Vitamins

History

- Purified diets of carbohydrate, protein, fat, minerals and water were not capable of normal growth
  - "Accessory growth factors"
- Casimir Funk, a Polish biochemist, isolated an antiberberi substance from rice polishings
  - Named it *vitamine*
    - An amine
    - Vital for life

Vitamins

- Essential organic compounds required in very small amounts (micronutrients) involved in fundamental functions of the body
- Unrelated chemically
  - Not only amines so "e" was dropped

Vitamins

- Not metabolic fuels (like glucose or fatty acids) or structural nutrients (like amino acids)
- Regulators (catalysts) of reactions, some of which are involved in energy metabolism

Vitamins

- Organic molecules in food
- Required in small amounts
- Classified based on solubility
  - Fat soluble
  - Water soluble

Fat-soluble Vitamins

Vitamin	Chemical name
A	Retinol
D_2	Ergocalciferol
D_3	Cholecalciferol
E	Tocopherol
K	Phylloquinone

Water-soluble Vitamins

Vitamin	Chemical name
B complex	
B_1	Thiamin
B_2	Riboflavin
B_3	Nicotinamide (niacin)
B_5	Pantothenic acid
B_6	Pyridoxine
B_7	Biotin
	Folacin (folic acid)
	Choline
B_{12}	Cyanocobalamin
C	Ascorbic acid

Vitamins

- All vitamins are metabolically essential but not all required in the diet
  - Most mammals can synthesize vitamin C; not humans and primates
  - No mammal can synthesize B vitamins but rumen bacteria do

Vitamins

- Some function as vitamins after undergoing a chemical change
  - Provitamins (e.g., β-carotene to vitamin A)

Classification

- Based on solubility in the laboratory, but solubility greatly influences how the body absorbs, transports and stores vitamins
- Fat-soluble
  - Vitamins A, D, E and K
- Water-soluble
  - B vitamins and vitamin C

The Basics of Water-Soluble Vitamins

- Dissolve in water
- B vitamins & vitamin C
- Absorbed mostly in small intestine & stomach
- Bioavailability
  - Nutritional status, other nutrients & substances in food, medications, age, illness
- Circulated to liver in blood
  - Not stored in large quantities

The Basics of Water-Soluble Vitamins

	General Characteristics
Vitamins in Foods	• Bound to proteins that must be cleaved prior to absorption • Easily destroyed during cooking
Digestion	• Digested mostly in small intestine
Absorption	• Absorbed mostly in small intestine, but also in stomach • Absorbed via simple diffusion when intake is high and active transport when intake is low • Bioavailability is influenced by many factors
Circulation	• Transported via blood to liver
Functions	• Many coenzyme and other roles, especially in energy metabolism
Toxicity Effects	• Minimal, although some exist

Naming the Vitamins

- First named vitamin A or B
- B-complex vitamins
- Given common names also
  - Thiamin
  - Riboflavin
  - Niacin
- Chemical names
  - Ascorbic acid

Memorizing B Vitamin Names & Numbers

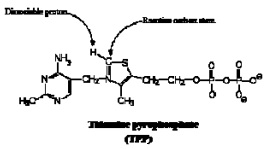
TABLE 10.3 Naming B Vitamins

Note that folate does not have a corresponding number.

Vitamin	Common Name	Mnemonic
B_1	Thiamin	*The*
B_2	Riboflavin	*Romans*
B_3	Niacin	*never*
B_5	Pantothenic acid	*painted*
B_6	Pyridoxine	*pyramids*
B_7	Biotin	*before*
B_{12}	Cobalamin	*college.*

Thiamin (Vitamin B_1)

- Contains thiol & amine group
- Thiamin pyrophosphate (TPP) or thiamin diphosphate
- Thiamin triphosphate

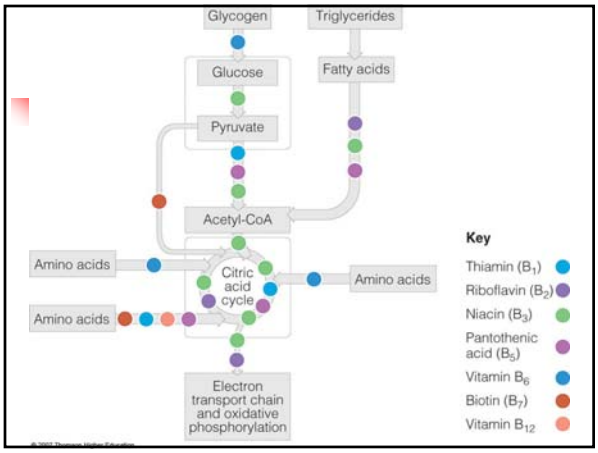


Bioavailability & Regulation of Thiamin in the Body

- Bioavailability
  - Increases when low
  - Uses simple diffusion when high
- Antithiamin factors
  - Raw fish, coffee, tea, berries, brussels sprouts, cabbage
- Vitamin C prevents oxidation
- Alcohol inhibits thiamin
- Excess excreted in urine

Functions of Thiamin

- ATP production
- Synthesis of DNA & RNA
- Noncoenzyme roles



Thiamin Deficiency: Beriberi

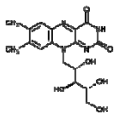
- "I can't, I can't"
- Prevalent in parts of the world that rely on unfortified, milled rice as staple
- Causes weak & impaired immune function
- Types
  - Dry, wet, infantile, cerebral (Wernicke-Korsakoff syndrome)

Did you know…

- Riboflavin is easily destroyed by light so milk is packaged in cardboard or cloudy plastic containers so it is not destroyed.

Regulation & Bioavailability of Riboflavin

- Types:
  - Free form
    - Can be absorbed
  - Bound to protein
  - Coenzyme (FMN or FAD)



- Absorption through simple diffusion when intake high
  - Active transport when intake low
- Animal foods more bioavailable
- Alcohol inhibits absorption
- Excess excreted in urine

Coenzyme Functions of Riboflavin

- Energy metabolism
- Redox reactions
- Formation of ATP, water, carbon dioxide
- β-oxidation
- Converts vitamin A & folate to active forms, tryptophan to niacin
- Forms vitamin B_6 & K

Riboflavin Deficiency

- Ariboflavinosis
  - Weakness, cheilosis, stomatitis, glossitis, anemia, confusion
- Alcoholics
- Diseases that interfere w/ riboflavin utilization

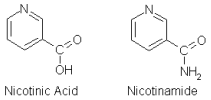
Normal

Glossitis

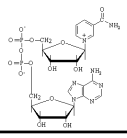
Cheilosis and stomatitis

Niacin (Vitamin B_3)

- Forms
  - Nicotinic acid
  - Nicotinamide



- Body uses both forms to make:
  - NAD^+
  - NADP



Dietary Sources of Niacin

- 1 mg niacin = 60 mg tryptophan
- Niacin equivalent
  - Combined amounts of niacin & tryptophan in foods

Bioavailability of Niacin

- Animal products more bioavailable than plant
- Increasing bioavailability
  - Treating grain products with alkaline substances cleaves protein from niacin

Regulation of Niacin in Body

- Small intestinal absorption
  - Simple diffusion when intake is high
  - Active transport when intake is low
- Circulated to liver
  - Attached to transport proteins
    - Converted to NAD^+ or NADP
- Liver converts tryptophan to niacin when needed

Functions of Niacin

- Coenzymes catalyze redox reactions related to energy metabolism
- Synthesizes fatty acids, cholesterol, steroid hormones, & DNA
- Metabolizes vitamin C & folate
- NAD^+
  - Protein synthesis
  - Maintenance, replication & repair of DNA
  - Glucose homeostasis
  - Cholesterol metabolism
- Lower LDL & increase HDL

Niacin Deficiency: Pellagra

- "Rough skin"
- Four Ds
  - Dermatitis
  - Dementia
  - Diarrhea
  - Death

Tryptophan, Niacin, & Pellagra

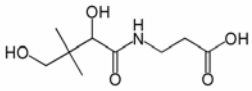
- Used to be thought of as infectious disease
- Joseph Goldberger
  - Studies done adding protein sources to diet
- Prevented & treated disease through diet
- Enrichment programs developed
- Rare in U.S.

Niacin Toxicity

- Nicotinic acid (1 g/day)
  - Skin inflammation
  - Itchiness
  - Flushing
  - Heartburn
  - Nausea
  - Increased plasma glucose
  - Liver damage

Regulation of Pantothenic Acid in the Body

- Bioavailability
- Increases via active transport when intake is low
- Circulated to liver via blood
- Not stored in body
- Coenzyme form high in liver, kidney, heart, adrenal glands, & brain



Functions of Pantothenic Acid in the Body

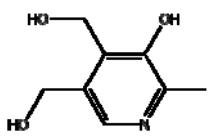
- Use of glucose, amino acids, & fatty acids for ATP production
- Synthesizes:
  - Heme
  - Cholesterol
  - Bile salts
  - Phospholipids
  - Fatty acids
  - Steroid hormones

Pantothenic Acid Deficiency & Toxicity

- Deficiency
  - Rare
  - "Burning feet syndrome"
- Toxicity
  - Rare
  - Nausea & diarrhea

Vitamin B_6

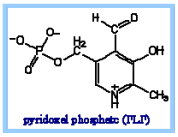
- Forms
  - Pyridoxine
  - Pyridoxal
  - Pyridoxamine



  - Similar biological activities

Regulation of Vitamin B_6 in the Body

- Absorbed in small intestine
- Circulated in blood to liver
  - Forms pyridoxal phosphate (PLP)
    - Coenzyme form of B_6
      - Stored in muscle & liver

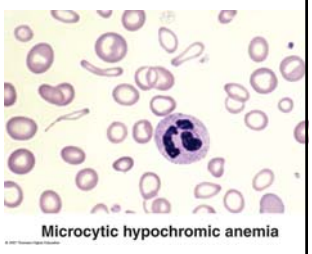


Functions of Vitamin B_6 in the Body

- PLP coenzyme to metabolism
  - Proteins & amino acids via transamination
- Synthesizes nonessential amino acids
- Produces nonprotein substances
  - Converts tryptophan to niacin

Vitamin B_6 Deficiency: Microcytic Hypochromic Anemia

- Results in inadequate heme production
- Decreases oxygen availability in tissues
- Impairs ability to produce ATP via aerobic metabolism

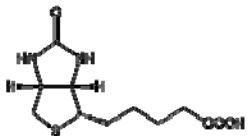

Microcytic hypochromic anemia

Vitamin B_6 Toxicity

- Excess supplement use
  - Severe neurological problems
    - Difficulty walking
    - Numbness in hands & feet

Bioavailability of Biotin

- Reduced by:
  - Avidin
    - Egg whites
  - Alcohol



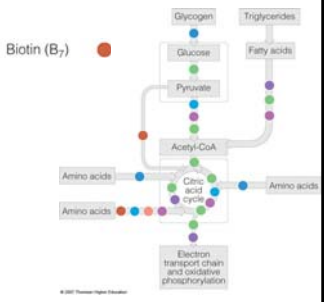
- Extreme heat destroys biotin

Regulation of Biotin

- Enzymes cleave to protein-biotin complexes in small intestine
- Produced by large intestine bacteria
- Circulates to liver via blood
- Small amounts stored in
  - Muscle
  - Liver
  - Brain

Functions of Biotin

- Catalyzes carboxylation reactions
- Use of amino acids & fatty acids in citric acid cycle for synthesis of fatty acids
- Gene expression

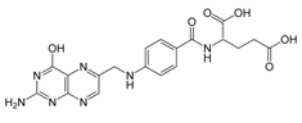


Biotin Deficiency

- Uncommon
- Seen in:
  - Individuals who eat large quantities of raw egg whites
  - Conditions impairing intestinal absorption
  - Genetic disorders
- Signs & Symptoms
  - Depression, hallucinations, skin irritations, infections, hair loss, poor muscle control, seizures, developmental delays in infants

Folate (Folacin)

- Consists of:
  - Nitrogen-containing double ring structure
  - Nitrogen-containing single ring structure
  - Glutamic acid
- Folic acid
  - Synthetic form
  - Fortified foods & supplements



Dietary Sources of Folate

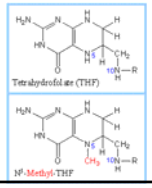
- Since 1998
- All cereal products in U.S. fortified with folic acid
- Heat, light, & oxygen destroy folate

Bioavailability of Folate

- Depends on form
- Influences
  - Genetic factors
  - Drugs
- Absorption higher with:
  - Fortified foods
  - Supplements
- Dietary folate equivalents (DFE)

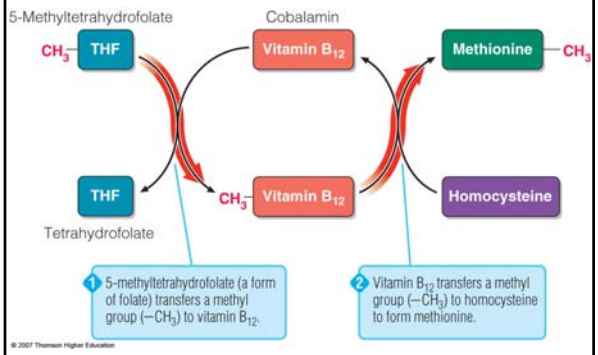
Regulation of Folate in Body

- Glutamate units must be cleaved before absorbed
  - Converted to tetrahydrofolate (THF)
  - Results in 5-methyl tetrahydrofolate
- Circulated to liver via blood
- Little is stored



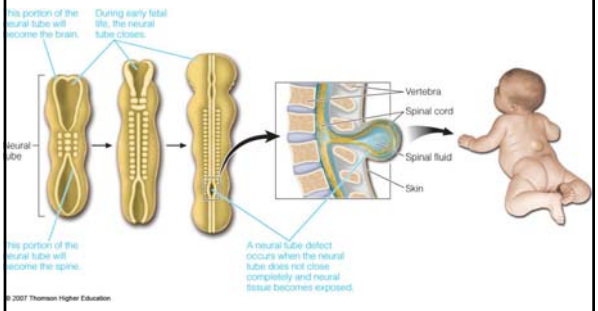
Function of Folate: Single-Carbon Transfers

- Coenzyme involved in transfer of single-carbon groups to form organic substances
  - Homocysteine to methionine
- Purines & pyrimidines
- Normal growth & development



Focus on Life Cycle Nutrition: Folate, Neural Tube Defects, & Spina Bifida

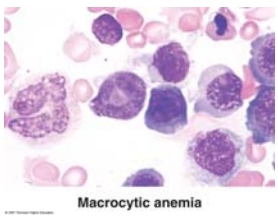
- Neural tube
  - Spinal cord & brain
- Defects result when:
  - Closure of neural tube is incomplete
- Spina bifida
  - 20 out of 100,000 babies



Folate, Neural Tube Defects, & Spina Bifida

- Folate supplementation decreases risk in some women
- IOM recommends:
  - That women capable of becoming pregnant take folic acid supplements and/or consume folic acid-fortified foods in addition to a varied diet

Folate Deficiency: Macrocytic Anemia


Macrocytic anemia

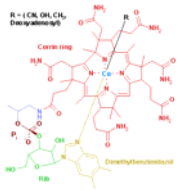
- Red blood cells (RBC) remain immature
- Cells are large & contain organelles not found in mature RBC

Folate Deficiency

- Alcoholics
- People w/ intestinal diseases
- People taking certain medications
- Elderly
- Genetic variations

Regulation of Vitamin B_{12} in the Body

- Must be cleaved before absorption
- Bound to R protein & intrinsic factor
- Once absorbed, binds to transcobalamin
- Circulates to liver via blood
- Stored in liver



Functions of Vitamin B_{12}

Coenzyme that catalyzes:

- Production of succinyl CoA
  - Uses amino acids & fatty acids for ATP production
    - Key for ruminants!!
- Conversion of homocysteine to methionine
  - Allows use of folate

Vitamin B_{12} Deficiency & Pernicious Anemia

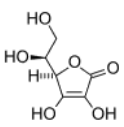
- Vegans
- Breastfed infants of B_{12}-deficient mothers
- Elderly
- Pernicious anemia
  - Gastric cells stop intrinsic factor secretion
  - Injections of B_{12} given
- Signs & symptoms
  - Macrocytic anemia, fatigue, difficulty sleeping, numbness, memory loss, severe neurological disturbances

Folate, Vitamin B_{12}, & Anemia

- B_{12} Deficiency
  - Caused by secondary folate deficiency
  - Folate "masks" B_{12} deficiency

Regulation of Vitamin C in the Body

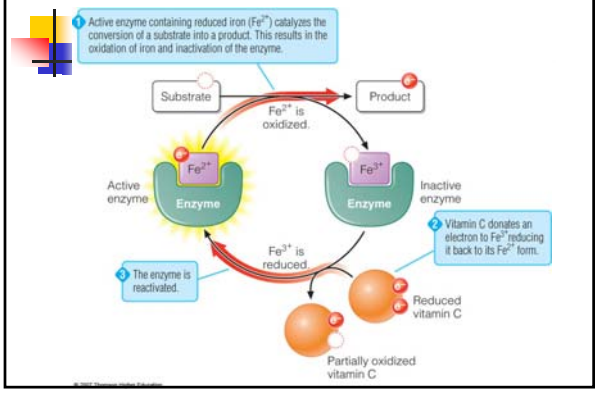
- Absorption in small intestine via active transport
- Uses glucose transport protein
- High intakes
  - Absorbed by simple diffusion in stomach & small intestine
- Circulates to liver via blood
- Excess excreted in urine



Functions of Vitamin C

- Antioxidant
- Accepts & donates electrons
- Involved in a variety of redox reactions

The "Recharging" of Enzymes



Examples

- Collagen
- Synthesis of carnitine
- Synthesis of hormones
  - Cholecystokinin
  - Gastrin

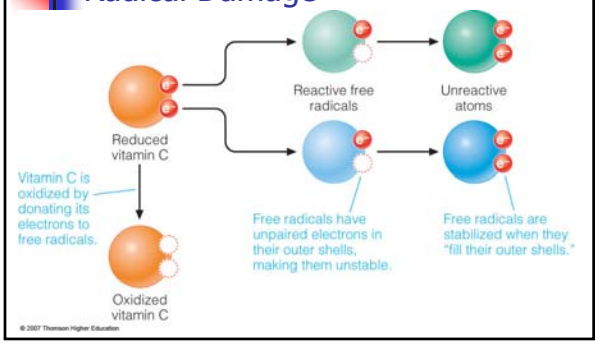
Bioavailability

- Enhances absorption of:
  - Iron
  - Copper
  - Chromium
- Consuming vitamin C sources with these minerals increases their bioavailability
- Example
  - Orange juice + iron-enriched cereal

Vitamin C & Protection from Free Radical Damage

- Free radicals
  - Charged substances that have unpaired electrons in their outer shells
  - Break DNA & oxidize fatty acids found in cell membranes
- Vitamin C
  - Destroys free radicals

Vitamin C & Protection from Free Radical Damage



Vitamin C, the Common Cold, & Other Diseases

- Suggested that large vitamin C doses benefit immune system
- More research needed:
  - Common cold
  - Cancer
  - Heart disease
  - Cataracts

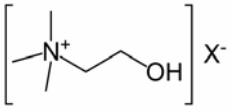
Vitamin C Deficiency & Toxicity

- Deficiency
  - Scurvy
- Signs & symptoms
  - Bleeding gums
  - Skin irritations
  - Bruising
  - Poor wound healing

- Toxicity
  - Nausea
  - Diarrhea
  - Cramping
  - Kidney stones

Choline: A "New" Essential Vitamin?

- IOM
  - Designated choline as essential in some situations
- Certain populations at risk
- ? conditionally essential
- Some do not consider it a vitamin

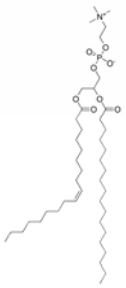


Dietary Sources of Choline

- Plant & animal foods
  - Eggs, liver, legumes, pork
- Lecithin
  - Mayonnaise & salad dressings

Regulation of Choline in the Body

- Unbound choline absorbed in small intestine
- Circulates to liver via blood
- Lecithin
  - Cleaved from glycerol backbone by pancreatic enzymes
  - Taken up by intestinal cells & reconstituted into lecithin molecules
  - Released into lymph
  - Becomes LDL
- Made in body by methionine



Functions of Choline in Body

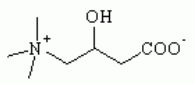
- Synthesizes phospholipids & acetylcholine
- Component of cell membranes & lipoproteins
- Muscle control
- Structural role
- Metabolic reactions

Choline Deficiency & Toxicity

- Deficiency
  - ? liver damage in adult men
- Toxicity
  - Fishy body odor, perspiration, salivation, low blood glucose, liver damage

Carnitine

- Conditionally essential for infants
- Classification being debated
- Animal sources
  - Meat, milk, & human milk



Regulation & Functions of Carnitine in the body

- Absorbed in small intestine
- Produced from methionine & lysine
- Assists fatty acids to cross membranes

Carnitine Deficiency & Toxicity

- Deficiency
  - Rare
  - Genetic conditions
    - Muscle weakness, hypoglycemia, heart irregularities
- Toxicity
  - None known

Summary

TABLE 10.4 General Functions of the Water-Soluble Vitamins and Choline

	Vitamins									
	Thiamin (B_1)	Riboflavin (B_2)	Niacin (B_3)	Pantothenic Acid (B_5)	Vitamin B_6	Biotin (B_7)	Folate	Vitamin B_{12}	Vitamin C	Choline[b]
Functions										
Coenzyme	X	X	X	X	X	X	X	X		
Energy metabolism[a]	X	X	X	X	X	X		X		
Antioxidant function									X	
Interconversion or activation of nutrients		X	X		X		X	X	X	
Blood health		X		X	X		X	X		
DNA or RNA synthesis	X		X				X			
Nerve/muscle function	X	X			X		X		X	X

[a]Note that these vitamins are not, themselves, energy-yielding nutrients but are involved in energy metabolism via their coenzyme roles.
[b]The roles that choline plays in the body are still being investigated.

Summary

TABLE 10.5 Major Food Sources of the Water-Soluble Vitamins and Choline

	Types of Food									
	Grains	Vegetables	Fruits	Dairy	Meat and/ or Eggs	Organ Meats	Seafood	Nuts and Seeds	Legumes	Mushrooms
Water-Soluble Vitamins										
Thiamin (B_1)*	X				X		X		X	
Riboflavin (B_2)*	X	X		X	X	X				X
Niacin (B_3)*	X				X	X	X			X
Pantothenic Acid (B_5)	X	X		X	X	X	X	X	X	X
Vitamin B_6	X	X	X		X	X	X		X	
Biotin (B_7)		X			X		X	X	X	X
Folate*	X	X	X			X			X	
Vitamin B_{12}				X	X	X	X			
Vitamin C		X	X						X	
Choline					X	X	X	X		

*Added to enriched cereal products.

Fat-Soluble Vitamins

- Organic substances that dissolve in lipids & are vital to health
- Micronutrients
- Vitamins A, D, E, & K
- Key players in:
  - Cell growth
  - Maturation
  - Gene regulation

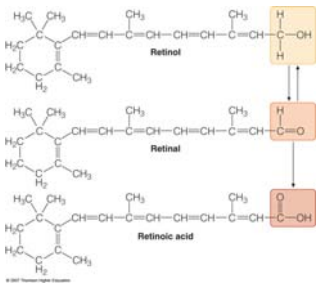
Basics of Fat-Soluble Vitamins

- Absorbed in small intestine
- Requires lipids & bile
- Circulated in lymph via chylomicrons
- Become part of lipoproteins or bound to transport proteins
- Antioxidant properties
- Stored in body

Vitamin A & the Carotenoids

Retinoids

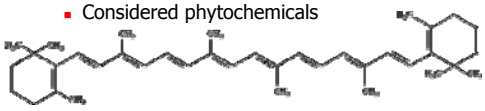
- Retinol (preformed vitamin A)
  - Most potent form
  - Can be synthesized from retinal
- Retinal
  - Can be converted to retinoic acid
- Retinoic acid



Carotenoids

Types

- Provitamin A carotenoids
  - Beta-carotene
  - Can be converted to vitamin A
- Nonprovitamin A carotenoids
  - Cannot be converted to vitamin A
  - Lycopene, astaxianthin, zeaxanthin, lutein
  - Considered phytochemicals



Dietary Sources of Vitamin A & Provitamin A Carotenoids

- Retinol activity equivalent (RAE)
  - 1 RAE = 12 micrograms beta-carotene & 1 microgram retinol
- Preformed vitamin A
  - Organ meats, liver, fatty fish, dairy products
- Provitamin A
  - Yellow, orange, red fruits/veg, leafy greens

Regulation of Vitamin A & Carotenoids in Body

- Contained in chylomicrons
- Enter lymph
- Join blood at thoracic duct
- Delivered to adipose tissue, muscle, & eye
- What is not used, taken back to liver
  - Carotenoids packaged into VLDLs
  - Vitamin A attached to retinol binding proteins & transthyretin

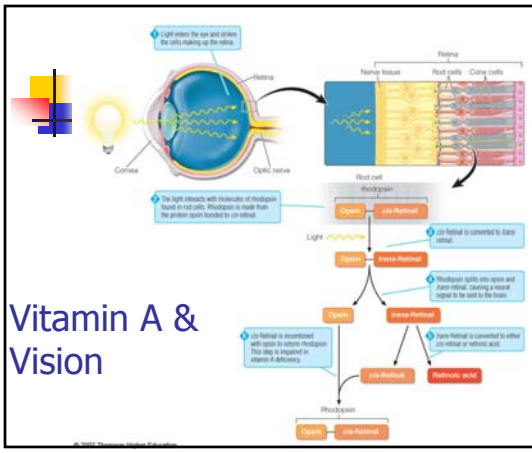
Vitamin A Synthesis and Storage

- β-carotene is converted to vitamin A in the intestinal mucosa
- 90% is stored in liver, mainly as the ester, retinyl palmitate
- Carotenoids can be stored in adipose tissue

Functions of Vitamin A

- Cell differentiation
- Maintaining healthy immune system
- Building strong bones
- Vision

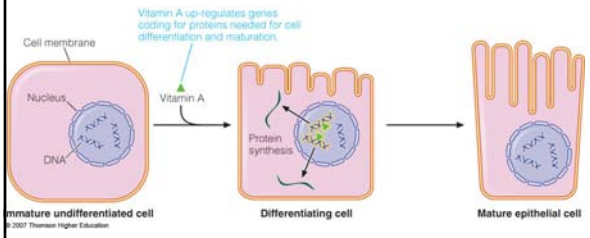
Vitamin A & Vision



Night Blindness

- Inadequate amounts of retinal to re-form rhodopsin
  - Compound in retina that consists of the protein opsin & vitamin *cis*-retinal that is needed for night vision
- Night vision becomes difficult

Vitamin A & Cell Differentiation



Vitamin A, Growth & Reproduction

- Regulates cell differentiation
- Example
  - During embryonic growth, vitamin A assists in differentiation & maturation of tissues & organs
- Needed for successful reproduction

Vitamin A & the Immune Function

- Maintains protective barriers
  - Epithelial tissues
- Helps produces lymphocytes & antibodies
  - Deficiencies – increased rate of infectious disease & illness

Vitamin A, the Carotenoids, & Cancer

- Epidemiological studies
  - Diets rich in vitamin A or carotenoids associated with lower risk of some types of cancers
  - Long-term, high-dose supplementation of beta-carotene in combination with other dietary factors increases incidence of lung & colorectal cancer
- Recommendation
  - Do not take vitamin A &/or beta-carotene supplements to reduce cancer risk

Vitamin A & Bone Health

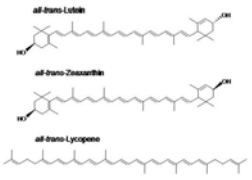
- Required for processes with osteoclasts & osteoblasts
  - Favors bone formation
- High preformed vitamin A intake
  - May lead to greater risk of bone fractures in older people
- Research needed?

Functions of Carotenoids

- Influences immune system
  - Antioxidant function
  - Regulation of gene expression
  - Maintenance of normal cell turnover
  - Decreases risk for certain diseases

Focus on Foods: Fruits, Vegetables, Carotenoids, & Health

- Lutein
  - May decrease growth of breast tumors
- Lycopene
  - Related to lower risk of prostate cancer
- Lutein & zeaxanthin
  - Related to decreased risk of macular degeneration



Make your plate colorful!

- Beta-carotene
  - Carrots, sweet potatoes
- Lycopene
  - Tomatoes, pink grapefruit, apricots, watermelon
- Lutein
  - Dark green leafy vegetables

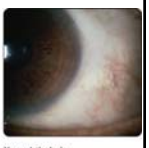
Vitamin A Deficiency

- Uncommon in industrialized countries
- Secondary vitamin A deficiency
  - Cystic fibrosis
  - Alcoholics

Vitamin A Deficiency Disorder (VADD)

- Increased risk of infection
- Night blindness
- Xerophthalmia
  - Dry eyes & scarring
  - Bitot's spots
  - Blindness
- Hyperkeratosis
  - Skin is rough, bumpy, irritated

Areas of the world where blindness due to vitamin A deficiency is most common



Xerophthalmia

Focus on Diet & Health: Vitamin A & International Child Health

- 100-400 million children have VADD
  - Nonindustrialized countries
  - Vitamin A supplementation decreases morbidity & mortality
- WHO
  - Recommends supplementation after 6 months in needed regions
- Biotechnology

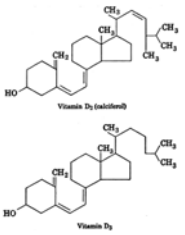
Biotechnology: Golden Rice

Vitamin A & Carotenoid Toxicity

- Upper safe levels are 4-10x requirements in nonruminants and 30x in ruminants
- Hypervitaminosis A in humans
  - Polar explorers eating polar bear or seal liver
  - Self-medication and overprescription
    - Blurred vision
    - Liver abnormalities
    - Reduced bone strength
    - Birth defects
    - Increase risk of lung cancer
    - Hypercarotenemia

Vitamin D

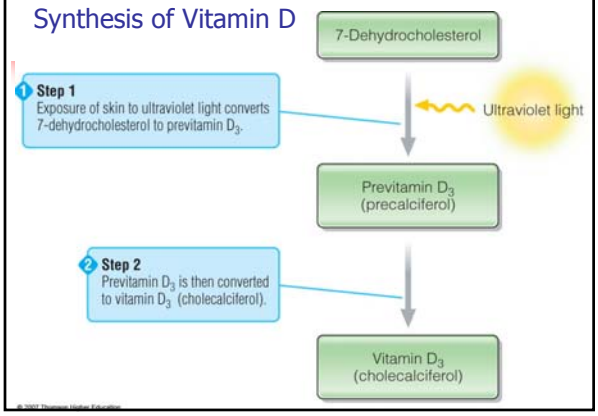
- Conditionally essential
- Forms
  - Ergocalciferol (D_2)
    - Plant sources & supplements
  - Cholecalciferol (D_3)
    - Animal foods & made by body



Regulation, Metabolism, & Synthesis of Vitamin D

- Packaged into micelles
- Absorbed into enterocyte
- Incorporated into chylomicrons
- Lymph, then blood
- Remnants taken to liver
- "Sunshine vitamin"

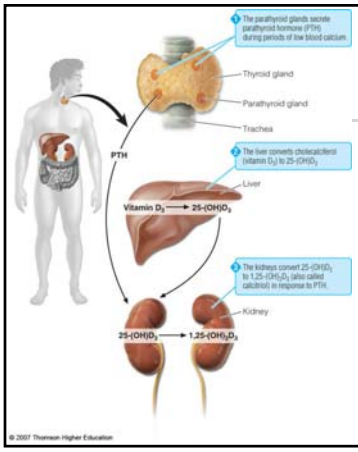
Synthesis of Vitamin D



Influences on Vitamin D Synthesis

- Areas with smog, overcast weather, very short days
- Darker skin
- Sunscreen
- Age-related changes

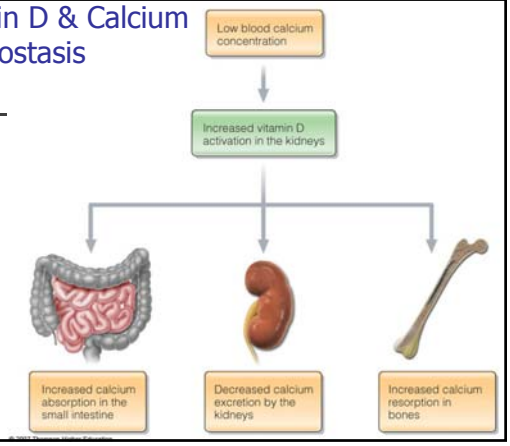
Activation of Vitamin D



Functions of Vitamin D

- Regulation of:
  - Blood calcium concentration
  - Gene expression
  - Cell differentiation

Vitamin D & Calcium Homeostasis



Vitamin D, Cell Differentiation, & Cancer

- Movement of vitamin D into nucleus
- Stimulation of genes coding for specific proteins
- Examples
  - Bone health
  - GI function
  - ? prevention of colon, breast, skin, prostate cancers

Vitamin D Deficiency

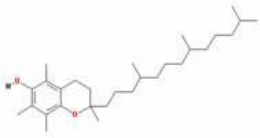
- Rickets
- Osteomalacia
- Osteoporosis
- People over 50:
  - Get > 15 minutes sun exposure/day
  - Increase vitamin D intake

Vitamin D Toxicity

- Hypercalcemia
  - Oversupplementation
  - Deposits of calcium in soft tissues
  - Affects function of nervous system
  - Promotes bone loss
  - Death

Vitamin E

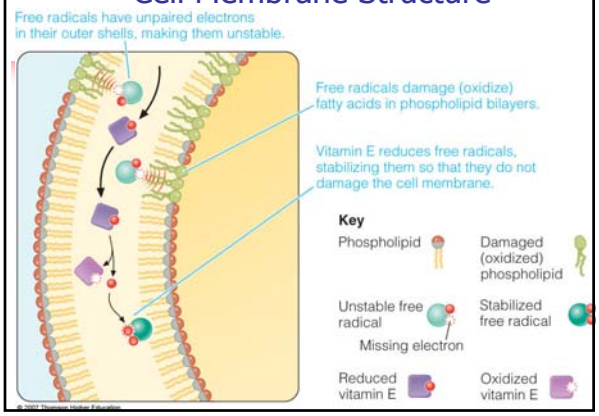
- 8 different compounds
- alpha-tocopherol
  - Most biologically active



Regulation of Vitamin E in Body

- Requires bile & synthesis of micelles
- Circulated in chylomicrons via lymph & blood
- Liver
  - Repackaged into VLDLs
- Excess
  - Stored in adipose tissue

Cell Membrane Structure



Vitamin E & Cancer

- Antioxidants protect DNA from free radical damage
- ? if vitamin E might prevent or cure cancer
- Diets high in vitamin E
  - Associated with decreased cancer risk
  - Little experimental evidence

Vitamin E & Cataracts

- Cloudy growths that develop on the lens of the eye
- Causes vision to become cloudy
- Can lead to blindness
- Evidence *suggests*:
  - Older people who take vitamin E supplements are at lower risk for developing cataracts

Vitamin E & Heart Disease

- Slows rate of plaque formation
- Supplementation
  - 400 mg/day
  - Causes overall increased risk of mortality
- Recommendation
  - Taking vitamin E supplements to decrease risk of heart disease is discouraged

Vitamin E Deficiency

- Uncommon
- Reports in:
  - Infants fed formulas with inadequate vitamin E
  - Genetic abnormalities
  - Fat malabsorption
- Symptoms
  - Neuromuscular problems, loss of coordination, muscular pain
  - Hemolytic anemia

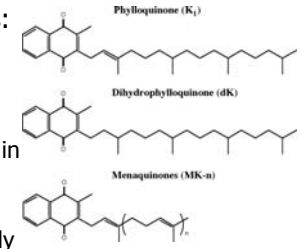
Vitamin E Toxicity

- Rare
- Very high doses:
  - Hemorrhages
    - Genetic differences
- Caution:
  - Vitamin E supplements

Vitamin K

Refers to 3 compounds:

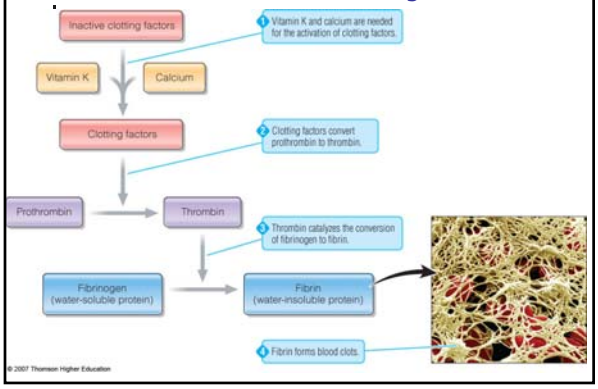
- Phylloquinone (K_1)
  - Food & supplements
- Menaquinone (K_2)
  - Produced by bacteria in large intestine
- Menadione (K_3)
  - Produced commercially



Regulation of Vitamin K in the Body

- Absorbed via micelles
  - Incorporated into chylomicrons
  - Enters lymph & then blood
- Vitamin K produced in large intestine
  - Enters epithelial cells by simple diffusion
- Liver
  - Packages dietary & bacterially produced forms into lipoproteins

Functions of Vitamin K: Coagulation

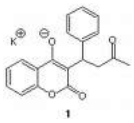


Did you know…

- Vitamin K also catalyzes carboxylation of other proteins for bone & tooth development
- Binds calcium
- If you take a calcium supplement, take a look at the label. More than likely, vitamin K is an ingredient!

Nutrient-Drug Interactions & Vitamin K

- Long-term antibiotic use
  - Kills intestinal bacteria
  - Increases risk for deficiency
- Coumadin (warfarin)
  - "Thins the blood"
  - Decreases activity of vitamin K
  - Eat a balanced diet
  - Limit foods high in vitamin K to one serving each day
- Dicoumarol found in moldy sweet clover
  - Sweet clover disease



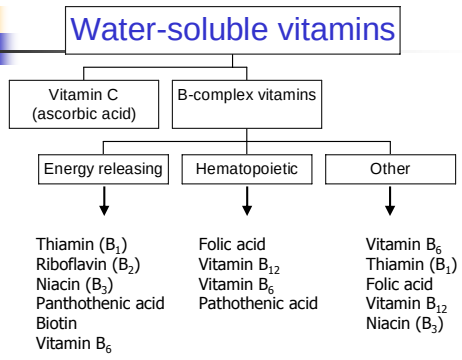
Vitamin K Deficiency & Toxicity

- Rare
  - Infants
  - Diseases that cause lipid malabsorption
  - Prolonged antibiotic use
- Deficiency signs
  - Excessive bleeding
- Few toxic effects

Vitamin K Injections During Infancy

- Infants born with low stores
- Large intestine lacks vitamin K-producing bacteria
- Human milk contains low levels
- Vitamin K deficiency bleeding (VKDB)
  - Mostly in breastfed infants
  - 5-10 babies/100,000 born

Water-soluble vitamins



Fat-soluble Vitamins

- Absorbed with dietary fat in small intestine
- 40-90% absorption efficiency
- Absorption typically regulated by need
  - ↑need→ ↑absorption
- Transported away from small intestine in chylomicra via blood and lymph (depending on size)

Fat-soluble Vitamins, Cont.

- Liver either stores the vitamin or repackages it for delivery to other cells
  - Excess vitamin accumulates in liver and adipose
  - Toxicities can occur; almost always associated with supplement use (not foods)

Water-soluble Vitamins

- Absorbed at the small intestine
- Absorption often highly regulated by either other vitamins or binding proteins in the small intestine
- Transported away from small intestine in blood
- Typically not stored; instead, kidney filters excess into urine
  - Thus, more important to get these vitamins *daily.*
  - Toxicities almost unheard of

Vitamin Supplements: Making Wise Choices

- Dietary supplements not approved by FDA for safety & effectiveness
- Responsibility of:
  - Manufacturers
  - Distributors

Sorting Fact from Fiction

- Office of Dietary Supplements
- http://ods.od.nih.gov
- Remember:
  - Safety first
  - Think twice about chasing the latest headline
  - Learn to spot false claims
  - More may not be better
  - "Natural" does not always mean safe

When Should You Consider Taking A Supplement?

- Food availability limited
- Not consuming certain foods
- Periods of rapid growth & development
- Economic situations are difficult
- Use of low-calorie diet

Remember…

- Supplements should never replace medications or a variety of foods
- Do not exceed ULs
- Keep a record of all dietary supplements taken & share with healthcare provider