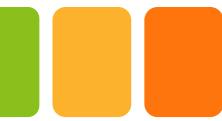




The Vitamins: An Overview

Chapters 10-11





The Vitamins – An Overview

- Support nutritional health: absence and presence
- Differ from macronutrients
 - Structure
 - Individual units, not linked together (like amino acids or glucose)
 - Function
 - Do not yield energy (no kcalories)
 - Assist with enzymatic processes of digestion and absorption
 - Food contents (μg or mg ; not grams like macronutrients)
- Similarities to macronutrients: essential for life!



Fat Soluble vs Water Soluble

○ Solubility

- Affects absorption, transport, and excretion
- Water-soluble
 - Not stored, must consume regularly
- Fat-soluble
 - Stored, can consume less frequently
 - Require bile for digestion and absorption (like fatty acids)

TABLE 10-2 Water-Soluble and Fat-Soluble Vitamins Compared

	Water-Soluble Vitamins: B Vitamins and Vitamin C	Fat-Soluble Vitamins: Vitamins A, D, E, and K
Absorption	Directly into the blood	First into the lymph, then the blood
Transport	Travel freely	Many require transport proteins
Storage	Circulate freely in water-filled parts of the body	Stored in the cells associated with fat
Excretion	Kidneys detect and remove excess in urine	Less readily excreted; tend to remain in fat-storage sites
Toxicity	Possible to reach toxic levels when consumed from supplements	Likely to reach toxic levels when consumed from supplements
Requirements	Needed in frequent doses (perhaps 1 to 3 days)	Needed in periodic doses (perhaps weeks or even months)

NOTE: Exceptions occur, but these differences between the water-soluble and fat-soluble vitamins are valid generalizations.



The Vitamins – An Overview

- Vitamins do not provide the body with energy/kcalories
- Bioavailability
 - *Quantity* provided by food differs from **amount absorbed and used by body**
 - Factors influencing bioavailability
 - Efficiency of digestion and transit time in GI tract
 - Nutrition status
 - Method of food preparation (raw, cooked, processed)
 - Source of nutrient (synthetic, fortified, naturally occurring)
 - Other foods consumed at same time



The Vitamins – An Overview

○ Precursors

- Inactive form of vitamins in foods
- Converted to active form in body
- Vitamin intake should include both active form and potential amount available from precursors
- RDA established for some vitamins: thiamin, riboflavin, niacin, B6, folate, B₁₂, and vitamin C

○ Organic nature

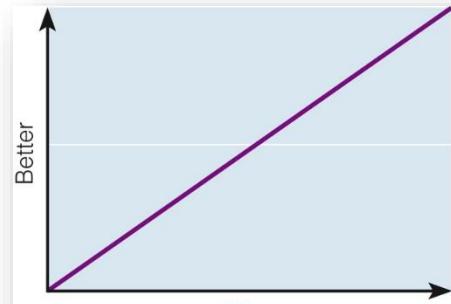
- Easily destroyed during processing
 - Cooking, storing (oxygenation), leaching into water



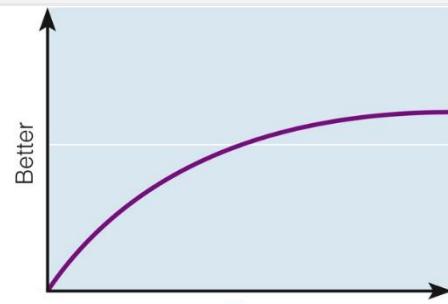


The Vitamins – An Overview

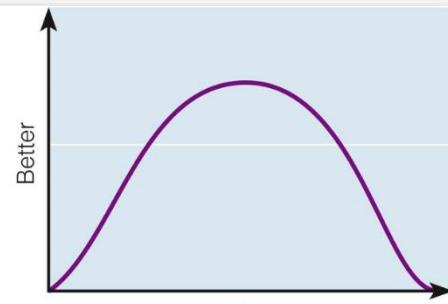
- Toxicity: more ≠ better
 - Excessive intakes can cause harm
 - Levels higher than Tolerable Upper Intake Levels (UL): the highest amount of a nutrient that is likely not to cause harm for most healthy people when consumed daily
 - UL established for: niacin, B₆, folate, choline, vitamin C



As you progress in the direction of more, the effect gets better and better, with no end in sight (real life is seldom, if ever, like this).



As you progress in the direction of more, the effect reaches a maximum and then a plateau, becoming no better with higher doses.



As you progress in the direction of more, the effect reaches an optimum at some intermediate dose and then declines, showing that more is better up to a point and then harmful. That too much can be as harmful as too little represents the situation with most nutrients.

Water Soluble Vitamins

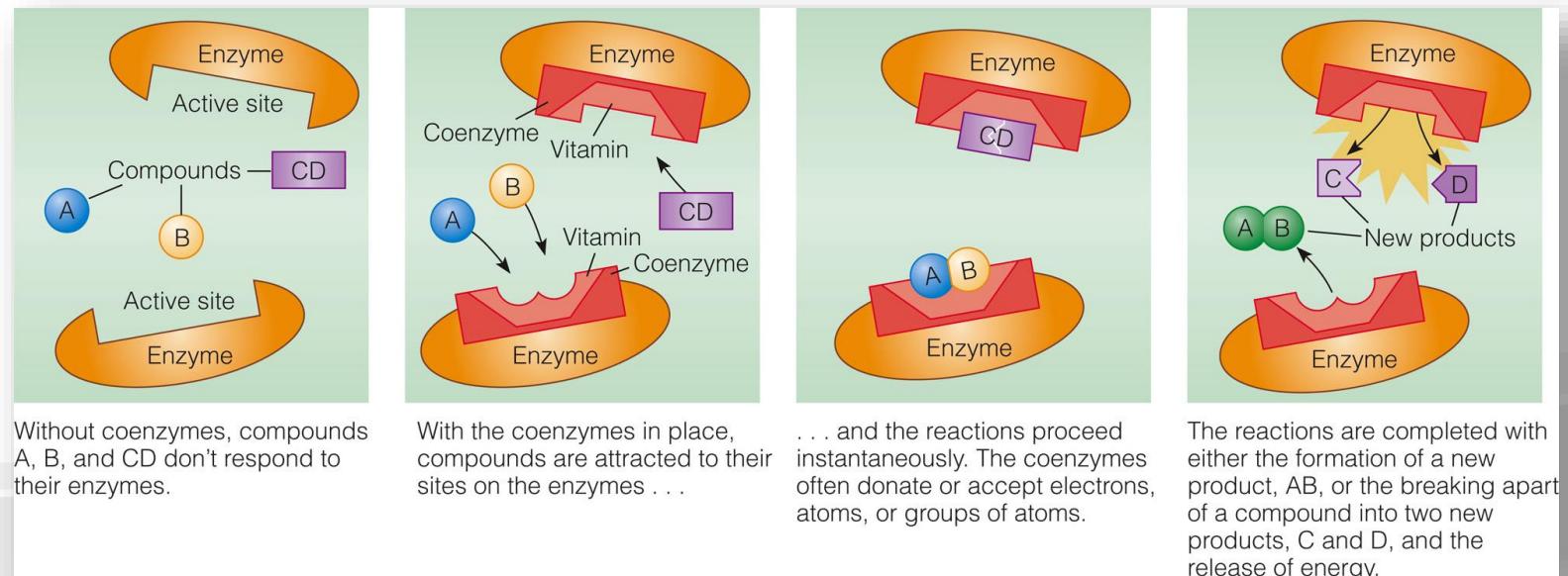
B vitamins

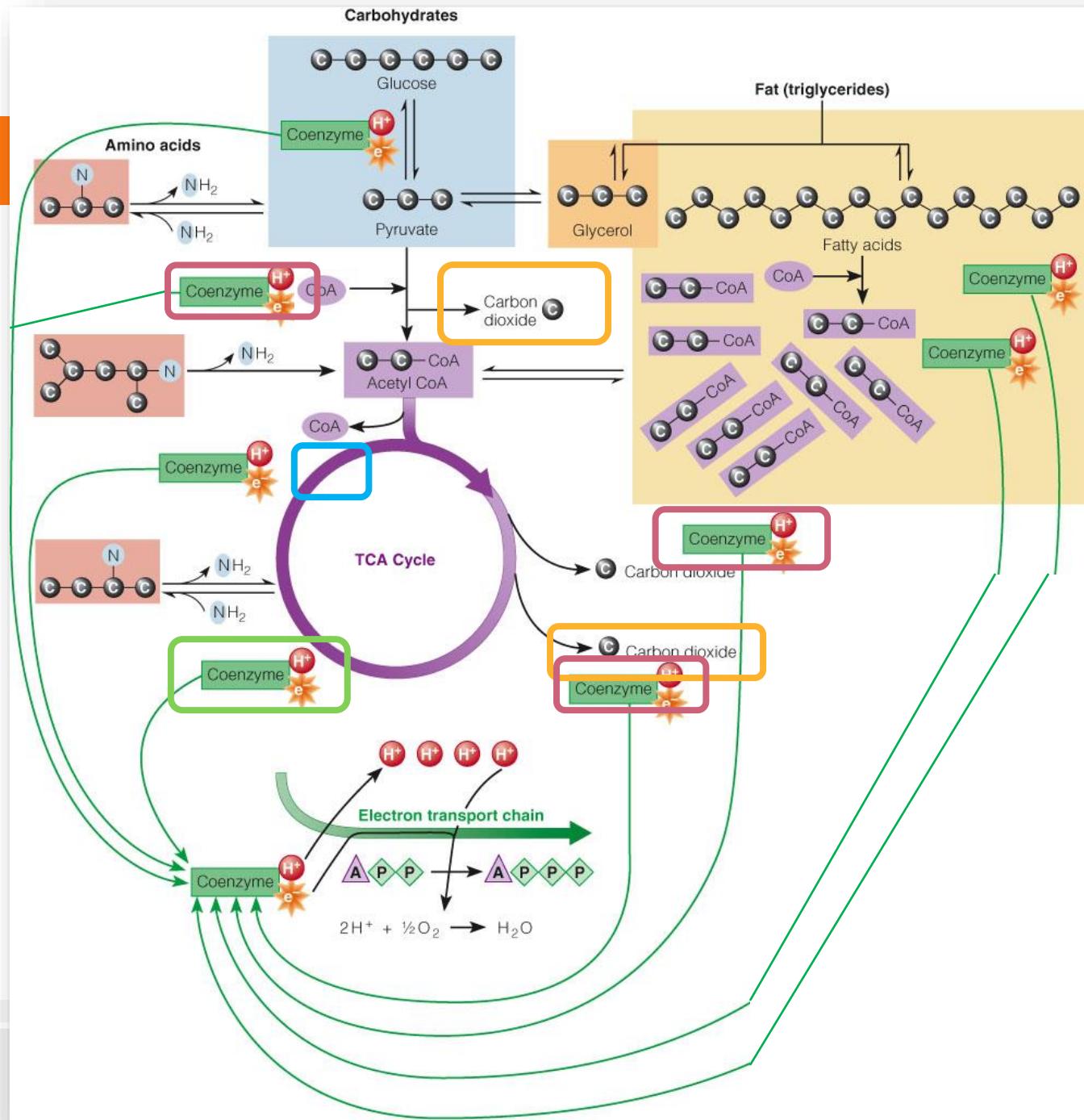
Vitamin and Chief Functions	Deficiency Symptoms	Toxicity Symptoms	Food Sources
Thiamin Part of coenzyme TPP in energy metabolism	Beriberi (edema or muscle wasting), anorexia, weight loss, neurological disturbances, muscular weakness, heart enlargement and failure	None reported	Enriched, fortified, or whole-grain products; pork
Riboflavin Part of coenzymes FAD and FMN in energy metabolism	Inflammation of the mouth, skin, and eyelids	None reported	Milk products; enriched, fortified, or whole-grain products; liver
Niacin Part of coenzymes NAD and NADP in energy metabolism	Pellagra (diarrhea, dermatitis, and dementia)	Niacin flush, liver damage, impaired glucose tolerance	Protein-rich foods
Biotin Part of coenzyme in energy metabolism	Skin rash, hair loss, neurological disturbances	None reported	Widespread in foods; GI bacteria synthesis
Pantothenic acid Part of coenzyme A in energy metabolism	Digestive and neurological disturbances	None reported	Widespread in foods
Vitamin B₆ Part of coenzymes used in amino acid and fatty acid metabolism	Scaly dermatitis, depression, confusion, convulsions, anemia	Nerve degeneration, skin lesions	Protein-rich foods
Folate Activates vitamin B ₁₂ ; helps synthesize DNA for new cell growth	Anemia, glossitis, neurological disturbances, elevated homocysteine	Masks vitamin B ₁₂ deficiency	Legumes, vegetables, fortified grain products
Vitamin B₁₂ Activates folate; helps synthesize DNA for new cell growth; protects nerve cells	Anemia; nerve damage and paralysis	None reported	Foods derived from animals
Vitamin C Synthesis of collagen, carnitine, hormones, neurotransmitters; antioxidant	Scurvy (bleeding gums, pinpoint hemorrhages, abnormal bone growth, and joint pain)	Diarrhea, GI distress	Fruits and vegetables



The B Vitamins – As Individuals

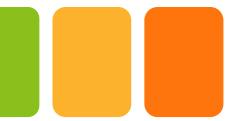
- Coenzymes: little helpers
 - Assist enzymes with release of energy from macronutrients
 - Without its coenzyme, an enzyme cannot function!
 - Coenzyme B vitamins: thiamin, riboflavin, niacin, pantothenic acid, biotin





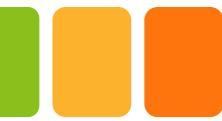
Metabolism Overview:

- **TPP:** Thiamin coenzyme
- **FAD:** Riboflavin coenzyme
- **NAD:** Niacin coenzyme
- **Biotin** coenzyme
- *Pantothenic acid coenzyme, too!*



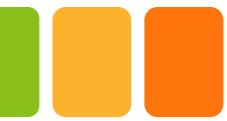
The B Vitamins – Thiamin (B₁)

- Roles in body
 - Metabolism coenzyme; crucial for nerve and muscle activity
- Deficiency
 - Malnourished, people experiencing homelessness, and alcoholics
- Severe deficiencies
 - Wernicke-Korsakoff syndrome (alcoholics):
 - Empty kcalories from alcohol replaces food intake
 - Disorientation, loss of short term memory, jerky eye movements, staggering gait
 - Beriberi (developing countries):
 - Rice polishing in Indonesia (removal of thiamin-rich germ and bran)
 - Nervous system effects (muscle weakness); cardiovascular system effects (dilated blood vessels; kidneys retain salt and water)



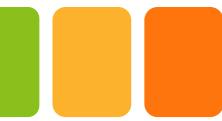
The B Vitamins – Thiamin

- Toxicity
 - No adverse effects = no UL
- Recommendations
 - Needs will be met if eating enough food to meet energy needs
 - Most people in the US consume sufficient or excess thiamin
- Food sources: whole grains, fortified or enriched grains, pork
- Destruction
 - Heat sensitive, water soluble
 - Conserving thiamin in food: use little or no water (steaming, microwaving) and cook food for short duration



The B Vitamins – Riboflavin

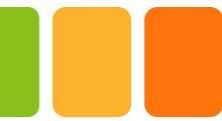
- Role in body
 - Metabolism coenzyme
- Deficiency
 - Inflammation of membranes of the mouth, skin, eyes, and GI tract
- Toxicity
 - No adverse effects
- Recommendations
 - Needs will be met if eating enough food to meet energy needs
 - Most people in the US consume sufficient or excess riboflavin



The B Vitamins – Riboflavin

- Food sources: milk and milk products
- Destruction
 - Ultraviolet light (milk = cardboard or opaque containers, not clear glass anymore!); irradiation; water soluble
 - Not destroyed by cooking

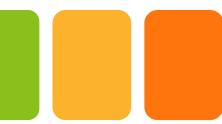




The B Vitamins – Niacin (B₃)

- Two chemical structures
 - Nicotinic acid (body can convert to...)
 - ...Nicotinamide (major form of niacin in blood)
- Role in body
 - Metabolism coenzyme; protects against neurological degradation
- Deficiency
 - Pellagra (American south in 1900s; developing countries):
 - Low protein, corn-based diet
 - Diarrhea, dermatitis, dementia and death
 - One of the first diseases to be attributed to a dietary deficiency





The B Vitamins – Niacin

- Toxicity
 - Naturally occurring form from food: no harm caused (physiological effect)
 - Supplements or drugs: pharmacological effect
 - 3-4 times RDA: “niacin flush” (capillaries dilate, tingling sensation, pain)
 - Medicinal use of nicotinic acid (large doses)
 - Potential benefits: lower LDL cholesterol and raise HDL cholesterol
 - Potential harm: liver disease, gout, peptic ulcers, diabetes, inflammatory disease



The B Vitamins – Niacin

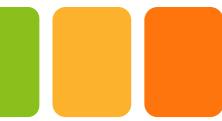
- Recommendations

- Body synthesizes niacin from amino acid tryptophan
 - Approximately 60 mg dietary tryptophan needed to make 1 mg of niacin
- RDA stated in niacin equivalents (NE): takes into account tryptophan as potential source
- Most people in the US consume excess niacin

- Food sources: meat, poultry, fish, legumes, enriched/whole grains

- Destruction:

- Water soluble; less vulnerable to food preparation losses (heat resistant)



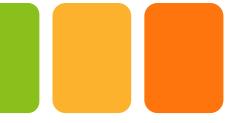
The B Vitamins – Biotin

- Role in body
 - Metabolism coenzyme; gluconeogenesis; fatty acid synthesis and breakdown
- Deficiency = rare
- Toxicity
 - No adverse effects = no UL
- Recommendations
 - Needed in very small amounts (AI set, not RDA)
- Food sources: widespread in foods, synthesized by GI bacteria



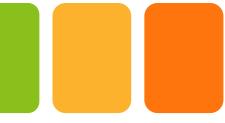
The B Vitamins – Pantothenic Acid

- Role in body
 - Metabolism coenzyme; involved in 100+ different steps in synthesis of lipids, neurotransmitters, steroid hormones, and hemoglobin
- Deficiency = rare
 - General failure of all body systems: fatigue, GI distress, neurological disturbances
- Toxicity
 - No adverse effects = no UL
- Recommendations
 - AI: amount needed to replace daily losses (5 mg/day)
- Food sources: widespread in foods
- Destruction: freezing, canning, refining, water-soluble



The B Vitamins – B₆

- Three forms
 - Pyridoxal, pyridoxine, and pyridoxamine
- Role in body
 - Metabolism coenzyme; active in 100+ reactions:
 - Carbohydrate, amino acid, and fatty acid metabolism
 - Synthesis of non-essential amino acids
 - Protein and urea metabolism
 - Conversion of tryptophan → niacin or serotonin
 - Synthesis of heme (hemoglobin), nucleic acids (RNA, DNA), lecithin (phospholipid)

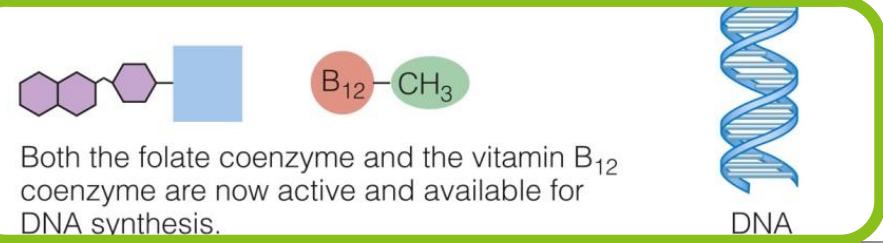
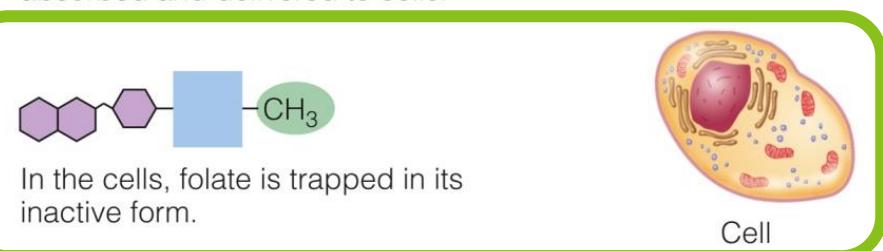
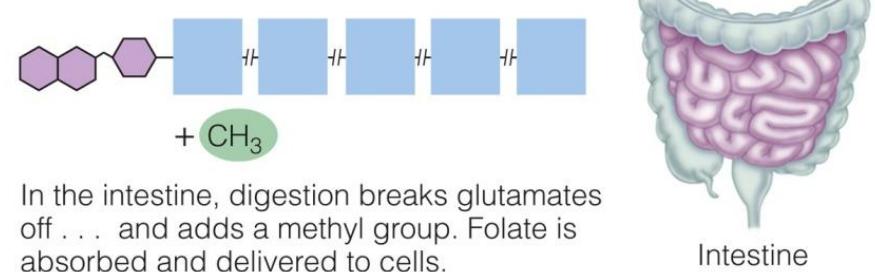
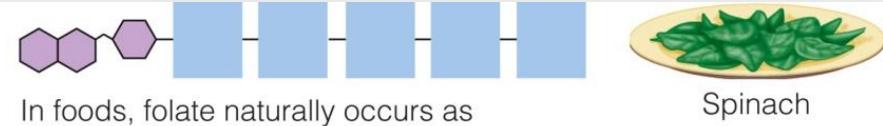
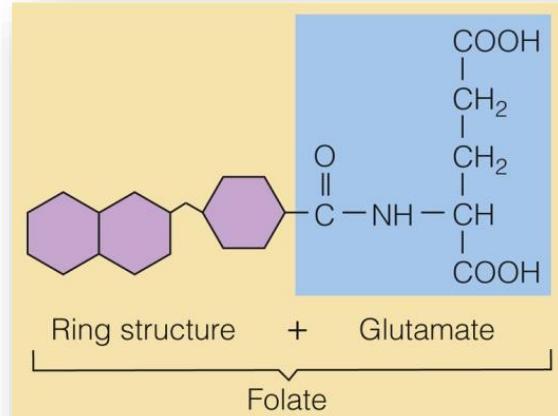


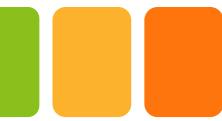
The B Vitamins – B₆

- Deficiency
 - Neurotransmitter synthesis declines, abnormal compounds accumulate in brain
 - Depression, confusion, abnormal brain patterns, and convulsions
- Toxicity
 - Occurs with very high doses (>20 times UL) for several months: irreversible neurological damage
- Recommendations
 - No real benefit to large doses
 - Stored extensively in muscle tissue (unlike other water-soluble vitamins)
- Food sources: meats, fish, poultry, potatoes
- Destruction: heat-sensitive, water-soluble

The B Vitamins – Folate

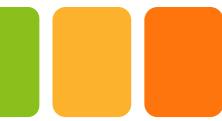
- AKA folacin or folic acid
- Absorption and activation is dependent on vitamin B₁₂
- Role in body
 - Metabolism coenzyme; prevention of birth defects
 - Fortified grain products; supplements





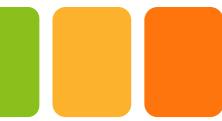
The B Vitamins – Folate

- Folate disposal
 - Liver incorporates excess into bile
 - Enters enterohepatic circulation pathway (pancreas → intestine → pancreas); repeatedly reabsorbed
 - Vulnerable: damaged GI tract cells = loss of folate
- Deficiency
 - Impairs cell division and protein synthesis
 - Replacement of red blood cells and GI tract cells falter: anemia, GI tract deterioration
 - Primary deficiencies: not enough in diet
 - Secondary deficiencies: not absorbed by body



The B Vitamins – Folate

- Toxicity
 - Naturally occurring from food/fortified foods appear to cause no harm
 - High-dose supplements can mask B₁₂ deficiency; leads to neurological damage
 - UL has been established
- Recommendations
 - Bioavailability depends on source
 - Food sources vs synthetic sources (1.7 times more available)
 - Dietary folate equivalents (DFE)
 - Increased need during pregnancy (cell multiplication)
- Food sources: legumes, fruit, vegetables (dark green, leafy)
- Destruction:
 - Heat-sensitive, water-soluble, vulnerable to oxidation



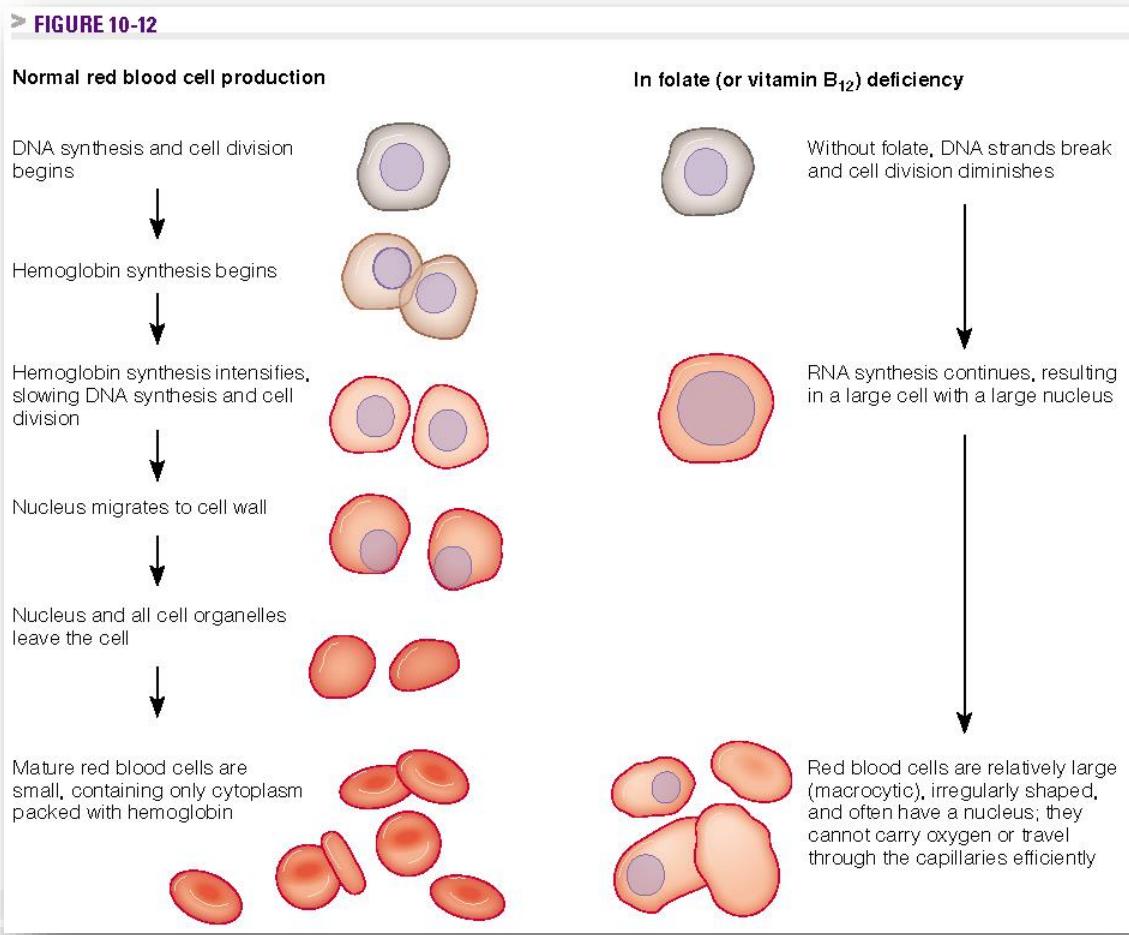
The B Vitamins – Vitamin B₁₂

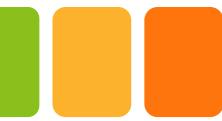
- Co-dependent with folate for activation
- Role in body
 - Both folate and B₁₂: DNA and RNA synthesis
 - Individual roles of vitamin B₁₂
 - Maintains protective sheath around nerve fibers; bone cell activity; metabolism
- Digestion and absorption: the “needy” vitamin
 - Stomach: released from proteins
 - Small intestine: binds with intrinsic factor (stomach secretion); at end of small intestine B₁₂ is absorbed into bloodstream
 - Bloodstream: transport is dependent on binding proteins
 - Enters enterohepatic circulation pathway (pancreas → intestine → pancreas); repeatedly reabsorbed



The B Vitamins – Vitamin B₁₂

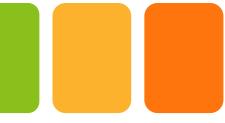
- Deficiency = rare
 - Inadequate absorption (not poor intake)
 - Lack of hydrochloric acid or intrinsic factor
 - Lack of intrinsic factor = pernicious anemia
 - Neurological degradation, folate-deficiency anemia (B₁₂ required to activate folate)
 - Folate “cures” blood symptoms of B₁₂ deficiency, but cannot stop progression of nerve damage





The B Vitamins – Vitamin B₁₂

- Toxicity
 - No adverse effects = no UL
- Recommendations
 - Needed in small amounts
 - RDA established: 2.4 µg
- Food sources: almost exclusively from animal products
 - Greatest bioavailability: fish and milk
 - Vegetarians and vegans must be especially diligent
- Destruction
 - Water-soluble



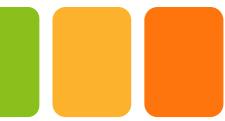
Interactions Among the B Vitamins

- Each B vitamin coenzyme = involved in energy metabolism
 - Directly: facilitate energy-releasing reactions
 - Indirectly: build new cells to deliver oxygen and nutrients to allow energy reactions to occur
- Deficiencies: single B-vitamin deficiencies seldom show up in isolation
 - Exceptions: beriberi and pellagra
 - US deficiencies: poverty, poor diet, illness, alcoholism
- Toxicities: unknown from food sources alone (excess eliminated through urine)
 - Overuse of dietary supplements → toxicity symptoms develop
- Food sources
 - Vitamin deficiency? Food > supplements!
 - Balanced and varied diet = ample B vitamins



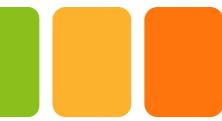
Pantry Check

- Chapter 2 Review:
 - Refining of grains caused loss of nutrient-rich bran and germ
 - 1940s legislation to enrich all grain products in the US with nutrients that were lost through refining process: iron, **thiamin, riboflavin, and niacin**
 - 1996 legislation added to prevent birth defects: **folate**
- Pantry check! Find a grain product and check the ingredient list for these nutrients
 - Not listed? Maybe it's a *whole grain* food (vitamins are naturally occurring in the bran and germ)!



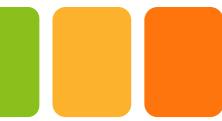
Vitamin-Like Compounds

- Choline: synthesis of neurotransmitters and phospholipids; supports neurological development of fetus during pregnancy
 - Body can manufacture from methionine (amino acid)
 - Conditionally essential nutrient
 - Adequate intake (AI) set: dietary choline is also needed
 - Deficiencies: rare
 - Toxicity: UL set based on blood pressure-lowering effect
 - Food sources: common in many foods; milk, eggs, peanuts
- Inositol, Carnitine
 - Can be synthesized by body (*not essential*); widespread in foods
 - No recommendations established



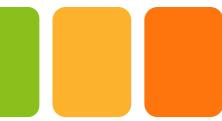
Vitamin C – Ascorbic Acid

- Antioxidant
 - Defends against *free radicals* (molecules with one or more unpaired electrons; unstable and highly reactive)
 - Neutralizes free radicals by donating electrons
 - Protects other substances from free radical damage
 - Vitamin C recycling (can accept electrons back)
 - Protects tissues from oxidative stress of free radicals
 - Enhances iron absorption (protects iron from oxidation)



Vitamin C

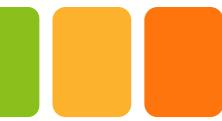
- *Cofactor* (small molecule that facilitates the action of an enzyme) in:
 - Collagen formation
 - Matrix for bone and tooth formation; scar formation; cell structure
 - Formation of collagen requires vitamin C
 - And other reactions
 - Conversion of amino acids to neurotransmitters
 - Synthesis of hormones



Vitamin C

- Increased needs in stress
 - Infections, burns, extreme temperatures, toxic heavy metal intake, certain medications, smoking
 - Adrenal glands release vitamin C and hormones into blood to help control oxidative activity of free radicals
- Prevention and treatment of common cold
 - Conflicting and controversial research: *slight* reduction in duration and severity of symptoms
 - Deactivates histamine to relieve nasal congestion





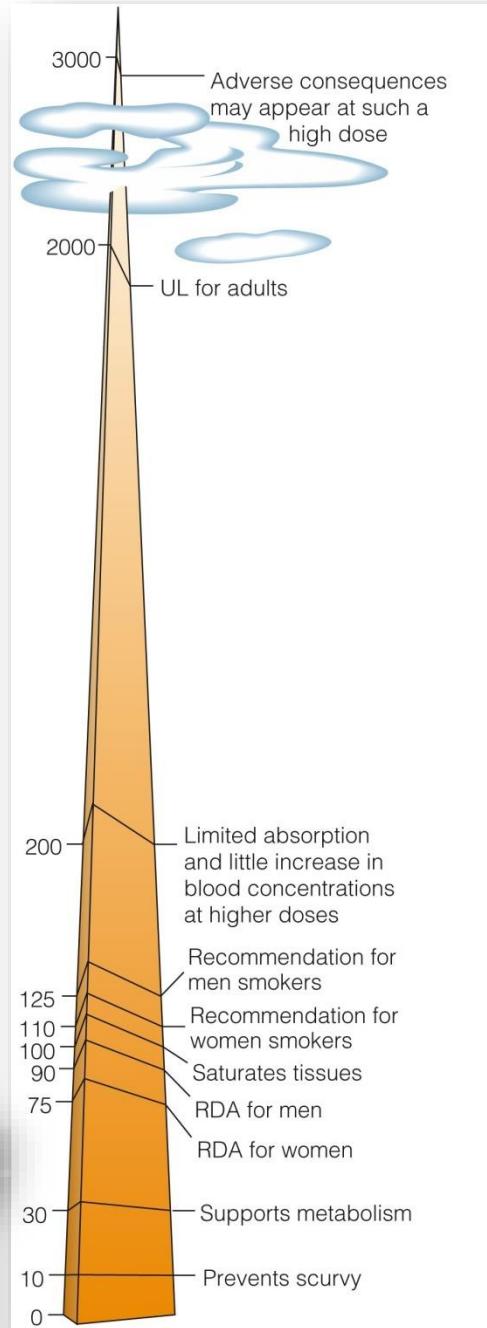
Vitamin C

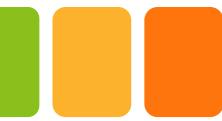
- Recommendations:

- Preventing scurvy: 10 mg (vs smokers: 125 mg)
- Absorption maximum: 200 mg

- Deficiency

- Gums bleed easily around teeth
- Capillaries under skin break spontaneously
- Psychological signs: hysteria, depression
- Sudden death





Vitamin C

- Toxicity
 - UL set based on supplementation side effects: diarrhea and GI distress
- Food sources:
 - Fruits: oranges, strawberries, kiwis
 - Vegetables: red bell peppers, brussels sprouts, potatoes
- Destruction:
 - Vulnerable to oxygen, heat-sensitive, water-soluble





Fat Soluble vs Water Soluble

○ Solubility

- Affects absorption, transport, and excretion
- Water-soluble
 - Not stored, must consume regularly
- Fat-soluble
 - Stored, can consume less frequently
 - Require bile for digestion and absorption (like fatty acids)

TABLE 10-2 Water-Soluble and Fat-Soluble Vitamins Compared

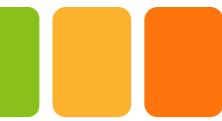
	Water-Soluble Vitamins: B Vitamins and Vitamin C	Fat-Soluble Vitamins: Vitamins A, D, E, and K
Absorption	Directly into the blood	First into the lymph, then the blood
Transport	Travel freely	Many require transport proteins
Storage	Circulate freely in water-filled parts of the body	Stored in the cells associated with fat
Excretion	Kidneys detect and remove excess in urine	Less readily excreted; tend to remain in fat-storage sites
Toxicity	Possible to reach toxic levels when consumed from supplements	Likely to reach toxic levels when consumed from supplements
Requirements	Needed in frequent doses (perhaps 1 to 3 days)	Needed in periodic doses (perhaps weeks or even months)

NOTE: Exceptions occur, but these differences between the water-soluble and fat-soluble vitamins are valid generalizations.



Fat Soluble Vitamins

Vitamin and Chief Functions	Deficiency Symptoms	Toxicity Symptoms	Significant Sources
Vitamin A Vision; maintenance of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; reproduction; immunity	Infectious diseases, night blindness, blindness (xerophthalmia), keratinization	Reduced bone mineral density, liver abnormalities, birth defects	Retinol: milk and milk products Beta-carotene: dark green, leafy and deep yellow/orange vegetables
Vitamin D Mineralization of bones (raises blood calcium and phosphorus by increasing absorption from digestive tract, withdrawing calcium from bones, stimulating retention by kidneys)	Rickets, osteomalacia	Calcium imbalance (calcification of soft tissues and formation of stones)	Synthesized in the body with the help of sunshine; fortified milk
Vitamin E Antioxidant (stabilization of cell membranes, regulation of oxidation reactions, protection of polyunsaturated fatty acids [PUFA] and vitamin A)	Erythrocyte hemolysis, nerve damage	Hemorrhagic effects	Vegetable oils
Vitamin K Synthesis of blood-clotting proteins and bone proteins	Hemorrhage	None known	Synthesized in the body by GI bacteria; dark green, leafy vegetables

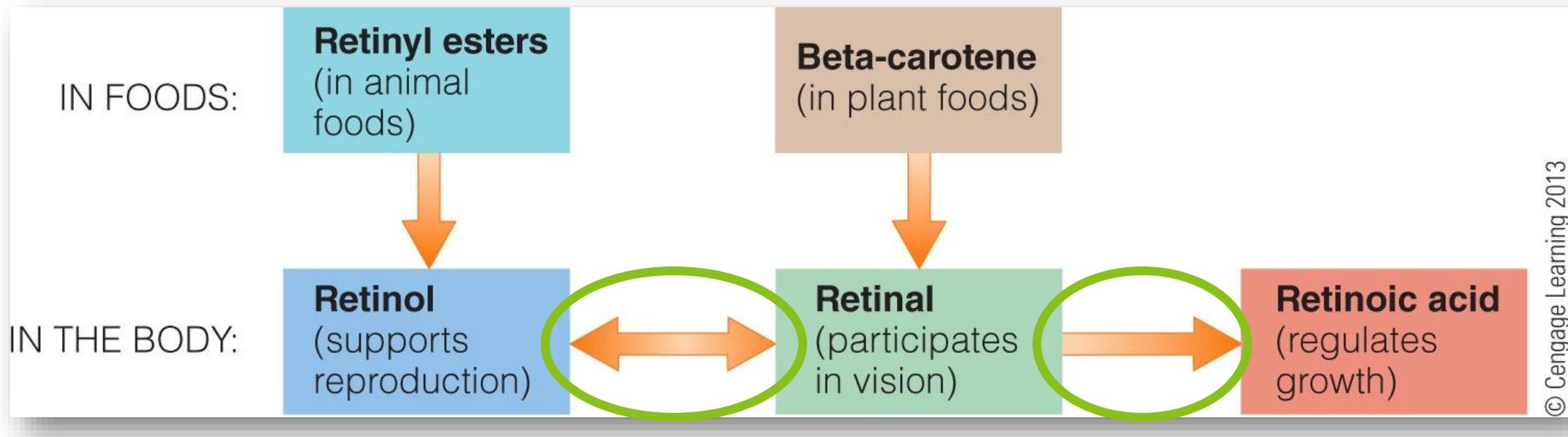


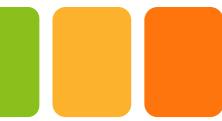
Vitamin A and Beta-Carotene

- Vitamin A, first fat-soluble vitamin recognized
 - Precursor (inactive form in food): beta-carotene (plant sources)
- Different forms
 - Retinoids: retinol, retinal, and retinoic acid
 - Animal sources
 - Each has specific function in body
 - Carotenoids (some can be converted to vitamin A)
 - Plant sources
 - Beta-carotene (can form retinol in the body)
- Conversion between compounds



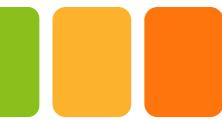
Conversion of Vitamin A Compounds





Vitamin A and Beta-Carotene

- Digestion and absorption
 - Protein participation: binds and transports vitamin A
 - Stored in liver until needed
 - Retinol-binding protein (RBP) as transporter: picks up vitamin A in liver and transports it in the blood
- Cellular receptors
 - Specific protein receptors determine functions of vitamin A within cells
 - Example: retinoic acid can *stimulate* growth in skin and *inhibit* growth in cancerous tumors



Vitamin A and Beta-Carotene: Roles in the Body

Retinol



Retinal



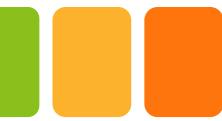
Retinoic Acid

- Supports reproduction
- Major transport and storage form of Vit A

- Vision

- Cornea: helps to maintain clear “window”
- Retina: converts light energy into nerve impulses
- Repeated small losses of retinal during visual activity
- Needs constant replenishment from diet or retinol stores
- 1/1000 of vitamin A in body is in retina

- Regulates cell differentiation, growth, and embryonic development



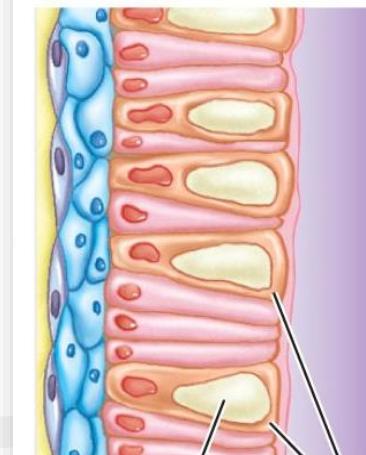
Vitamin A and Beta-Carotene: Roles in the Body

- Most vitamin A in body = cells lining internal and external surfaces (epithelial cells)
 - Protein synthesis and cell differentiation
 - Skin: protection from sun damage
 - Mucous membranes: maintain integrity of linings of mouth, stomach, intestine, lungs, bladder, urethra, uterus, vagina, eyelids, and sinus passages
 - Differentiation of epithelial cells and goblet cells (mucus-secreting cells)
 - Mucus protects organs from microorganisms and damaging substances (e.g. gastric juice)

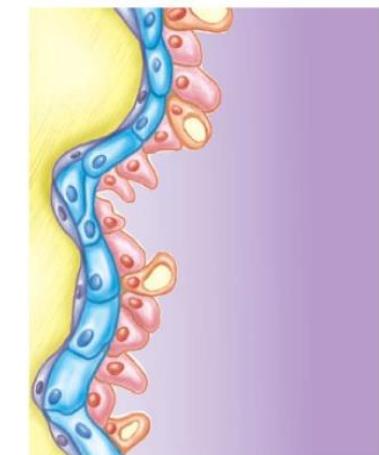
Whitney & Rolfes, Understanding Nutrition (15th ed.)

Vitamin A maintains healthy cells in the mucous membranes.

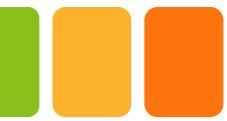
Without vitamin A, the normal structure and function of the cells in the mucous membranes are impaired.



Mucus

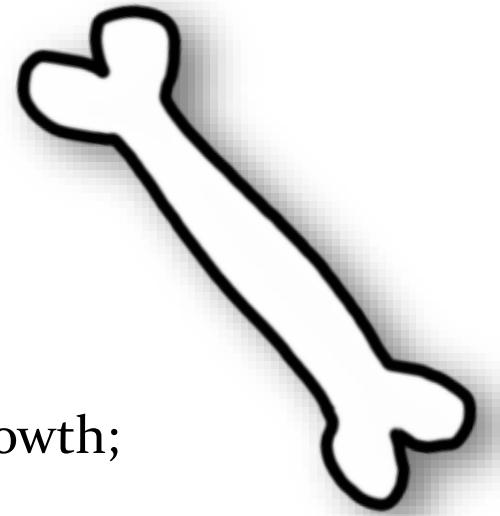


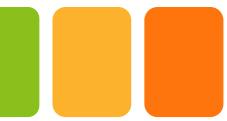
Goblet cells



Vitamin A and Beta-Carotene: Roles in the Body

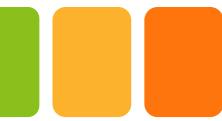
- Reproduction and growth
 - Sperm development
 - Normal fetal development
 - Growth of children
 - Bone remodeling: some bone degradation is needed for bone growth; vitamin A assists with dismantling
- Antioxidant
 - Beta-carotene can serve as anti-oxidant (even when not converted to retinol)





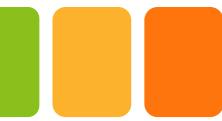
Vitamin A Deficiency

- Vitamin A status dependent upon:
 - Body stores (90% in liver)
 - Insufficient dietary intake → 1-2 years for deficiency to develop (adults)
 - Protein status
 - Retinol binding protein (RBP) transports vitamin A through the body
 - Protein status determines ability to deliver vitamin A to needed sites
- Major problem in developing countries
 - 250 million children affected



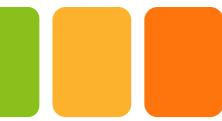
Consequences of Vitamin A Deficiency

- Infectious disease risk/severity
 - Measles, malaria, HIV, lung diseases
- Blindness
 - Night blindness: lack of retinal at back of eye (retina)
 - Xerophthalmia: lack of retinal at front of eye (cornea)
 - Leading cause of blindness worldwide (500,000 preschool children/year)
- Keratinization
 - Change in shape and size of epithelial cells due to secretion of keratin (hard, inflexible protein of hair and nails)
 - Skin becomes dry, rough, and scaly; normal digestion and absorption of nutrients from GI tract falters; weakened defenses in mucous membranes



Vitamin A Toxicity

- Develops when binding proteins are loaded
 - Excess vitamin A damages cells
- Danger from concentrated amounts of *preformed* vitamin A:
 - Animal sources, fortified foods, supplements
 - Children are most vulnerable: need less, more sensitive
- UL set for *preformed* vitamin A
 - Balanced diet = unlikely to supply toxic levels
- Symptoms: bone defects, birth defects, acne

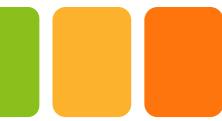


Beta-carotene Toxicity

- Found in many fruits and vegetables
- Inefficient conversion to vitamin A (will not cause vit A toxicity)
- Overconsumption from food
 - Stored in subcutaneous fat: yellow skin
- Overconsumption from supplements
 - Antioxidant becomes prooxidant



© 2002 Massachusetts Medical Society



Vitamin A and Beta-Carotene

- Recommendations

- Retinoids + carotenoids = retinol activity equivalents (RAE)
 - 1 µg retinol = 12 µg beta-carotene
 - Supplements often measured in International Units (IU)

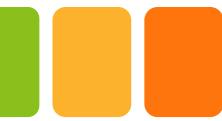
- Animal sources = richest in vitamin A

- Liver, fish, liver oils, eggs, milk and milk products
 - Lost in skim milk and margarine: fortified
 - Toxicity concerns: liver has 3x RDA

- Plant sources

- Vitamin A precursors: carotenoids
 - Beta-carotene = most vitamin A activity
 - Colorful vegetables: deep orange, dark green
 - Biofortified foods: golden rice





Vitamin D

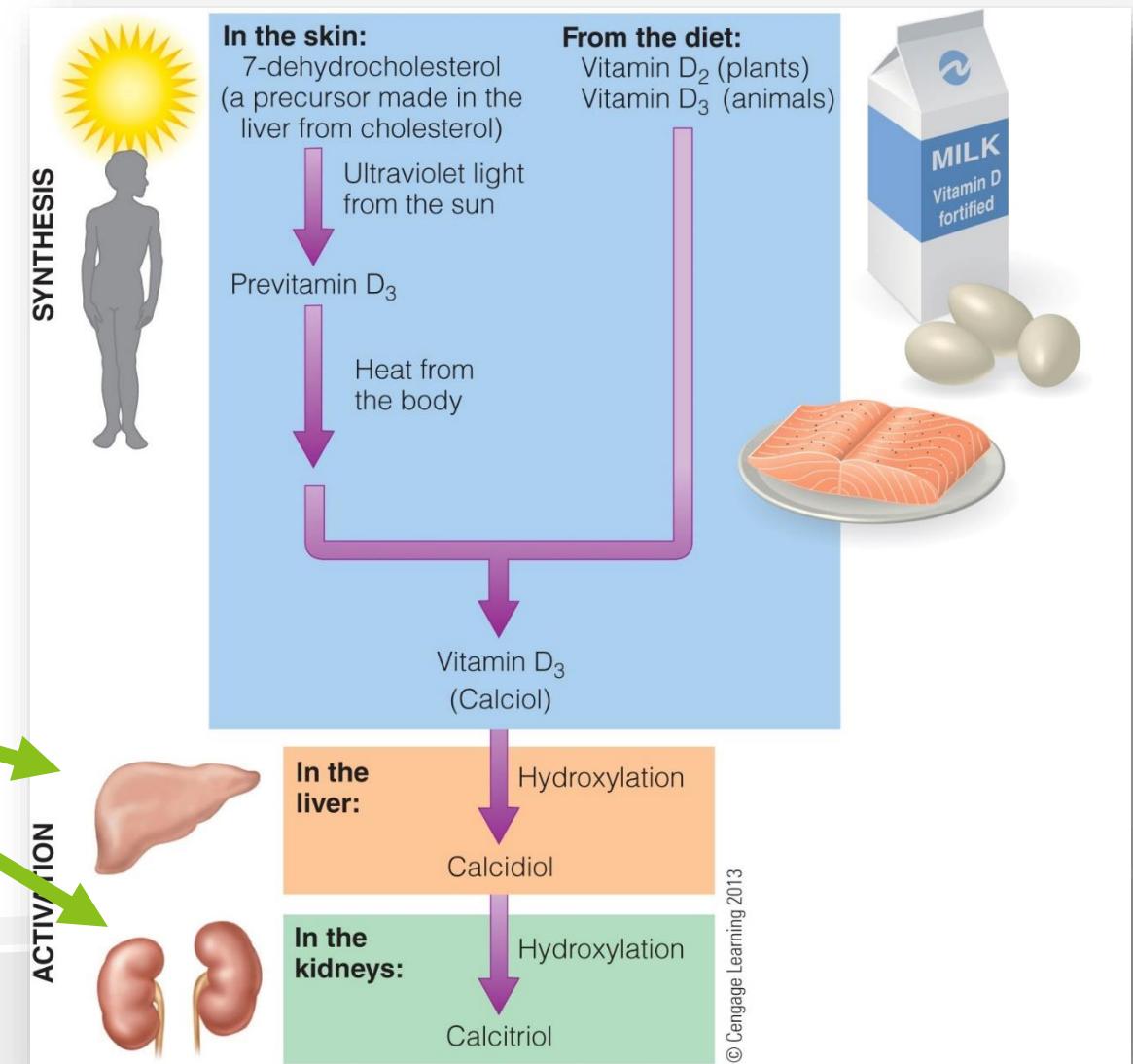
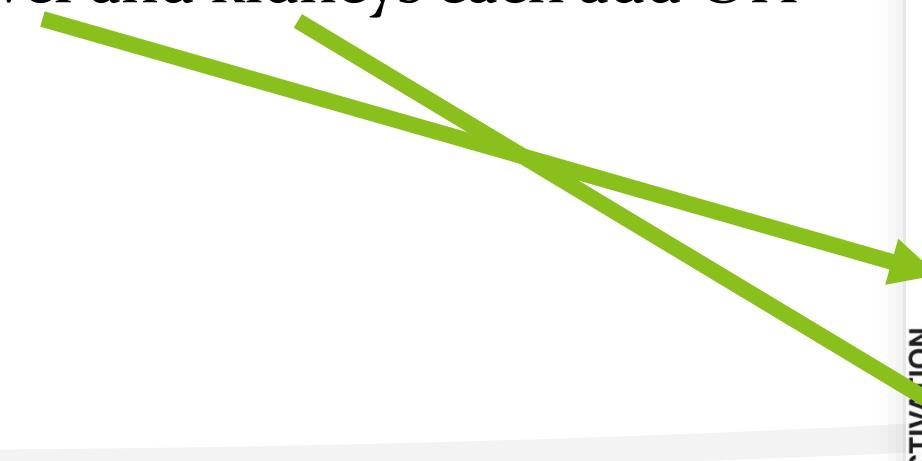


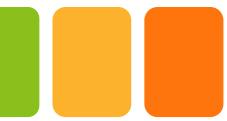
- Not an essential nutrient
 - Body synthesizes from sunlight + precursor from cholesterol
- Two forms of dietary vitamin D
 - D₂: plant sources
 - D₃: animal sources; synthesis in skin

Vitamin D Synthesis and Activation

Activation of vitamin D:

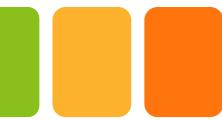
- Two reactions needed to activate both forms: liver and kidneys each add OH group





Vitamin D Roles in the Body

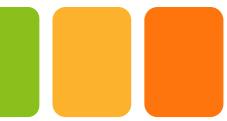
- Active form = hormone
 - Binding protein carries it to target organs: intestines, kidneys, bones
- Bone growth
 - Enhances calcium and phosphorus absorption (when diet is sufficient)
 - Provides minerals from other sources (when diet is insufficient)
 - Reabsorption by kidneys
 - Mobilization from bones into blood
- Other roles
 - Enhances/suppresses activity of genes that regulate cell growth



Vitamin D Deficiency

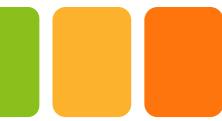
- Overt signs = relatively rare
- Insufficiency = quite common
- Factors: dark skin, breastfeeding without supplementation, lack of sunlight, not using fortified milk, older people especially likely to be deficient
- Vit D deficiency can create calcium deficiency
 - Rickets (children): bones fail to calcify normally; bend under weight
 - Osteomalacia (adults): poor mineralization of bones; soft, flexible, brittle, and deformed
 - Osteoporosis: loss of calcium from bones; fractures





Vitamin D Toxicity and Recommendations

- Most likely of the vitamins to have toxic effects
 - Not from diet or sunlight, but from supplements
 - UL has been set
- Raises blood calcium concentrations
 - Forms stones in soft tissues (especially in kidneys)
 - May harden blood vessels, dangerous in arteries (can be fatal)
- Recommendations may be insufficient
 - Especially for people with dark pigmentation
 - Difficult to meet RDA without sunlight, fortification, or supplementation



Vitamin D Sources

- Few food sources
 - Oily fish, egg yolks, fortified milk
- Sun exposure
 - No risk of toxicity
 - Absorption influenced by: skin color, latitude, season, time of day, sunscreen use
 - Expose hands, arms, and face on clear summer day for 5-10 minutes, 2-3 times/week



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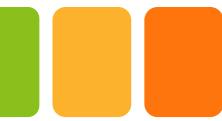


Sunshine break!

Go get some vitamin D!

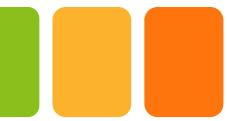
No, really... take a break and
go outside!





Vitamin E Roles in the Body

- Two subgroups: tocopherols and tocotrienols
 - Four members in each subgroup: alpha, beta, gamma, and delta
 - **α-tocopherol** = only one with vitamin E activity in the body
 - RDA: α-tocopherol only
- Antioxidant
 - Stops chain reaction of free radicals producing more free radicals
 - Protect cells and their membranes
 - May reduce risk of heart disease



Vitamin E Deficiency and Toxicity

- Deficiency
 - Primary deficiency = rare
 - Secondary deficiency due to fat malabsorption
 - Effects of deficiency
 - Erythrocyte hemolysis: red blood cells break open
 - Neuromuscular dysfunction in prolonged deficiency
- Toxicity = rare
 - Liver regulates vitamin E concentrations
 - UL = 65x greater than recommended intake for adults
 - Extremely high doses of vitamin E may interfere with vitamin K activity; possibility of hemorrhage



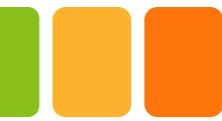
Vitamin E Recommendations and Sources

- Widespread in foods
 - Vegetable oils, seeds, nuts
 - Destroyed by processing: heat and oxidation
 - US intakes fall short of recommendations
 - Higher requirements for smokers

© Craig, M. Moore

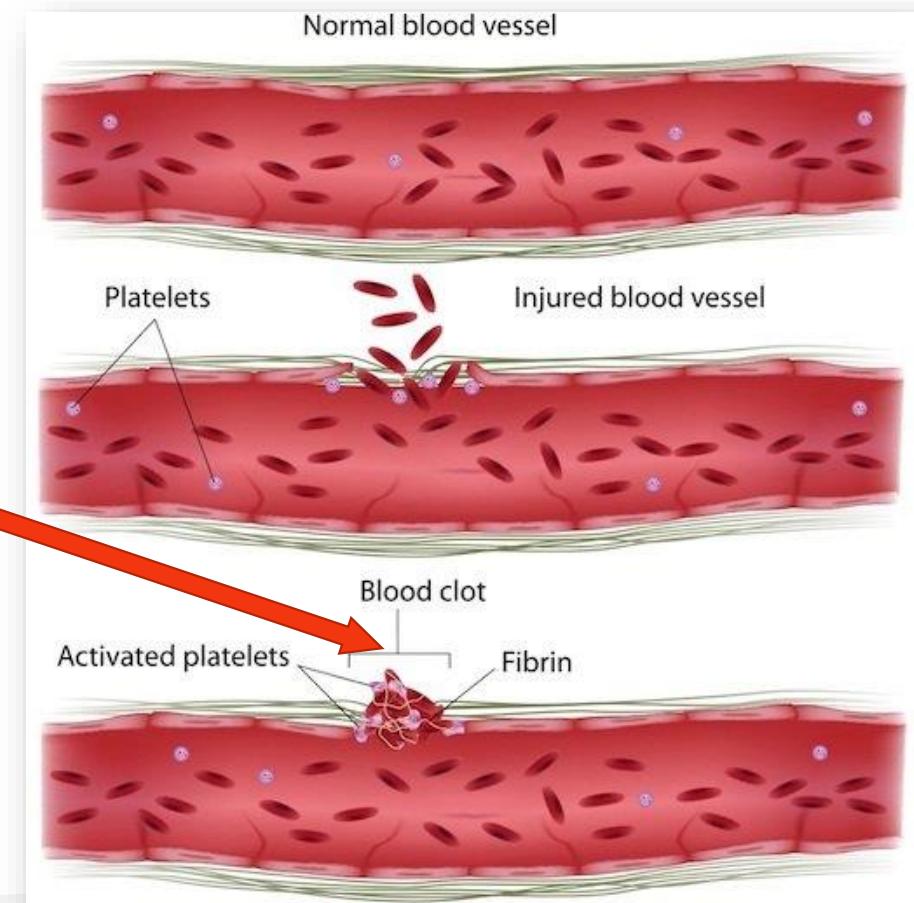


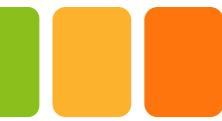
Fat-soluble vitamin E is found predominantly in vegetable oils, seeds, and nuts.



Vitamin K Roles in the Body

- Primary role in blood clotting
 - Initiates chain reaction that produces **fibrin**
- Bone density
 - Helps osteocalcin (protein) bind to bone-forming minerals
- May be associated with reduced risk for some diseases





Vitamin K Deficiency and Toxicity

- Deficiency
 - Primary deficiency = rare
 - Secondary deficiency:
 - Fat absorption falters (bile production failure)
 - Some drugs disrupt synthesis and action (e.g. antibiotics in GI tract)
 - Newborn infants = sterile intestinal tract (no gut bacteria)
 - Single dose given at birth to prevent hemorrhage
- Toxicity = rare
 - No adverse effects = no UL
 - High doses can reduce effectiveness of anticoagulant drugs (blood thinners)

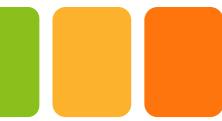




Vitamin K Sources

- RDA: 90 ug/day women; 120 ug/day men
- Can be obtained from food and non-food sources
 - Synthesized from bacteria in the GI tract (menaquinone)
 - Stored in liver
 - Insufficient to meet total need (and low bioavailability)
 - Food sources (phylloquinone)
 - Leafy green vegetables, vegetable oils





Fat Soluble Vitamin Interactions

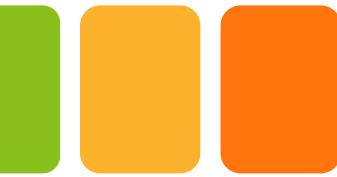
- Function together
 - Vitamins E and A
 - E protects A from oxidation; E helps with absorption and storage of A
 - Vitamins A, D and K
 - Bone growth and remodeling
 - Vitamins E and K
 - Blood clotting



Highlight 10

Supplements or Foods: Debate coming soon!

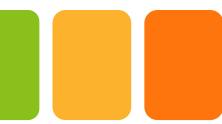




Highlight 11

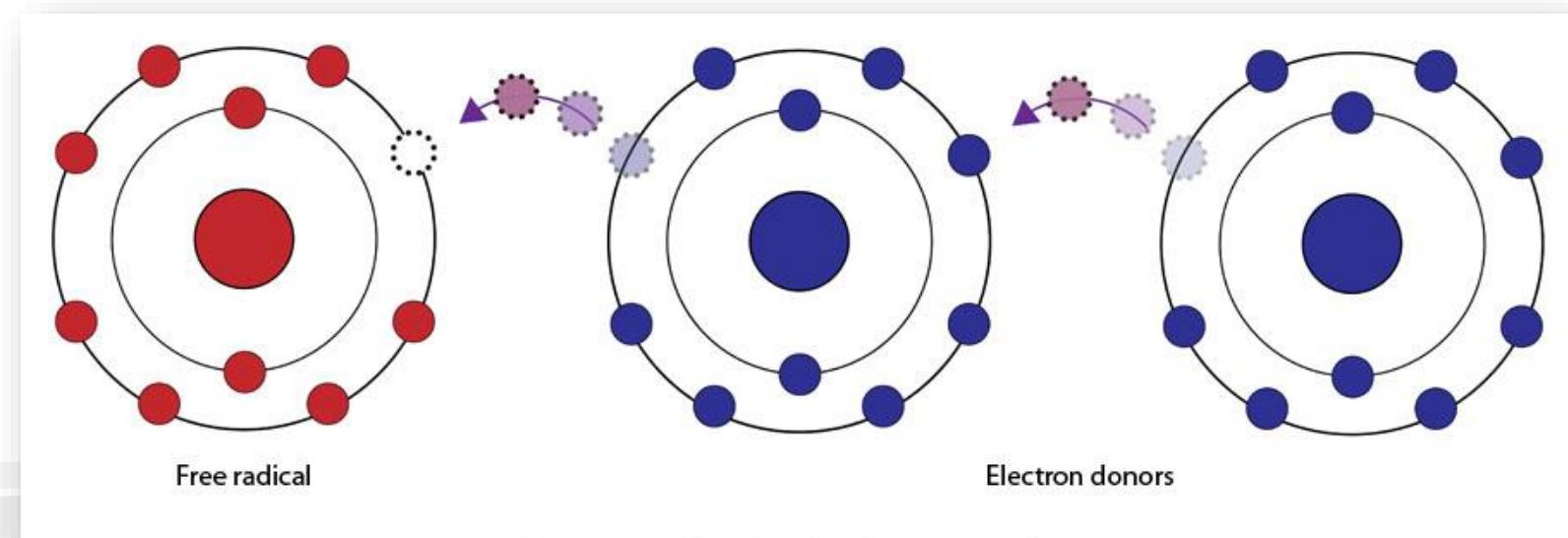
Antioxidant Nutrients in Disease Prevention





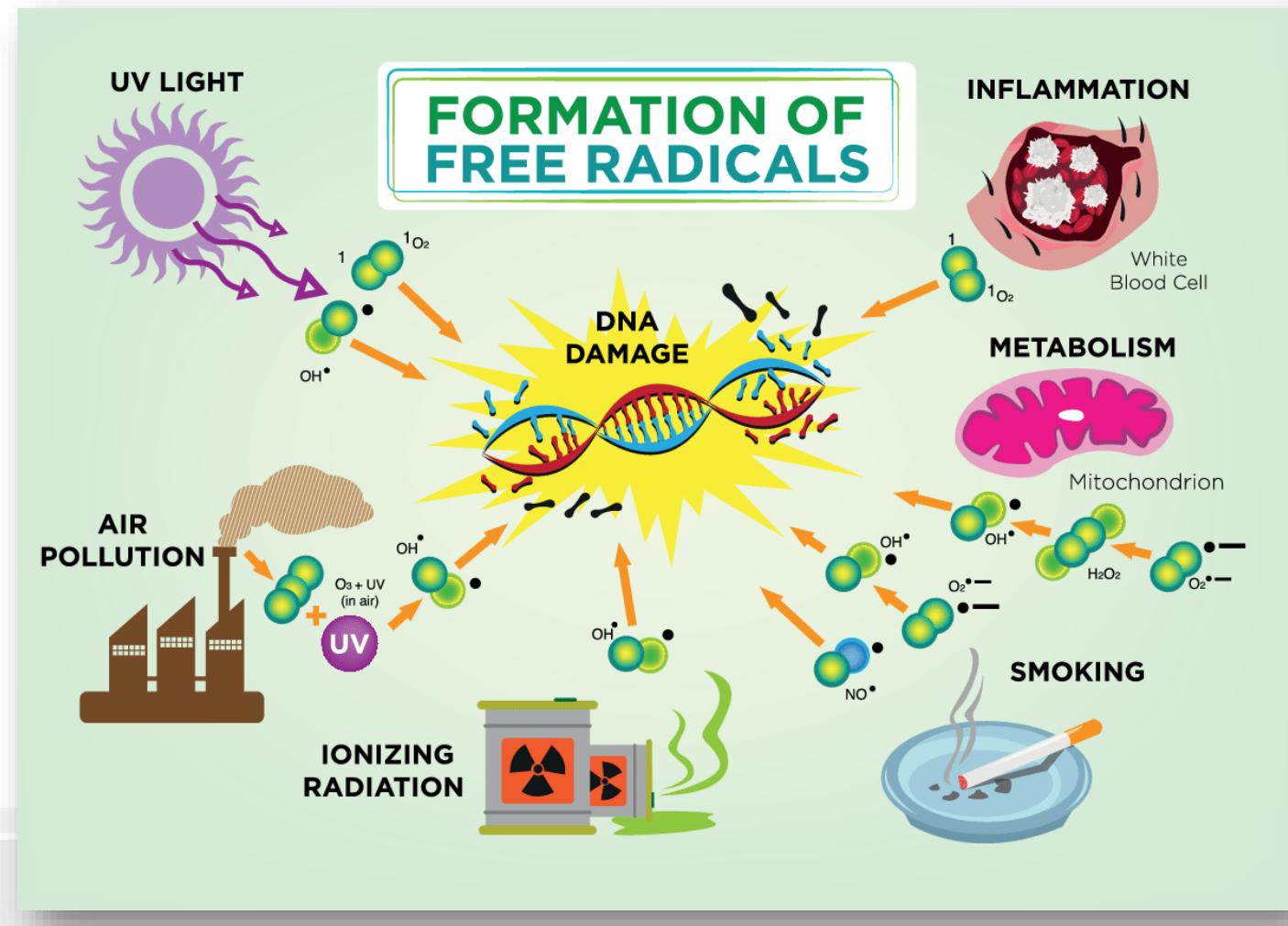
Free Radicals and Disease

- Free radical: compound with one or more unpaired electrons
- Electron-snatching chain reaction: steal electrons from vulnerable compound, compound becomes free radical
- Chain continues and damages DNA, cells, etc. = oxidative stress



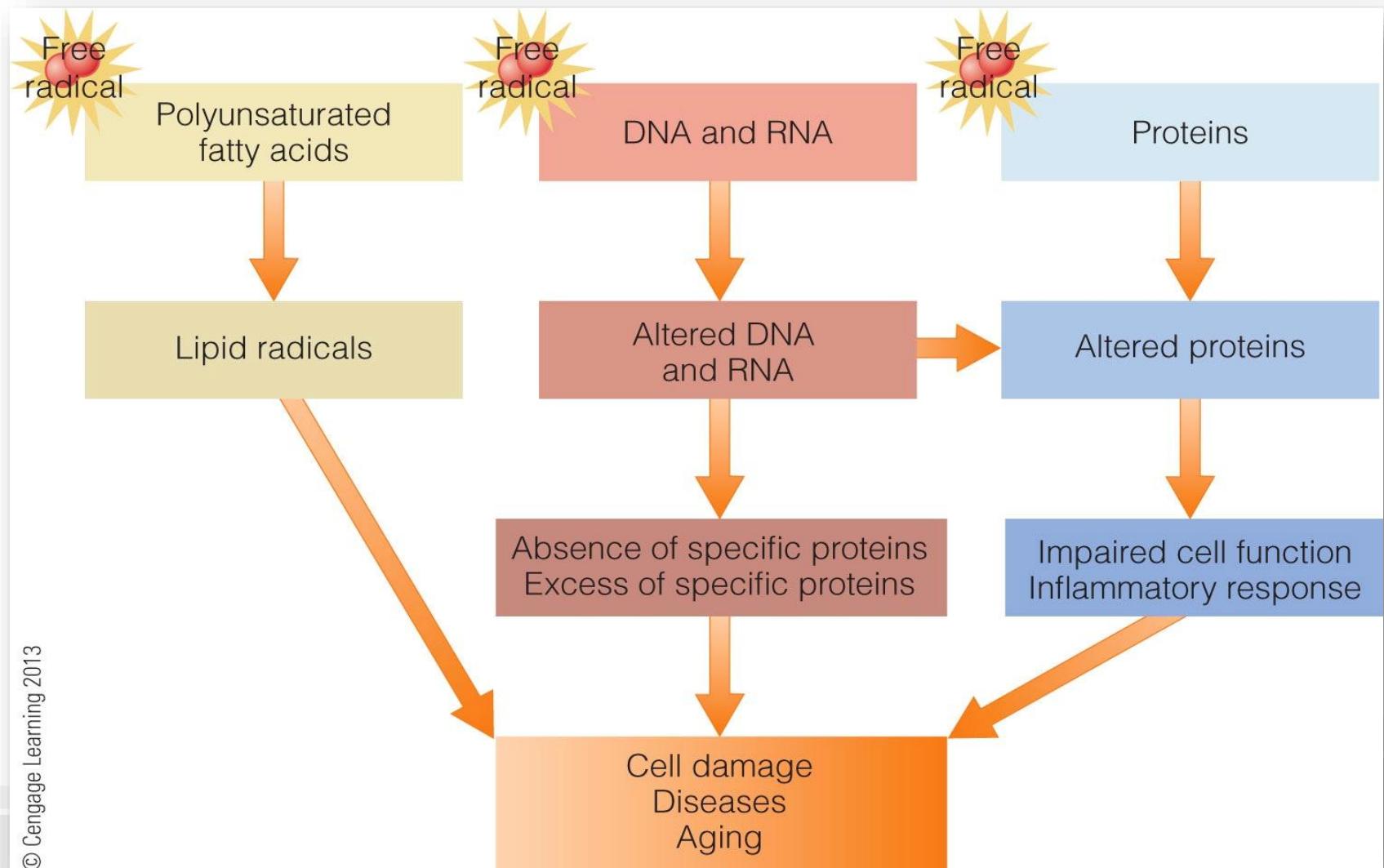
Free Radicals and Disease

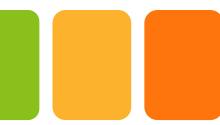
- Free radical production
 - Normal bodily functions: metabolic process
 - Environmental factors: UV radiation, air pollution, smoking
 - Sometimes helpful: oxidative bursts from immune system





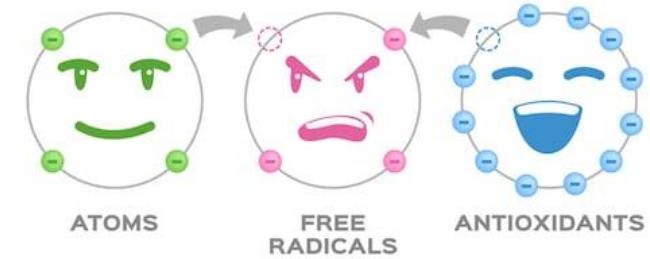
Free Radicals and Disease

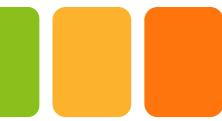




Antioxidants and Disease

- Neutralize free radicals by donating electron
- Remain stable after donating electrons
- May be protective factor:
 - Aging process
 - Cognitive performance
 - Development of disease: cancer, heart disease, arthritis, cataracts, diabetes
 - Atherosclerosis (in arteries, oxidized LDL accelerates formation of artery-clogging plaques)
 - Vitamin E: protects against LDL oxidation, blood clotting, inflammation
 - Vitamin C: protects against LDL oxidation, raise HDL, improves blood pressure
 - Cancer
 - Vitamin E and C: inhibits cancer formation





Foods, Supplements, or Both?

- Dietary antioxidants need to be replenished regularly
 - Foods, especially fruits and vegetables
 - Antioxidants + vitamins, minerals, and fiber
 - Antioxidant actions of fruits and vegetables > nutrients alone
 - Supplements
 - Contents are limited compared to food sources
 - Potential for harm isn't fully understood
 - Physiological levels = antioxidant effect
 - Pharmacological doses = prooxidant effect
- Want to add more antioxidants to your body? Balanced and varied diet is key!