Objectives for Chapter 7

- Describe the characteristics of vitamins.
- Explain the differences between fat-soluble and water-soluble vitamins, and classify each vitamin according to its solubility.
- Define the term antioxidant and explain which vitamins perform this function.
- List at least one good food source for each of vitamins A, D, E, and K.
- List at least one major role in the body for vitamins A, D, E, and K.
- Name at least one toxicity symptom for a fat-soluble vitamin.
- List at least one good food source for each of the water-soluble vitamins.
- Name at least one disease associated with a water-soluble vitamin deficiency.
- Explain the role of vitamin supplements in the diet.
What Are Vitamins?

Vitamins are essential nutrients

- Tasteless, organic compounds needed in small amounts
- A deficiency will cause physiological symptoms
- Consuming too much of some vitamins will cause adverse effects
What Are Vitamins?

Vitamins are fat-soluble or water-soluble

- Fat-soluble: A, D, E, and K are absorbed with dietary fat and can be stored in body
- Water-soluble vitamins are absorbed with water and enter the bloodstream directly
  - Not stored in body, but excesses still harmful
Vitamins Found Widely in MyPlate

<table>
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<tr>
<th>Vegetables</th>
<th>Fruit</th>
<th>Grains</th>
<th>Protein</th>
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<tr>
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<td>Folate</td>
<td>Folic acid</td>
<td>Niacin</td>
<td>Riboflavin</td>
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<tr>
<td>Vitamin A</td>
<td>Vitamin C</td>
<td>Niacin</td>
<td>Thiamin</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>Vitamin C</td>
<td></td>
<td>Vitamin B₆</td>
<td>Vitamin B₆</td>
<td>Vitamin A₂</td>
</tr>
<tr>
<td>Vitamin E</td>
<td></td>
<td>Vitamin B₁₂ (if fortified)</td>
<td>Vitamin B₁₂</td>
<td>Vitamin D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Riboflavin</td>
<td>Thiamin</td>
<td></td>
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</table>
What Are Vitamins?

- Some vitamins function as **antioxidants**, substances that neutralize free radicals.
  - Vitamins A, C, and E, and beta-carotene are antioxidants
  - **Free radicals** are unstable oxygen-containing molecules that can damage the cells of the body and possibly contribute to the increased risk of chronic diseases
Free Radicals

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

Oxidative stress

Free radicals (unstable molecules that damage cells)

Which can:
- Accelerate process of aging
- Increased risk of:
  - heart disease
  - cancer
  - diabetes
  - arthritis
  - macular degeneration
  - Parkinson’s disease
  - Alzheimer’s disease

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

“Neutralized” free radicals

Figure 7.4
What Are Vitamins?

- Vitamins differ in **bioavailability**, which is the degree to which a nutrient is absorbed from foods and used in the body.
  - Vitamins can be destroyed by air, water, or heat
  - Don’t expose your produce to air
  - A little water is enough
  - Reduce cooking time
  - Keep your food cool

- Overconsumption of some vitamins can be toxic

- **Provitamins** can be converted to vitamins by the body
Vitamins

- Source
- Function
- Too much
- Too little
- Recommendation
Vitamin A

Vitamin A: Two forms of vitamin A are available in the human diet:

1. **Preformed vitamin A**: Retinoids ANIMAL
2. **Provitamin A**: Carotenoids PLANT
Vitamin A

**Vitamin A: Retinoids (ANIMAL)**

Preformed vitamin A is **only** found in animal foods: liver, eggs, fortified milk, cheese
Vitamin A

Provitamin A: Carotenoids PLANT

- Some plants contain provitamin A carotenoids, which are converted to retinoids in your body.
- Carotenoids, including beta-carotene, are pigments which give orange color to carrots, cantaloupe, sweet potatoes. There are carotenoids in, spinach and broccoli… but they’re green…. What makes them green?
Vitamin A

Functions:

- Essential for eye health
- Involved in cell differentiation, reproduction, and immunity by promoting gene expression for:
  - Healthy skin, mucus membranes
  - Bone growth
  - Fetal development
  - White blood cells to fight harmful bacteria
Vitamin A

Too much: Hypervitaminosis A

- Because vitamin A is fat soluble, the body stores excess amounts, primarily in the liver, and these levels can accumulate.
- Chronic intakes of excess vitamin A lead to dizziness, nausea, headaches, skin irritation, pain in joints and bones, coma, and even death.
- Although hypervitaminosis A can be due to excessive dietary intakes, the condition is usually a result of consuming too much preformed vitamin A from supplements.
- Carotenoids in food are not toxic but can turn your orange!
Vitamin A

Too little: Avitaminosis A

- Chronic vitamin A deficiency can cause night blindness - reversible
- Prolonged vitamin A deficiency leads to xerophthalmia - permanent damage to the cornea
  - Number-one cause of preventable blindness in children, mostly in developing countries
- Vitamin A deficiency also associated with stunting of bones
Vitamin A

How Much?

RDAs for vitamin A are given as mcg of retinol activity equivalents (RAE) to account for the different bioactivities of retinoids and carotenoids.

Currently, vitamin A is listed on food and supplement labels in international units (IUs) even though nutrition scientists rarely use this measure.

An RAE cannot be directly converted into an IU without knowing the source(s) of vitamin A. For example,

The RDA of 900 mcg RAE for adolescent and adult men is equivalent to:
- 3,000 IU if the food or supplement source is preformed vitamin A.
- 6,000 IU of beta-carotene from supplements
- 18,000 IU of beta-carotene from food

Adult females: 700 mcg RAE
Adult males: 900 mcg RAE
Vitamin E

"Vitamin E" is the collective name for a group of fat-soluble compounds with distinctive antioxidant activities.

There are 8 different forms of vitamin E but the most active form in the body is **alpha-tocopherol**.

Food sources of vitamin E: vegetable oils, nuts, seeds, avocado, some green leafy vegetables, supplements and fortified cereals.
Vitamin E

Functions:

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

Too much:

- No known risk of consuming too much vitamin E from natural food sources
- Over-consumption of synthetic form in dietary supplements and fortified foods can increase risk of a hemorrhage: upper limit is 1,000 mg/day
Vitamin E

Too little:
Although rare, chronic deficiency of vitamin E can cause nerve problems, muscle weakness, and free radical damage to cell membranes
Vitamin E

Recommendation:

15 mg/day for men and women

<table>
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<th>Food</th>
<th>Milligrams (mg) per serving</th>
<th>Percent DV*</th>
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</thead>
<tbody>
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<tr>
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<td>Mango, sliced, ½ cup</td>
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<tr>
<td>Tomato, raw, 1 medium</td>
<td>0.7</td>
<td>4</td>
</tr>
<tr>
<td>Spinach, raw, 1 cup</td>
<td>0.6</td>
<td>3</td>
</tr>
</tbody>
</table>
Vitamin K

Two forms of vitamin K:
- Synthesized by intestinal bacteria (menaquinone)
- Found in green plants (phylloquinone)

Sources: Leafy greens are best source
Vitamin K

Functions

Vitamin K

1. Helps our blood clot in a process called coagulation. Vitamin K is essential in the production of four proteins needed to clot blood.

2. Aids in healthy bone formation- research is being done now on why it’s seen that those with low vitamin K intake have increased hip fractures.
Vitamin K

Too much:

- No known problems of consuming too much vitamin K from foods or supplements
- People taking anticoagulant medications such as warfarin (Coumadin) need to keep vitamin K intake consistent
  - Changes in intake can increase or decrease drug effectiveness
Vitamin K

Too little:

- Vitamin K deficiency that is severe enough to affect blood clotting is extremely rare
  - At risk: people with problems absorbing fat
Vitamin K

Recommendation:
Interestingly researchers don’t know how much of our vitamin K needs are met with the vitamin K produced by bacteria in our gut.

Scientists just use what is currently consumed as the recommendation:
Adult females: 90 mcg
Adult males: 120 mcg
Vitamin D

Called “Sunshine Vitamin” because vitamin D is made in the body with help of sunlight (UV).

It’s naturally present in very few foods: fortified milk and yogurt, fortified cereals, fatty fish (examples: sardines, salmon, tuna)

Added to some foods and available as a dietary supplement.
Vitamin D

- Functions: Active form in the body acts as a hormone

- Vitamin D promotes calcium absorption in the gut and maintains adequate calcium and phosphate concentrations to enable normal mineralization of bone.

- It is also needed for bone growth and bone remodeling by osteoblasts and osteoclasts.

- Vitamin D has other roles in the body, including modulation of cell growth, neuromuscular and immune function, and reduction of inflammation.

- Adequate intake may prevent type 2 diabetes and some cancers
Vitamin D

Too much:

- Overuse of supplements may lead to hypervitaminosis D, which causes hypercalcemia
  - Damaging calcium deposited in kidneys, lungs, blood vessels, heart
Vitamin D

Too little: Without sufficient vitamin D, bones can become thin, brittle, or misshapen.

**Rickets:** vitamin D deficiency disease in children
- On the rise in United States
- The bones of children with rickets aren’t adequately mineralized with calcium and phosphorus, causing them to weaken and leading to bowed legs

**Osteomalacia:** adult equivalent of rickets
Vitamin D

Daily needs:

• Sun exposure cannot meet everyone’s vitamin D needs
  • Dark skin and use of sunscreen reduce vitamin D production
  • Sunlight intensity during winter in northern latitude not sufficient to make vitamin D
• Therefore, vitamin D needs based on dietary sources

• Males and females ages 19-70: 600IU/day
• HINT: Labels are still using the old rec of 400IU/day
BREAK
The B Vitamins and Vitamin C Are Water-Soluble

- Water-soluble vitamins are not stored in body
  - Excess is excreted in urine
  - However, routine intakes of excessive amounts can be harmful.

- B vitamins share common role as *coenzymes*
  - Help many enzymes produce chemical reactions in cells
How B Vitamins Function as Coenzymes

- **Two compounds approach the enzyme, but a coenzyme is needed for the reaction to occur.**
- **Once the coenzyme is present, the compounds can interact with the enzyme.**
- **The enzyme changes shape.**
- **The reaction occurs, and the product is released.**
Thiamin (B$_1$)

First vitamin discovered

- Food sources: enriched and whole grain products, pork

- Functions:
  - Transmission of nerve impulses
  - Metabolism of carbohydrates and certain amino acids - Very important this is how we get energy!
  - Plays role in breakdown of alcohol in body
Thiamin (B₁)

Too much:
- No known toxicity, no UL set

Too little:
**Beriberi**: thiamin deficiency disease (loss of appetite, weight, memory; confusion)
- Rare in U.S., due to enrichment of grain

**Wernicke–Korsakoff syndrome (wet brain)**: Chronic alcohol abuse can lead to advanced form: progressively damaging brain disorder. Due to thiamin-deficient diet, and alcohol interferes with thiamin absorption
Riboflavin (B$_2$)

Sources:
Food sources: milk, yogurt, enriched cereals and grains (Light-sensitive vitamin, abundant in milk opaque containers preserve riboflavin content)

Functions:
- Important for energy metabolism
- Keeps cells healthy
- Enhances functions of other B vitamins, such as niacin and B$_{12}$
Riboflavin (B₂)

Too much:
- Excess riboflavin excreted in urine: bright yellow color
  No known toxicity

Too little:
Deficiency symptoms rarely seen in healthy individuals eating a balanced diet (part of enriched grains).

Deficiency: Sore throat, swelling inside mouth, inflamed and purplish-red tongue, dry and scaly lips

- Glossitis (inflamed tongue is a deficiency symptom)
Niacin ($B_3$)

Food sources: meat, fish, poultry, enriched grains, fortified cereals- can be made from the amino acid tryptophan

- Protein-rich foods are good sources of tryptophan, thus a source of niacin

Functions: needed for energy metabolism and to:

- Synthesize fat and cholesterol
- Keep skin cells and digestive system healthy

- Sometimes prescribed in high doses (40 times UL) by physicians to decrease blood LDL cholesterol and triglycerides, increase HDL
Niacin (B₃)

Too much:
Overconsumption of niacin supplements can cause flushing, nausea, vomiting, be toxic to liver, raise blood glucose levels: UL is 35 mg/day to prevent flushing. Energy drinks.

Too little:
- **Pellagra**: niacin deficiency disease (Four Ds)
  - Dermatitis, Diarrhea, Dementia, Death
  - Once common in South, due to corn-based diet

Casal’s necklace (dermatitis that forms as a result of pellagra)
Vitamin B₆

Food sources

- Meat, fish, poultry, fortified cereals, nuts, legumes, peanut butter, many fruits and vegetables

Functions: as coenzyme for over 100 enzymes in protein metabolism, needed to:

- Make amino acids, convert tryptophan to niacin and hemoglobin in red blood cells
- Keep immune and nervous systems healthy
- Metabolize fats and carbohydrates and break down glycogen
Vitamin $\text{B}_6$

Too much or too little:
- UL is 100 mg/day to prevent nerve damage
- Deficiency symptoms:
  - Sore tongue, skin inflammation, depression, confusion, anemia
- Those with alcoholism at risk for deficiency due to poor diet and alcohol causes body to lose $\text{B}_6$
Folate (B9)

- Naturally occurring form in foods (legumes, broccoli, asparagus, leafy greens such as spinach)
- **Folic acid**: synthetic form of folate added to foods and supplements (fortified grains)

Functions: Vital for DNA synthesis
- To create and maintain new cells, including red blood cells
- Folate deficiency during pregnancy can result in neural tube birth defects (examples: spina bifida, anencephaly).
- Reduces risks of some cancers
Folate

Too much or too little:

- UL = 1,000 µg/day of folic acid from enriched/fortified foods and supplements
  - Too much folic acid (not naturally-occurring folate in foods) masks vitamin $B_{12}$ deficiency anemia
- Folate deficiency can lead to macrocytic anemia
Vitamin $B_{12}$

Food sources:

- Naturally occurring $B_{12}$ only found in animal foods (meat, fish, poultry, dairy)
- Synthetic $B_{12}$ found in fortified foods such as soy milk and some cereals

Requires intrinsic factor, protein made in stomach, in order to be absorbed in small intestine

- Pernicious anemia results in people who cannot make intrinsic factor: treatment requires $B_{12}$ injection to bypass intestine
- Symptoms may take years to appear since $B_{12}$ is stored in the liver
Vitamin B$_{12}$

Functions:

- To make DNA
- For healthy nerves and cells, especially red blood cells
Vitamin $\text{B}_{12}$

Too much or too little:

- No upper level set since no known risk from consuming too much $\text{B}_{12}$, natural or synthetic
- Deficiency can cause macrocytic anemia (because folate can’t be utilized properly)
  - Lack of intrinsic factor causes pernicious anemia, involves nerve damage
Vitamin C

Also known as ascorbic acid

Sources: Fruits and veggies: citrus fruits are great sources.
  - Function: coenzyme to synthesize and use certain amino acids
    - Needed to make collagen, most abundant protein in body, present in connective tissue
      - Important for healthy bones, skin, blood vessels, teeth
    - Also acts as an antioxidant
    - Helps absorb iron from plant foods
    - Breaks down histamine, cause of inflammation
Vitamin C

Too much or too little:

- UL = 2,000 mg/day to avoid nausea, stomach cramps, diarrhea
  - People with a history of kidney stones or hemochromatosis (body stores too much iron) should avoid excess.
- Deficiency disease: scurvy
Myths and Facts about the Common Cold

The truth about catching a cold:
- Direct or indirect contact with cold virus

Vitamin C and the common cold
- Research shows vitamin C to be ineffective in preventing colds, but may reduce severity in some people, possibly antihistamine effect

Other cold remedies: jury is still out
- Echinacea and zinc studies are inconclusive

What you can do to prevent colds?
How Should You Get Your Vitamins?

Vitamin supplements are not a substitute for healthy eating

- Cannot provide all of missing substances of a healthy diet

Who might benefit from a supplement?

- People who cannot meet their needs through a regular, varied diet, such as:
  - pregnant or lactating women, older people, strict vegetarians, people with food allergies, medical conditions, or low-calorie diets
How Should You Get Your Vitamins?

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

- Consult health professional before taking vitamin/mineral supplements
  - Read supplement label carefully
    - USP seal of approval tests supplement to ensure quality and safety (but does not endorse or validate health claims)