Chapter 7

Vitamins

PowerPoint® Lecture Slide Presentation
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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 either fat-soluble or water-soluble.

- Fat-soluble vitamins A, D, E and K are absorbed with dietary fat and can be stored in body.
- Water-soluble vitamins are absorbed with water and enter the bloodstream directly.
  - Not stored in body, but excesses still harmful
Liver is the main storage for Vitamin A (90%) and a little for Vitamin K & D. Vitamin E is stored in fat and muscle tissues. Vitamins A & D can build up to toxicity levels; E & K are unlikely to be toxic.

Water soluble vitamins are not stored in the body. They enter the blood stream directly and excess is excreted, though dietary excess can still be harmful. Large amounts of Vitamin B6, Folate, Niacin, even Vitamin C can be problematic.
Vitamins Can Be Destroyed by Air, Water, or Heat

Proper food preparation and storing techniques can reduce loss.

- Don’t expose produce to air.
- A little water is enough when cooking.
  - Water-soluble vitamins leech into water.
- Reduce cooking time.
  - Microwave, steam, or stir-fry vegetables until just tender.
- Refrigeration delays vitamin loss.
Fat-Soluble and Water-Soluble Vitamins

<table>
<thead>
<tr>
<th>Characteristics of the Fat-Soluble and Water-Soluble Vitamins</th>
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</thead>
<tbody>
<tr>
<td>While each of the vitamins have unique functions and features, a few generalizations about the fat-soluble and water-soluble vitamins can aid understanding.</td>
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</tbody>
</table>

<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>Absorption</td>
<td>Absorbed like fats, first into the lymph, then the blood.</td>
</tr>
<tr>
<td>Transport and Storage</td>
<td>Must travel with protein carriers in watery body fluids; stored in the liver or fatty tissues.</td>
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<tr>
<td>Excretion</td>
<td>Not readily excreted; tend to build up in the tissues.</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Toxicities are likely from supplements, but occur rarely from food.</td>
</tr>
<tr>
<td>Requirements</td>
<td>Needed in periodic doses (perhaps weeks or even months) because the body can draw on its stores.</td>
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</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 Precursors

- Some vitamins exist as **precursors**, or provitamins
Vitamin A

Vitamin A: retinoids (retinol, retinal, retinoic acid)

- Preformed vitamin A (retinol) only found in animal foods: liver, eggs, fortified milk, cheese
- Some plants contain provitamin A carotenoids, which are converted to retinol in your body.
- Carotenoids, including beta-carotene (an antioxidant), are pigments which give color to carrots, cantaloupe, sweet potatoes, spinach, broccoli.
- Like fat-soluble vitamins, absorbed more efficiently if fat present in intestinal tract
A Jack of All Trades

- 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
**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

*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.
Vitamin A

Too much or too little:

- Excessive amounts of preformed vitamin A can accumulate to toxic levels.
  - Upper limit for adults: 3,000 µg (micrograms)
- Carotenoids in food are not toxic.
  - Excess carotenoids cause nonthreatening condition: carotenodermia (look like a carrot, on palms of hands)
- Chronic vitamin A deficiency causes night blindness.
- Prolonged vitamin A deficiency leads to xerophthalmia.
  - #1 cause of preventable blindness in children, mostly in developing countries
    - As many as 500,000 children go blind each year due to vitamin A deficiency.
- Vitamin A deficiency also associated with stunting of bones
Vitamin E - tocopherol

- 8 different forms of naturally occurring Vitamin E
- Alpha-tocopherol is most active form in body
- **Functions:**
  - Acts as a powerful antioxidant
  - Protects cell membranes, *prevents oxidation of LDL cholesterol*
  - Acts as an anticoagulant, inhibiting formation of harmful clots inside bloodstream
- **Daily needs:** Adults need 15 mg of alpha-tocopherol equivalents. The synthetic form in supplements is only half as active as the natural form.
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.

- **Erythrocyte hemolysis**, resulting in anemia
Vitamin E

Food sources: vegetable oils, nuts, seeds, fortified cereals, some green leafy vegetables

Too much or too little:

• No known risk of consuming too much vitamin E from natural food sources

• Over-consumption of synthetic form in dietary supplements and fortified foods can increase risk of a hemorrhage: upper limit is 1,000 mg/day

• Although rare, chronic deficiency of vitamin E can cause nerve problems, muscle weakness, and free radical damage to cell membranes.
Two forms of vitamin K:

- Menaquinone synthesized by intestinal bacteria that exist naturally in your intestinal tract.
- Phylloquinone found in green plants

Functions:

- Essential for blood clotting
- Involved in synthesizing four blood clotting factors
- Important to bone health
Daily needs: based on current consumption since amount contributed by intestinal synthesis is unknown

- Men need 120 µg/day (micrograms)
- Women need 90 µg/day

Food sources: green vegetables such as broccoli, asparagus, spinach, salad greens, brussels sprouts, cabbage; also vegetable oils and margarine
Vitamin K

Too much or too little:

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

Called “Sunshine Vitamin” because vitamin D is made in the body with help of sunlight (UV); with enough sun exposure, most people can synthesize all the Vitamin D needed

- Cholesterol-containing compound in skin is converted to inactive form of vitamin D

- People with insufficient sunlight exposure must meet needs through diet; whether from sunlight or foods, Vitamin D enters body in an inactive form

- Inactive form converted to circulating form in liver, goes back into the blood, to active form in kidneys
**Vitamin D**

**Functions:** once active, it acts as a hormone

- Regulates two important bone minerals: calcium (Ca) and phosphorus (P)
  - Stimulates intestinal absorption of Ca and P to maintain healthy blood levels and build and maintain bones
  - When dietary calcium is inadequate, Vitamin D and parathyroid hormone cause calcium to leave bones to maintain necessary blood levels.
- May prevent type 2 diabetes and breast, colon and prostate cancers
Vitamin D

• Sun exposure cannot meet everyone’s vitamin D needs.
  • Skin pigment melanin and use of sunscreens reduce vitamin D production.
  • Sunlight intensity during winter in northern latitude not sufficient to make vitamin D (limited outdoor activities)
  • air pollution

Therefore, vitamin D needs based on dietary sources
• Adults: 5-15 micrograms per day, depending on age

Food sources: fortified milk and yogurt, fortified cereals, fatty fish (Examples: sardines, salmon, tuna)
Vitamin D

Too much or too little:

• Overuse of supplements may lead to hypervitaminosis D, which causes hypercalcemia.
  • Damaging calcium deposited in kidneys, lungs, blood vessels, heart
  • UL: 2,000 IU (50 µg)
• **Rickets**: vitamin D deficiency disease in children
  • On the rise in U.S. due to decreased milk consumption, other factors
  • 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
Too Little Vitamin D – A Danger to Bones

Rickets leads to bowed legs to unmineralized bone and also beaded ribs as calcium is deposited on the ribs, rather than in the ribs.
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
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”
Thiamin (B\textsubscript{1})

- First vitamin discovered

**Functions:**

- Transmission of nerve impulses
- Metabolism of carbohydrates and certain amino acids
- Plays role in breakdown of alcohol in body
- Daily needs: men: 1.2 mg/day; women: 1.1 mg/day
- Food sources: enriched and whole grain products, pork
Thiamin (B₁)

- Too much or too little:
  - No known toxicity, no UL set
  - **Beriberi:** thiamin deficiency disease (loss of appetite, weight, memory; confusion)
    - Rare in U.S., due to enrichment of grains
    - Chronic alcohol abuse can lead to advanced form: **Wernicke-Korsakoff syndrome**, progressively damaging brain disorder
      - With a thiamin-deficient diet, alcohol will interfere with thiamin absorption
Riboflavin (B$_2$)

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$_{12}$

Daily needs:

- Men: 1.2 mg/day; women: 1.1 mg/day
Riboflavin (B₂)

- Food sources: milk and milk products, yogurt, enriched cereals and grains

- Too much or too little:
  - Excess riboflavin excreted in urine: bright yellow color
  - No UL set
  - Deficiency symptoms rarely seen in healthy individuals eating a balanced diet:
    - Sore throat, swelling inside mouth, inflamed and purplish-red tongue, dry and scaly lips
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. (Corn is a poor source of niacin.)
• Pellagra symptoms: 4 “D’s”
  • Diarrhea
  • Dermatitis
  • Dementia
  • Death
Niacin ($B_3$)

- **Active forms:** nicotinic acid and nicotinamide
- **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
- **Daily needs:** men: 14 mg/day; women: 16 mg/day
  - Can also be made in the body from the amino acid **tryptophan:** daily needs expressed in niacin equivalents (NE)
Niacin ($B_3$)

Food sources: meat, fish, poultry, enriched whole-grain breads, fortified cereals

- Protein-rich foods are good sources of tryptophan.

Too much or too little:

- Overconsumption of niacin supplements can cause flushing, nausea, vomiting, be toxic to liver, raise blood glucose levels: UL is 35 mg/day to prevent flushing.
Vitamin B₆

- **Active forms**: pyridoxine, pyridoxal and pyridoxamine

- **Functions**: as coenzyme for over 100 enzymes in protein metabolism, needed to:
  - Make nonessential amino acids, convert tryptophan to niacin and hemoglobin in red blood cells
  - Keep immune and nervous systems healthy
  - Metabolize fats and carbohydrates and break down glycogen

- **Daily needs**: men 1.3-1.7 mg/day; women 1.3-1.5 mg/day, depending on age
Vitamin B₆

Food sources

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

Too much or too little:

• UL is 100 mg/day to prevent nerve damage
• Deficiency symptoms:
  • Sore tongue, skin inflammation, depression, confusion, anemia
• Those with alcoholism at risk for deficiency due to poor diet and alcohol causes body to lose B₆
Folate

- Naturally occurring form in foods
- **Folic acid:** synthetic form of folate added to foods and supplements

**Functions:** vital for DNA synthesis

- To create and maintain new cells, including red blood cells
- To help body use amino acids
- Folate deficiency during pregnancy can result in neural tube birth defects (Examples: spina bifida, anencephaly).
- Reduces risks of some cancers
Folate (Folic Acid)

Daily needs:

• Folic acid is absorbed 1.7 times more efficiently than folate found naturally in foods.

• Women who might become pregnant need 400 µg extra from fortified foods/supplements.

Food sources:

• **Fruits**, enriched grains (rice, pasta, breads, cereals) legumes, broccoli, **asparagus**, leafy greens such as **spinach**
**SNAPSHOT 7-9**

**FOLATE**

**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

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*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.

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

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**GOOD SOURCES**

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount</th>
<th>µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEEF LIVER (cooked)</td>
<td>3 oz</td>
<td>221</td>
</tr>
<tr>
<td>LENTILS (cooked)</td>
<td>½ c</td>
<td>179</td>
</tr>
<tr>
<td>PINTO BEANS (cooked)</td>
<td>½ c</td>
<td>146</td>
</tr>
<tr>
<td>SPINACH (raw)</td>
<td>1 c</td>
<td>58</td>
</tr>
<tr>
<td>ASPARAGUS</td>
<td>½ c</td>
<td>131</td>
</tr>
<tr>
<td>ENRICHED CEREAL (ready-to-eat)</td>
<td>¼ c</td>
<td>82</td>
</tr>
<tr>
<td>AVOCADO</td>
<td>½ c</td>
<td>45</td>
</tr>
<tr>
<td>BEETS</td>
<td>½ c</td>
<td>68</td>
</tr>
</tbody>
</table>
Vitamin $\text{B}_{12}$

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

Functions:

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

Daily needs:

- Adults: 2.4 $\mu$g/day
- Ability to absorb naturally occurring $B_{12}$ from foods declines with age
Vitamin B₁₂

Who is at particular risk of a B₁₂ deficiency?  
Answer: vegans

**SNAPSHOT 7-10**  
**VITAMIN B₁₂**

**DRI RECOMMENDED INTAKE:**  
Adults: 2.4 µg/day

**CHIEF FUNCTIONS:**  
Part of coenzymes needed in new cell synthesis; helps to maintain nerve cells

**DEFICIENCY:**  
Pernicious anemia, anemia (large-cell type), smooth tongue, tingling or numbness, fatigue, memory loss, disorientation, degeneration of nerves progressing to paralysis

**TOXICITY:**  
None reported

*These foods provide 10 percent or more of the vitamin B₁₂ Daily Value in a serving. For a 2,000-calorie diet, the DV is 6 µg/day.

*The name pernicious anemia refers to the vitamin B₁₂ deficiency caused by a lack of stomach intrinsic factor, but not to anemia from inadequate dietary intake.

*Large cell-type anemia is known as either macrocytic or megaloblastic anemia.

**GOOD SOURCES**

- **CHICKEN LIVER**  
  3 oz = 14.0 µg

- **SARDINES**  
  3 oz = 7.5 µg

- **SIRLOIN STEAK**  
  3 oz = 2.0 µg

- **TUNA (in water)**  
  3 oz = 3.0 µg

- **COTTAGE CHEESE**  
  1 c = 2.0 µg

- **SWISS CHEESE**  
  1/2 oz = 1.5 µg

- **POORK ROAST (lean)**  
  3oz = 1.0 µg
Vitamin C

- Also known as ascorbic acid
- **Function:** coenzyme to synthesize and use certain amino acids
  - Needed to make collagen, most abundant protein in body, present in connective tissue
    - Important for healthy bones, skin, blood vessels, teeth
  - Also acts as an antioxidant (like beta-carotene & Vitamin E)
- Helps absorb iron from plant foods
- Breaks down histamine, cause of inflammation
Vitamin C

• 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
Vitamin C

- 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
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
Vitamin C

Daily Needs:

- Men: 90 mg  Women: 75 mg/day
- Smokers: 35+ mg/day
- 1c OJ=100mg; 1c broccoli=75mg; 1c strawberries=89mg

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.
Biotin and Pantothenic Acid

- Biotin and pantothenic acid are also important in energy metabolism.
- The vitamin found in coenzyme A is pantothenic acid.
- Both vitamins are readily available in foods.
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: wash hands frequently in soap and water to reduce risk of cold
What Are Antioxidants?

Compounds that neutralize free radicals that can cause oxidative stress and cell damage

• Examples: vitamins C and E, the mineral selenium, the phytochemicals, carotenoids and flavonoids (black & green teas)

• Damaging effects of free radicals contribute to: heart disease, cancer, aging, diabetes, arthritis, macular degeneration, cataracts

• It is recommended to obtain antioxidants from a well-balanced diet and not advocated to take supplements.
Phytochemical Color Guide

- **Red**: can promote a healthy heart, improve memory function and maintain/promote urinary tract health.

- **Yellow/Orange**: can maintain a healthy heart, vision health and a healthy immune system. Antioxidants prevent free radicals and fight heart disease & cancer.

- **White/Brown**: may help control blood pressure and cholesterol and promote a healthy heart.

- **Green**: Vision health and strong bones and teeth are health-promoting effects.

- **Blue/Purple**: Urinary tract health, memory function and healthy aging are the benefits of these foods.
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