Chapter 7: Vitamins
Student learning outcomes: At the end of this chapter, you should be able to:

- Compare and contrast water-soluble and fat-soluble vitamins
- Describe the role of vitamins in health and disease
- Plan a diet to meet vitamin recommendations
THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about vitamins?
- Which foods are high in vitamins?
Vitamins

- **Organic compounds**: contain carbon

- **Micronutrients**: essential in small amounts

- Functions: promote and regulate body processes necessary for growth, reproduction, and the maintenance of health
Vitamins

Water soluble
- B Vitamins
  - Thiamin
  - Riboflavin
  - Niacin
  - Biotin
- Vitamin C

Fat soluble
- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K
- Vitamin B₁₂
- Pantothenic acid
- Vitamin B₆
- Folate
## Fat-soluble & water-soluble vitamins

<table>
<thead>
<tr>
<th>Water-soluble vitamins</th>
<th>Fat-soluble vitamins</th>
</tr>
</thead>
<tbody>
<tr>
<td>B vitamins</td>
<td></td>
</tr>
<tr>
<td>• Thiamin ($B_1$)</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>• Riboflavin ($B_2$)</td>
<td>Vitamin D</td>
</tr>
<tr>
<td>• Niacin ($B_3$)</td>
<td>Vitamin E</td>
</tr>
<tr>
<td>• Biotin</td>
<td>Vitamin K</td>
</tr>
<tr>
<td>• Pantothenic acid</td>
<td></td>
</tr>
<tr>
<td>• Vitamin $B_6$ (pyridoxine)</td>
<td></td>
</tr>
<tr>
<td>• Folate (folic acid)</td>
<td></td>
</tr>
<tr>
<td>• Vitamin $B_{12}$ (cobalamin)</td>
<td></td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td></td>
</tr>
</tbody>
</table>
Vitamin fortification

- Adds nutrients to foods
- Government mandated and voluntary
- Prevents deficiencies leading to diseases but may also cause toxicity
Vitamin fortification

![Graph showing the decline in deaths from pellagra over time with notes on voluntary and mandatory flour enrichment in some states and 22 states.]

**Fortified Breakfast Cereal Nutrition Facts**

<table>
<thead>
<tr>
<th>Serving Size</th>
<th>Cereal with 1/2 Cup Vitamins A&amp;D Fat Free Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Per Serving</td>
<td>Calories</td>
</tr>
<tr>
<td>1 Cup (50g/1.8 oz.)</td>
<td>180</td>
</tr>
</tbody>
</table>

**Total Fat:** 0.5g* 1% 1%

**Saturated Fat:** 0g 0% 0%

**Trans Fat:** 0g

**Cholesterol:** 0mg 0% 0%

**Sodium:** 260mg 12% 14%

**Potassium:** 100mg 3% 9%

**Total Carbohydrate:** 35g 12% 14%

**Dietary Fiber:** 2g 9% 9%

**Sugars:** 7g

**Other Carbohydrate:** 26g

**Protein:** 3g

- Vitamin A 15% 20%
- Vitamin C 25% 25%
- Calcium 0% 15%
- Iron 100% 100%
- Vitamin D 10% 25%
- Vitamin E 100% 100%
- Thiamin 100% 100%
- Riboflavin 100% 110%
- Niacin 100% 100%
- Vitamin B6 100% 100%
- Folic Acid 100% 100%
- Vitamin B12 100% 110%
- Pantothenate 100% 100%
- Phosphorus 10% 20%
- Magnesium 8% 10%
- Zinc 100% 100%
- Copper 4% 6%

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Which choice is highest in vitamins?

Frozen foods are often frozen in the field in order to minimize nutrient losses. Thus, frozen fruits and vegetables may supply more vitamins than “fresh” ones.

The high temperatures used in canning reduce nutrient content. However, because canned foods keep for a long time, do not require refrigeration, and are often less expensive than fresh or frozen foods, they provide an available, affordable source of nutrients that may be the best choice in some situations.

Sometimes “fresh” produce is lower in nutrients than you would expect because it has spent a week in a truck, traveling to your store, several days on a shelf, and maybe another week in your refrigerator.

George Semple
Tips for preserving the vitamins in your food  Table 7.2

- Store food away from heat and light and eat it soon after purchasing it.
- Cut fruits and vegetables as close as possible to the time when they will be cooked or served.
- Don’t soak vegetables.
- Cook vegetables with as little water as possible by microwaving, pressure-cooking, roasting, grilling, stir-frying, or baking rather than boiling them.
- If foods are cooked in water, use the cooking water to make soups and sauces so that you can retrieve some of the nutrients.
- Don’t rinse rice before cooking, in order to avoid washing away water-soluble vitamins.
Vitamin bioavailability

- Affected by:
  - Absorption /// Fat-soluble vitamins: need dietary fat
  - Transport in blood
    - Water-soluble vitamins: blood proteins
    - Fat-soluble vitamins: chylomicrons
  - Conversion of inactive provitamins or vitamin precursors into active vitamins
Vitamin bioavailability

1. In the mouth, chewing breaks food into small particles, helping to release vitamins.
2. In the stomach, digestion of food releases vitamins. Some niacin is absorbed here.
3. The gallbladder releases bile, which emulsifies fat and helps absorb fat-soluble vitamins.
4. The pancreas secretes digestive enzymes that aid in the release of vitamins from food.
5. In the small intestine, fat-soluble vitamins are incorporated into micelles and then absorbed by simple diffusion. Once they are inside the mucosal cells, fat-soluble vitamins are packaged in chylomicrons, which enter the lymph before passing into the blood.
6. Water-soluble vitamins are absorbed from the small intestine directly into the blood. Many depend on energy-requiring transport systems or must bind to specific molecules in the gastrointestinal tract to be absorbed. Vitamin B₁₂ is absorbed in the lower portion of the small intestine.
7. In the large intestine, bacteria synthesize small amounts of vitamins, some of which are absorbed.
Vitamin functions
Coenzymes

- Bind enzymes to promote their activity

- Carriers of electrons, atoms, or chemical groups that participate in the reactions

- Organic non-protein molecules ///
  Examples: B vitamins
Coenzymes

1. The vitamin combines with a chemical group to form the functional coenzyme (active vitamin).

2. The functional coenzyme combines with the incomplete enzyme to form the active enzyme.

3. The active enzyme binds to one or more molecules and accelerates the chemical reaction to form one or more new molecules.

4. The new molecules are released, and the enzyme and coenzyme (vitamin) can be reused or separated.
Free radicals & antioxidants

- **Reactive oxygen molecules**: cause oxidative damage by stealing electrons from other compounds, causing changes in their structure and function
  - **Examples**: Free radicals – generated by the body or from exposure to the environment

- **Antioxidants**: destroy reactive oxygen molecules
  - **Examples**: Vitamin C, vitamin E, and selenium
Free radicals & antioxidants

Free radicals can damage DNA and other molecules.

Antioxidants neutralize free radicals so they can no longer damage molecules such as DNA.

Vitamin C neutralizes free radicals.

Damaged DNA is repaired.

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Meeting vitamin needs

- DRIs include RDA, AI, and UL

- Vitamin A and C amounts are required on food labels as %DV
Meeting vitamin needs

The Daily Value for Vitamin C is 60 mg. Based on this label, how many mg of vitamin C are in a cup orange juice?

a) 40  
b) 60  
c) 72  
d) 120

To determine the exact amount of a vitamin in a food, look up the Daily Value (see Appendix F) and multiply it by the % Daily Value on the label.
Concept check

- Which food groups contain the greatest variety of vitamins?

- Why might a low-fat diet affect the bioavailability of fat-soluble vitamins?

- What is the principal function of coenzymes?

- How do antioxidants protect our cells?
Water-soluble vitamins

- **B vitamins**: involved in converting the energy in carbohydrate, fat, and protein into ATP

- **Vitamin C**: needed to make connective tissue and as an antioxidant

- **Choline**: vitamin?

- Not stored - need to be consumed regularly

- Excreted in urine
Thiamin (vitamin B₁) functions

- Coenzyme needed for glucose breakdown of glucose to provide energy

- Needed for metabolism of other sugars, certain amino acids and synthesis of ribose (in RNA)

- Important for nerve function because:
  - Glucose is nerve cell energy source
  - Needed for synthesis of neurotransmitters (chemical signals from neurons)
Thiamin (vitamin $B_1$) functions
Thiamin (vitamin B₁)

- **RDA**: men = 1.2 mg/day; women = 1.1 mg/day

- **Sources**: bran layer of whole grain, enriched grains, pork, legumes, and seeds

- **Deficiency**:
  - **Beriberi**: weakness, nerve degeneration, heart changes
  - **Wernicke-Korsakoff** syndrome in alcoholics: mental confusion, psychosis, memory disturbances, coma

- **Excess**: no reported effects
Thiamin (vitamin B$_1$) sources

- Sunflower seeds (1/4 c)
- Walnuts (1/4 c)
- Peanuts (1/4 c)
- Lentils (1 c)
- Pork (3 oz)
- Beef (3 oz)
- Trout (3 oz)
- Chicken (3 oz)
- 2% Milk (1 c)
- Cheddar cheese (1.5 oz)
- Orange juice (1 c)
- Kiwi (2 med)
- Apple (1 med)
- Corn (1/2 c)
- Asparagus (1/2 c)
- Spinach, raw (1 c)
- Oatmeal (1 c)
- Spaghetti (1 c)
- Brown rice (1 c)
- White bread (2 sl)
- Whole-wheat bread (2 sl)

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Thiamin (vitamin B₁) deficiency

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Riboflavin functions

- Forms two active coenzymes that act as electron carriers functioning in reactions needed to produce ATP from carbohydrate, fat, and protein.

- Involved in converting folate, niacin, vitamin B$_6$ and vitamin K into their active forms.
Riboflavin

- **RDA**: men = 1.3 mg/day; women = 1.1 mg/day

- **Sources**: dairy products, liver, red meat, poultry, fish, whole grains, enriched grains, asparagus, broccoli, mushrooms, leafy greens

- **Deficiency**: injuries heal poorly; cracking of lips and corners of mouth; sensitivity to light; eye burning, tearing, itching; skin flaking around nose, eyebrows, earlobes

- **Excess**: no reported effects but turns urine bright fluorescent yellow
Riboflavin sources
Niacin functions

- Coenzyme in glucose metabolism and synthesis of fatty acids and cholesterol
Niacin

- **RDA**: men = 16 mg NE/day ; women = 14 mg NE/day

- **Sources**: meats, fish, peanuts, whole and enriched grains, legumes, wheat bran, synthesized from the essential amino acid tryptophan

- **Deficiency**: Pellagra: fatigue, decreased appetite, indigestion, 4Ds = dermatitis, diarrhea, dementia, death

- **Excess**: no reported effects from food but supplements can be toxic causing skin flushing and rash, tingling in hands and feet, nausea, vomiting, diarrhea, high blood sugar levels, liver function abnormalities, blurred vision
Niacin sources

- Sunflower seeds (1/4 c)
- Walnuts (1/4 c)
- Peanuts (1/4 c)
- Lentils (1 c)
- Pork (3 oz)
- Beef (3 oz)
- Trout (3 oz)
- Chicken (3 oz)
- 2% Milk (1 c)
- Cheddar cheese (1.5 oz)
- Orange juice (1 c)
- Kiwi (2 med)
- Apple (1 med)
- Corn (1/2 c)
- Asparagus (1/2 c)
- Spinach, raw (1 c)
- Oatmeal (1 c)
- Spaghetti (1 c)
- Brown rice (1 c)
- White bread (2 sl)
- Whole-wheat bread (2 sl)

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Niacin deficiency

Observation
Goldberger observed that individuals in institutions such as hospitals, orphanages, and prisons suffered from pellagra, but the staff did not. If pellagra were an infectious disease, both populations would be equally affected.

Hypothesis
Goldberger hypothesized that pellagra was due to a deficiency in the diet.

Experiments
Experimental design: Goldberger and coworkers added nutritious foods, including meat, milk, and vegetables, to the diets of children in two orphanages.
Results: Those consuming the healthier diets recovered from pellagra. Those without the disease who ate the new diet did not contract pellagra, supporting the hypothesis that it was caused by a dietary deficiency.
Experimental design: Goldberger and colleagues fed eleven volunteers a diet believed to be lacking in the dietary substance that prevents pellagra.
Results: Six of the eleven developed symptoms of pellagra after 5 months of consuming the experimental diet, supporting the hypothesis that it was caused by a dietary deficiency.
Continued experiments: Human and animal studies by a number of scientists lead to the identification of nicotinic acid, better known as the water-soluble B vitamin niacin, in 1937, as the dietary component that cures and prevents pellagra.

Theory
Pellagra is caused by a deficiency of the B vitamin niacin.
Biotin functions

- Coenzyme in energy production and glucose synthesis
- Important in fatty acid and amino acid metabolism
Biotin

- **AI**: 30 μg/day

- **Sources**: cooked eggs, liver, yogurt, nuts, synthesized by gastrointestinal bacteria (fruit and meat are poor sources)

- **Deficiency**: with malabsorption or malnutrition; taking certain medications for long periods; eating raw eggs; causes nausea, thinning hair, loss of hair color, tingling in hands and feet, red skin rash, depression, lethargy, hallucinations

- **Excess**: no reported effects
Pantothenic acid functions

- Part of coenzyme A (CoA) needed for:
  - carbohydrate, fatty acid, and amino acid breakdown
  - modification of proteins
  - synthesis of neurotransmitters, steroid hormones, and hemoglobin

- Needed to form a molecule essential for cholesterol and fatty acid synthesis
Pantothenic acid

- **AI**: 5 mg/day

- **Sources**: widely distributed in foods, abundant in meat, eggs, whole grains, legumes (lesser amounts in milk, vegetables, fruits)

- **Deficiency**: rare due to wide distribution

- **Excess**: no reported effects
Vitamin B₆ functions

- Important for:
  - amino acid and protein metabolism
  - synthesis of nonessential amino acids, neurotransmitters, hemoglobin
  - conversion of tryptophan into niacin
  - glycogen breakdown
Vitamin B₆ functions

- 3 forms: pyridoxal, pyridoxine, pyridoxamine
  - converted into active coenzyme pyridoxal phosphate needed for the activity of >100 enzymes in carbohydrate, fat, and protein metabolism
Vitamin B<sub>6</sub> functions
Vitamin B₆ functions

Proteins

Amino acids

Methionine

Homocysteine

Vitamin B₆

Cysteine

High levels in the blood increase cardiovascular disease risk
Vitamin B₆

- **RDA**: men and women ages 19 to 50 = 1.3 mg/day

- **Sources**: chicken, fish, pork, organ meats, whole grains, legumes, sunflower seeds, bananas, broccoli, spinach, some fortified cereals (refined grains are not good sources)

- **Deficiency**: poor growth, skin lesions, decreased immunity, anemia, neurological symptoms

- **Excess**: no reported effects from food but supplements can be toxic causing severe nerve impairment
Folate (folic acid) functions

- Folate coenzymes needed for DNA synthesis (especially needed in rapidly-dividing tissues) and some amino acid metabolism

- Important in early pregnancy for neural tube formation, which develops into the brain and spinal cord

- Prevent homocysteine levels from rising to prevent heart disease
Folate (folic acid) functions

Day 19
- Neural tissue

Day 20
- Fold to form a groove

Day 22
- Sides almost touch to form a tube

Day 28
- Neural tube closure complete

Normal spine
- Spine with mild spina bifida
- Spine with severe spina bifida
Folate (folic acid) functions

Red blood cell precursor → Folate adequate → Normal cell division → Red blood cells

Red blood cell precursor → Folate deficient → Cells are unable to divide (megaloblast) → Macrocyte

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Folate & vitamin $\text{B}_{12}$

Supplemental folic acid can prevent macrocytic anemia, thus “hiding” vitamin $\text{B}_{12}$ deficiency. Untreated vitamin $\text{B}_{12}$ deficiency can cause irreversible nerve damage.

Folic acid from food and supplements

This form of folate, needed for the synthesis of DNA, cannot be made if vitamin $\text{B}_{12}$ is deficient. The resulting folate deficiency causes macrocytic anemia.

Active folate

Inactive folate

Folate and vitamin $\text{B}_{12}$ are both needed to convert homocysteine to methionine. When either is deficient, homocysteine levels rise.

Methionine

Homocysteine

Vitamin $\text{B}_{6}$

Cysteine

Proteins

Amino acids

High levels in the blood increase cardiovascular disease risk

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Folate (folic acid)

- **RDA**: men and women = 400 µg/day

- **Sources**: enriched grains, leafy greens, asparagus, legumes, nuts, oranges, liver, yeast

- **Deficiency**: neural tube defects including spina bifida and anencephaly, macrocytic or megaloblastic anemia, poor growth, nerve development and function problems, diarrhea, tongue inflammation, increased risk of heart disease and some cancers

- **Excess**: concerns that excess will prevent folate-deficiency symptoms and mask B\textsubscript{12} deficiencies
Folate (folic acid) sources
Vitamin $B_{12}$ (cobalamin) functions

- Important for:
  - ATP production from certain fatty acids
  - Conversion of homocysteine to methionine
  - Maintenance of myelin coating on nerves
  - Amino acid and protein metabolism
Vitamin B$_{12}$ (cobalamin) functions

1. Vitamin B$_{12}$ in food is bound to protein.
2. In the stomach, acid and pepsin help release vitamin B$_{12}$ from food proteins.
3. Cells in the stomach lining release intrinsic factor (IF).
4. In the upper portion of the small intestine (duodenum), intrinsic factor binds to vitamin B$_{12}$.
5. In the lower part of the small intestine (ileum), the vitamin B$_{12}$-intrinsic factor complex binds to receptors on cells, allowing absorption. A small amount of B$_{12}$ not bound to intrinsic factor can be absorbed through passive diffusion.
6. In the colon, vitamin B$_{12}$ is synthesized by microorganisms but cannot be absorbed.
Vitamin $B_{12}$ (cobalamin)

- **RDA**: men and women = 2.4 µg/day

- **Sources**: found naturally only in animal products, also in *fortified products*

- **Deficiency**: pernicious anemia, increased homocysteine, decreased folate activation, numbness and tingling, gait abnormalities, memory loss, disorientation, paralysis, death

- **Excess**: no reported effects from intakes of up to 100 µg/day from food or supplements
Vitamin B$_{12}$ (cobalamin) sources

- Sunflower seeds (1/4 c)
- Walnuts (1/4 c)
- Peanuts (1/4 c)
- Lentils (1 c)
- Pork (3 oz)
- Beef (3 oz)
- Trout (3 oz)
- Chicken (3 oz)
- 2% Milk (1 c)
- Cheddar cheese (1.5 oz)
- Orange juice (1 c)
- Kiwi (2 med)
- Apple (1 med)
- Corn (1/2 c)
- Asparagus (1/2 c)
- Spinach, raw (1 c)
- Oatmeal (1 c)
- Spaghetti (1 c)
- Brown rice (1 c)
- White bread (2 sl)
- Whole-wheat bread (2 sl)

RDA
men and women

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Vitamin C (ascorbic acid) functions

- Synthesis and maintenance of collagen, the base of all connective tissue
- Needed for synthesis of neurotransmitters, hormones, bile acids, and carnitine (needed for fatty acid breakdown)
- Antioxidant in blood and body fluids
  - Helps maintain the immune system
  - Regenerates active antioxidant form of vitamin E
  - Enhances iron absorption
Vitamin C (ascorbic acid) functions

Collagen molecule

No vitamin C

Vitamin C

Weak, abnormal connective tissue

Strong, healthy, cross-linked connective tissue
Vitamin C (ascorbic acid)

- **RDA**: men = 90 mg/day, women = 75 mg/day

- **Sources**: citrus fruits, strawberries, kiwis, cantaloupe, cabbage-family and dark-green vegetables, green and red peppers, okra, tomatoes, potatoes

- **Deficiency**: scurvy (gum and tooth problems, joint pain, bleeding, poor wound healing, bone fractures, fatigue, depression, hysteria)

- **Excess**: excessive vitamin C supplementation can cause diarrhea, nausea, abdominal cramps, possible increased kidney stone formation
Choline

- Water-soluble substance included in “vitamin B complex” supplements

- Synthesized to a limited extent by humans

- Essential nutrient

  - Not currently classified as a vitamin
Choline functions

Needed for:

- Synthesis of neurotransmitter acetylcholine
- Structure and function of cell membranes
- Lipid transport
- Homocysteine metabolism
Choline

- **AI**: men = 550 mg/day, women = 425 mg/day

- **Sources**: egg yolks, liver, meat, fish, wheat germ, nuts

- **Deficiency**: during pregnancy can interfere with fetal brain development in the fetus and causes fatty liver and muscle in adults

- **Excess**: fishy body odor, sweating, reduced growth rate, low blood pressure, and liver damage at levels higher than can be obtained from food
Concept check

- Why do people think B vitamin supplements give them energy?

- What is the role of vitamin B$_6$ in amino acid metabolism?

- How can folate and vitamin B$_{12}$ deficiency both cause macrocytic anemia?

- What is the role of vitamin C in collagen formation, and how does deficiency cause symptoms of scurvy?
### Water-soluble vitamin summary

**A summary of the water-soluble vitamins and choline**  
Table 7.3

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Sources</th>
<th>Recommended intake for adults</th>
<th>Major functions</th>
<th>Deficiency diseases and symptoms</th>
<th>Groups at risk of deficiency</th>
<th>Toxicity</th>
<th>UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamin (vitamin B₁, thiamin mononitrate)</td>
<td>Pork, whole and enriched grains, seeds, nuts, legumes</td>
<td>1.1–1.2 mg/day</td>
<td>Coenzyme in glucose and energy metabolism; needed for neurotransmitter synthesis and normal nerve function</td>
<td>Beriberi: weakness, apathy, irritability, nerve tingling, poor coordination, paralysis, heart changes</td>
<td>Alcoholics, those living in poverty</td>
<td>None reported</td>
<td>ND</td>
</tr>
<tr>
<td>Riboflavin (vitamin B₂)</td>
<td>Dairy products, whole and enriched grains, dark green vegetables, meats</td>
<td>1.1–1.3 mg/day</td>
<td>Coenzyme in energy and lipid metabolism</td>
<td>Inflammation of the mouth and tongue, cracks at corners of the mouth</td>
<td>None</td>
<td>None reported</td>
<td>ND</td>
</tr>
<tr>
<td>Niacin (nicotinamide, nicotinic acid, vitamin B₃)</td>
<td>Beef, chicken, fish, peanuts, legumes, whole and enriched grains; can be made from tryptophan</td>
<td>14–16 mg NE/day</td>
<td>Coenzyme in energy metabolism and lipid synthesis and breakdown</td>
<td>Pellagra: diarrhea, dermatitis on areas exposed to sun, dementia</td>
<td>Those consuming a limited diet based on corn; alcoholics</td>
<td>Flushing nausea, rash, tingling extremities</td>
<td>35 mg/day from fortified foods and supplements</td>
</tr>
<tr>
<td>Biotin</td>
<td>Liver, egg yolks; synthesized in the gut</td>
<td>30 μg/day</td>
<td>Coenzyme in glucose synthesis and energy and fatty acid metabolism</td>
<td>Dermatitis, nausea, depression, hallucinations</td>
<td>Those consuming large amounts of raw egg whites; alcoholics</td>
<td>None reported</td>
<td>ND</td>
</tr>
<tr>
<td>Pantothenic acid (calcium pantothenate)</td>
<td>Meat, legumes, whole grains; widespread in foods</td>
<td>5 mg/day</td>
<td>Coenzyme in energy metabolism and lipid synthesis and breakdown</td>
<td>Fatigue, rash</td>
<td>Alcoholics</td>
<td>None reported</td>
<td>ND</td>
</tr>
</tbody>
</table>
## Water-soluble vitamin summary

<table>
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<tr>
<th>Vitamin</th>
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<th>Toxicity</th>
<th>UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin (B_6) (pyridoxine, pyridoxal phosphate, pyridoxamine)</td>
<td>Meat, fish, poultry, legumes, whole grains, nuts and seeds</td>
<td>1.3–1.7 mg/day</td>
<td>Coenzyme in protein and amino acid metabolism, neurotransmitter and hemoglobin synthesis, many other reactions</td>
<td>Headache, convulsions, other neurological symptoms, nausea, poor growth, anemia</td>
<td>Alcoholics</td>
<td>Numbness, nerve damage</td>
<td>100 mg/day</td>
</tr>
<tr>
<td>Folate (folate acid, folacin, pteroyglutamic acid)</td>
<td>Leafy green vegetables, legumes, seeds, enriched grains, orange juice</td>
<td>400 (\mu g) DFE/day</td>
<td>Coenzyme in DNA synthesis and amino acid metabolism</td>
<td>Macrocytic anemia, inflammation of tongue, diarrhea, poor growth, neural tube defects</td>
<td>Pregnant women, alcoholics</td>
<td>Masks (B_12) deficiency</td>
<td>1000 (\mu g)/day from fortified food and supplements</td>
</tr>
<tr>
<td>Vitamin (B_{12}) (cobalamin, cyanocobalamin)</td>
<td>Animal products</td>
<td>2.4 (\mu g)/day</td>
<td>Coenzyme in folate and homocysteine metabolism; nerve function</td>
<td>Pernicious anemia, macrocytic anemia, nerve damage</td>
<td>Vegans, elderly people with stomach or intestinal disease</td>
<td>None reported</td>
<td>ND</td>
</tr>
<tr>
<td>Vitamin C (ascorbic acid, ascorbate)</td>
<td>Citrus fruit, broccoli, strawberries, greens, peppers</td>
<td>75–90 mg/day</td>
<td>Coenzyme in collagen (connective tissue) synthesis; hormone and neurotransmitter synthesis; antioxidant</td>
<td>Scurvy: poor wound healing, bleeding gums, loose teeth, bone fragility, joint pain, pinpoint hemorrhages</td>
<td>Alcoholics, elderly people</td>
<td>GI distress, diarrhea</td>
<td>2000 mg/day</td>
</tr>
<tr>
<td>Choline*</td>
<td>Egg yolks, organ meats, wheat germ, meat, fish, nuts, synthesis in the body</td>
<td>425–550 mg/day</td>
<td>Synthesis of cell membranes and neurotransmitters</td>
<td>Fatty liver, muscle damage, abnormal prenatal development</td>
<td>None</td>
<td>Sweating, low blood pressure, liver damage</td>
<td>3500 mg/day</td>
</tr>
</tbody>
</table>

*Choline is technically not a vitamin, but recommendations have been made for its intake.

Note: UL, Tolerable Upper Intake Level; NE, niacin equivalent; DFE, dietary folate equivalent; ND, not determined due to insufficient data.
Water-soluble vitamins

- **B vitamins**: involved in converting the energy in carbohydrate, fat, and protein into ATP
- **Vitamin C**: needed to make connective tissue and as an antioxidant
- **Choline**: vitamin?
- Not stored - need to be consumed regularly
- Excreted in urine
Vitamins

- Water soluble
  - B Vitamins
    - Thiamin
    - Riboflavin
    - Niacin
    - Biotin
  - Vitamin C
    - Pantothenic acid
    - Vitamin B₆
    - Folate
    - Vitamin B₁₂
- Fat soluble
  - Vitamin A
  - Vitamin D
  - Vitamin E
  - Vitamin K
Fat-soluble vitamins

- Vitamins A, D, E, and K
- Found with fats in foods
- Require special handling for absorption, transport and excretion /// Excretion limitations increases the risk of toxicity
- Stored in the liver and fatty tissues
  - Intakes can vary without a risk of deficiency if average intake over weeks/months meets needs
Vitamin A

- **Retinoids**: chemical forms of preformed vitamin A /// Retinol, retinal, retinoic acid

- **Carotenoids**: yellow-orange pigments synthesized by plants and many microorganisms
  
  - Some are vitamin A precursors converted to retinoids
  
  - Example: **beta-carotene**, provitamin converted into vitamin A
Vitamin A functions

■ Cell differentiation

- Immature cells change in structure and function to become specialized by changing gene expression (turning genes on and off)

- Necessary for maintenance of epithelial tissue
Vitamin A functions

- Part of rhodopsin, a visual pigment in the eye
  - When light strikes rhodopsin, it initiates a series of events that
  - Result in a nerve signal being sent to the brain, which allows us to see
- Carotenoids may function as antioxidants
Vitamin A functions

1. Rhodopsin
2. Opsin
3. Signal to brain
4. Retinal
5. Opsin
6. Vitamin A from blood
7. Low blood vitamin A

Vitamin A deficiency
Healthy vitamin A status

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Vitamin A

- **RDA**: men = 900 µg/day ; women = 700 µg/day

- **Sources**: vitamin A in animal products (eggs, dairy), provitamin A in fruits and vegetables // beta-carotene in orange, yellow, and dark green vegetables

- **Deficiency**: xerophthalmia (night blindness progressing to permanent blindness), abnormal jaw bone growth in children, increased infections

- **Excess**: nausea, vomiting, headache, dizziness, blurred vision, lack of muscle coordination, birth defects, liver damage, bone fractures; excess β-carotene can cause hypercarotenemia
Vitamin A sources

Sunflower seeds (1/4 c)
Almonds (1/4 c)
Lentils (1 c)
Eggs (2 large)
Beef liver (2 oz)
Salmon (3 oz)
Chicken (3 oz)
2% Milk (1 c)
Cheddar cheese (1.5 oz)
Low-fat yogurt, plain (1 c)
Orange (1 med)
Kiwi (2 med)
Apricots (2 med)
Tomato, raw (1/2 c)
Carrots, cooked (1/2 c)
Mustard greens, cooked (1/2 c)
Oatmeal (1 c)
White rice (1 c)
Whole-wheat bread (2 sl)
Vitamin A deficiency
Vitamin A deficiency
Vitamin A excess


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Vitamin D

- Made in skin with exposure to ultraviolet (UV) light

- Inactive until modified in liver and kidneys

- Essential in the diet only when exposure to sunlight is limited or the body’s ability to synthesize it is reduced
Vitamin D activation

1. We get vitamin D from the diet and from synthesis in the skin.
2. In order to function, vitamin D must be chemically modified, first by the liver and then by the kidneys.
3. At the intestine, active vitamin D increases the absorption of calcium and phosphorus from the diet; at the bone, it increases bone breakdown, releasing calcium and phosphorus into the blood; and at the kidneys, active vitamin D stimulates calcium retention, reducing the amount of calcium excreted in the urine.
4. Normal blood levels of calcium and phosphorus support bone mineralization.
Vitamin D functions

- Maintains normal levels of the minerals calcium and phosphorus in the blood
  - Calcium is needed for bone health and functioning of nerves, muscles, glands, and other tissues
  - Low blood calcium stimulates parathyroid hormone (PTH) release which stimulates vitamin D activation
- Changes gene expression
  - Intestines: turns on genes for calcium absorption
  - Bone: turns on genes bone breakdown
Vitamin D

- **RDA:** adults 70 and under = 600 IU (15 μg)/ day

- **Sources:** widespread in diet, liver, egg yolks, oily fish (for example, salmon), fortified foods

- **Deficiency:** low calcium absorption leading to rickets in children (pigeon breast and bowed legs) and osteomalacia and osteoporosis in adults

- **Excess:** causes high calcium concentrations in blood and urine, deposition of calcium in soft tissues such as the blood vessels and kidneys, and cardiovascular damage
Vitamin D sources

- Sunflower seeds (1/4 c)
- Almonds (1/4 c)
- Lentils (1 c)
- Eggs (2 large)
- Beef liver (2 oz)
- Salmon (3 oz)
- Chicken (3 oz)
- 1% Milk (1 c)
- Cheddar cheese (1.5 oz)
- Low-fat yogurt, plain (1 c)
- Orange (1 med)
- Kiwi (2 med)
- Apricots (2 med)
- Tomato, raw (1/2 c)
- Carrots, cooked (1/2 c)
- Mustard greens, cooked (1/2 c)
- Oatmeal (1 c)
- White rice (1 c)
- Whole-wheat bread (2 s)

RDA ages 1–70

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Vitamin D sources
Vitamin D deficiency
Vitamin E functions

- Antioxidant
  - Protects lipids including those in membranes of red blood cells, white blood cells, nerve cells, lung cells
  - Defends cells against damage caused by heavy metals (lead and mercury) and toxins (carbon tetrachloride, benzene, drugs)
  - Reduced risk of heart disease, cancer, Alzheimer’s disease, macular degeneration, other chronic diseases

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Vitamin E functions

- Possible anti-inflammatory functions, modulation of immunity, regulation of cell growth and death genes, detoxification of harmful substances
Vitamin E functions

To neutralize reactive electron-scavenging molecules, such as free radicals, vitamin E donates one of its electrons.

The antioxidant function of vitamin E can be restored by another antioxidant vitamin—vitamin C, which gives an electron back to vitamin E.
Vitamin E

- **RDA**: adults = 15 mg alpha-tocopherol/day

- **Sources**: seeds, nuts, plant oils, leafy-green vegetables, wheat germ, fortified cereals

- **Deficiency**: hemolytic anemia in infants; rare in adults causing poor muscle coordination, weakness, impaired vision

- **Excess**: no reported effects from food but large doses can interfere with blood clotting
Vitamin E sources

- Sunflower seeds (1/4 c)
- Almonds (1/4 c)
- Lentils (1 c)
- Eggs (2 large)
- Beef liver (2 oz)
- Salmon (3 oz)
- Chicken (3 oz)
- 1% Milk (1 c)
- Cheddar cheese (1.5 oz)
- Low-fat yogurt, plain (1 c)
- Orange (1 med)
- Kiwi (2 med)
- Apricots (2 med)
- Tomato, raw (1/2 c)
- Carrots, cooked (1/2 c)
- Mustard greens, cooked (1/2 c)
- Oatmeal (1 c)
- White rice (1 c)
- Whole-wheat bread (2 sl)

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Vitamin K functions

- Needed for
  - production of clotting factors
  - synthesis of proteins involved in bone formation and breakdown
Vitamin K functions

DAMAGED TISSUE

Series of reactions involving clotting factors, several of which require vitamin K for formation

PROTHROMBIN

(Requires vitamin K for formation)

THROMBIN

FIBRINOGEN

FIBRIN

Fibrin threads that form the webbing of a blood clot

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Anticoagulants

- Synthesis of blood clotting proteins
- Normal blood clotting
- Active vitamin K
- Inactive vitamin K
- Warfarin
- Prevention of blood clotting

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Vitamin K

- **RDA**: men = 120 µg/day, women = 90 µg/day

- **Sources**: leafy-green vegetables, some vegetable oils

- **Deficiency**: abnormal blood clotting causing bruising and bleeding, reduced bone density causing fractures

- **Excess**: no reported effects from food but large doses can interfere with blood clotting
Vitamin K sources
# Fat-soluble vitamins

## Table 7.4

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Sources</th>
<th>Recommended intake for adults</th>
<th>Major functions</th>
<th>Deficiency diseases and symptoms</th>
<th>Groups at risk of deficiency</th>
<th>Toxicity</th>
<th>UL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (retinol, retinal, retinoic acid, vitamin A acetate, vitamin A palmitate, retinyl palmitate, provitamin A, carotene, β-carotene, carotenoids)</td>
<td>Retinol: liver, fish, fortified milk and margarine, butter, eggs; carotenoids: carrots, leafy greens, sweet potatoes, broccoli, apricots, cantaloupe</td>
<td>700–900 µg/day</td>
<td>Vision, health of cornea and other epithelial tissue, cell differentiation, reproduction, immune function</td>
<td>Xerophthalmia: night blindness, dry cornea, eye infections; poor growth, dry skin, impaired immune function</td>
<td>People living in poverty (particularly children and pregnant women), people who consume very low-fat or low-protein diets</td>
<td>Headache, vomiting, hair loss, liver damage, skin changes, bone pain, fractures, birth defects</td>
<td>3000 µg/day of preformed vitamin A</td>
</tr>
<tr>
<td>Vitamin D (calciferol, cholecalciferol, calcitriol, ergocalciferol, dihydroxy vitamin D)</td>
<td>Egg yolk, liver, fish oils, tuna, salmon, fortified milk, synthesis from sunlight</td>
<td>600–800 IU/day (15–20 µg/day)</td>
<td>Absorption of calcium and phosphorus, maintenance of bone</td>
<td>Rickets in children: abnormal growth, misshapen bones, bowed legs, soft bones; osteomalacia in adults: weak bones and bone and muscle pain</td>
<td>Some breast-fed infants; children and elderly people (especially those with dark skin and little exposure to sunlight); people with kidney disease</td>
<td>Calcium deposits in soft tissues, growth retardation, kidney damage</td>
<td>4000 IU/day (100 µg/day)</td>
</tr>
<tr>
<td>Vitamin E (tocopherol, alpha-tocopherol)</td>
<td>Vegetable oils, leafy greens, seeds, nuts, peanuts</td>
<td>15 mg/day</td>
<td>Antioxidant, protects cell membranes</td>
<td>Broken red blood cells, nerve damage</td>
<td>People with poor fat absorption, premature infants</td>
<td>Inhibition of vitamin K activity</td>
<td>1000 mg/day from supplemental sources</td>
</tr>
<tr>
<td>Vitamin K (phyloquinones, menaquinone)</td>
<td>Vegetable oils, leafy greens, synthesis by intestinal bacteria</td>
<td>90–120 µg/day</td>
<td>Synthesis of blood-clotting proteins and proteins in bone</td>
<td>Hemorrhage</td>
<td>Newborns (especially premature), people on long-term antibiotics</td>
<td>Anemia, brain damage</td>
<td>ND</td>
</tr>
</tbody>
</table>

Note: UL, Tolerable Upper Intake Level; ND, not determined due to insufficient evidence.
Concept check

- How does vitamin A help us see in the dark?
- Why do the leg bones bow when children are vitamin D deficient?
- How does vitamin E protect membranes?
- What is the role of vitamin K in blood clotting?
Vitamins

- Water soluble
  - B Vitamins
    - Thiamin
    - Riboflavin
    - Niacin
    - Biotin
  - Vitamin C
    - Pantothenic acid
    - Vitamin B₆
    - Folate
    - Vitamin B₁₂

- Fat soluble
  - Vitamin A
  - Vitamin D
  - Vitamin E
  - Vitamin K
What are similarities and differences between:

- Water soluble and fat-soluble vitamins?
- B Vitamins?
- B Vitamins and Vitamin C?
- Vitamins A, D, E, and K?
- Vitamin C and Vitamin E?
- Vitamin D and Vitamin E?
THINK about this – then share within a PAIR – then SHARE with the class

- What do you know about supplements?
Supplements

- Contain vitamins and minerals, herbs and other plant-derived substances, and/or body compounds not essential in the diet

- Help obtain adequate amounts of specific nutrients but do not provide all the benefits of foods
<table>
<thead>
<tr>
<th>Group</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dieters</td>
<td>People who consume fewer than 1600 Calories/day should take a multivitamin/multimineral supplement.</td>
</tr>
<tr>
<td>Vegans and those who eliminate all dairy foods</td>
<td>To obtain adequate vitamin B&lt;sub&gt;12&lt;/sub&gt;, people who do not eat animal products need to take supplements or consume vitamin B&lt;sub&gt;12&lt;/sub&gt;-fortified foods. Because dairy products are an important source of calcium and vitamin D, those who do not consume dairy products may benefit from taking supplements that provide calcium and vitamin D.</td>
</tr>
<tr>
<td>Infants and children</td>
<td>Supplemental fluoride, vitamin D, and iron are recommended under certain circumstances.</td>
</tr>
<tr>
<td>Young women and pregnant women</td>
<td>Women of childbearing age should consume 400 μg of folic acid daily from either fortified foods or supplements. Supplements of iron and folic acid are recommended for pregnant women, and multivitamin/multimineral supplements are usually prescribed during pregnancy.</td>
</tr>
<tr>
<td>Older adults</td>
<td>Because of the high incidence of atrophic gastritis in adults over age 50, vitamin B&lt;sub&gt;12&lt;/sub&gt; supplements or fortified foods are recommended. It may also be difficult for older adults to meet the RDAs for vitamin D and calcium, so supplements of these nutrients are often recommended.</td>
</tr>
<tr>
<td>Individuals with dark skin pigmentation</td>
<td>People with dark skin may be unable to synthesize enough vitamin D to meet their needs for this vitamin and may therefore require supplements.</td>
</tr>
<tr>
<td>Individuals with restricted diets</td>
<td>Individuals with health conditions that affect what foods they eat or how nutrients are used may require vitamin and mineral supplements.</td>
</tr>
<tr>
<td>People taking medications</td>
<td>Medications may interfere with the body’s use of certain nutrients.</td>
</tr>
<tr>
<td>Cigarette smokers and alcohol users</td>
<td>People who smoke heavily require more vitamin C and possibly vitamin E than do nonsmokers. Alcohol consumption inhibits the absorption of B vitamins and may interfere with B vitamin metabolism.</td>
</tr>
</tbody>
</table>
Herbal supplements

- **Herb**: non-woody, *seed-producing plant* that dies at the end of the growing season

- Also refers to any botanical or plant-derived substance
Herbal supplements
Herbal supplements

<table>
<thead>
<tr>
<th>Product</th>
<th>Suggested benefit and uses</th>
<th>Side effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astragalus (bei qi, huang qi, ogi, hwang ki, milk vetch)</td>
<td>Enhances the immune system</td>
<td>Can interact with drugs that suppress the immune system and affect blood sugar levels and blood pressure</td>
</tr>
<tr>
<td>Bitter orange (Seville orange, sour orange, Zhi shi)</td>
<td>Relieves heartburn and nasal congestion, stimulates appetite, promotes weight loss</td>
<td>Increased heart rate and blood pressure, fainting, heart attack, stroke</td>
</tr>
<tr>
<td>Cat’s Claw (uña de gato)</td>
<td>Relieves arthritis and stimulates the immune system</td>
<td>Headache, dizziness, vomiting; Should not be taken by individuals who are pregnant</td>
</tr>
<tr>
<td>Chamomile</td>
<td>Aids gastrointestinal upset, promotes relaxation and sleep</td>
<td>Allergic reactions</td>
</tr>
<tr>
<td>Dandelion (lion’s tooth, blowball)</td>
<td>Relieves minor digestive problems, increases urine production, supports liver and kidney health</td>
<td>Upset stomach and diarrhea, allergic reactions</td>
</tr>
<tr>
<td>Echinacea (purple coneflower, coneflower)</td>
<td>Stimulates the immune system, prevents and treats colds and other upper respiratory infections.</td>
<td>Allergic reactions</td>
</tr>
<tr>
<td>Ephedra (Ma Huang, Chinese ephedra)</td>
<td>Treats colds and nasal congestion, aids in weight loss, increases energy, and enhances athletic performance</td>
<td>High blood pressure, irregular heartbeat, heart attack, stroke, death; banned by the FDA, but the ban does not apply to traditional Chinese herbal remedies or to products like herbal teas regulated as conventional foods</td>
</tr>
<tr>
<td>Ginger</td>
<td>Relieves motion sickness and nausea</td>
<td>Gas, bloating, heartburn, nausea</td>
</tr>
<tr>
<td>Ginkgo (Ginkgo biloba, maidenhair tree, fossil tree)</td>
<td>Improves memory and mental function, improves circulation</td>
<td>Gastrointestinal distress, headache, dizziness, allergic skin reactions</td>
</tr>
</tbody>
</table>

# Herbal supplements

## Potential benefits and side effects of common herbal ingredients

<table>
<thead>
<tr>
<th>Product</th>
<th>Suggested benefit and uses</th>
<th>Side effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginseng (Asian ginseng, Chinese ginseng)</td>
<td>Increases sense of well-being and stamina; improves mental and physical performance, enhances immune function, improves sexual function, lowers blood glucose, controls blood pressure</td>
<td>Headache, insomnia, gastrointestinal upset with prolonged use</td>
</tr>
<tr>
<td>Hawthorn</td>
<td>Strengthens heart muscle</td>
<td>Possible drug interactions</td>
</tr>
<tr>
<td>Hoodia (Kalahari cactus, Xhoba)</td>
<td>Suppresses appetite</td>
<td>Safety unknown; potential risks, side effects, and interactions with medicines and other supplements have not been studied</td>
</tr>
<tr>
<td>Kava (kava kava, awa, kava pepper)</td>
<td>Relieves anxiety, stress, insomnia, menopausal symptoms</td>
<td>Liver damage, including hepatitis and liver failure (which can cause death); FDA has issued a warning that using kava supplements has been linked to a risk of severe liver damage</td>
</tr>
<tr>
<td>Milk thistle (Mary thistle, holy thistle)</td>
<td>Protects against liver disease, improves liver function</td>
<td>Gastrointestinal upset, allergic reactions, low blood sugar</td>
</tr>
<tr>
<td>Red clover (cow clover, meadow clover, wild clover)</td>
<td>Relieves menopausal symptoms, breast pain associated with menstrual cycles, and symptoms of prostate enlargement; lowers blood cholesterol</td>
<td>Headache, nausea, rash</td>
</tr>
<tr>
<td>Saw palmetto (American dwarf palm tree, cabbage palm)</td>
<td>Improves urinary flow with enlarged prostate</td>
<td>Mild stomach discomfort</td>
</tr>
<tr>
<td>St. John's wort (hypericum, Klamath weed, goatweed)</td>
<td>Promotes mental well-being; treats depression, anxiety, and/or sleep disorders</td>
<td>Increased sensitivity to sunlight, anxiety, dry mouth, dizziness, gastrointestinal symptoms, fatigue, headache, sexual dysfunction; interacts with many medications, including antidepressants, birth control pills, digoxin, warfarin, and seizure-control drugs</td>
</tr>
<tr>
<td>Valerian (all-heal, garden heliotrope)</td>
<td>Mild sedative, relieves sleep disorders and anxiety</td>
<td>Gastrointestinal upset, headache, and tiredness possible with prolonged use</td>
</tr>
<tr>
<td>Yohimbe (yohimbe bark)</td>
<td>Acts as aphrodisiac; treats sexual dysfunction, including erectile dysfunction in men</td>
<td>High blood pressure, increased heart rate, headache, anxiety, dizziness, nausea, vomiting, tremors, and sleeplessness</td>
</tr>
</tbody>
</table>


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Debate

Are herbal supplements helpful or harmful?
Regulation of supplements

- Dietary Supplement Health and Education Act (DSHEA) of 1994 defined the term dietary supplement and created labeling standards.

- FDA established “current Good Manufacturing Practice” (cGMP) regulations:
  - Requires manufacturers to test their products to ensure identity, purity, strength, and composition.

- FDA pre-market review required if ingredient not sold in the US before October 15, 1994.
Choosing supplements

- Do not exceed 100% of Daily Values
- Consider why you want it
- Compare product costs
- Read the label
- Check the expiration date
- Consider your medical history
- Approach herbal supplements with caution
- Report harmful effects
# Supplements

## Supplement Facts

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount Per Serving</th>
<th>DV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C (as ascorbic acid)</td>
<td>60mg</td>
<td>100%</td>
</tr>
<tr>
<td>Pantothenic Acid (as calcium, pantothenate)</td>
<td>20mg</td>
<td>200%</td>
</tr>
<tr>
<td>Vitamin B-6 (as pyridoxine HCL)</td>
<td>8mg</td>
<td>400%</td>
</tr>
<tr>
<td>Niacin</td>
<td>5mg</td>
<td>25%</td>
</tr>
<tr>
<td>Folate (as folic acid)</td>
<td>100mcg</td>
<td>25%</td>
</tr>
<tr>
<td>Zinc (as zinc gluconate)</td>
<td>5mg</td>
<td>33%</td>
</tr>
<tr>
<td>Copper (as copper gluconate)</td>
<td>500mcg</td>
<td>25%</td>
</tr>
<tr>
<td>NADH (Nicotinamide Adenine Dinucleotide)</td>
<td>1000mcg</td>
<td></td>
</tr>
<tr>
<td>Hoodia Gordonii Extract (20:1 Extract-</td>
<td>100mg</td>
<td></td>
</tr>
<tr>
<td>Equal to 2000 mg of whole plant)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-Hydroxytryptophan (Griffonia Simplicifolia)</td>
<td>25mg</td>
<td></td>
</tr>
<tr>
<td>N, N Dimethylglycine</td>
<td>50mg</td>
<td></td>
</tr>
<tr>
<td>Trimethylglycine</td>
<td>75mg</td>
<td></td>
</tr>
<tr>
<td>L-Phenylalanine</td>
<td>600mg</td>
<td></td>
</tr>
<tr>
<td>Decaffeinated Green Tea Extract</td>
<td>175mg</td>
<td></td>
</tr>
<tr>
<td>(Total Catechins 130mg, Epigallocatechin Gallocate (EGCG)</td>
<td>70mg</td>
<td></td>
</tr>
<tr>
<td>Salvia Scalarea Extract</td>
<td>50mg</td>
<td></td>
</tr>
<tr>
<td>Choline (as bitartrate)</td>
<td>75mg</td>
<td></td>
</tr>
</tbody>
</table>

*Daily Value (DV, not established)*

**Recommended Use:** As a dietary supplement take two capsules before breakfast on an empty stomach (or before exercise) and two capsules at mid-afternoon preferably with 8 oz of water.

This supplement contains more than 100% of the Daily Value for vitamin B-6. Does this amount exceed the UL?

This supplement contains many ingredients that are not vitamins or minerals and therefore have no Daily Value or UL. The ones shown in blue are herbs. Are they safe when taken in these amounts?
Concept check

- Why is it recommended that vegans and older adults take vitamin $B_{12}$ supplements?

- Who regulates the safety of dietary supplements?

- How can the UL be used when evaluating a dietary supplement?
What is happening in this picture?

- Why does this treatment help them meet their need for vitamin D?
- Why are children in Russia at risk for vitamin D deficiency?
- What else could be done to ensure that they get adequate amounts of vitamin D?
Applications

What advice could you give to a loved one about vitamin consumption to decrease disease risk?
What should I eat?

- Focus on foliage for folate, vitamin A, and vitamin K
- B (vitamin) sure
- Get your antioxidants // Try for 5 colors of fruits and veggies each day
- Soak up some D // Get outside to stay fit and make some vitamin // Have three servings of dairy per day boost intake
Nutrition in the news

- Supplements
- Functional foods
- Vitamin D deficiency and supplements
Checking student learning outcomes

- How are water-soluble and fat-soluble vitamins similar and different?

- How do vitamins contribute to health and disease?

- What advice would you give to a loved one about vitamin consumption?