Chapter 13
• Trace Minerals
• Minerals in the Human Body
• The Trace Minerals—An Overview
• Needed in very small quantities in the body.
• Perform many essential functions important to health.
• Toxic levels can easily be reached with the use of supplements.
• We can get the amounts of trace minerals needed by consuming a wide variety of foods.
• The Trace Minerals—An Overview
• Food sources
  – Depend on soil and water composition
  – Depend on food processing
• Deficiencies
  – Can affect people of all ages
    • Growth failure in children
  – May be difficult to recognize
  – Affect many body systems
• The Trace Minerals—An Overview
• Deficiencies
  – Severe deficiencies—easy to recognize
  – Others can be difficult to diagnose.
  – Mild deficiencies are easily overlooked.
  – Deficiencies have wide-reaching effects
    • Active in all the body systems—GI, blood, bone, central nervous system
  – Deficiencies affect all ages
    • in children, they can result in growth failure
• The Trace Minerals—An Overview
• Toxicities
  – Most are toxic at 2 ½ -7 x above the RDA.
  – FDA does not limit amounts in supplements.
• Interactions among the trace minerals
  – Common and coordinated to meet body needs
  – Can lead to nutrient imbalances
    • Excess of one may cause a deficiency of another
• Iron
• Too little and too much can be harmful
• Roles in the body
  – Required by enzymes needed for amino acids, hormones, and neurotransmitters
  – Part of electron carriers in electron transport chain
  – Hemoglobin and myoglobin
    • Helps accept, carry, and release oxygen
    • Iron
Absorption

- Body conserves iron
  - Balance maintained primarily through absorption
- Ferritin
  - Iron-storage in small intestine
- Transferrin
  - Iron transport protein

http://nutrition.jbpub.com/animations/animations.cfm?id=29&debug=0

Iron

Iron absorption

- Iron is regulated through absorption:
  - more iron is absorbed when stores are empty, less is absorbed when stores are full
- Mucosal ferritin receives iron from food and stores it in cell in the small intestine
- When needed, it is released to mucosal transferrin, which transfers it to blood transferrin
- Transferrin transports it to the body
- If it is not needed, excess is discarded when G.I. tract cells shed every 3-5 days

http://nutrition.jbpub.com/animations/animations.cfm?id=29&debug=0

Iron Absorption

Iron Absorption and Metabolism

- Heme and Nonheme Iron
  - Heme iron
    - Found in foods that are from the flesh of animals (meat, poultry, and fish)
    - Represents only 10% of a day's iron consumption
    - Has an absorption rate of 25%
  - Nonheme iron
    - Found in plant-derived and animal-derived foods
    - Has an absorption rate of 17%

Iron: Heme vs. Nonheme

Iron Absorption

Absorption Enhancing Factors

- MFP Factor:
  - Found in meat, fish, poultry,
  - Enhances absorption of non-heme iron from foods eaten at the same meal.

- Vitamin C:
  - Enhances non-heme absorption.

- Acids:
  - Citric acid, lactic acid from foods, some sugars

Iron Absorption

Factors that Inhibit Nonheme iron absorption

- Phytates in legumes, whole grains, rice
- Vegetable proteins in soybeans, legumes and nuts
- Calcium in milk
- Tannic acids in coffee and tea
• Iron Absorption
  • Difficult to assess iron absorption with meal consumption
  • Most relevant factors
    • are MFP factor and vitamin C in enhancing absorption
    • phytates in inhibiting absorption
  • Individual variation in absorption
    • Overall, approximately **18%** is absorbed from mixed diets (10% in vegetarian diets)
      • Health, stage in life cycle, and iron status
        – Can vary from 2%-35%
• Iron Absorption
  • Absorption increases:
    • when iron stores are depleted
    • with increased body need (pregnancy)
    • with rapid growth and development
  • Absorption decreases:
    • when body stores are adequate
    • gastrointestinal disease

Transport and Storage:
• Carried by transferrin to the bone marrow
  – Used for RBC production
• Surplus iron is stored in the protein **ferritin** -
  – mainly in the liver, and also in the bone marrow and spleen.
• When iron concentrations are very high, excess is converted to another storage protein **hemosiderin**.
• Iron Recycling
• Iron Absorption

Recycling:
• Liver recycles iron
  – Average RBC lives approximately 4 months
  – Liver and spleen remove iron from old RBCs
    • Sends it back to the bone marrow to make new RBCs
  – Lose iron daily via GI tract, blood losses
• Iron
• Deficiency
  – Most common nutrient deficiency worldwide
    • Affecting 1.6 billion people
  – Populations affected in U.S.
    • 10% of toddlers, adolescents girls, and women of childbearing age
  – Vulnerable stages in life
    • Women in reproductive years
    • Pregnancy
    • Infants and young children
    • Adolescence
• Blood Loss
  • Ulcers, menstrual loss, blood donors
  • Iron
• Iron Deficiency
  • Assessment of Iron Deficiency
    • Stage 1 – Iron stores diminish; measured by serum ferritin
    • Stage 2 – Transport iron decreases; measured by transferrin saturation
    • Stage 3 – Hemoglobin production declines and hematocrit declines. Hemoglobin and hematocrit are late indicators of iron status.
• Iron Deficiency
• Iron Deficiency and Anemia
  • Iron deficiency
    • there is depletion of the body’s iron stores.
  • Iron-deficiency anemia
    • the severe depletion of iron stores
    • also called microcytic (small) hypochromic (pale) anemia.
    • Symptoms include fatigue, weakness, headaches, apathy, pallor and poor resistance to cold temperatures.
• Iron Deficiency
• Iron
• Deficiency and behavior
  • Energy metabolism is impaired
  • Reduces work capacity and mental productivity
  • Unmotivated, apathetic
  • Symptoms of a deficiency may be confused with behavioral issues.
• Iron Deficiency and Pica
  • Generally found in women and children from low-income groups
  • Eating ice, clay, paste, and other nonfood substances
  • Eating nonfood substances will not correct the deficiency.
  • Results in anemia
• Iron Toxicity
• Iron Overload
  • Hemochromatosis
    • a genetic disorder that enhances iron absorption
  • Hemosiderosis
    • Repeated blood transfusions
    • Massive doses of supplemental iron
    • Rare metabolic disorders
• Iron Poisoning
  • UL for adults: 45 mg/day
  • Ingestion of iron supplements is the leading cause of accidental poisoning in children
Symptoms include nausea, vomiting, diarrhea, constipation, rapid heartbeat, weak pulse, dizziness, shock, and confusion

Iron

Iron Toxicity
- Iron and Heart Disease – may be a link to high iron stores
- Iron and Cancer – may be a link with free radical activity resulting in damage to DNA; free iron can generate free radicals

Iron: Sources
- Significant sources
  - Red meats, fish, poultry, shellfish, eggs
  - Legumes, dried fruits
- Whole grains, iron enriched grains
- Dark greens and dried fruit
- Iron in Selected Foods

Iron Supplementation
- May need supplements:
  - women of childbearing age
  - pregnant women
  - infants and young children
  - teenagers
- Best absorption from ferrous sulfate
- Take on empty stomach between meals or at bedtime for best absorption
- Do not take with milk, tea, or coffee
- Constipation is common side effect

Zinc

Roles:
- Cofactor for multiple enzymes
- Assists in immune function, growth and development
- Blood clotting
- Thyroid hormone function
- Needed to produce active Vitamin A
- Taste, wound healing
- Sperm production, fetal development
- Zinc

Zinc Roles in the Body
- Gene expression
- Involved in growth, development, and immune function
- Affects platelets in blood clotting and wound healing
- Needed to produce the retinal form of vitamin A
- Affects thyroid hormone function
- Influences behavior and learning performance
- Taste perception
- Wound healing
Sperm development
Fetal development

- Zinc

Zinc Roles in the Body
  - Supports the work of metalloenzymes
    - Helps to make parts of DNA and RNA
    - Manufactures heme for hemoglobin
    - Assists in essential fatty acid metabolism
    - Releases vitamin A from liver stores
    - Metabolizes carbohydrates
    - Synthesizes proteins
    - Metabolizes alcohol
    - Disposes of damaging free radicals

Zinc Absorption
  - Varies; about 15-40% is absorbed and it is based on your zinc status;
    - The more you need, the more you absorb
  - Fiber and phytates bind with it; limit absorption
  - Held in reserve by metallothionein in the intestinal cell
  - Then metallothionein releases it to the blood (carried on albumin and transferrin)
    - http://nutrition.jbpub.com/animations/animations.cfm?id=30&debug=0

Zinc Deficiency
At risk include pregnant women, young children, elderly, poor

Deficiency
  - Growth retardation
  - Arrested sexual maturation
  - Diarrhea
  - Decreased immune response
  - Damage CNS and brain, poor motor development and cognitive performance
  - Vitamin A deficiency
  - Zinc
    - Deficiency symptoms
      - Growth retardation, delayed sexual maturation, impaired immune function, hair loss, eye and skin lesions, loss of appetite
      - The boy on the left is 17 years old but is only 4 feet tall (like a 7 year in the U.S.)
    - Partially reversible when zinc is added to the diet

Zinc Toxicity
  - 50-450 mg may cause diarrhea, vomiting, fever
  - Upper Level is set at 40 mg

Recommendations:
  - Men- 11 mg
  - Women- 8 mg
Sources:
- Protein containing foods such as shellfish, meats, poultry and legumes
- **Zinc in Selected Foods**
  - RDA for men: 11 mg  
  - RDA for women: 8 mg
- **Iodine**

Roles:
- Part of the thyroid hormone that regulates:
  - body temperature
  - metabolic rate
  - reproduction
  - growth
  - RBC production
  - nerve and muscle function

Iodine

Deficiency:
- Iodide is part of thyroid hormone
- In deficiency, body’s thyroid hormone decreases
- Body secretes more thyroid stimulating hormone (TSH)
- Thyroid gland enlarges to trap as much iodide as possible
- **Goiter** results- Enlargement of the thyroid gland
- Affects 200 million people worldwide; prevalent in South America, Asia, and Africa
- sluggishness and weight gain, decreased mental performance
- in pregnancy- **Cretinism** in the child

Goiter

Iodine

Recommendations:
- 150 mcg/day
- Significant sources
  - Iodized salt, seafood, bread, dairy products, plants grown in iodine-rich soil and animals fed those plants
  - **Fluoride**

Fluoride Roles in the Body
- Formation of teeth and bones
- Helps to make teeth resistant to decay
- Fluorapatite is the stabilized form of bone and tooth crystals
- Fluoride and Dental Caries
  - Widespread health problem
  - Dental caries: 95% of population have decayed, missing or filled teeth
- Can lead to nutrition problems due to issues with chewing
• Fluoride
  • Significant sources
    – Fluorinated drinking water
    – Tea, seafood
  • Deficiency symptoms
    – Susceptibility to tooth decay
  • Recommendations
    – Men: 4 mg/day
    – Women: 3 mg/day
• Fluoride
  • Monitor fluoride content of local water supply.
  • Supervise toddlers during tooth brushing.
  • Watch quantity of toothpaste used (pea size) for toddlers.
  • Use fluoride supplements only if prescribed by a physician.

• End of Chapter 13
• Trace Minerals
• Highlight 13
• Phytochemicals and Functional Foods
• Phytochemicals
  • Found in plant-derived foods
    – Have biological activity in the body
• Give foods taste, aroma, color, and other characteristics.
• Physiological effects
  – Suppression of diseases
  – Adverse effects if consumed in excess
• The Phytochemicals
• Defending against Cancer
  – Phytoestrogens mimic estrogen
    • Found in soybeans, legumes, flaxseeds, whole grains, fruits and vegetables
    • Antioxidant activity
    • Slow the growth of breast and prostrate cancer
    • Supplements may stimulate the growth of cancers that depend upon estrogen.
• Phytochemicals
• Defending against cancer
  – Protect against DNA damage
  – Soybeans
    • Phytoestrogens
  – Tomatoes
    • Lycopene
• Defending against heart disease
  – Flavonoids
    • Food sources
      – Whole grains, legumes, soy, fruits, vegetables, teas, chocolate, red wine, nuts, olive oil
    • Heart-protection factors
      – Carotenoids – fruits and vegetables
      – Phytosterols – soybeans
      – Lignans – flaxseeds
• Phytochemicals and Functional Foods
• Phytochemicals are nonnutrient compounds.
• Only a few of the thousands of phytochemicals have been researched.
• There are many questions and few answers about their role in human health.
• Foods that provide health benefits beyond those of nutrients are now called functional foods.
• Some have an identified role in disease prevention.
• The Phytochemicals
  • Defending against Cancer
    – Lycopene
      • Powerful antioxidant
      • Inhibits the growth of cancer cells
      • Found in tomatoes and cooked tomato products, apricots, guava, papaya, pink grapefruits, and watermelon
      – Five servings of fruits and vegetables are recommended every day.
• The Phytochemicals
• Defending against Heart Disease
  – Flavonoids in foods
    • Powerful antioxidants
    • Protect against LDL cholesterol oxidation and reduce blood platelet stickiness
    • Lowers risk of chronic diseases
    • Found in whole grains, legumes, soy, vegetables, fruits, herbs, spices, teas, chocolate, nuts, olive oil, and red wines
• Phytochemicals
• Phytochemicals
• Functional Foods
• All foods that have a potentially beneficial effect on health
  – Whole
  – Fortified
  – Modified
• Characteristics similar to food and drugs
• Consumption patterns for beneficial effect
• Cost
• Unanswered Questions
• Research for safety and effectiveness is still in progress
Questions

• Does it work?
• How much does it contain?
• Is it safe?
• Is it healthy?

• Phytochemicals and Functional Foods

The End

• The Phytochemicals

• Defending against Heart Disease
  • Carotenoids in foods especially lutein and lycopene
    • Lower risk of heart disease
    • Found in fruits and vegetables
  • Phytosterols
    • May protect against heart disease
    • Inhibit cholesterol absorption
    • Lower blood pressure
    • Act as antioxidants
    • Found in soybeans and other vegetables
    • Lignans, found in flax seed, are converted to phytosterols by intestinal bacteria.

• The Phytochemicals

• The Phytochemicals in Perspective
  • Difficult to assess one food and its benefits alone
  • Actions of phytochemicals are complementary and overlapping