THE FAT-SOLUBLE VITAMINS: A
Fat-soluble vitamins differ from water-soluble vitamins
- Require bile for digestion and absorption
- Travel through lymphatic system
- Many require transport proteins in bloodstream
- Excesses are stored
  - Liver and adipose tissue
- Risk of toxicity is greater
VITAMIN A AND BETA-CAROTENE

- Vitamin A, first fat-soluble vitamin recognized
  - Precursor – beta-carotene
- Three different forms
  - Retinol, retinal, and retinoic acid
    - Conversion to other forms
- Absorption and conversion
  - Beta-carotene
VITAMIN A AND BETA-CAROTENE

- Digestion and absorption of vitamin A
  - Protein participation
- Storage
  - Liver
- Transport protein
  - Retinol-binding protein (RBP)
- Cellular receptors for vitamin A
VITAMIN A AND BETA-CAROTENE – ROLES IN THE BODY

- Major roles
  - Vision
  - Protein synthesis and cell differentiation
  - Reproduction and growth
- Regulation of gene expression
VITAMIN A AND BETA-CAROTENE – ROLES IN THE BODY

- Retinol
  - Supports reproduction
  - Major transport and storage form
- Retinal
  - Active in vision
- Retinoic acid
  - Regulates cell differentiation, growth, and embryonic development
CONVERSION OF VITAMIN A COMPOUNDS

IN FOODS:
- Retinyl esters (in animal foods)
- Beta-carotene (in plant foods)

IN THE BODY:
- Retinol (supports reproduction)
- Retinal (participates in vision)
- Retinoic acid (regulates growth)
VITAMIN A AND BETA-CAROTENE – ROLES IN THE BODY

- Vision
  - Cornea
  - Retina
    - Photosensitive cells
    - Rhodopsin
  - Repeated small losses of retinal
    - Need for replenishment
VITAMIN A’S ROLE IN VISION

As light enters the eye, rhodopsin within the cells of the retina absorbs the light. The cells of the retina contain rhodopsin, a molecule composed of opsin (a protein) and cis-retinal (vitamin A).

As rhodopsin absorbs light, retinal changes from cis to trans, which triggers a nerve impulse that carries visual information to the brain.
VITAMIN A AND BETA-CAROTENE – ROLES IN THE BODY

- Protein synthesis & cell differentiation
  - Epithelial cells
    - Skin
    - Mucous membranes
  - Goblet cells
Vitamin A maintains healthy cells in the mucous membranes. Without vitamin A, the normal structure and function of the cells in the mucous membranes are impaired.
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VITAMIN A AND BETA-CAROTENE – ROLES IN THE BODY

- Reproduction and growth
  - Sperm development
  - Normal fetal development
  - Growth of children
    - Bone remodeling
- Antioxidant
  - Beta-carotene
VITAMIN A AND BETA-CAROTENE – VITAMIN A DEFICIENCY

- Vitamin A status
  - Adequacy of stores
    - Liver
  - Protein status
- Consequences of deficiency
  - Risk of infectious diseases
  - Blindness
  - Death
- Infectious diseases
  - Measles severity
  - Malaria, lung diseases, and HIV
- Night blindness
  - Inadequate supply of retinal to retina
- Blindness (xerophthalmia)
  - Lack of vitamin A at the cornea
  - Develops in stages
VITAMIN A AND BETA-CAROTENE – VITAMIN A DEFICIENCY

- Keratinization
  - Change in shape & size of epithelial cells
    - Skin becomes dry, rough, and scaly
    - Normal digestion and absorption of nutrients from GI tract falters
    - Weakened defenses in respiratory tract, vagina, inner ear, and urinary tract
VITAMIN A AND BETA-CAROTENENE – VITAMIN A TOXICITY

- Develops when binding proteins are swamped
  - Free vitamin A damages cells

- Toxicity is a real possibility
  - Preformed vitamin A from animal sources
  - Fortified foods
  - Supplements

- Children are most vulnerable
Beta-carotene

- Found in many fruits and vegetables
- Inefficient conversion
- Overconsumption from food
  - Yellow skin
- Overconsumption from supplements
  - Antioxidant becomes prooxidant
  - Alcohol consumption and tobacco use
VITAMIN A AND BETA-CAROTENE – VITAMIN A TOXICITY

- Bone defects
  - May weaken bones
    - Osteoporosis
  - Interferes with vitamin D
- Birth defects
  - Cell death in the spinal cord
- Acne
  - Vitamin A relative – Retin-A
VITAMIN A AND BETA-CAROTENE

- Recommendations
  - Expressed as retinol activity equivalents (RAE)
  - Supplements often measured in International Units (IU)
Food sources

- Animal sources
  - Liver and toxicity concerns
- Plant sources
  - Vitamin A precursors
  - Bioavailability
  - Colors of food
# Vitamin A in Selected Foods

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving size (kcalories)</th>
<th>Micrograms RAE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread, whole wheat</td>
<td>1 oz slice (70 kcal)</td>
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</tr>
<tr>
<td>Cornflakes, fortified</td>
<td>1 oz (110 kcal)</td>
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</tr>
<tr>
<td>Spaghetti pasta</td>
<td>¼ c cooked (99 kcal)</td>
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</tr>
<tr>
<td>Tortilla, flour</td>
<td>1 10”-round (234 kcal)</td>
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</tr>
<tr>
<td>Broccoli</td>
<td>½ c cooked (22 kcal)</td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td>¼ c shredded raw (24 kcal)</td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td>1 medium baked w/skin (133 kcal)</td>
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</tr>
<tr>
<td>Tomato juice</td>
<td>¼ c (31 kcal)</td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>1 medium raw (109 kcal)</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>1 medium raw (62 kcal)</td>
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</tr>
<tr>
<td>Strawberries</td>
<td>¼ c fresh (22 kcal)</td>
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</tr>
<tr>
<td>Watermelon</td>
<td>1 slice (92 kcal)</td>
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</tr>
<tr>
<td>Milk, fortified</td>
<td>1 c reduced-fat 2% (121 kcal)</td>
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<tr>
<td>Yogurt, plain</td>
<td>1 c low-fat (155 kcal)</td>
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</tr>
<tr>
<td>Cheddar cheese</td>
<td>1½ oz (171 kcal)</td>
<td></td>
</tr>
<tr>
<td>Cottage cheese</td>
<td>¼ c low-fat 2% (101 kcal)</td>
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</tr>
<tr>
<td>Pinto beans</td>
<td>¼ c cooked (117 kcal)</td>
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</tr>
<tr>
<td>Peanut butter</td>
<td>2 tbs (188 kcal)</td>
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</tr>
<tr>
<td>Sunflower seeds</td>
<td>1 oz dry (165 kcal)</td>
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</tr>
<tr>
<td>Tofu (soybean curd)</td>
<td>¼ c (76 kcal)</td>
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<tr>
<td>Ground beef, lean</td>
<td>3 oz broiled (244 kcal)</td>
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<tr>
<td>Chicken breast</td>
<td>3 oz roasted (140 kcal)</td>
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</tr>
<tr>
<td>Tuna, canned in water</td>
<td>3 oz (99 kcal)</td>
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</tr>
<tr>
<td>Egg</td>
<td>1 hard cooked (78 kcal)</td>
<td></td>
</tr>
</tbody>
</table>

**Excellent, and sometimes unusual, sources:**

- Beef liver: 3 oz fried (184 kcal)
- Sweet potatoes: ½ c cooked (116 kcal)
- Mango: 1 (135 kcal)

Vitamin A

Dark green and deep orange vegetables (green) and fruits (purple) and fortified foods such as milk contribute large quantities of vitamin A. Some foods are rich enough in vitamin A to provide the RDA and more in a single serving.

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

**Best sources per kilocalorie**