Chapter 7 Vitamins: Vital Keys to Health

BIOL 103

Understanding Vitamins

- Vitamins
  - Needed in small amounts
  - Not an energy source
  - Individual units rather than long chains
  - Organic compounds essential for normal functioning, growth, and maintenance of the body

Vitamins are organic!

Understanding Vitamins

- Fat-soluble vs. water-soluble
  - Fat-soluble: Vitamins A, D, E, K
    - Absorbed with fat into lymphatic system
    - Stored in larger quantities
  - Water-soluble: B Vitamins and Vitamin C
    - Absorbed into bloodstream
    - Stored in small amounts
  - Which is more vulnerable to cooking losses?
Understanding Vitamins

- Food preparation affects vitamins in foods
  - Enrichment and fortification
    - **Enrichment** — ______ lost nutrients in processed foods
    - **Fortification** — ______ extra nutrients to foods that wouldn’t have them naturally
    - Some is required by law

- **Provitamins**
  - Inactive forms of vitamin
  - Body must change them to active form
  - Example: beta-carotene

Understanding Vitamins

- Vitamins found in all food groups
  - Factors that determine amounts
    - Source (animal vs. plant)
    - Sunlight
    - Moisture
    - Growing conditions
    - Plant’s maturity at harvest
    - Packaging and storage
Vitamin A: The Retinoids

- Forms of Vitamin A:
  - Active forms (retinoids)
    - Retinol
    - Retinal
    - Retinoic acid
  - Precursors (carotenoids)

Vitamin A

- Functions of Vitamin A:
  1. Vision: night and day
     - Becomes part of the retina
     - Keeps eye surface healthy
     - Allows night and color vision
  2. Immune function
     - Produce immune cells to fight microorganisms
  3. Cell production and differentiation
     - Regulates production of enzymes, blood carrier proteins, and structural proteins (like those in the skin)
  4. Skin
     - Needed to replace epithelial cells of your skin
  5. Reproduction
     - Keep reproductive tracts healthy
     - Women: maintain fertility; Men: sperm production
     - Embryo development
  6. Bones
     - Helps produce bone cells
     - Required for bone remodeling → increase in osteoclasts
Vitamin A

- **Dietary Recommendations**
  - **Retinol activity equivalent (RAE)** = 1 μg retinol

- **Sources of Vitamin A**
  - Animal food sources (retinoids)
  - Plant food (provitamin A carotenoids)
  - Fortified foods

**Vitamin A Deficiency:**
- **The Eyes**
  - *Xerophthalmia*
- **The Skin and Other Epithelial Cells**
  - Keratin
- **Immune function**
  - Vulnerable to infection
- **Other Effects:**
  - Growth retardation, bone deformities, defective teeth, and kidney stones
Vitamin A Deficiency

Xerophthalmia

Hyperkeratosis

Vitamin A

• Toxicity
  – Symptoms: fatigue, vomiting, abdominal pain, bone and joint pain, loss of appetite, skin disorders, headache, blurred or double vision, and liver damage

1. Teratogen
  • Agent that causes birth defects: cleft palate, heart abnormalities, brain malfunction

2. Discoloration of skin

3. Acne Treatment:
  • Retin-A and Accutane

The Carotenoids

• Plant pigments (deep yellow, range, red color)
• Can be converted to vitamin A
  – Beta-carotene supplies the most vitamin A of the carotenoids.
• Functions: “acts as potent antioxidants”
  1. Vision
  2. Lower risk of certain cancer
The Carotenoids

- Food Sources, Absorption, and Storage of Carotenoids
  - Good sources
    - Orange and yellow fruit and vegetables, dark green vegetables
  - Body absorbs 20–40% of carotenoids eaten
  - Dietary fat and cooking with heat increases absorption

Vitamin D

- Forms and formations
  - Activated in liver and kidney
    - 25-hydroxyvitamin D [25(OH)D] or calcitrol
- Functions:
  1. Essential for bone health
  2. Protects against certain cancers and other chronic diseases
  3. Helps regulate insulin formation and secretion

Vitamin D

- Sources
  - Exposure to sunlight
  - Fortified foods, milk, cereal
  - Oily fish, egg yolk, liver
  - Supplements
Vitamin D

- Deficiency
  - Rickets in children
  - Osteomalacia and osteoporosis in adults

- Toxicity
  - Hypercalcemia
    (Stones, groans, thrones, psychiatric overtones)

Vitamin E

- Forms
  - Family of eight similar compounds
  - Only alpha-tocopherol considered for human vitamin E requirement

- Functions
  - Antioxidant
    - Protects cell membranes from free radicals
    - May lower risk of some chronic diseases
Vitamin E

- Dietary Recommendations
  - Related to intake of polyunsaturated fatty acids
  - RDA
    - 15 mg/day alpha tocopherol for adults
    - 19 mg/day for breastfeeding
- Food Sources
  - Nuts, seeds, vegetable oil, whole grain, wheat germ oil, fruit, vegetables, and animal products

Vitamin E

- Deficiency
  - Occurs with fat malabsorption or rare genetic disorders
- Toxicity
  - Nontoxic and adverse effects have not been found
  - Can interfere with blood clotting

Vitamin K

- Forms: K1 and K2
- Functions
  - Blood clotting
  - Bone health
- Dietary Recommendations
  - Men 120 mg/day
  - Women 90 mg/day
- Food sources
  - Green vegetables, plant oils, intestinal bacteria

Vitamin K

- Food sources
  - Green vegetables, plant oils, intestinal bacteria
Vitamin K

- Deficiency
  - Rare in healthy people
  - Newborn babies at risk
- Toxicity
  - Rare
  - Can interfere with anticoagulant medications

The Water-Soluble Vitamins

- What to keep in mind about each vitamins:
  - Function
  - Food sources
  - Toxicity vs. Deficiency

Summary of Fat-Soluble Vitamins

<table>
<thead>
<tr>
<th>Fat-Soluble Vitamin</th>
<th>Major Dietary Sources</th>
<th>Some Major Functions in the Body</th>
<th>Possible Symptons of Deficiency or Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A (Retinal)</td>
<td>Provitamin A (beta-carotene) in deep green and orange vegetables and fruits, mineral oil in meats</td>
<td>Component of visual pigments needed for maintenance of epithelial lining of respiratory, digestive, urinary, and reproductive tracts</td>
<td>Vision problems due to faulty epithelial lining of respiratory, digestive, urinary, and reproductive tracts</td>
</tr>
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<td>Vitamin D</td>
<td>Dairy products, egg yolks, fatty fish, liver, exposure to sunlight</td>
<td>Facilitates absorption and utilization of calcium and phosphorus, promotes bone growth</td>
<td>Rickets (bone deformities in children, bone softening in adults)</td>
</tr>
<tr>
<td>Vitamin E (tocopherol)</td>
<td>Vegetable oils, nuts, seeds</td>
<td>Antioxidant, helps prevent damage to cells of all types</td>
<td>None well documented in human populations</td>
</tr>
<tr>
<td>Vitamin K (phylloquinone)</td>
<td>Green vegetables, tea (also certain other plants)</td>
<td>Important in blood coagulation</td>
<td>Defects in blood clotting - hemorrhage and bruising</td>
</tr>
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Vocabs to Know:

- **Coenzyme**: a small compound that helps enzymes in biochemical reactions. Most coenzymes are derived from vitamins or are made from vitamins.
- **Energy Metabolism**: process of generating energy from nutrients (glucose, fatty acids, amino acids).
  - Glycogen Metabolism
  - Fat Metabolism
  - Protein Metabolism
The Water-Soluble Vitamins

- Eight B Vitamins
  - Act primarily as coenzymes in energy metabolism
- Vitamin C
  - Antioxidant
  - Can stabilize Vitamin E

Thiamin/B1

- Functions
  - Coenzyme in energy metabolism
  - Part of the coenzyme thiamin pyrophosphate (TPP)
    - Helps break down glucose → energy
    - Make RNA and DNA
    - Helps power protein
    - Helps synthesize and regulate neurotransmitters

Thiamin

- Dietary recommendations
  - Men 1.2 mg/d
  - Women 1.1 mg/d
  - Pregnancy 1.4 mg/d
  - Breastfeeding 1.5 mg/d
- Food sources
  - Pork, legumes, nuts and seeds, fish and seafood, enriched grain products
  - Cooking reduces content

- Deficiency
  - Beriberi: Overall profound muscle weakness and nerve destruction
  - Milder symptoms: Headache, irritability, depression, and loss of appetite
- Toxicity
  - No reports of thiamin toxicity
Riboflavin/B2

- Functions
  - Coenzyme in energy metabolism
  - Supports antioxidants

- Food sources
  - Milk and dairy products
  - Enriched grains, eggs

Riboflavin

- Deficiency
  - *Ariboflavinosis*
    - Occurs most often in chronic alcoholism

- Toxicity
  - No reported cases

Milk Packaging

- Light breaks down riboflavin easily, so foods high in riboflavin are stored in opaque containers.
- That’s why it’s rare to see milk in bottles...

Ariboflavinosis/Riboflavin Deficiency
**Niacin/B3**

- **Functions**
  - Coenzyme in energy metabolism
  - Supports fatty acid synthesis

**Niacin**

- **Food sources**
  - Can be made from amino acid **tryptophan**
  - Whole and enriched grains
  - Meat, poultry, fish, nuts, and peanuts

- **Deficiency**
  - **Pellagra**
    - “Four Ds”: Dermatitis, diarrhea, dementia, and death
    - Can worsen if also deficient in __________.
  - Toxicity and Medicinal uses
    - High doses used to treat high blood cholesterol
    - Side effects: skin flushing, liver damage

**Pyridoxine/Vitamin B₆**

- **Functions**
  - **PLP**, coenzyme in protein and amino acid metabolism
  - Produce non-essential amino acids
  - Produce neurotransmitters & hemoglobin
  - Helps to lower blood levels of **homocysteine**
Vitamin B₆

- Food sources
  - Meat, fish, poultry, potatoes, fortified meat substitutes, bananas, sunflower seeds

Vitamin B₆

- Deficiency
  - Microcytic hypochromic anemia
  - Heart disease (high homocysteine)
  - Damage nervous system → depression, headaches, confusion, convulsion

- Toxicity and Medicinal Uses
  - Can cause subtle neurological damage
  - Other symptoms: upset stomach, headache, sleepiness, and a tingling, prickling, or burning sensation

Folate/B9

- Functions
  - Coenzyme in DNA synthesis and cell division
  - Coenzyme in AA metabolism
  - Needed for normal red blood cell maturation
  - Works with B6 and B12 to help control homocysteine levels

Folate

- Food sources
  - Fortified cereals, enriched grains
  - Green leafy vegetables, orange juice, sunflower seeds, and legumes
Folate
- Deficiency
  - Anemia and diarrhea
    - Megaloblastic anemia
  - Birth defects
    - Spina bifida
  - Heart disease
- Toxicity
  - Can mask vitamin B₁₂ deficiency with folate supplements
  - Hypersensitive people may suffer hives or respiratory distress

Cobalamin/Vitamin B₁₂
- “cobalt containing compounds”
- Functions
  - Needed for normal folate function
    - DNA and red blood cell synthesis
    - Metabolize homocysteine
  - Maintains myelin sheath around nerves
- Food sources:
  - Only animal foods: meats, liver, milk, eggs
  - Some fortified foods

Spina Bifida

Vitamin B₁₂
- Absorption
  - Requires intrinsic factor
- Deficiency
  - Can lead to pernicious anemia, resulting in nerve damage
  - Red blood cells can look enlarged (megaloblastic anemia)
- Toxicity
  - No UL set
**Pantothenic Acid/B5**

- **Functions**
  - Component of **coenzyme A**
- **Food sources**
  - Widespread in foods
  - Reduced by freezing, canning, and refining
- **Deficiency and toxicity:** Rare

**Biotin/B7**

- **Functions**
  - Coenzyme
  - Amino acid metabolism (AA → glucose)
  - Fatty acid synthesis
  - Release of energy from fatty acids
  - DNA synthesis
- **Food sources**
  - Cauliflower, liver, peanuts, cheese
  - Protein avidin (raw egg whites) binds biotin and prevents absorption
- **Deficiency and toxicity are rare**

**Choline: A Vitamin-Like Substance**

- **Function**
  - Helps metabolize homocysteine
- **Food sources**
  - Milk, liver, egg yolk, and peanuts
  - Overall abundant in food
- **Deficiency**
  - Unlikely in healthy people
- **Toxicity**
  - Diarrhea, falling blood pressure, and fishy body odor

**Vitamin C**

- **Functions**
  - Antioxidant
  - Needed for collagen synthesis
  - Enhances the absorption of iron from plant foods
  - Makes other essential compounds (e.g. steroid hormones, bile salts, thyroid hormones, parts of DNA)
Vitamin C

- Food sources
  - Fruits: citrus, strawberries, kiwi, fortified juice
  - Vegetables: broccoli, tomatoes, potatoes, cabbage, leafy green, peppers

Vitamin C

- Deficiency
  - Scurvy

- Toxicity
  - May cause GI distress in high doses

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<td>Antioxidant, immune support</td>
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Bogus Vitamins

- Unnecessary substances found in some supplements
- May be marketed as “vitamins” and “health boosters”
- Examples
  - Hesperidin
  - Pangamic acid
  - Rutin