Unit 6

Vitamins
Defining a vitamin
Essential ____________________ substances

Body ____________________ synthesize enough to maintain health
Absence from the diet will produce ____________________ signs and symptoms

May be fat- or water-soluble
Natural versus synthetic

Fat soluble vs. Water soluble
Fat soluble
  Absorbed with _________________ in diet
  ____________________________ by the body
  Vitamin A,D,E,K
Water soluble
  Absorbed with ______________________
  Readily ______________________________ the body with ____________
  Vitamin C and Vitamin B-Complex

Historical Perspective
Foods found to cure illnesses
  Liver extract –
  Citrus fruits –
  All vitamins have probably been discovered – TPN can support life

Vitamin Toxicity
Toxicity of vitamin ____ is most likely
  Unlikely to develop toxicity of any vitamin unless individual vitamin supplements are used
  Balanced multivitamin and mineral supplement supplies <

Malabsorption of Vitamins
Fat malabsorption leads to deficiencies of fat-soluble vitamins
  ____________________________ affects absorption of some B vitamins
  ____________________________ affect absorption of some B vitamins

Fat Soluble Vitamins
Digestion and Absorption of Fat-Soluble Vitamins
Absorption of Fat-Soluble Vitamins
  40 – 90% of ingested fat-soluble vitamins absorbed (less efficient when consumed in higher quantities)
Distribution of Fat-Soluble Vitamins

Types of Fat-Soluble Vitamins
Vitamin A
Vit A is a ring structure w/ a fatty acid tail
Refs to preformed **retinoids** and **provitamin A carotenoids**
__________________________ – active forms of Vit A
Retinol, retinal, and retinoic acid
__________________________ – substance that can be made into a vitamin
__________________________ – photosynthetic pigment in fruits and vegetables
(yellow → orange → red)

Vitamin A in Foods
Preformed (____________________________)
Liver, fish oils, fortified milk, eggs, other fortified foods
Contributes ~70% of vitamin A intake for Americans

Provitamin A (____________________________________)
Dark leafy green, yellow-orange vegetables/fruits

Functions of Vitamin A:
Vision
Retinal and Opsin is responsible in forming __________________________
Retinal turns visual light into nerve signals in retina of eye
Retinoic acid required for structural components of eye
__________________________ in the retina (Bright lights & Color vision)
__________________________ in the retina (Dim lights & Black and white vision)

Growth and Differentiation of Cells
Retinoic acid is necessary for __________________________
Important for embryo development, __________________________
Retinoic acid influences production, structure, and function of epithelial cells that line the outside (skin) and external passages (mucus forming cells) within the body

Immunity
Deficiency leads to
Supplementation may decrease severity of infections in deficient person

Measuring Vitamin A
International unit (IU)-

Retinol activity equivalent (RAE) –

RDA for Vitamin A for Adults
________ RAE for men, _____________ RAE for women
Average intake meets RDA because much stored in the liver

Deficiency of Vitamin A
Most susceptible populations:

Preschool children with low F&V intake; Urban poor; Older adults; Liver disease (limits storage); _______________________________

Consequences:

_______________________________ (Conjunctival xerosis, Bitot’s spots, Xerophthalmia)
Poor growth; Decreased mucus production, Decreased immunity, Bacterial invasion of the eye

Upper Level for Vitamin A

_______________µg retinol

________________________ results from long-term supplement use (2 – 4 x RDA)

Toxicity: Fatal dose (______ g)

Toxicity of Vitamin A

Acute –
symptoms disappear when intake stops GI effects, Headaches, Blurred vision,
Poor muscle coordination

Chronic –

Bone and muscle pain, Loss of appetite, Skin disorders, Headache, Dry skin, Hair loss, Increases liver size, Vomiting

Teratogenic

Tends to produce physical defect on developing fetus as a result of excess vitamin A intake
Spontaneous abortion and Birth defects

Vitamin D

Prohormone –

Synthesis from sun exposure: Sufficient sun exposure makes this a vitamin
How much sunlight do you need?

Food Sources of Vitamin D

Fatty fish (salmon, herring), Fortified milk, Some fortified cereal

Functions of Vitamin D

Regulate blood calcium level

With parathyroid hormone, releases calcium from bone

Cell differentiation
Linked to reduction of breast, ovarian, colon, and prostate cancer development

Vitamin D Needs

Due to variation in sunlight exposure, no RDA set, but AI established as:
5 µg/d (200 IU/d) for adults under age 51
10-15 µg/d (400 - 600 IU/d) for older adults
Light skinned individuals can produce enough vitamin D to meet the AI from casual
sun exposure
Infants are born with vitamin D, but AAP recommends supplementing breastfed infants with 5 µg (200 IU)/d until weaned to fortified infant formula

**Vitamin D Deficiency**
- Rickets –
- Osteomalacia –
- Vitamin D resistance –

**Upper Level for Vitamin D**
UL = 50 µg/d (2000 IU/d)
Regular intake of 5-10x the AI can be toxic
- Over-absorption of calcium (hypercalcemia), increase calcium excretion
- Calcium deposits in kidneys, heart, and blood vessels, narrowing of pulmonary arteries and aorta, facial changes, mental retardation

**Vitamin E**
- Tocopherols and tocotrienols

**Vitamin E in Foods**
- Plant oils, Wheat germ, Asparagus, Peanuts, Margarine, Nuts and seeds
- Actual amount is dependent on harvesting, processing, storage and cooking

**Functions of Vitamin E**
- Antioxidant:

  - Free Radicals

    - Antioxidant
      - Peroxyl-radical from
      - Protects PUFAs within the cell membrane and plasma lipoproteins

    - Redox agent –

**Vitamin E Needs**
- RDA = 15 mg/d for women and men (22 IU of natural source or 33 IU of synthetic form)

**Vitamin E Deficiency**
- Rare
- Consequences of deficiency: Hemolytic anemia, Nervous system damage
- Susceptible populations: Premature infants, People with fat malabsorption, Smokers (destroys vit E)
Upper Level for Vitamin E

Upper Level is ________ IU (natural sources) or ________ IU (synthetic forms)
Inhibit vitamin ____ metabolism and anticoagulants
Possible impact on ____________________ health

Vitamin K ("KOagulation")
Phylloquinone (K1) from plant sources
Menaquinones (K2) from fish oils, meats, and intestinal bacteria

Dietary Sources of Vitamin K
Liver, Green leafy vegetables, Broccoli, Peas, Green beans, Resistant to cooking losses,
Limited vitamin K stored in the body

Functions of Vitamin K

____________________________: Formation of osteocalcin, Low intake is
increases risk for hip fractures

Vitamin K Needs
AI = _____ µg/d for women, _____ µg/d for men

Vitamin K Deficiency
____________________________: Destroy intestinal bacteria, Inhibit vitamin K synthesis and
absorption, Potential for excessive bleeding
Excess vitamins__ and __ interferes with vitamin ___
Newborns are injected with vitamin K (breast milk is a poor source)

Vitamin K – Toxicity

Water-Soluble Vitamins

General characteristics
Dissolve in water and Readily excreted

In the diet

Consumed in ____________________ form, cleaved during digestion,
absorbed as free vitamins
50 – 90% B vitamins in diet are absorbed
Once absorbed,

Vitamin C
Ascorbic acid (reduced form), dehydroascorbic acid (oxidized form)
Synthesized by most animals (______________________________)

Vitamin C in Foods
Citrus fruits, Potatoes, Green peppers, Cauliflower, Broccoli, Strawberries, Romaine
lettuce, Spinach
Sensitive to heat so it’s easily lost through cooking & sensitive to iron, copper, oxygen

Functions of Vitamin C
Biosynthesis: Hormones, Neurotransmitters, Bile acids
______________ functions: WBC have highest concentration of Vit C

**Vitamin C Needs**

RDA is ___ mg/d for male adults & ____ mg/d for female adults
Needs increased under certain conditions
+35 mg/d for smokers, Oral contraceptives, Tissue injury

**Deficiency of Vitamin C**

Deficient for _________________ days
Consequences of deficiency
Fatigue, Pinpoint hemorrhages, bleeding gums and joints, Impaired wound healing,
Bone pain, fractures and Diarrhea

**Upper Level for Vitamin C**

Fairly nontoxic (at <__ gm)
Chronic high doses may lead to (UL = __ g/d)
Stomach inflammation, Diarrhea, Kidney stones

**Vitamin B1: ________________**
Contains sulfur and nitrogen group and is destroyed by alkaline and heat
Coenzyme: Thiamin pyrophosphate (TPP)

**Thiamin in Foods**
White bread, pork, hot dogs, luncheon meat, cold cereal, Enriched grains/ whole grains

**Functions of Thiamin**
Thiamin pyrophosphate (TPP) is a coenzyme in the metabolism of ________________,
 branched-chain amino acids, and pentoses
Decarboxylase & Transketolase

**Thiamin Needs**
RDA ____mg/d for women and ____ mg/d for men
No UL; surplus is rapidly lost in urine

**Thiamin-Deficiency Disease**
**Beriberi:**

Peripheral neuropathy: Impaired sensory, motor and reflex
Occurs within 7 days on a thiamin deficient diet

Mainly in alcoholics: Alcohol ↓ thiamin absorption and ↑ excretion, Poor quality diet
Consequences of deficiency: Involuntary eye movement, Double vision, Ataxia:
staggering, poor muscle coordination, Mental confusion, “drunken stupor”

**Vitamin B2: __________**
Coenzymes: Flavin mononucleotide (FMN) and Flavin adenine dinucleotide (FAD)

**Riboflavin in Foods**
Milk/products, Enriched grains, Liver, Oyster, Brewer’s yeast
Functions of Riboflavin

Coenzymes in oxidation-reduction reactions(FMN shuttles hydrogen ions and electrons to into the electron transport chain)

Riboflavin Needs

RDA 1.1 mg/d for women and 1.3 mg/d for men
No UL, toxicity not documented, readily excreted

Riboflavin-Deficiency Diseases

Occurs within 2 months, usually in combination with other deficiencies
Glossitis- tongue; Cheilosis- corner mouth; Seborrheic dermatitis- skin; Stomatitis-mouth

Vitamin B3: Nicotinic acid (niacin) and nicotinamide (niacinamide)
Coenzyme: Nicotinamide adenine dinucleotide (NAD)
Nicotinamide adenine dinucleotide phosphate (NADP)

Niacin in foods
Mushrooms; Enriched grains; Beef, chicken, turkey, fish
Heat stable; little cooking loss; 60 mg tryptophan can be converted into 1 mg niacin

Functions of Niacin

Coenzyme (NADH and NADPH) in oxidation-reduction reactions
Catabolic reactions use Glycolysis, Citric acid cycle, Alcohol dehydrogenase
Anabolic reactions use Fatty acid synthesis

Niacin Needs

RDA: 14 NE/day for women and 16 NE/day for men

Niacin-Deficiency Diseases

: Occurs in 50-60 days and is prevented with an adequate protein diet
Consequences of deficiency include Diarrhea, Dementia, Dermatitis

Upper Level for Niacin

Toxicity effects: Flushing of skin, Itching, Nausea, Liver damage
UL = 35 mg/d of supplemental niacin

Vitamin B4: Consumed as Coenzyme ___

Vitamin B4: Pantothenic Acid in Foods
“From every side”; Meat; Milk; Mushrooms; Liver; Peanuts

Functions of Pantothenic Acid
Part of Coenzyme-A
Pantothenic Acid Needs
  Adequate Intake = 5 mg/d; Average intake usually exceeds AI
  No UL

Pantothenic Acid-Deficiency Diseases
  Rare; Listlessness, fatigue, headache, sleep disturbance, nausea, abdominal distress;
  Alcoholics at risk
  Usually in combination with other deficiencies

Vitamin B5: _____________________
  Exists in free and protein-bound (biocytin) forms; biocytin must be cleaved from protein by
  biotinidase before being absorbed

Sources of Biotin:
  Cauliflower, yolk, liver, peanuts, cheese; Intestinal synthesis of biotin; Biotin content only
  available for a small number of foods; We excrete more than we consume

Functions of Biotin
  Cofactor in carboxylase reactions (addition of CO2)
  Citric acid cycle, Fatty acid synthesis, and Fatty acid elongation
  Allows for breakdown of amino acids

Biotin Needs
  AI = 30 µg/d for adults (This may overestimate the amount needed for adults) and No UL

Biotin-Deficiency Diseases
  Susceptible populations: Those with high intake of raw egg whites and Alcoholics
  Consequences of deficiency
    Skin rash; Hair loss; Convulsion; Neurological disorders

Vitamin B6: ______________________________________________________________
  Three compounds: Pyridoxal, Pyridoxine, Pyridoxamine
  Main coenzyme form: pyridoxal phosphate (PLP)

Vitamin B6 in Foods
  Meat, fish, poultry; Whole grains (not part of enrichment program); Banana, Spinach,
  Avocado, Potato
  Heat and alkaline sensitive

Functions of Vitamin B6
  Heme synthesis; Participates in 100+ enzymatic reactions (Decarboxylation of amino acid
  and Transamination reaction ); Carbohydrate metabolism; Lipid metabolism;
  Neurotransmitter synthesis

Vitamin B6 Needs
  RDA = 1.3 - 1.7 mg/d for adults and average intake is more than the RDA

Vitamin B6 Deficiency Diseases
  Rare and Consequences of deficiences include Microcytic hypochromic anemia; Seborrheic
  dermatitis; Convulsion, depression, confusion; Reduced immune response; Peripheral
  nerve damage

Pharmacologic Use of Vitamin B6

Upper Level for Vitamin B6
  100 mg/d and is Based on development of nerve damage with toxicity
Folate (Folic acid, Folacin)
Consists of pteridine group, para-aminobenzoic acid (PABA), and glutamic acid
Coenzyme form: tetrahydrolfolic acid (THFA)

Folate in Foods
Liver; Fortified breakfast cereals; Grains, legumes; Foliage vegetables

Functions of Folate
DNA synthesis: Synthesis of adenine and guanine and Anticancer drug methotrexate
Homocysteine metabolism; Neurotransmitter formation ; Amino acid metabolism
RDA = 400 µg/d for adults

Folate-Deficiency Diseases
Consequences of deficiency
Megaloblastic anemia: Similar signs and symptoms of vitamin B-12 deficiency
Neural tube defects

Upper Level for Folate
UL for synthetic folate = 1 mg/d
Toxicity symptoms: Epilepsy, Skin disorder, Respiratory disorder
FDA limits nonprescription supplements to 400 µg per tablet for non-pregnant adults

Vitamin B-12:
Forms of Vitamin B-12
Cyanocobalamin (free vitamin B-12); Methylcobalamin (coenzyme); 5-deoxyadenosylcobalamin (coenzyme)
Contains cobalt

Vitamin B-12 in Foods
Synthesized by bacteria, fungi and algae
Animal products: Organ meat, Seafood, Eggs, Hot dogs, Milk

Functions of Vitamin B-12
Coenzymes that move 1-C groups
Citric acid cycle, Oxidation of fatty acids, Folate metabolism
Nervous system functions – maintenance of myelin sheath

Vitamin B-12 Needs
RDA = 2.4 µg/d for adults and elderly adults while average intake exceeds RDA and no UL

Vitamin B-12-Deficiency Diseases
Looks like folate deficiency
Causes: Usually due to decreased absorption ability
Consequences
Pernicious anemia
Nerve degeneration, weakness; Tingling/numbness in the extremities (parasthesia);
Paralysis and death
Susceptible populations
Older adults; Infants of vegan mothers; Vegans (after many years); People with malabsorptive diseases
Treatment
Monthly injections
Nasal gel
Weekly ingestion of megadoses