The Water-Soluble Vitamins:
The Vitamins--An Overview

- Vitamins differ from carbohydrate, fat and protein in structure, function and food contents.
- Vitamins are similar to the energy-yielding nutrients in that they are vital to life, organic and available from foods.
- Both deficiencies and excesses of the vitamins can affect health.
The organic nature of vitamins means they can be destroyed by exposure to light, oxidation, cooking, and storage.
The Vitamins--An Overview

- Solubility and storage
  - Water-soluble vitamins (B vitamins and vitamin C) are absorbed directly into the blood and travel freely.
    - Circulate freely
    - Excreted in urine
    - Needed frequently
Solubility and storage

- Fat-soluble vitamins (vitamins A, D, K and E) are absorbed first into the lymph, then the blood.
  - Many require protein carriers.
  - Stored in cells associated with fat
  - Less readily excreted
  - **Needed periodically**
The Vitamins--An Overview

- **Toxicity**
  - Water-soluble vitamins *can* reach toxic levels with supplement use.
  - Fat-soluble vitamins *are likely to* reach toxic levels with supplement use.
  - DRI Committee has established **Tolerable Upper Intake Levels** for niacin, vitamin B₆, folate, choline and vitamin C.
Thiamin (Vitamin B₁)

- Casimir Funk in 1911 obtained vitamin B1 as a crystalline substance from rice polishings. He called it 'vitalamine' because it was vital and contained nitrogen as an amine. Some food factors active in minute amounts, and discovered since then, are not amines; yet the term vitamin is used to describe them.
Thiamin (Vitamin B₁)

- Thiamin is involved in energy metabolism as part of the coenzyme thiamin pyrophosphate (TPP). I.E. Energy reactions

- Thiamin Recommendations (1998 RDA)
  - RDA Men: 1.2 mg/day
  - RDA Women: 1.1 mg/day
Thiamin (Vitamin B₁)

- Thiamin Deficiency
  - Deficiency Symptoms
    - Enlarged heart and possible cardiac failure
    - **Muscular weakness**
    - Apathy, poor short-term memory, confusion, and irritability
    - Anorexia and weight loss
Thiamin (Vitamin B₁)

- Thiamin Deficiency
  - Wernicke-Korsakoff syndrome is a severe deficiency that develops in those who abuse alcohol.
  - Deficiency results in the disease beriberi.
  - No reported toxicities
Thiamin (Vitamin B₁)

- Thiamin Food Sources
  - Whole-grain, fortified or enriched grain products
  - Moderate amounts in all foods
  - Pork
<table>
<thead>
<tr>
<th>Food</th>
<th>Serving size (kcalories)</th>
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<tbody>
<tr>
<td>Bread, whole wheat</td>
<td>1 oz slice (70 kcal)</td>
</tr>
<tr>
<td>Cornflakes, fortified</td>
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<td>1/2 c cooked (99 kcal)</td>
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**Excellent, and sometimes unusual, sources:**

- Pork chop, lean: 3 oz broiled (169 kcal)
- Soy milk: 1 c (81 kcal)
- Squash, acorn: 1/2 c baked (69 kcal)

**THIAMIN**

Many different foods contribute some thiamin, but few are rich sources. Together, several servings of a variety of nutritious foods will help meet thiamin needs. Bread and cereal selections should be either whole grain or enriched.
Thiamin (Vitamin B₁)

- **Other Information**
  - Steaming and microwaving are cooking methods that conserve thiamin.
  - Thiamin leaches into water with boiling or blanching.
  - The vitamin is easily destroyed by heat.
Riboflavin (Vitamin B$_2$)

- **Riboflavin** is involved in **energy metabolism**.
- Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) are the coenzyme forms.
  - RDA Men: 1.3 mg/day
  - RDA Women: 1.1 mg/day
Riboflavin (Vitamin B2)

- Riboflavin Deficiency and Toxicity
  - Deficiency Symptoms
    - Inflamed eyelids, sensitivity to light, and reddening of the cornea
    - Sore throat and cracks and redness at the corners of the mouth
    - Painful, smooth and purplish red tongue
    - Skin lesions covered with greasy scales

- Deficiency disease is ariboflavinosis
  - No reported toxicities
Riboflavin (Vitamin B₂)

- Riboflavin Food Sources
  - **Milk products**, including yogurt and cheese
  - Enriched and whole grains
  - Liver
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**Excellent, and sometimes unusual, sources:**

- Liver: 3 oz fried (184 kcal)
- Clams, canned: 3 oz (126 kcal)
- Mushrooms: ½ c cooked (21 kcal)
Riboflavin (Vitamin $B_2$)

- Other information
  - Easily destroyed by ultraviolet light and irradiation
  - Not destroyed by cooking
Niacin (Vitamin B₃)

- **Niacin** is involved in the metabolism of glucose, fat, and alcohol. I.E. **Energy Reaction**

- Nicotinamide adenine dinucleotide (NAD), and NADP, the phosphate form of NAD, are the coenzyme forms.

- **Niacin Recommendations (1998 RDA)**
  - RDA Men: 16 NE/day
  - RDA Women: 14 NE/day
  - Upper level of 35 mg/day for adults
Niacin (Vitamin B₃)

- Niacin Deficiency
  - A deficiency of niacin results in the disease **pellagra**.
- Deficiency Symptoms
  - Diarrhea, abdominal pain, and vomiting
  - Inflamed, swollen, smooth and bright red tongue
  - Depression, apathy, fatigue, loss of memory, and headache
  - Rash when exposed to sunlight
Niacin (Vitamin B₃)

- Niacin Toxicity
  - Niacin flush dilates the capillaries and may be painful.

- Toxicity Symptoms
  - Painful flush, hives and rash
  - Excessive sweating
  - Blurred vision
  - Liver damage
  - Impaired glucose tolerance
Niacin (Vitamin B₃)

- Niacin Food Sources
  - Milk
  - Eggs, meat, poultry and fish
  - Whole-grain and enriched breads and cereals
  - Nuts and all protein-containing foods
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</table>

Key:
- Yellow: Breads and cereals
- Green: Vegetables
- Purple: Fruits
- White: Milk and milk products
- Milk: Legumes, nuts, seeds
- Red: Meats

NIACIN
Members of the meat group (red) are prominent niacin sources.

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Niacin (Vitamin B₃)

- **Other Information**
  - Also called nicotinic acid, nicotinamide, and niacinamide
  - The amino acid tryptophan is the precursor. (60mg = 1mg niacin)
  - The vitamin can be lost from foods when it leaches into water.
  - Resistant to heat
As part of a coenzyme used in energy metabolism, biotin assists in glycogen synthesis, fat synthesis, and amino acid metabolism.

Biotin Recommendations (1998 Adequate Intake)

- AI Adults: 30 μg/day
Biotin Deficiency
Deficiencies are rare.

Deficiency Symptoms
- Depression, lethargy, and hallucinations
- Numb or tingling sensation in the arms and legs
- Red, scaly rash around the eyes, nose and mouth
- Hair loss

Biotin can be bound with a protein called avidin.

No reported toxicities
Biotin

- Biotin Food Sources
  - Widespread in foods
  - Organ meats, egg yolks and fish
  - Soybeans
  - Whole grains
- Biotin can also be synthesized by intestinal bacteria.
Pantothenic acid is involved in energy metabolism as a part of coenzyme A.

Pantothenic Acid Recommendations (1998 Adequate Intake)
- AI Adults: 5 mg/day
Pantothenic Acid

● **Pantothenic Acid Deficiency and Toxicity**
  ● Deficiency is rare.
  ● Deficiency Symptoms
    ● Vomiting, nausea, and stomach cramps
    ● Insomnia and fatigue
    ● Depression, irritability, restlessness, and apathy
    ● Hypoglycemia and increased sensitivity to insulin
  ● No reported toxicities
Pantothenic Acid

- Pantothenic Acid Food Sources
  - Widespread in foods
  - Organ meats
  - Mushrooms, avocados, and broccoli
  - Whole grains
  - Can be destroyed by freezing, canning, and refining
Vitamin B₆

- **Pyridoxine**: The coenzyme forms of vitamin B₆ (pyridoxal phosphate [PLP] and pyridoxamine phosphate [PMP]) are involved in **amino and fatty acid metabolism**, the conversion of tryptophan to niacin or serotonin, and the production of red blood cells.

- **Vitamin B₆ Recommendations (1998 RDA)**
  - RDA Adults 19-50 years: 1.3 mg/day
Vitamin $B_6$

- Vitamin $B_6$ Deficiency
  - Deficiency Symptoms
    - Scaly dermatitis
    - Anemia – small cell type
    - Depression, confusion, abnormal brain wave pattern, and convulsions
  - Alcohol destroys the vitamin
Vitamin B₆

- Vitamin B₆ Toxicity
  - Toxicity Symptoms
    - Depression, fatigue, irritability, and headaches
    - Nerve damage causing numbness and muscle weakness leading to inability to walk
    - Convulsions
    - Skin lesions
  - Upper level for adults: 100 mg/day
Vitamin B₆ Food Sources

- Meats, fish, poultry and liver
- Legumes and soy products
- Non-citrus fruits
- Fortified cereals
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Excellent, and sometimes unusual, sources:

- Prune juice ¾ c (137 kcal)
- Bluefish 3 oz baked (135 kcal)
- Squash, acorn ½ c baked (69 kcal)

VITAMIN B₆

Many foods—including vegetables, fruits, and meats—offer vitamin B₆. Variety helps a person meet vitamin B₆ needs.

Key:
- Yellow: Breads and cereals
- Green: Vegetables
- Purple: Fruits
- White: Milk and milk products
- Brown: Legumes, nuts, seeds
- Red: Meats

Best sources per calorie

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Vitamin B₆

- Other Information
  - Easily destroyed by heat
  - Vitamin B₆ is ineffective in curing carpal tunnel syndrome and sleep disorders.
Folate

- **Folate** is involved in the synthesis of DNA and the **formation of new cells**.
- The coenzymes THF (tetrahydrofolate) and DHF (dihydrofolate) require **vitamin B_{12}** to function correctly.
In foods, folate naturally occurs as polyglutamate. (Folate occurs as monoglutamate in fortified foods and supplements.)

In the intestine, digestion breaks glutamates off . . . and adds a methyl group. Folate is absorbed and delivered to cells.

In the cells, folate is trapped in its inactive form.

To activate folate, vitamin B$_{12}$ removes and keeps the methyl group, which activates vitamin B$_{12}$.

Both the folate coenzyme and the vitamin B$_{12}$ coenzyme are now active and available for DNA synthesis.
Folate

- Folate Recommendations (1998 RDA)
  - RDA Adults: 400 μg/day
  - Dietary Folate Equivalents (DFE) is a calculation that accounts for the bioavailability differences between folate from foods and folate from supplements.

- There are higher recommendations for pregnant women.
Folate

- **Folate and Neural Tube Defects**
  - Neural tube defects include spina bifida and anencephaly.
  - Women of childbearing age should eat folate-rich foods and folate-fortified foods and take folate supplements containing 0.4 mg (400 microgram) of folate daily.
  - Pregnant women should take folate supplements.
Neural Tube Defects

Key:
- Purple line: Rate per 100,000

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Folate

- **Folate and Heart Disease**
  - High levels of *homocysteine* and low levels of folate increase risk of heart disease.
  - Folate breaks down homocysteine.

- Folate may help to prevent cancer.
Folate Deficiency

Deficiency Symptoms

- **Macrocytic anemia**, also called megaloblastic anemia – large cell type
- Smooth, red tongue
- Mental confusion, weakness, fatigue, irritability and headaches

Most vulnerable of all the vitamins to interactions with medications

- Anticancer drugs
- Antacids and aspirin
Folate Toxicity

- Masks vitamin $B_{12}$ deficiency symptoms
- Upper level for adults: 1000 μg/day
Folate

- Folate Food Sources
  - Fortified grains
  - Leafy green vegetables
  - Legumes and seeds
  - Liver

- Other Information
  - Easily destroyed by heat and oxygen
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</tr>
<tr>
<td>Tomato juice</td>
<td>½ cup (31 kcal)</td>
</tr>
<tr>
<td>Banana</td>
<td>1 medium raw (109 kcal)</td>
</tr>
<tr>
<td>Orange</td>
<td>1 medium raw (62 kcal)</td>
</tr>
<tr>
<td>Strawberries</td>
<td>½ cup fresh (22 kcal)</td>
</tr>
<tr>
<td>Watermelon</td>
<td>1 slice (92 kcal)</td>
</tr>
<tr>
<td>Milk</td>
<td>1 cup reduced-fat 2% (121 kcal)</td>
</tr>
<tr>
<td>Yogurt, plain</td>
<td>1 cup low-fat (155 kcal)</td>
</tr>
<tr>
<td>Cheddar cheese</td>
<td>1½ oz (171 kcal)</td>
</tr>
<tr>
<td>Cottage cheese</td>
<td>½ cup low-fat 2% (101 kcal)</td>
</tr>
<tr>
<td>Pinto beans</td>
<td>½ cup cooked (117 kcal)</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>2 tbs (188 kcal)</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td>1 oz dry (165 kcal)</td>
</tr>
<tr>
<td>Tofu (soybean curd)</td>
<td>½ cup (76 kcal)</td>
</tr>
<tr>
<td>Ground beef, lean</td>
<td>3 oz broiled (244 kcal)</td>
</tr>
<tr>
<td>Chicken breast</td>
<td>3 oz roasted (140 kcal)</td>
</tr>
<tr>
<td>Tuna, canned in water</td>
<td>3 oz (99 kcal)</td>
</tr>
<tr>
<td>Egg</td>
<td>1 hard cooked (78 kcal)</td>
</tr>
<tr>
<td><strong>Excellent, and sometimes unusual, sources:</strong></td>
<td></td>
</tr>
<tr>
<td>Lentils</td>
<td>½ cup cooked (115 kcal)</td>
</tr>
<tr>
<td>Asparagus</td>
<td>½ cup cooked (22 kcal)</td>
</tr>
<tr>
<td>Orange juice</td>
<td>¼ cup fresh (84 kcal)</td>
</tr>
</tbody>
</table>

**Key:**
- Yellow: Breads and cereals
- Green: Vegetables
- Purple: Fruits
- Light purple: Milk and milk products
- Brown: Legumes, nuts, seeds
- Orange: Meats

**FOLATE**
Vegetables (green) and legumes (brown) are rich sources of folate, as are fortified grain products (yellow).
Eat More Fruits and Vegetables!
Vitamin B\textsubscript{12} (Cobalamin)

- Vitamin B\textsubscript{12} is involved in the synthesis of new cells, \textit{maintains nerve cells}, \textit{reforms folate} coenzymes, and helps break down some fatty acids and amino acids.

- Vitamin B\textsubscript{12} Recommendations (1998 RDA)
  - RDA Adults: 2.4 μg/day
Vitamin B$_{12}$ (Cobalamin)

- Vitamin B$_{12}$ Deficiency and Toxicity
  - Deficiency Symptoms
    - Anemia – large cell type (same as Folate)
    - Fatigue and depression
    - Degeneration of peripheral nerves progressing to paralysis (irreversible)
Vitamin $\text{B}_{12}$ (Cobalamin)

- Vitamin $\text{B}_{12}$ Deficiency and Toxicity
  - Atrophic gastritis in older adults destroys stomach cells, which **diminishes intrinsic factor** and hydrochloric acid production.
  - Deficiency disease is called **pernicious anemia**

- No known toxicities
Vitamin B$_{12}$ (Cobalamin)

- Vitamin B$_{12}$ Food Sources
  - Meat, fish, poultry, and shellfish
  - Milk, cheese and eggs
  - Fortified cereals
Vitamin $\text{B}_{12}$ (Cobalamin)

- **Other Information**
  - **Binds with intrinsic factor in the small intestine for absorption**
  - Easily destroyed by microwave cooking
Choline

Choline is involved in the synthesis of acetylcholine and lecithin.

Choline Recommendations (1998 Adequate Intake)

- AI Men: 550 mg/day
- AI Women: 425 mg/day
Non-B Vitamins

- Choline Deficiency and Toxicity
  - **Deficiencies are rare.**
  - Deficiency symptom is liver damage
  - **Toxicity Symptoms**
    - Body odor and sweating
    - Salivation
    - Reduced growth rate
    - Low blood pressure
    - Liver damage
  - Upper level for adults: 3500 mg/day
Non-B Vitamins

- Choline Food Sources
  - Milk
  - Liver
  - Eggs
  - Peanuts
Non-B Vitamins

- Inositol and Carnitine
  - Inositol is made from glucose and is part of the cell membrane structure.
  - Carnitine is made from lysine and transports long-chain fatty acids to be oxidized.
The B Vitamins--In Concert

- The B Vitamins are interdependent. The presence of one may affect the absorption, metabolism and excretion of another.

- A deficiency of one may affect the functioning or deficiency of another.

- A variety of foods from each food group will provide an adequate supply of all the B vitamins.
The B Vitamins--In Concert

- B Vitamin Deficiencies
  - Deficiencies rarely occur singly except for beriberi and pellagra.
  - Can be primary or secondary causes
  - Glossitis and cheilosis are two symptoms common to B vitamin deficiencies.

- B vitamin toxicities can occur with supplements.