE UPPER INTAKE LEVEL:
Adults: 2,000 mg/day

CHIEF FUNCTIONS:
Collagen synthesis (strengthens blood vessel walls, forms scar tissue, provides matrix for bone growth), antioxidant, restores vitamin E to active form, supports immune system, boosts iron absorption

DEFICIENCY:
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TOXICITY:
Nausea, abdominal cramps, diarrhea; rashes; interference with medical tests and drug therapies; in susceptible people, aggravation of gout or kidney stones.

*These foods provide 10 percent or more of the vitamin C Daily Value in a serving. For a 2,000-calorie diet, the DV is 60 mg/day.
The B Vitamins in UNISON

B vitamins function as part of coenzymes

- coenzymes help enzymes do their jobs
B Vitamin Roles in Metabolism

Key:

<table>
<thead>
<tr>
<th>Coenzyme</th>
<th>Vitamin</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPP</td>
<td>thiamin</td>
</tr>
<tr>
<td>FAD</td>
<td>riboflavin</td>
</tr>
<tr>
<td>FMN</td>
<td>niacin</td>
</tr>
<tr>
<td>NAD</td>
<td>vitamin B₆</td>
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<tr>
<td>NADP</td>
<td>folate</td>
</tr>
<tr>
<td>PLP</td>
<td>pantothenic acid</td>
</tr>
<tr>
<td>THF</td>
<td>biotin</td>
</tr>
<tr>
<td>CoA</td>
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<tr>
<td>Bio</td>
<td></td>
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<tr>
<td>B₁₂</td>
<td></td>
</tr>
</tbody>
</table>

Brain and other tissues metabolize carbohydrates.

Muscles and other tissues metabolize protein.

Bone tissues make new blood cells.

Liver and other tissues metabolize fat.

Digestive tract lining replaces its cells.
Thiamin, riboflavin, niacin, pantothenic acid, and biotin – participate in the release of energy from the energy nutrients.

Folate and vitamin B$_{12}$ help cells multiply.

Vitamin B$_6$ helps the body use amino acids to synthesize proteins.
In a B vitamin deficiency, every cell is affected.

- Symptoms include
  - Nausea
  - Severe exhaustion
  - Irritability
  - Depression
  - Forgetfulness
  - Loss of appetite and weight
  - Impairment of immune response
  - Abnormal heart action
  - Skin problems
  - Swollen red tongue
  - Teary, red eyes
  - Pain in muscles
Thiamin

- Plays a critical role in the energy metabolism of all cells.
- Occupies a site on nerve cell membranes.
- Nerve processes and their responding muscles depend heavily on thiamin.
Beriberi

- First observed in East Asia, where rice provided 80 to 90 percent of the total calories most people consumed.
- Polished rice became widespread, and beriberi became epidemic.
Thiamin Deficiency
In developed countries today, alcohol abuse often leads to a severe form of thiamin deficiency, Wernicke-Korsakoff syndrome.

- Alcohol impairs thiamin absorption
- Symptoms
  - Apathy, irritability, mental confusion, memory loss, jerky movement, staggering gait
DRI RECOMMENDED INTAKES:
Men: 1.2 mg/day
Women: 1.1 mg/day

CHIEF FUNCTIONS:
Part of coenzyme active in energy metabolism

DEFICIENCY:*
Beriberi with possible edema or muscle wasting; enlarged heart, heart failure, muscular weakness, pain, apathy, poor short-term memory, confusion, irritability, difficulty walking, paralysis, anorexia, weight loss

TOXICITY:
None reported

*These foods provide 10 percent or more of the thiamin Daily Value in a serving. For a 2,000-calorie diet, the DV is 1.5 mg/day.
*Severe thiamin deficiency is often related to heavy alcohol consumption.
Riboflavin plays a role in energy metabolism.

When thiamin is deficient, riboflavin usually is also.
Riboflavin

DRI RECOMMENDED INTAKES:
Men: 1.2 mg/day
Women: 1.1 mg/day

CHIEF FUNCTIONS:
Part of coenzyme active in energy metabolism

DEFICIENCY:
Cracks and redness at corners of mouth; painful, smooth, purplish red tongue; sore throat; inflamed eyes and eyelids, sensitivity to light; skin rashes

TOXICITY:
None reported

*These foods provide 10 percent or more of the riboflavin Daily Value in a serving. For a 2,000-calorie diet, the DV is 1.7 mg/day.

GOOD SOURCES*

- MILK
  1 c = 0.45 mg

- BEEF LIVER (cooked)
  3 oz = 2.9 mg

- COTTAGE CHEESE
  1 c = 0.38 mg

- ENRICHED CEREAL (ready-to-eat)
  1/4 c = 0.43 mg

- SPINACH (cooked)
  1/2 c = 0.21 mg

- YOGURT (plain)
  1 c = 0.60 mg

- PORK CHOP (lean only)
  3 oz = 0.23 mg

- MUSHROOMS (cooked)
  1/2 c = 0.23 mg
Niacin

- Participates in energy metabolism of every cell.
- Deficiency disease is **pellagra**, which appeared in Europe in the 1700s when corn from the New World became a staple food.
- In the early 1900s in the U.S., pellagra was affecting hundreds of thousands in the South and Midwest.
Pellagra is still common in parts of Africa and Asia.

Pellagra still occurs in the U.S. among poorly nourished people, especially those with alcohol addiction.
Pellagra symptoms: 4 “D’s”

- Diarrhea
- Dermatitis
- Dementia
- Death
The key nutrient that prevents pellagra is niacin.

Or, consuming adequate tryptophan which can be converted to niacin in the body.

The amount of niacin in a diet is stated in terms of niacin equivalents (NE), a measure that takes available tryptophan into account.
**Niacin Sources**

**SNAPSHOT 7-8 Niacin**

**DRI RECOMMENDED INTAKES:**
- Men: 16 mg/day
- Women: 14 mg/day

**TOLERABLE UPPER INTAKE LEVEL:**
- Adults: 35 mg/day

**CHIEF FUNCTIONS:**
Part of coenzymes needed in energy metabolism

**DEFICIENCY:**
Pellagra, characterized by flaky skin rash (dermatitis) where exposed to sunlight; mental depression, apathy, fatigue, loss of memory, headache; diarrhea, abdominal pain, vomiting; swollen, smooth, bright red or black tongue

**TOXICITY:**
Painful flush, hives, and rash ("niacin flush"); excessive sweating; blurred vision; liver damage, impaired glucose tolerance

* *Niacin DRI Recommended Intakes are expressed in niacin equivalents (NE); the Tolerable Upper Intake Level refers to preformed niacin.

* These foods provide 10 percent or more of the niacin Daily Value in a serving. For a 2,000-calorie diet, the DV is 20 mg/day. The DV values are for preformed niacin, not niacin equivalents.

**GOOD SOURCES**

- **CHICKEN BREAST**
  - 3 oz = 8.9 mg

- **TUNA (in water)**
  - 3 oz = 11.3 mg

- **PORK CHOP**
  - 3 oz = 3.9 mg

- **ENRICHED CEREAL**
  - (ready-to-eat) 1/4 c = 5.0 mg

- **BAKED POTATO**
  - 1 whole potato = 3.3 mg

- **MUSHROOMS (cooked)**
  - 1/2 c = 3.5 mg
Supplements may be taken as a treatment to lower blood lipids associated with cardiovascular disease.

Symptoms of toxicity

- Life-threatening drop in blood pressure
- Liver injury
- Peptic ulcers
- Vision loss
- Niacin flush
Folate helps synthesize DNA and so is important for making new cells.
Deficiency of folate causes anemia, diminished immunity, and abnormal digestive function.

Deficiencies are related to increased risk of cervical cancer (in women infected with HPV), breast cancer (in women who drink alcohol) and pancreatic cancer (in men who smoke).
Adequate intakes of folate during pregnancy can reduce a woman’s chances of having a child with a neural tube defect (NTD).

NTD arise in the first days or weeks of pregnancy, long before most women suspect they are pregnant.
In the late 1990s the FDA ordered fortification of all enriched grain products with an absorbable synthetic form of folate, *folic acid*.

Since fortification began, the U.S. incidence of NTD dropped by 25 percent.
Folate and Birth Defects

Key:
- Rate per 100,000
Tolerable Upper Intake Level for folate is 1,000 micrograms a day for adults.

A concern about fortifying the nation’s food supply with folic acid is folate’s ability to mask deficiencies of vitamin B\textsubscript{12}. 
Sources of Folate and Recommendations

**DRI RECOMMENDED INTAKE:**
Adults: 400 μg/day

**TOLERABLE UPPER INTAKE LEVEL:**
Adults: 1,000 μg/day

**CHIEF FUNCTIONS:**
Part of a coenzyme needed for new cell synthesis

**DEFICIENCY:**
Anemia, smooth, red tongue; depression, mental confusion, weakness, fatigue, irritability, headache; a low intake increases the risk of neural tube birth defects

**TOXICITY:**
Masks vitamin B₁₂-deficiency symptoms

*These foods provide 10 percent or more of the folate Daily Value in a serving. For a 2,000-calorie diet, the DV is 400 μg/day.

*Folate recommendations are expressed in dietary folate equivalents (DFE). Note that for natural folate sources, 1 μg = 1 DFE; for enrichment sources, 1 μg = 1.7 DFE.

*Some highly enriched cereals may provide 400 or more micrograms in a serving.

**GOOD SOURCES:**

- **BEEF LIVER (cooked)**
  3 oz = 221 μg

- **LENTILS (cooked)**
  ½ c = 179 μg

- **PINTO BEANS (cooked)**
  ½ c = 146 μg

- **SPINACH (raw)**
  1 c = 58 μg

- **ASPARAGUS**
  ½ c = 131 μg

- **AVOCADO**
  ½ c = 45 μg

- **ENRICHED CEREAL**
  (ready-to-eat)²
  ⅔ c = 82 μg

- **BEETS**
  ½ c = 68 μg
Vitamin $B_{12}$ and folate are closely related: each depends on the other for activation.

Main roles: helps maintain nerves and is a part of coenzymes needed in new blood cell synthesis.
Vitamin $B_{12}$

- Symptoms of deficiency of either folate or vitamin $B_{12}$ include the presence of immature red blood cells.

- Administering extra folate often clears up this blood condition but allows the $B_{12}$ deficiency to continue.

- Vitamin $B_{12}$’s other functions then become compromised, and the results can be devastating: damaged nerves, creeping paralysis, and general muscle and nerve malfunctioning.
Intrinsic factor is a compound made by the stomach needed for the absorption of $\text{B}_{12}$.

A few people have an inherited defect in the gene for intrinsic factor, which makes $\text{B}_{12}$ absorption poor.
Vitamin B<sub>12</sub> must be injected to bypass the defective absorptive system.

This anemia of the vitamin B<sub>12</sub> deficiency caused by a lack of intrinsic factor is known as pernicious anemia.
The anemia of folate deficiency is indistinguishable from that of vitamin $B_{12}$ deficiency.

*Blood cells of pericious anemia.* The cells are larger than normal and irregular in shape.

*Normal blood cells.* The size, shape, and color of these red blood cells show that they are normal.
Who is at particular risk of a $B_{12}$ deficiency?  

Answer: vegans
Vitamin B₆ participates in more than 100 reactions in body tissues.

- Needed to convert one amino acid to another amino acid that is lacking
- Aids in conversion of tryptophan to niacin
- Plays important roles in the synthesis of hemoglobin and neurotransmitters
- Assists in releasing glucose from glycogen
- Has roles in immune function and steroid hormone activity
- Critical to fetal nervous system development
**SNAPSHOT 7-11  VITAMIN B₆**

**DRI RECOMMENDED INTAKE:**
Adults (19–50 yr):  1.3 mg/day

**TOLERABLE UPPER INTAKE LEVEL:**
Adults: 100 mg/day

**CHIEF FUNCTIONS:**
Part of a coenzyme needed in amino acid and fatty acid metabolism; helps to convert tryptophan to niacin and to serotonin; helps to make hemoglobin for red blood cells

**DEFICIENCY:**
Anemia, depression, confusion, abnormal brain wave pattern, convulsions; greasy, scaly dermatitis

**TOXICITY:**
Depression, fatigue, impaired memory, irritability, headaches, nerve damage causing numbness and muscle weakness progressing to an inability to walk and convulsions; skin lesions

**GOOD SOURCES***

- **BEEF LIVER (cooked)**
  - 3 oz = 0.87 mg

- **BANANA**
  - 1 whole banana = 0.66 mg

- **BAKED POTATO**
  - 1 whole potato = 0.70 mg

- **CHICKEN BREAST**
  - 3 oz = 0.35 mg

- **SWEET POTATO**
  - (cooked) 1/2 c = 0.29 mg

- **SPINACH (cooked)**
  - 1/2 c = 0.22 mg

*These foods provide 10 percent or more of the vitamin B₆ Daily Value in a serving. For a 2,000-calorie diet, the DV is 2 mg/day.
People with an inherited rare disorder that raises the blood level of the amino acid homocysteine almost invariably suffer from a severe form of cardiovascular disease.

CVD sufferers without the inherited disorder also sometimes accumulate homocysteine in the blood.
When healthy men with elevated homocysteine are given supplements of folate, vitamin B\textsubscript{6}, and vitamin B\textsubscript{12}, their homocysteine values drop significantly.

However, a drop in CVD has not emerged so far from controlled studies.
Biotin and pantothenic acid are also important in energy metabolism.

Both vitamins are readily available in foods.
Many substances that people claim are B vitamins are not.

- Choline – important in fetal development
  - Common in foods

- Carnitine, inositol, and lipoic acid – nonvitamins because they are nonessential
  - Common in foods
### Conclusion

**TABLE 7-5** The Fat-Soluble Vitamins—Functions, Deficiencies, and Toxicities

<table>
<thead>
<tr>
<th>VITAMIN A</th>
<th>DEFICIENCY SYMPTOMS</th>
<th>TOXICITY SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OTHER NAMES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retinol, retinal, retinoic acid; main precursor is beta-carotene</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CHIEF FUNCTIONS IN THE BODY</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vision; health of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; regulation of gene expression; reproduction; immunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta-carotene: antioxidant</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DEFICIENCY DISEASE NAME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypovitaminosis A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SIGNIFICANT SOURCES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retinol: fortified milk, cheese, cream, butter, fortified margarine, eggs, liver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta-carotene: spinach and other dark, leafy greens; broccoli; deep orange fruits (apricots, cantaloupe) and vegetables (winter squash, carrots, sweet potatoes, pumpkin)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blood/Circulatory System</th>
<th>Anemia (small cell type) (^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bones/Teeth</td>
<td>Cessation of bone growth, painful joints; impaired enamel formation, cracks in teeth, tendency toward tooth decay</td>
</tr>
<tr>
<td>Digestive System</td>
<td>Diarrhea, changes in intestinal and other body linings</td>
</tr>
<tr>
<td>Immune System</td>
<td>Frequent infections</td>
</tr>
<tr>
<td>Nervous/Muscular System</td>
<td>Night blindness (retinal) Mental depression</td>
</tr>
<tr>
<td>Skin and Cornea</td>
<td>Keratinization, corneal degeneration leading to blindness, (^a) rashes</td>
</tr>
<tr>
<td>Other</td>
<td>Kidney stones, impaired growth</td>
</tr>
</tbody>
</table>

\(^a\) Corneal degeneration progresses from *keratinization* (hardening) to *xerosis* (drying) to *xerophthalmia* (thickening, opacity, and irreversible blindness).
<table>
<thead>
<tr>
<th>VITAMIN D</th>
<th>DEFICIENCY SYMPTOMS</th>
<th>TOXICITY SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OTHER NAMES</strong></td>
<td>Blood/Circulatory System</td>
<td>Raised blood calcium; calcification of blood vessels and heart tissues</td>
</tr>
<tr>
<td>Calciferol, cholecalciferol, dihydroxy vitamin D; precursor is cholesterol</td>
<td>Bones/Teeth</td>
<td>Abnormal growth, misshapen bones (bowing of legs), soft bones, joint pain, malformed teeth</td>
</tr>
<tr>
<td>CHIEF FUNCTIONS IN THE BODY</td>
<td>Nervous System</td>
<td>Calcification of tooth soft tissues; thinning of tooth enamel</td>
</tr>
<tr>
<td>Mineralization of bones (raises blood calcium and phosphorus via absorption from digestive tract and by withdrawing calcium from bones and stimulating retention by kidneys)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEFICIENCY DISEASE NAME</td>
<td>Other</td>
<td>Excessive thirst, headaches, irritability, loss of appetite, weakness, nausea</td>
</tr>
<tr>
<td>Rickets, osteomalacia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIGNIFICANT SOURCES</td>
<td></td>
<td>Kidney stones; calcification of soft tissues (kidneys, lungs, joints); mental and physical retardation of offspring</td>
</tr>
<tr>
<td>Self-synthesis with sunlight; fortified milk or margarine, liver, sardines, salmon, shrimp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin E</td>
<td></td>
<td></td>
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<tr>
<td>-----------</td>
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</tr>
</tbody>
</table>

**Other Names**
Alpha-tocopherol, tocopherol

**Chief Functions in the Body**
Antioxidant (quenching of free radicals), stabilization of cell membranes, support of immune function, protection of polyunsaturated fatty acids; normal nerve development

**Deficiency Disease Name**
(No name)

**Significant Sources**
Polyunsaturated plant oils (margarine, salad dressings, shortenings), green and leafy vegetables, wheat germ, whole-grain products, nuts, seeds

<table>
<thead>
<tr>
<th>Blood/Circulatory System</th>
<th>Deficiency Symptoms</th>
<th>Toxicity Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red blood cell breakage, anemia</td>
<td>Augments the effects of anticlotting medication</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Digestive System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve degeneration, weakness, difficulty walking, leg cramps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>General discomfort, nausea</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nervous/Muscular System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blurred vision</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatigue</th>
</tr>
</thead>
</table>
**VITAMIN K**

<table>
<thead>
<tr>
<th>OTHER NAMES</th>
<th>DEFICIENCY SYMPTOMS</th>
<th>TOXICITY SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylloquinone, naphthoquinone</td>
<td>Blood/Circulatory System</td>
<td>Hemorrhage</td>
</tr>
<tr>
<td></td>
<td>Bones</td>
<td>Poor skeletal mineralization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interference with anticlotting medication</td>
</tr>
</tbody>
</table>

**CHIEF FUNCTIONS IN THE BODY**
Synthesis of blood-clotting proteins and proteins important in bone mineralization

**DEFICIENCY DISEASE NAME**
(No name)

**SIGNIFICANT SOURCES**
Bacterial synthesis in the digestive tract; green leafy vegetables, cabbage-type vegetables, soybeans, vegetable oils.
## Conclusion

<table>
<thead>
<tr>
<th>Vitamin C</th>
<th>Deficiency Symptoms</th>
<th>Toxicity Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Other Names</strong></td>
<td>Digestive System</td>
<td>Nausea, abdominal cramps, diarrhea, excessive urination</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>Immune System</td>
<td>Immune suppression, frequent infections</td>
</tr>
<tr>
<td><strong>Chief Functions in the Body</strong></td>
<td>Mouth, Gums, Tongue</td>
<td>Bleeding gums, loosened teeth</td>
</tr>
<tr>
<td>Collagen synthesis (strengthens blood vessel walls, forms scar tissue, matrix for bone growth), antioxidant, restores vitamin E to active form, hormone synthesis, supports immune cell functions, helps in absorption of iron</td>
<td>Nervous/Muscular System</td>
<td>Muscle degeneration and pain, depression, disorientation</td>
</tr>
<tr>
<td></td>
<td>Skeletal System</td>
<td>Headache, fatigue, insomnia</td>
</tr>
<tr>
<td></td>
<td>Skin</td>
<td>Bone fragility, joint pain</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Aggravation of gout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rashes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interference with medical tests; kidney stones in susceptible people</td>
</tr>
<tr>
<td><strong>THIAMIN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>OTHER NAMES</strong></td>
<td>Vitamin B&lt;sub&gt;1&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>CHIEF FUNCTIONS IN THE BODY</strong></td>
<td>Part of a coenzyme needed in energy metabolism, supports normal appetite and nervous system function</td>
<td></td>
</tr>
<tr>
<td><strong>DEFICIENCY DISEASE NAME</strong></td>
<td>Beriberi (wet and dry)</td>
<td></td>
</tr>
<tr>
<td><strong>SIGNIFICANT SOURCES</strong></td>
<td>Occurs in all nutritious foods in moderate amounts; pork, ham, bacon, liver, whole and enriched grains, legumes, seeds</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DEFICIENCY SYMPTOMS</strong></th>
<th><strong>TOXICITY SYMPTOMS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood/Circulatory System</strong></td>
<td>Edema, enlarged heart, abnormal heart rhythms, heart failure</td>
</tr>
<tr>
<td><strong>Nervous/Muscular System</strong></td>
<td>Degeneration, wasting, weakness, pain, apathy, irritability, difficulty walking, loss of reflexes, mental confusion, paralysis</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Anorexia; weight loss</td>
</tr>
<tr>
<td><strong>(No symptoms reported)</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Riboflavin

### Other Names
- Vitamin B<sub>2</sub>

### Chief Functions in the Body
Part of a coenzyme needed in energy metabolism, supports normal vision and skin health

### Deficiency Disease Name
- Ariboflavinosis

### Significant Sources
- Milk, yogurt, cottage cheese, meat, liver, leafy green vegetables, whole-grain or enriched breads and cereals

### Deficiency Symptoms

<table>
<thead>
<tr>
<th>Syndrome</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth, Gums, Tongue</td>
<td>Cracks at corners of mouth, smooth magenta tongue; sore throat</td>
</tr>
<tr>
<td>Nervous System and Eyes</td>
<td>Hypersensitivity to light, reddening of cornea</td>
</tr>
<tr>
<td>Skin</td>
<td>Skin rash</td>
</tr>
</tbody>
</table>

### Toxicity Symptoms
- (No symptoms reported)

---

*Small-cell anemia is termed microcytic anemia; large-cell type is macrocytic or megaloblastic anemia.*  
*bCracks at the corners of the mouth are termed cheilosis (kee-LOH-sis).*  
*cSmoothness of the tongue is caused by loss of its surface structures and is termed glossitis (gloss-EYE-tis).*
### Table 7-6 The Water-Soluble Vitamins—Functions, Deficiencies, and Toxicities (continued)

**Niacin**

<table>
<thead>
<tr>
<th>OTHER NAMES</th>
<th>DEFICIENCY SYMPTOMS</th>
<th>TOXICITY SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotinic acid, nicotinamide, niacinamide, vitamin B₃; precursor is dietary tryptophan</td>
<td>Digestive System: Diarrhea; vomiting; abdominal pain</td>
<td>Nausea, vomiting</td>
</tr>
<tr>
<td>CHIEF FUNCTIONS IN THE BODY: Part of coenzymes needed in energy metabolism</td>
<td>Mouth, Gums, Tongue: Black or bright red swollen smooth tongueᵃ</td>
<td></td>
</tr>
<tr>
<td>DEFIciENCY DISEASE NAME: Pellagra</td>
<td>Nervous System: Irritability, loss of appetite, weakness, headache, dizziness, mental confusion progressing to psychosis or delirium</td>
<td></td>
</tr>
<tr>
<td>SIGNIFICANT SOURCES: Synthesized from the amino acid tryptophan; milk, eggs, meat, poultry, fish, whole-grain and enriched breads and cereals, nuts, and all protein-containing foods</td>
<td>Skin: Flaky skin rash on areas exposed to sun</td>
<td>Painful flush and rash, sweating</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Liver damage; impaired glucose tolerance</td>
</tr>
<tr>
<td><strong>Folate</strong></td>
<td><strong>Other Names</strong></td>
<td>Follic acid, folacin, pteroylglutamic acid</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Chief Functions in the Body</strong></td>
<td>Part of a coenzyme needed for new cell synthesis</td>
<td></td>
</tr>
<tr>
<td><strong>Deficiency Disease Name</strong></td>
<td>(No name)</td>
<td></td>
</tr>
<tr>
<td><strong>Significant Sources</strong></td>
<td>Asparagus, avocado, leafy green vegetables, beets, legumes, seeds, liver, enriched breads, cereal, pasta, and grains</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DEFICIENCY SYMPTOMS</strong></th>
<th><strong>TOXICITY SYMPTOMS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood/Circulatory System</td>
<td>Anemia (large-cell type), elevated homocysteine</td>
</tr>
<tr>
<td>Digestive System</td>
<td>Heartburn, diarrhea, constipation</td>
</tr>
<tr>
<td>Immune System</td>
<td>Suppression, frequent infections</td>
</tr>
<tr>
<td>Mouth, Gums, Tongue</td>
<td>Smooth red tongue, Increased risk of neural tube birth defects</td>
</tr>
<tr>
<td>Nervous System</td>
<td>Depression, mental confusion, fatigue, irritability, headache</td>
</tr>
<tr>
<td></td>
<td>Masks vitamin B₁₂ deficiency</td>
</tr>
<tr>
<td><strong>VITAMIN B₁₂</strong></td>
<td><strong>OTHER NAMES</strong></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td><strong>CHIEF FUNCTIONS IN THE BODY</strong></td>
<td>Part of coenzymes needed in new cell synthesis, helps maintain nerve cells</td>
</tr>
<tr>
<td><strong>DEFICIENCY DISEASE NAME</strong></td>
<td>(No name)³</td>
</tr>
<tr>
<td><strong>SIGNIFICANT SOURCES</strong></td>
<td>Animal products (meat, fish, poultry, milk, cheese, eggs)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DEFICIENCY SYMPTOMS</strong></th>
<th><strong>TOXICITY SYMPTOMS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood/Circulatory System</td>
<td>Anemia (large-cell type)⁶</td>
</tr>
<tr>
<td>Mouth, Gums, Tongue</td>
<td>Smooth tongue³</td>
</tr>
<tr>
<td>Nervous System</td>
<td>Fatigue, nerve degeneration progressing to paralysis</td>
</tr>
<tr>
<td>Skin</td>
<td>Tingling or numbness</td>
</tr>
</tbody>
</table>

³Smoothness of the tongue is caused by loss of its surface structures and is termed glossitis (gloss-EYE-tis).
⁶Small-cell anemia is termed microcytic anemia; large-cell type is macrocytic or megaloblastic anemia.
³The name pernicious anemia refers to the vitamin B₁₂ deficiency caused by lack of intrinsic factor, but not to that caused by inadequate dietary intake.
<table>
<thead>
<tr>
<th>OTHER NAMES</th>
<th>DEFIENCY SYMPTOMS</th>
<th>TOXICITY SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyridoxine, pyridoxal, pyridoxamine</td>
<td>Blood/Circulatory System</td>
<td>Anemia (small-cell type)*</td>
</tr>
<tr>
<td>CHIEF FUNCTIONS IN THE BODY</td>
<td>Nervous/Muscular System</td>
<td>Depression, confusion, abnormal brain wave pattern, convulsions</td>
</tr>
<tr>
<td>Part of a coenzyme needed in amino acid and fatty acid metabolism, helps convert tryptophan to niacin and to serotonin, helps make red blood cells</td>
<td>Skin</td>
<td>Rashes, greasy, scaly dermatitis</td>
</tr>
<tr>
<td>(No name)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIGNIFICANT SOURCES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meats, fish, poultry, liver, legumes, fruits, potatoes, whole grains, soy products</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Pantothenic Acid

**Other Names**

(None)

**Chief Functions in the Body**

Part of a coenzyme needed in energy metabolism

**Deficiency Disease Name**

(No name)

**Significant Sources**

Widespread in foods

<table>
<thead>
<tr>
<th>System</th>
<th>Deficiency Symptoms</th>
<th>Toxicity Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digestive System</td>
<td>Vomiting, Intestinal distress</td>
<td>Water retention (infrequent)</td>
</tr>
<tr>
<td>Nervous/Muscular System</td>
<td>Insomnia, fatigue</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Hypoglycemia, increased sensitivity to insulin</td>
<td></td>
</tr>
</tbody>
</table>

# Biotin

**Other Names**

(None)

**Chief Functions in the Body**

A cofactor for several enzymes needed in energy metabolism, fat synthesis, amino acid metabolism, and glycogen synthesis

**Deficiency Disease Name**

(No name)

**Significant Sources**

Widespread in foods

<table>
<thead>
<tr>
<th>System</th>
<th>Deficiency Symptoms</th>
<th>Toxicity Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood/Circulatory System</td>
<td>Abnormal heart action</td>
<td>(No toxicity symptoms reported)</td>
</tr>
<tr>
<td>Digestive System</td>
<td>Loss of appetite, nausea</td>
<td></td>
</tr>
<tr>
<td>Nervous/Muscular System</td>
<td>Depression, muscle pain, weakness, fatigue, numbness of extremities</td>
<td></td>
</tr>
<tr>
<td>Skin</td>
<td>Dry around eyes, nose, and mouth</td>
<td></td>
</tr>
</tbody>
</table>

*Small-cell anemia is termed microcytic anemia; large-cell anemia is macrocytic or megaloblastic anemia.*
### Food Feature: Choosing Foods Rich in Vitamins

#### Vitamin A

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount (Energy)</th>
<th>µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef liver</td>
<td>3 oz fried (184 cal)</td>
<td>9.092</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>1 whole boiled (159 cal)</td>
<td>1.287</td>
</tr>
<tr>
<td>Carrots</td>
<td>½ c boiled (35 cal)</td>
<td>0.957</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>½ melon (97 cal)</td>
<td>0.860</td>
</tr>
<tr>
<td>Spinach</td>
<td>½ c boiled (21 cal)</td>
<td>0.369</td>
</tr>
<tr>
<td>Butternut squash</td>
<td>½ c baked (41 cal)</td>
<td>0.361</td>
</tr>
<tr>
<td>Milk, fat-free</td>
<td>1 c (85 cal)</td>
<td>0.161</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>½ c boiled (33 cal)</td>
<td>0.089</td>
</tr>
<tr>
<td>Peach</td>
<td>1 fresh medium (42 cal)</td>
<td>0.026</td>
</tr>
<tr>
<td>Orange juice</td>
<td>1 c (fresh)</td>
<td>0.025</td>
</tr>
<tr>
<td>Summer squash</td>
<td>½ c boiled (18 cal)</td>
<td>0.013</td>
</tr>
<tr>
<td>Apple</td>
<td>1 fresh medium (81 cal)</td>
<td>0.013</td>
</tr>
<tr>
<td>Sirloin steak</td>
<td>3 oz lean (171 cal)</td>
<td>0.005</td>
</tr>
<tr>
<td>Whole-wheat bread</td>
<td>1 slice (70 cal)</td>
<td>0.000</td>
</tr>
<tr>
<td>Baked potato</td>
<td>1 whole (220 cal)</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The abundant green bars indicate that vegetables are rich sources of vitamin A in the form of beta-carotene. The top sources supply much more than the Daily Value in a single serving.

#### Vitamin E

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount (Energy)</th>
<th>mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower seeds</td>
<td>2 tbs dry (103 cal)</td>
<td>9.6</td>
</tr>
<tr>
<td>Sunflower seed oil</td>
<td>1 tbs (124 cal)</td>
<td>6.5</td>
</tr>
<tr>
<td>Wheat germ</td>
<td>1 oz (117 cal)</td>
<td>6.0</td>
</tr>
<tr>
<td>Safflower oil</td>
<td>1 tbs (124 cal)</td>
<td>6.0</td>
</tr>
<tr>
<td>Cottonseed oil</td>
<td>1 tbs (124 cal)</td>
<td>5.0</td>
</tr>
<tr>
<td>Peanuts</td>
<td>1 oz dry roasted (166 cal)</td>
<td>3.0</td>
</tr>
<tr>
<td>Corn oil</td>
<td>1 tbs (124 cal)</td>
<td>3.0</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>2 tbs (190 cal)</td>
<td>2.9</td>
</tr>
<tr>
<td>Canola oil</td>
<td>1 tbs (124 cal)</td>
<td>2.9</td>
</tr>
<tr>
<td>Shrimp</td>
<td>3 oz boiled (84 cal)</td>
<td>1.0</td>
</tr>
<tr>
<td>Parsley</td>
<td>½ c fresh chopped (11 cal)</td>
<td>1.0</td>
</tr>
<tr>
<td>Apple</td>
<td>1 fresh medium (81 cal)</td>
<td>0.4</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>1 baked (117 cal)</td>
<td>0.3</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>1 ½ oz (170 cal)</td>
<td>0.2</td>
</tr>
<tr>
<td>Whole-wheat bread</td>
<td>1 slice (70 cal)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Orange and blue bars show that vegetable oils and nuts are good sources of vitamin E.

#### Thiamin

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount (Energy)</th>
<th>mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork chop</td>
<td>3 oz broiled (275 cal)</td>
<td>0.98</td>
</tr>
<tr>
<td>Black beans</td>
<td>1 c cooked (228 cal)</td>
<td>0.42</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td>2 tbs dry (103 cal)</td>
<td>0.41</td>
</tr>
<tr>
<td>Watermelon</td>
<td>1 slice (91 cal)</td>
<td>0.23</td>
</tr>
<tr>
<td>Green peas</td>
<td>½ c cooked (67 cal)</td>
<td>0.23</td>
</tr>
<tr>
<td>Orange juice</td>
<td>¾ c fresh (84 cal)</td>
<td>0.17</td>
</tr>
<tr>
<td>Oysters</td>
<td>5 oysters simmered (125 cal)</td>
<td>0.16</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>½ c cooked (73 cal)</td>
<td>0.13</td>
</tr>
<tr>
<td>Sirloin steak</td>
<td>3 oz lean (171 cal)</td>
<td>0.11</td>
</tr>
<tr>
<td>Whole-wheat bread</td>
<td>1 slice (70 cal)</td>
<td>0.10</td>
</tr>
<tr>
<td>Milk, fat-free</td>
<td>1 c (85 cal)</td>
<td>0.09</td>
</tr>
<tr>
<td>Cabbage</td>
<td>½ c cooked (33 cal)</td>
<td>0.09</td>
</tr>
<tr>
<td>Summer squash</td>
<td>½ c cooked (18 cal)</td>
<td>0.04</td>
</tr>
<tr>
<td>Apple</td>
<td>1 fresh medium (81 cal)</td>
<td>0.02</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>1 ½ oz (170 cal)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

The mix of colors in this table's bars shows that many kinds of foods supply some thiamin, but few are rich sources. Together, a day's nutrient-dense foods helps supply the needed amounts of thiamin.
Food Feature: Choosing Foods Rich in Vitamins

- Foods work in harmony to provide most nutrients
- A variety of foods works best
Controversy: Vitamin Supplements: Do the Benefits Outweigh the Risks?

About half of the U.S. population buys nutrient supplements, spending *billions* of dollars each year.

Do you take supplements?

a. Yes

b. No
Controversy: Vitamin Supplements: Do the Benefits Outweigh the Risks?

Which is the best source?
## Arguments in Favor of Taking Supplements

### Table C7-1: Some Valid Reasons for Taking Supplements

<table>
<thead>
<tr>
<th>These People May Need Supplements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>People with nutrient deficiencies.</td>
</tr>
<tr>
<td>Women in their childbearing years (supplemental or enrichment sources of folic acid are recommended to reduce risk of neural tube defects in infants).</td>
</tr>
<tr>
<td>Pregnant or lactating women (they may need iron and folate).</td>
</tr>
<tr>
<td>Newborns (they are routinely given a vitamin K dose).</td>
</tr>
<tr>
<td>Infants (they may need various supplements, see Chapter 13).</td>
</tr>
<tr>
<td>Those who are lactose intolerant (they need calcium to forestall osteoporosis).</td>
</tr>
<tr>
<td>Habitual dieters (they may eat insufficient food).</td>
</tr>
<tr>
<td>Elderly people often benefit from some of the vitamins and minerals in a balanced supplement (they may choose poor diets, have trouble chewing, or absorb or metabolize less efficiently; see Chapter 14).</td>
</tr>
<tr>
<td>Victims of AIDS or other wasting illnesses (they lose nutrients faster than foods can supply them).</td>
</tr>
<tr>
<td>Those addicted to drugs or alcohol (they absorb fewer and excrete more nutrients; nutrients cannot undo damage from drugs or alcohol).</td>
</tr>
<tr>
<td>Those recovering from surgery, burns, injury, or illness (they need extra nutrients to help regenerate tissues).</td>
</tr>
<tr>
<td>Strict vegetarians (they may need vitamin B₁₂, vitamin D, iron, and zinc).</td>
</tr>
<tr>
<td>People taking medications that interfere with the body's use of nutrients.</td>
</tr>
</tbody>
</table>
In the U.S. and Canada, adults rarely suffer nutrient deficiencies, but they do still occur. Luckily, deficiency diseases quickly resolve when a physician identifies them and prescribes therapeutic doses (two to ten times the DRI).
Nutrient needs increase during certain stages of life and so sometimes nutrient supplementation is needed.

1. Women who lose a lot of blood and therefore a lot of iron during menstruation each month may need an ________ supplement.

2. Newborns require a single dose of vitamin ___ at birth.

3. Women of childbearing age need supplements of ________ to reduce the risk of NTD.

Answers: 1. iron; 2. K; 3. folic acid
Subclinical deficiencies are more common than classical deficiencies.

- People who don’t eat enough food to deliver the needed amounts of nutrients, such as habitual dieters, otherwise healthy elderly, and vegetarians who omit entire food groups and may not find an appropriate substitute.
Any condition that interferes with a person’s appetite, ability to eat, or ability to absorb or use nutrients can easily impair nutrition status.
Arguments Against Taking Supplements

- Unlike foods, supplements can easily cause nutrient imbalances or toxicities.
- The higher the dose, the greater the risk of harm.
### Arguments Against Taking Supplements

#### Table C7-2: Typical Vitamin and Mineral Supplement Values for Adults

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Tolerable Upper Intake Levels</th>
<th>Daily Values</th>
<th>Typical Multivitamin-Mineral Supplement</th>
<th>Average Single Nutrient Supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A</td>
<td>3,000 mg (10,000 IU)</td>
<td>5,000 IU</td>
<td>5,000 IU</td>
<td>8,000 to 10,000 IU</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>50 μg (2,000 IU)</td>
<td>400 IU</td>
<td>400 IU</td>
<td>400 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>1,000 mg (1,500 to 2,200 IU)</td>
<td>30 IU</td>
<td>30 IU</td>
<td>100 to 1,000 IU</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>—</td>
<td>80 μg</td>
<td>40 μg</td>
<td>—</td>
</tr>
<tr>
<td>Thiamin</td>
<td>—</td>
<td>1.5 mg</td>
<td>1.5 mg</td>
<td>50 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>—</td>
<td>1.7 mg</td>
<td>1.7 mg</td>
<td>25 mg</td>
</tr>
<tr>
<td>Niacin (as niacinamide)</td>
<td>35 mg</td>
<td>20 mg</td>
<td>20 mg</td>
<td>100 to 500 mg</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>100 mg</td>
<td>2 mg</td>
<td>2 mg</td>
<td>100 to 200 mg</td>
</tr>
<tr>
<td>Folate</td>
<td>1,000 μg</td>
<td>400 μg</td>
<td>400 μg</td>
<td>400 μg</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>—</td>
<td>6 μg</td>
<td>6 μg</td>
<td>100 to 1,000 μg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>—</td>
<td>10 mg</td>
<td>10 mg</td>
<td>100 to 500 mg</td>
</tr>
<tr>
<td>Biotin</td>
<td>—</td>
<td>30 μg</td>
<td>30 μg</td>
<td>300 to 600 μg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>2,000 mg</td>
<td>60 mg</td>
<td>10 mg</td>
<td>500 to 2,000 mg</td>
</tr>
<tr>
<td>Choline</td>
<td>3,500 mg</td>
<td>—</td>
<td>10 mg</td>
<td>250 mg</td>
</tr>
<tr>
<td><strong>Minerals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>2,500 mg</td>
<td>1,000 mg</td>
<td>160 mg</td>
<td>250 to 600 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>4,000 mg</td>
<td>1,000 mg</td>
<td>110 mg</td>
<td>—</td>
</tr>
<tr>
<td>Magnesium</td>
<td>350 mg³</td>
<td>400 mg</td>
<td>100 mg</td>
<td>250 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>45 mg</td>
<td>18 mg</td>
<td>18 mg</td>
<td>18 to 30 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>40 mg</td>
<td>15 mg</td>
<td>15 mg</td>
<td>10 to 100 mg</td>
</tr>
<tr>
<td>Iodine</td>
<td>1,100 μg</td>
<td>150 μg</td>
<td>150 μg</td>
<td>—</td>
</tr>
<tr>
<td>Selenium</td>
<td>400 μg</td>
<td>70 μg</td>
<td>10 μg</td>
<td>50 to 200 μg</td>
</tr>
<tr>
<td>Fluoride</td>
<td>10 mg</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Copper</td>
<td>10 mg</td>
<td>2 mg</td>
<td>0.5 mg</td>
<td>—</td>
</tr>
<tr>
<td>Manganese</td>
<td>11 mg</td>
<td>2 mg</td>
<td>5 mg</td>
<td>—</td>
</tr>
<tr>
<td>Chromium</td>
<td>—</td>
<td>120 μg</td>
<td>25 μg</td>
<td>200 to 400 μg</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2,000 μg</td>
<td>75 μg</td>
<td>25 μg</td>
<td>—</td>
</tr>
</tbody>
</table>
No one knows for sure how many people in the U.S. suffer from supplement toxicities but in the year 2005, over 125,000 adverse events were reported from vitamins, minerals, essential oils, herbs, and other supplements.

Toxic overdoses are more common in children due to fruit-flavored, chewable vitamins shaped like cartoon characters that young children like to eat in amounts that can cause poisoning.
Another problem arises when people who are ill use high doses of supplements to cure themselves.

Marketing materials are often misleading and false.
No one knows exactly how to formulate the “ideal” supplement

- Should phytochemicals be added? If yes, how much?
- What nutrients should be added?
False Sense of Security

- Using supplements may lull people into a false sense of security.

- People may think it is not important which foods they choose because the supplement will take care of any discrepancies.

- Self-diagnosing a condition and taking a supplement may postpone a diagnosis.
Nutrients are absorbed best when ingested with food.

Taken in pure, concentrated form, nutrients are likely to interfere with one another’s absorption or with the absorption of nutrients from foods eaten with them.

- Zinc hinders copper and calcium absorption
- Iron hinders zinc absorption
- Vitamin C enhances iron absorption
Can Supplements Prevent Heart Disease or Cancer?

Can taking a supplement prevent these killers?
Antioxidant nutrients help to quench free radicals, rendering them harmless to cellular structures.

Population studies support the theory that people with high intakes of fruits and vegetables that supply the antioxidant nutrients enjoy better health than people with lower intakes.
### Table C7-3 Antioxidant Terms

- **Antioxidant nutrients** vitamins and minerals that oppose the effects of oxidants on human physical functions. The antioxidant vitamins are vitamin E, vitamin C, and beta-carotene. The mineral selenium also participates in antioxidant activities.

- **Electrons** parts of an atom; negatively charged particles. Stable atoms (and molecules, which are made of atoms) have even numbers of electrons in pairs. An atom or molecule with an unpaired electron is an unstable *free radical*.

- **Oxidants** compounds (such as oxygen itself) that oxidize other compounds. Compounds that prevent oxidation are called *antioxidants*, whereas those that promote it are called *prooxidants* (*anti* means “against”; *pro* means “for”).

- **Oxidative stress** damage inflicted on living systems by free radicals.

- **Subclinical**, or **marginal, deficiency** a nutrient deficiency that has no outward clinical symptoms. The term is often used to market unneeded nutrient supplements to consumers.
After years of recording health data, evidence shows that vitamin E supplements offered no protection against heart attack incidence, hospitalization, or death from heart failure.

In fact, an alarming increased risk for death emerged for people taking vitamin E supplements.
Similar to the hopeful beginnings of the vitamin E story, beta-carotene showed early promise as a cancer fighter.

Results from controlled clinical human trials reveal no benefit from beta-carotene.

In fact, there was a 38 percent increase in deadly lung cancer among smokers taking beta-carotene compared with placebos.
Supplements Must Be Safe, or the Government Would Not Allow Their Sales, Right?

Consumers who take supplements without solid research are at least wasting their money, or at worst risking their health.
Supplements Must Be Safe, or the Government Would Not Allow Their Sales, Right?

<table>
<thead>
<tr>
<th>Dietary Supplement Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>aristolochic acid</strong> a Chinese herb ingredient known to attack the kidneys and to cause cancer; U.S. consumers have required kidney transplants and must take lifelong anti-rejection medication after use. Banned by the FDA but available in supplements sold on the Internet.</td>
</tr>
<tr>
<td><strong>coenzyme Q-10</strong> an enzyme made by cells and important for its role in energy metabolism. With diminished coenzyme Q-10 function, oxidative stress increases, as may occur in aging. Preliminary research suggests that it may be of value for treating certain conditions; toxicity in animals appears to be low. No safe intake levels for human beings have been established.</td>
</tr>
<tr>
<td><strong>DHEA</strong> a hormone secretion of the adrenal gland whose level falls with advancing age. DHEA may protect antioxidant nutrients. Real DHEA is available only by prescription; the herbal DHEA imitator for sale in health-food stores is not active in the body. No safety information exists for either.</td>
</tr>
<tr>
<td><strong>dietary supplement</strong> a product, other than tobacco, that is added to the diet and contains one of the following ingredients: a vitamin, mineral, herb, botanical (plant extract), amino acid, metabolite, constituent, or extract, or a combination of any of these ingredients.</td>
</tr>
<tr>
<td><strong>ephedrine</strong> one of a group of compounds with dangerous amphetamine-like stimulant effects; extracted from the herb ma huang and recently banned by the FDA, but still available from Internet sources. The most severe reported side effects of ephedrine include heart attack, stroke, and sudden death.</td>
</tr>
<tr>
<td><strong>garlic oil</strong> an extract of garlic; may or may not contain the chemicals associated with garlic; claims for health benefits unproved.</td>
</tr>
<tr>
<td><strong>green pills, fruit pills</strong> pills containing dehydrated, crushed vegetable or fruit matter. An advertisement may claim that each pill equals a pound of fresh produce, but in reality a pill may equal one small forkful—minus nutrient losses incurred in processing.</td>
</tr>
</tbody>
</table>
- **kelp tablets** tablets made from dehydrated kelp, a kind of seaweed used by the Japanese as a foodstuff.
- **ma huang** an evergreen plant that supposedly boosts energy and helps with weight control. Ma huang, also called ephedra, contains ephedrine (see above) and is especially dangerous in combination with kola nut or other caffeine-containing substances.
- **melatonin** a hormone of the pineal gland believed to help regulate the body's daily rhythms, to reverse the effects of jet lag, and to promote sleep. Claims for life extension or enhancement of sexual prowess are without merit.
- **nutritional yeast** a preparation of yeast cells, often praised for its high nutrient content. Yeast is a source of B vitamins as are many other foods. Also called brewer's yeast; not the yeast used in baking.
- **organ and glandular extracts** dried or extracted material from brain, adrenal, pituitary, or other glands or tissues providing few nutrients but posing a theoretical risk of “mad cow disease.” See Chapter 12.
- **SAM-e** an amino acid derivative that may have an antidepressant effect on the brain in some people, but it is not recommended as a substitute for standard antidepressant therapy.
- **thousands of others.**

*Dehydroepiandrosterone.*

Note: According to legal definitions, all of the substances listed qualify as dietary supplements, even though some appear to have the effects of drugs, not nutrients. Table 11-7 on page 423 describes many more medicinal herbs, including their effects and their hazards.
What Are the Risks of Taking Nutrient Supplements?

Supplements may endanger the taker’s health in these ways:

- Vitamin A intakes of about twice the DRI taken over years are associated with osteoporosis and hip fractures
- Daily supplements of beta-carotene may increase lung cancer in smokers or in people exposed to asbestos
- High doses of vitamin C taken by women with diabetes may increase their likelihood of dying of CVD
If you cannot meet your needs from foods, a supplement containing nutrients only can prevent serious problems.
Choosing a Type

### Table C7-5: Some Invalid Reasons for Taking Supplements

Watch out for plausible-sounding, but false, reasons given by marketers trying to convince you, the consumer, that you need supplements. The invalid reasons listed below have gained strength by repetition among friends, on the Internet, and by the media:

- You fear that foods grown on today’s soils lack nutrients (a common false statement made by sellers of supplements).
- You feel tired and falsely believe that supplements can provide energy.
- You hope that supplements can help you cope with stress.
- You wish to build up your muscles faster or without physical exercise.
- You want to prevent or cure self-diagnosed illnesses.
- You hope excess nutrients will produce unnamed mysterious beneficial reactions in your body.

People who should never take supplements without a physician’s approval include those with kidney or liver ailments (they are susceptible to toxicities), those taking medications (nutrients can interfere with their actions), and smokers (who should avoid products with beta-carotene).
Choosing a Type

Don’t fall for meaningless labels such as, “Advanced Formula,” “Maximum Power,” “Stress formula,” “Time Release,” and the like.

This symbol means that a supplement contains the nutrients states and that it will dissolve in the system – the symbol does not guarantee safety, purity, or health advantages.
Watch the dose you select.

Avoid any preparation that in a daily dose provides more than the DRI recommended intake of vitamin A, vitamin D or any mineral, or more than the Tolerable Upper Intake Level for any nutrient.
People in developed nations are far more likely to suffer from *overnutrition* and poor lifestyle choices than from nutrient deficiencies.

Invest energy in eating a wide variety of fruits and vegetables in generous quantities, along with the recommended daily amounts of whole grains, lean meats, and milk products every day, and take supplements only when they are needed.