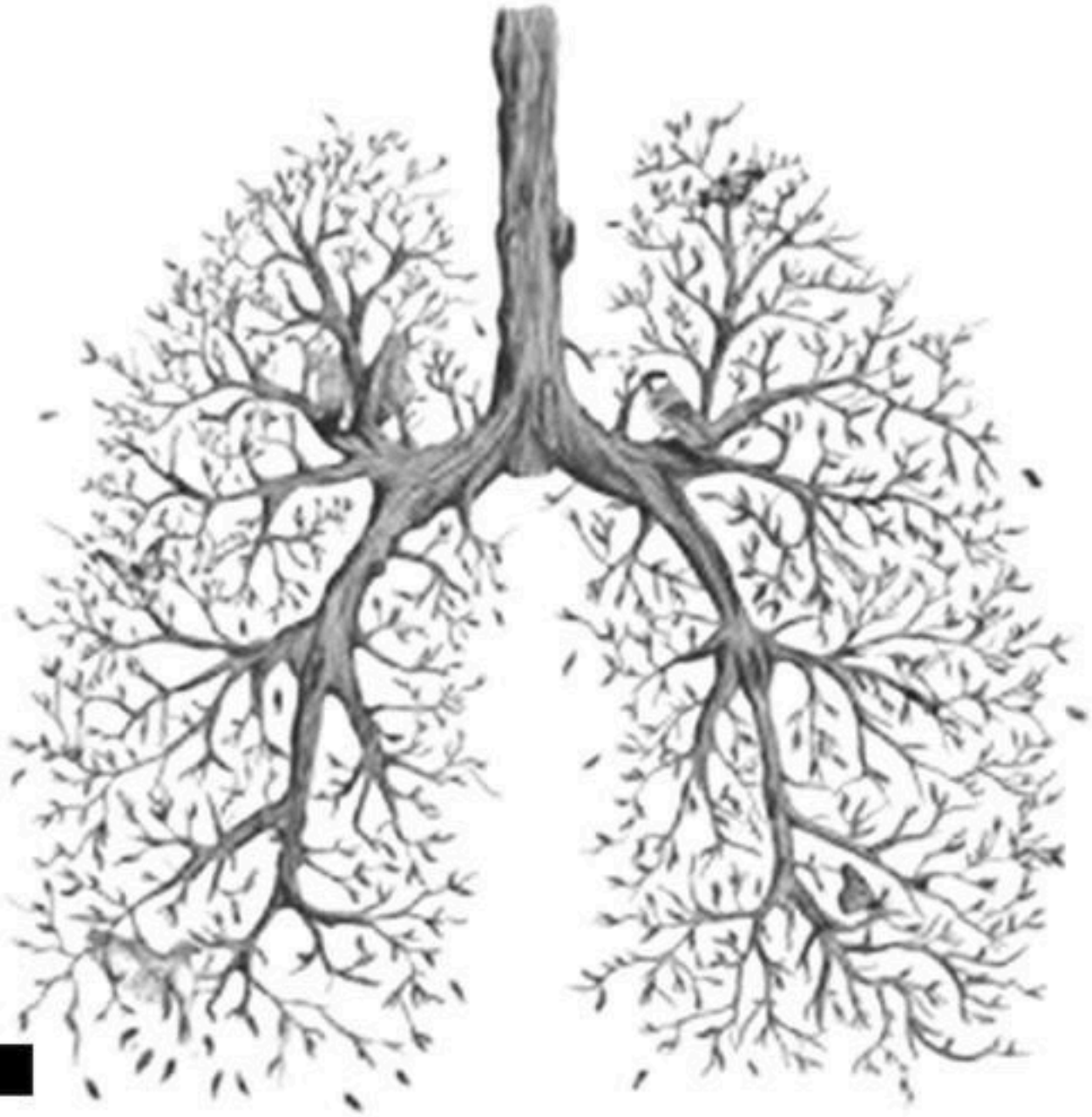


By Mohamed F. Abu Alia



Medical Committee
The University of Jordan

Community Medicine



Slides

Sheet

Slide #: 9

Doctor: Ahmad Al-bataineh

Date:

Dr. Ahmad Atwan Al-Bataineh

Lecture: 1

**The Nutrients and
Their Metabolism**

**Krause's *Food
& Nutrition Therapy***

Nutrition definition

“The science/study of nutrients (that come from food), their action, interaction, and balance in relation to health and disease; and the process by which the organism (body) ingests, digests, absorbs, transports, utilizes and excretes food substances.”

Background definitions:

- **Nutrients**: “Chemical substances in food that nourish the body by providing energy, building materials, and factors to regulate needed chemical reactions.”
- **Essential nutrients**: Must be provided by food because the body does not produce them in sufficient quantities or can not make them at all.
- **Nonessential nutrients**: Healthy, well-nourished bodies can make them in sufficient quantities to satisfy their needs.

Functions of nutrients in food:

a. Provide energy sources

b. Build tissue

c. Regulate metabolic processes

Essential Nutrients cont'd:

- The essential nutrients are:
 - Some forms of carbohydrate (glucose)
 - Certain constituents of fat [the essential fatty acids: linoleic acid (omega-6) and linolenic acid (omega-3)]
 - Certain constituents of protein (the essential amino acids such as lysine, histidine, etc)
 - 15 vitamins
 - About 25 minerals
 - Water

Six categories of nutrients

- 1. Carbohydrates:** contain carbon, hydrogen, and oxygen combined in small molecules called sugars and large molecules represented mainly by starch.
- 2. Lipids (fats and oils):** contain carbon, hydrogen, and oxygen as do carbohydrates, but the amount of oxygen is much less. Triglyceride is the main form of food fat.
- 3. Proteins:** contain carbon, hydrogen, and oxygen, plus nitrogen and sometimes sulfur atoms arranged in small compounds called amino acids. Chains of amino acids make up dietary proteins.

Six categories of nutrients (cont'd):

- 4. Vitamins:** are organic compounds that serve to catalyze or support a number of biochemical reactions in the body.
- 5. Minerals:** are inorganic elements or compounds that play important roles in metabolic reactions and serve as structural components in body tissues such as bone.
- 6. Water:** is vital to the body as a solvent and lubricant and as a medium for transporting nutrients and waste.

Nutrients are classified into :

■ A. Macronutrients (carbohydrates, fats, and proteins).

1. Provide calories for energy

2. Needed in large quantities

■ B. Micronutrients (vitamins, minerals, and water).

1. Needed in smaller amounts

Dietary guidelines for the population

- Eat a variety of foods.
- Maintain a healthy weight.
- Choose a diet low in fat, saturated fat, and cholesterol.
- Choose a diet with plenty of vegetables, fruits, and grains.
- Use sugars only in moderation.
- Use salt and sodium only in moderation.

Components of a nutritional assessment

- 1. Historical data: Medical history and diet history (24 hour recall, FFQ).
- Anthropometric measurements [height, weight, body mass index (BMI), waist circumference, hip circumference, etc..].
- Clinical assessment (physical examinations).
- Biochemical analyses (laboratory).

Carbohydrates are classified into:

- Monosaccharides are seldom found free in nature and are the simplest form of carbohydrate.
- Disaccharides and polysaccharides consist of monosaccharides linked together.
- Also carbohydrates are classified into simple and complex carbohydrates.

Monosaccharides

- Glucose
- Fructose
- Galactose

Disaccharides

- Sucrose
- Lactose
- Maltose

Sweetness of Sugars

<u>Sugar or Sugar Product</u>	<u>Sweetness Value</u>
Levulose, fructose	173
Invert sugar	130
Sucrose	100
Glucose	74
Sorbitol	60
Mannitol	50
Galactose	32
Maltose	32
Lactose	16

Sweetness of Artificial Sweeteners

<u>Artificial Sweeteners</u>	<u>Sweetness Value</u>
Cyclamate (banned in U.S.)	30
Aspartame (NutraSweet)	180
Acesulfame-K (Sunette)	200
Saccharin (Sweet'n Low)	300
Sucralose (Splenda)	600
Alitame (approval pending)	2000

Oligosaccharides

- Polymers containing 2 to 20 sugar molecules
- Readily water soluble and often sweet

Polysaccharides

- Amylose
- Amylopectin
- Resistant starch
- Dextrins
- Glycogen (animal carbohydrate)

Dietary Fiber and Functional Fiber

- Cellulose
- Beta-glucans
- Chitin and chitosan
- Hemicellulose
- Pectins, gums, and mucilages
- Fructans
- Algal polysaccharides
- Lignin

Role of Fiber in Digestion and Absorption

- Increase fecal volume
- Decrease GI transit time
- Slowed or decreased nutrient absorption
- Bind cholesterol and minerals
- Modify serum lipid concentrations
 - Short-chain fatty acids

Glycemic Index

- Relative ability of different dietary carbohydrates to raise blood glucose levels
- Advantages of foods with low glycemic index (GI)

Lipids

■ Functions

- Energy (9 kcal/g)
- Organ positioning, protection
- Fat-soluble vitamins and phytochemicals

Fatty Acids

- Saturated (SFA)
- Monounsaturated (MFA)
- Polyunsaturated (PUFA)
- Location of double bonds; how named:
 - Omega-6
 - Omega-3
- Essential fatty acids

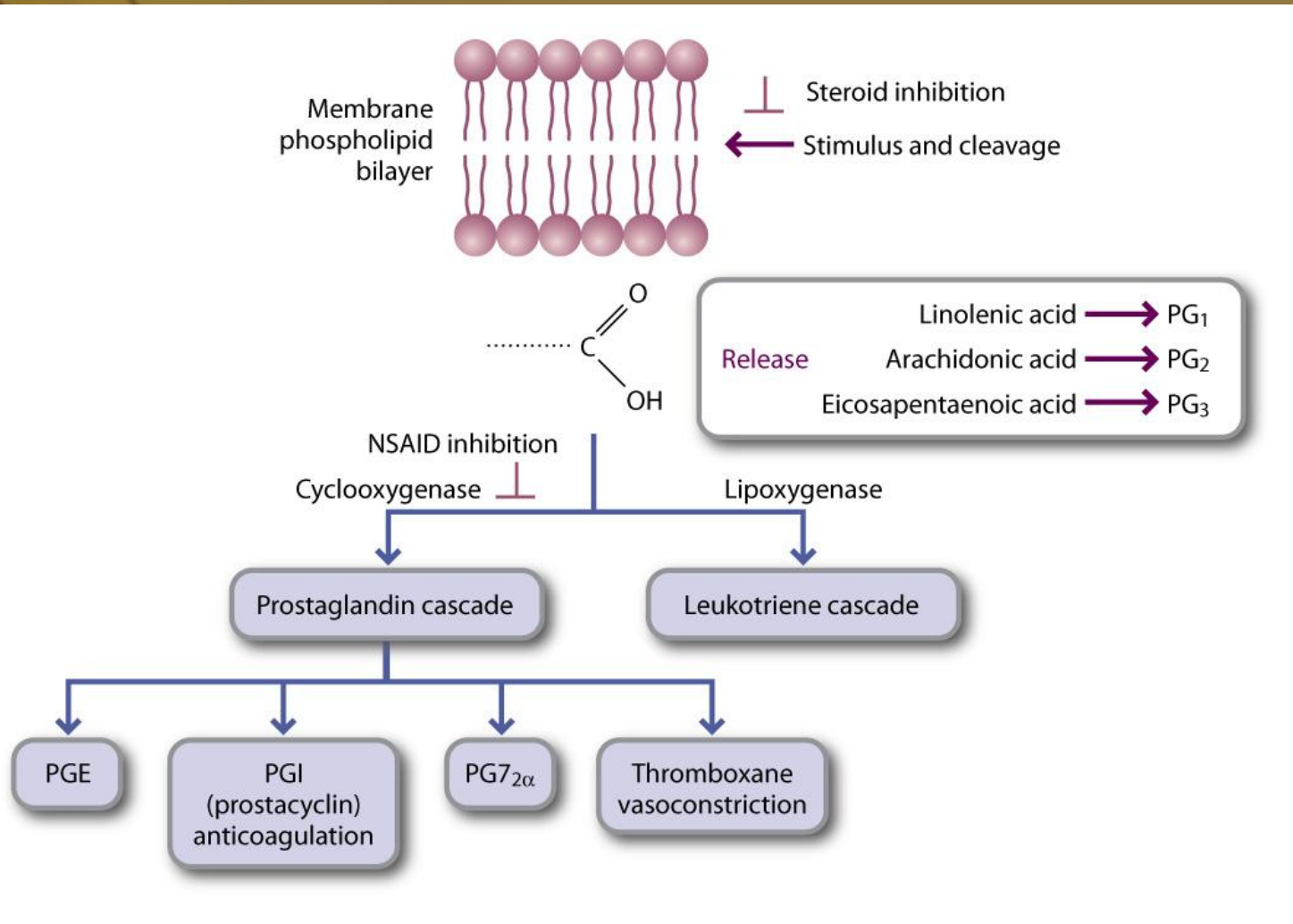
Trans-Fatty Acids

- *Trans* versus *cis* format
- Sources of *trans*-fatty acids
 - Partially hydrogenated margarine, shortening, commercial frying fat, high-fat baked goods, salty snacks
- Negative health effects

Types of Lipids

- Triglycerides
- Phospholipids (e.g., lecithin)
- Sphingolipids, alcohols, waxes, isoprenoids, and steroids (including cholesterol)
- Glycolipids
- Synthetic lipids (MCT, structured lipids, fat replacers)

Other Lipid Issues: Eicosanoid Synthesis



Alcohol








- Toxic substance
- 7 kcal/g
- Effects on drug metabolism
- Cirrhosis of the liver

Amino Acids and Protein

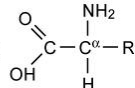
- Essential amino acids
- Nonessential amino acids




Structure and Function of the 20 Amino Acids Required by Humans

All amino acids have the same general structure $\begin{array}{c} \text{NH}_2 \\ | \\ \text{O} \\ // \\ \text{C} - \text{C}^{\alpha} - \text{R} \\ | \\ \text{OH} \\ | \\ \text{H} \end{array}$ in which R is different for each.

FUNCTIONAL TYPE	AMINO ACID (abbr.)	R GROUP	CHARACTERISTICS OF THE AMINO ACID
Aliphatic	Glycine (Gly) G	H	Tiny R group (H), which allows hairpin bends in the peptide chains
	Alanine (Ala) A	CH ₃	Can be deaminated to pyruvate and used for glucose synthesis
	Valine (Val) V*	$\begin{array}{c} \text{CH}_3 \\ \\ \text{---CH} \\ \\ \text{CH}_3 \end{array}$	Branched-chain amino acids; metabolized in muscle
	Leucine (Leu) L*	$\begin{array}{c} \text{CH}_3 \\ \\ \text{---CH}_2\text{---CH} \\ \\ \text{CH}_3 \end{array}$	Branched-chain amino acids more hydrophobic; muscle metabolism
	Isoleucine (Ile) I*	$\begin{array}{c} \text{CH}_3 \\ \\ \text{---CH---CH}_2\text{---CH}_3 \\ \\ \text{CH}_3 \end{array}$	Branched-chain amino acids most hydrophobic; muscle metabolism
Sulfur	Cysteine (Cys) C**	---CH ₂ ---SH	Essential for glutathione synthesis; synthesis limited in chronic diseases
	Methionine (Met) M*	M*---CH ₂ ---CH ₂ ---S---CH ₃	Converted to S-adenosylmethionine (SAM), the universal methyl donor, and cysteine
Hydroxyl	Serine (Ser) S	---CH ₂ ---OH	Hydroxyl group phosphorylated to activate and inactivate protein
	Threonine (Thr) T	---CH ₂ ---OH---CH ₃	Also site for regulatory phosphorylation
Aromatic	Phenylalanine (Phe) F*	---CH ₂ --- 	Converted to tyrosine for synthesis of norepinephrine, epinephrine, and dopamine
	Tyrosine (Tyr) Y	---CH ₂ --- 	Converted to neurotransmitters norepinephrine, epinephrine, and dopamine
	Tryptophan (Trp) W*	---CH ₂ --- 	Converted to neurotransmitter serotonin and to niacin
Cyclic	Proline (Pro) P*	$\begin{array}{c} \text{---CH}_2 \\ \\ \text{---CH}_2 \\ \\ \text{---CH}_2 \end{array}$	Allows triple helix; proline in collagen to be hydroxylated for cross-linkage
Basic	Lysine (Lys) K	---CH ₂ ---CH ₂ ---CH ₂ ---CH ₂ ---NH ₃ ⁺	Site for hydroxylation in proteins; hydrophilic; used in signaling
	Histidine (His) H**	---CH ₂ --- 	Hydrophilic, binds zinc in signaling proteins
	Arginine (Arg) R	---CH ₂ ---CH ₂ ---CH ₂ ---NH--- 	Formed in the urea cycle; essential for synthesis of nitric oxide signaling pathway
Acidic	Aspartic acid (Asp) D	---CH ₂ --- 	Takes a second nitrogen to form asparagine (Asn) N $\begin{array}{c} \text{---CH}_2\text{---C} \\ // \quad \backslash \\ \text{O} \quad \text{NH}_2 \end{array}$
	Glutamic acid (Glu) E	---CH ₂ ---CH ₂ --- 	Takes a second nitrogen to form glutamine (Gln) Q $\begin{array}{c} \text{---CH}_2\text{---CH}_2\text{---C} \\ // \quad \backslash \\ \text{O} \quad \text{NH}_2 \end{array}$

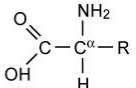
Structure and Function of the 20 Amino Acids Required by Humans— cont'd

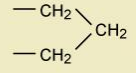
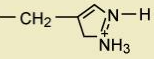
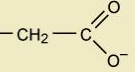
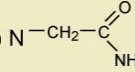
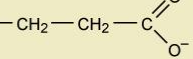
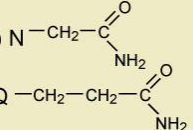
All amino acids have the same general structure  in which R is different for each.

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Aromatic	Phenylalanine (Phe) F*	—CH ₂ — 	Converted to tyrosine for synthesis of norepinephrine, epinephrine, and dopamine
	Tyrosine (Tyr) Y	—CH ₂ — 	Converted to neurotransmitters norepinephrine, epinephrine, and dopamine
	Tryptophan (Trp) W*	—CH ₂ — 	Converted to neurotransmitter serotonin and to niacin

Amino acids marked with an asterisk (*) are essential; those with a double asterisk (**) are essential in infants and in chronic diseases.

Structure and Function of the 20 Amino Acids Required by Humans— cont'd

All amino acids have the same general structure  in which R is different for each.

FUNCTIONAL TYPE	AMINO ACID (abbr.)	R GROUP	CHARACTERISTICS OF THE AMINO ACID
Cyclic	Proline (Pro) P*		Allows triple helix; proline in collagen to be hydroxylated for cross-linkage
Basic	Lysine (Lys) K	$-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\overset{+}{\text{N}}\text{H}_3$	Site for hydroxylation in proteins; hydrophylic; used in signaling
	Histidine (His) H**		Hydrophilic, binds zinc in signaling proteins
	Arginine (Arg) R	$-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{NH}-\overset{+}{\text{C}}(\text{NH}_2)-\text{NH}_2$	Formed in the urea cycle; essential for synthesis of nitric oxide signaling pathway
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	Glutamic acid (Glu) E		Takes a second nitrogen to form glutamine (Gln) Q 

Amino acids marked with an asterisk (*) are essential; those with a double asterisk (**) are essential in infants and in chronic diseases.

Dietary Protein Quality

- Limiting amino acid
- Net protein utilization
- Protein digestibility corrected amino acid score (PDCAAS)
- Denaturation
- Vegetable vs animal protein
- Food processing
- Complementary proteins

Vitamins

- Vital dietary substances needed to regulate the metabolism, normal growth and body functions.
- Vitamins are organic compounds.

Summary of Vitamins

Vitamins are classified into two groups according to their solubility:

Fat-Soluble Vitamins

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

Water-Soluble Vitamins

- Thiamin
- Riboflavin
- Niacin
- Pantothenic acid
- Vitamin B₆
- Folate
- Vitamin B₁₂
- Biotin
- Vitamin C

Vitamin A

- Retinol (animal sources) and carotenoids (plant sources)
- Absorption, transport, and storage
- Essential roles in vision, normal cell differentiation, and cell surface function, growth and development, immune functions, and reproduction
- DRIs

Vitamin A: Retinal Activity Equivalents

Vitamin A Activity

1 retinol activity equivalent (RAE) =
1 mcg of retinol

12 mcg of β -carotene (from food)

3.33 IU of vitamin A activity (on a label)*

For example: 5000 IU vitamin A (supplement or food label) =
1500 RAE = 1500 mcg of retinol

Data from Institute of Medicine, Food and Nutrition Board: *Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc*, Washington, DC, 2001, National Academies Press.

*The vitamin A activity on a food or supplement label is stated in international units (IU), a term outdated scientifically but still required legally on labels.

Sources of Vitamin A

Vitamin A Content of Selected Foods

Food	RAE*
Turkey, 1 cup	15,534
Sweet potato, baked, 1 small	7,374
Carrots, raw, 1 cup	5,553
Spinach, cooked, 1 cup	6,882
Mixed vegetables, frozen, 1 cup	2,337
Cantaloupe, 1 cup	1,625
Peaches, canned, 1 cup	283

From U.S. Department of Agriculture, Agricultural Research Service: Nutrient Database for Standard Reference, Release 18, retrieved 2005, Data Laboratory home page, <http://www.nal.usda.gov/fnic/foodcomp/Data/SR18/sr18.html>.

*RAE, Retinol activity equivalents, 1 IU = 0.3 mg of retinol; RAE from plant sources calculated based on 12 mg b-carotene = 1 RAE.

Vitamin A Deficiency

- Blindness in the developing world
- Night blindness
- Failures in systemic functions
- Xerophthalmia, hyperkeratosis, and keratomalacia
- Follicular hyperkeratosis
- Increased risk for infection

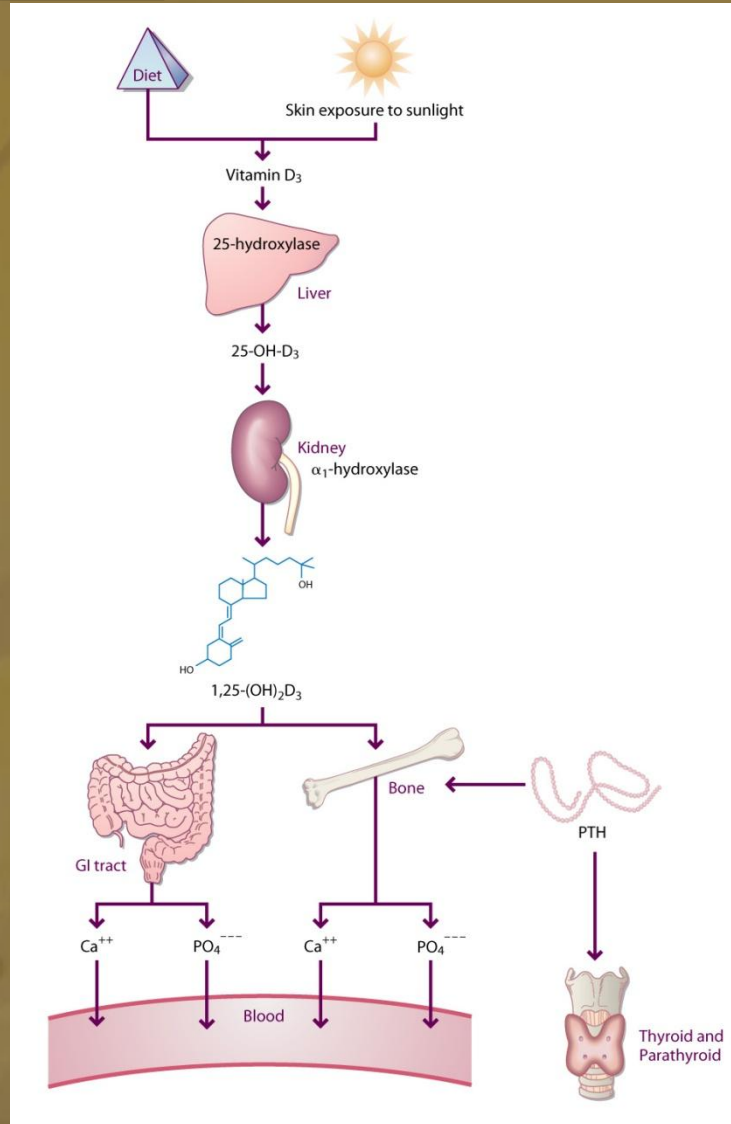
Signs of Vitamin A Toxicity

- Serum vitamin A of 75 to 2000 RAE/100 ml
- Bone pain and fragility
- Hydrocephalus and vomiting (infants and children)
- Dry, fissured skin
- Brittle nails
- Hair loss (alopecia)
- Gingivitis
- Cheilosis
- Anorexia
- Irritability
- Fatigue
- Hepatomegaly and abnormal liver function
- Ascites and portal hypertension

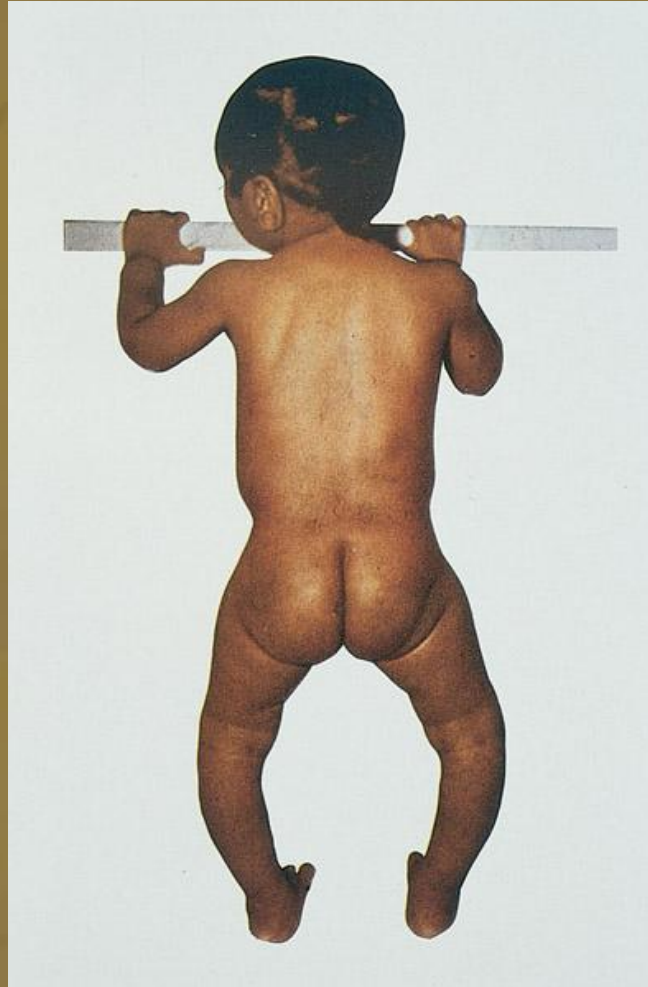
Vitamin D (chole-calceferol)

- Production in skin when exposed to UV irradiation
- Absorption, transport, and storage
- Functions as a steroid hormone
- Maintains calcium and phosphorus homeostasis
- DRIs

Metabolism and Function of Vitamin D



Vitamin D Deficiency



From Latham MC et al: *Scope manual on nutrition*, Kalamazoo, Mich, 1980, The Upjohn Company. Copyright by Rose Lee Nemir, MD.

Vitamin D Deficiency

- Rickets in children
- Osteomalacia in adults
- Osteoporosis

Signs of Vitamin D Toxicity

- Excessive calcification of bones
- Kidney stones
- Metastatic calcification of soft tissue (kidney, heart, lung, and tympanic membrane)
- Hypercalcemia
- Headache
- Weakness
- Nausea and vomiting
- Constipation
- Polyuria
- Polydipsia

Vitamin E (tocopherol)

- Protection against damage by reactive oxygen species
- Tocopherols and tocotrienols
- Absorption, transport, and storage
- Lipid-soluble antioxidant
- DRIs

Vitamin E deficiency

- Breakdown of red blood cells
- Anemia

Vitamin K

- Blood clotting and bone formation
- Phylloquinones and menaquinones
- Absorption, transport, and storage
- DRIs
- Best sources are green leafy vegetables; smaller amounts in dairy products, meats, eggs, fruits, and cereals

Vitamin K Deficiency

- Hemorrhage
- Fatal anemia
- Hemorrhagic disease in the newborn
- Hip fracture in older adults
- Bleeding tendencies

Thiamin

- Coenzyme in carbohydrate metabolism
- Normal growth
- Normal function of heart, nerves, and muscle
- Absorption, transport, and storage
- DRIs
- Richest sources are yeast and liver; cereal grains provide most in human diets
- Destroyed by heat, oxidation, and radiation; stable when frozen

Thiamin Deficiency

Clinical Features of Thiamin Deficiency

Deficiency Type	Features
Early stage of deficiency	Anorexia Indigestion Constipation Malaise Heaviness and weakness of legs Tender calf muscles “Pins and needles” and numbness in legs Anesthesia of skin, particularly at the tibia Increased pulse rate and palpitations
Wet beriberi	Edema of legs, face, trunk, and serous cavities
	Tense calf muscles
	Fast pulse
	Distended neck veins
	High blood pressure
	Decreased urine volume

Thiamin Deficiency

Clinical Features of Thiamin Deficiency - continued

Dry beriberi	Worsening of early-stage polyneuritis
	Difficulty walking
	Wernicke-Korsakoff syndrome: possible
	Encephalopathy
	<ul style="list-style-type: none">• Loss of immediate memory
	<ul style="list-style-type: none">• Disorientation
	<ul style="list-style-type: none">• Nystagmus (jerky movements of eyes)
	<ul style="list-style-type: none">• Ataxia (staggering gait)

Thiamin Deficiency

Clinical Features of Thiamin Deficiency - continued

Infantile beriberi (2-5 mo of age)	Acute: <ul style="list-style-type: none">• Decreased urine output• Excessive crying; thin and plaintive whining• Cardiac failure
	Chronic:
	• Constipation and vomiting
	• Fretfulness
	• Soft, toneless muscles
	• Pallor of skin with cyanosis

Riboflavin

- Essential for metabolism of carbohydrates, amino acids, and lipids; supports antioxidant protection
- Absorption, transport, and storage
- DRIs
- Green leafy vegetables are rich sources; most comes from meat, dairy products, and fortified grains in American diet

Riboflavin deficiency

- Ariboflavinosis
- Wound aggravation
- Cracks at corners of the mouth
- Swollen red tounge
- Eye irritation
- Skin eruptions

Niacin

- Nicotinamide and nicotinic acid
- Essential for energy production and metabolism
- Biosynthesis (from tryptophan), absorption, transport, and storage
- DRIs
- Sources: lean meats, poultry, fish, peanuts, and yeasts

Niacin deficiency

■ Pellagra is the four D syndrome:

1. Dermatitis
2. Diarrhea
3. Dementia
4. Death

Niacin Deficiency (Pellagra)



From Latham MC et al: *Scope manual on nutrition*, Kalamazoo, Mich, 1980, The Upjohn Company. Copyright by Thomas Spies, MD

Pantothenic Acid

- Critical roles in metabolism, integral part of coenzyme A: fat, cholesterol, and heme formation and amino acid activation.
- Absorption, transport, and storage
- DRIs
- Present in all plant and animal tissues
- Deficiency impairs lipid synthesis and energy production

Vitamin B₆

- Pyridoxine
- Metabolism of amino acids, neurotransmitters, glycogen, sphingolipids, heme, and steroids
- Absorption, transport, and storage
- DRIs
- Good sources include meats, whole grains, vegetables, nuts

Vitamin B6 deficiency

- Anemia
- CNS: hyperirritability, convulsions, neuritis

Folate (Folic acid)

- Pteroylmonoglutamic acid
- Part of DNA
- Formation and maturation of red and white blood cells in bone marrow; single-carbon carrier in heme formation
- DRIs
- Rich sources include liver, mushrooms, and green leafy vegetables

Folate Deficiency

- Impaired biosynthesis of DNA and RNA
- Certain type of anemia: Megaloblastic anemia (large immature red blood cells), macrocytic anemia
- Folate-responsive homocystinemia
- Neural tube defects (NTD).

Vitamin B₁₂

- Cobalamin: coenzyme in synthesis of heme for hemoglobin, normal red blood cell formation
- Absorption, transport, and storage
- DRIs
- Richest sources are liver, kidney, milk, eggs, fish, cheese, and muscle meats
- Not naturally found in plant foods

Vitamin B₁₂ Deficiency

- Impaired cell division
- Megaloblastic anemia
- Neurologic abnormalities
- Pernicious anemia: B12 is necessary extrinsic factor that combines with intrinsic factor of gastric secretions for absorption.

Biotin

- Coenzyme A partner
- Synthesis of fatty acids
- Synthesis of amino acids and purines
- Carboxyl carrier; also has noncarboxylase roles
- DRIs
- Rich sources are milk, liver, egg yolk and a few vegetables
- Deficiency is rare: parenteral nutrition

Ascorbic Acid (Vitamin C)

- Vitamin C; oxidation-reduction reactions
- Intercellular cement substance, firm capillary walls and collagen formation
- Helps prepare iron for absorption and release to tissue for red blood cell formation
- Synthesis of collagen and carnitine and other metabolic reactions; antioxidant; promotes resistance to infection
- DRIs
- Best sources are fruits, vegetables, organ meats

Vitamin C Deficiency

- Easily destroyed by oxidation, lost in cooking water
- Scurvy (deficiency disease)
- Impaired wound healing; edema; hemorrhages; and weakness in bone, cartilage, teeth, and connective tissues
- Sore gums
- Anemia
- Wound healing, tissue formation
- Tendency to bruise easily

Vitamin C Toxicity

- GI disturbances and diarrhea
- Possible role in gastric carcinogenesis
- Renal oxalate stones
- False-positive urinary glucose test

Choline

- Essential component of animal tissues
- Widely distributed in fat, in the form of lecithin, in eggs, soybeans, milk, etc.
- Supplemental choline successful in diminishing short-term memory loss associated with Alzheimer's disease

Carnitine

- Functions in the transport of long-chain fatty acids into mitochondria for oxidation as sources of energy
- Meats and dairy products are good sources
- Muscle weakness and hypoglycemia are symptoms of deficiency

myo-Inositol

- Provides structural support in membranes
- Source of arachidonic acid and important intracellular signals and secondary cell messengers
- Synthesized from glucose and also obtained from fruits, grains, vegetables, nuts, legumes, and organ meats

Ubiquinones

- Referred to as coenzyme Q₁₀ (CoQ₁₀)
- Function as essential components of the mitochondrial electron transport chain
- Function as a fat-soluble antioxidant
- Found in fish oils, nuts, fish, and meats

Bioflavonoids

- No known immediate metabolic function
- Reduce capillary fragility
- Potentiate the antiscorbutic activity of ascorbic acid
- Reduced risk of cardiovascular disease and several cancers
- Ubiquitous in foods of plant origin

Minerals

- Minerals are inorganic elements or compounds that play important roles in metabolic reactions and serve as structural components in body tissues such as bones.
- Minerals cannot be manufactured in the body, they have to be provided with food.

Mineral Classifications

- Macrominerals
- Microminerals
- Ultratrace minerals

Bioavailability of Minerals

- Reduced by formation of soaps, binding to free fatty acids, precipitation, mineral-mineral interactions, organic inhibitors such as phytates and oxalates, stress
- Enhanced by ascorbic acid (for nonheme iron), gastric acidity, hemostatic adaptations

Calcium Metabolism

- Intestinal absorption
- Renal excretion
- Skin losses
- Serum calcium
- Blood calcium and parathyroid hormone
- Role of other hormones

Functions of Calcium

- Acquire optimal bone mass and density
- Maintain bone health
- Transport functions of cell membranes
- Nerve transmission
- Regulation of heart muscle function
- Blood clotting
- Role in obesity

Sources of Calcium

- Yogurt
- Milk
- Cheese
- Small bones of sardines and canned salmon
- Dark green leafy vegetables
- Molasses
- Clams and oysters
- Fortified foods

Calcium Deficiency

- Lower peak bone mass
- Increased blood PTH levels leads to low bone mass
- Osteomalacia
- Chronic diseases, such as colon cancer, hypertension, osteoporosis

Phosphorus

- Absorption, transport, storage, and excretion
- DNA and RNA are phosphate based
- High-energy phosphate bonds in ATP and other cellular forms of energy
- Phospholipids
- Enzyme activation and buffer system
- Hydroxyapatite in bones and teeth

Sources of Phosphorus

- Meat, poultry, fish, and eggs
- Milk and milk products
- Nuts and legumes
- Cereals and grains
- Food additives

Magnesium

- Absorption, transport, storage, and excretion
- Cofactor for more than 300 enzymes
- Neuromuscular transmission and activity
- Bone density

Sources of Magnesium

■ Milk

■ Bread

■ Coffee

■ Ready-to-eat cereals

■ Beef

■ Potatoes

■ Dried beans and lentils

Sulfur

- Constituent of three amino acids: cystine, cysteine, and methionine
- May be considered an antioxidant
- Essential component of three vitamins: thiamin, biotin, and pantothenic acid
- Food sources include meat, poultry, fish, eggs, dried beans, broccoli, and cauliflower

Microminerals (Trace Elements)

- Essential to optimal growth, health, and development
- Exist in two forms
 - As charged ions
 - Bound to proteins or complexed in molecules

Iron

- Heme vs nonheme iron
- Ferritin carries bound iron
- Ferric vs ferrous iron
- Role of transferrin
- Factors affecting bioavailability

Functions of Iron

- Red blood cell function
- Myoglobin activity
- Numerous heme and nonheme enzymes
- Oxidation-reduction activity in respiratory gas transport and cytochrome activity
- Immune function and cognitive performance

Sources of Iron

- Liver
- Seafood
- Kidney, heart
- Lean meat, poultry
- Dried beans and vegetables
- Egg yolks
- Dried fruits
- Dark molasses
- Whole grain and enriched breads and cereals

Iron Deficiency

- High-risk groups
- Hypochromic, microcytic anemia
- Caused by injury, hemorrhage, or illness, unbalanced diet
- Athletic amenorrhea

Iron Overload

- Major cause is hemochromatosis
- Hemosiderosis may lead to hemochromatosis
- Risks of iron supplements for older adults

Zinc

- Functions in association with more than 300 enzymes
- Synthesis or degradation of major metabolites
- Structural roles in proteins
- Intracellular signal in brain cells
- Transport processes, immune function, and genetic expression

Sources of Zinc

- Meat, fish, poultry
- Milk and milk products
- Oysters and other shellfish
- Liver
- Ready-to-eat fortified breakfast cereals
- Whole grain cereals
- Beans, nuts, soy products

Zinc Deficiency

- Decreased taste acuity
- Delayed wound healing
- Growth retardation
- Immune deficiencies
- Skin lesions

Fluoride

- Beneficial to tooth enamel, prevention of dental caries
- Found in fluoridated drinking water, fluoridated toothpaste, foods and drinks made using fluoridated water
- Toxicity, fluorosis appears at daily doses of 0.1 mg/kg

Copper

- Component of many enzymes
- Ceruloplasmin
- Roles in mitochondrial energy production

Sources of Copper

- Shellfish
- Organ meats
- Muscle meats
- Chocolate
- Nuts
- Cereal grains
- Dried legumes
- Dried fruits

Iodine

- Synthesis of triiodothyronine (T_3) and thyroxine (T_4)
- Inhibited by goitrogens
- Selenium is important in iodine metabolism

Sources of Iodine

- Iodized salt
- Seafood
- Content of cow's milk and eggs depends on the animal's diet
- Content of vegetables depends on soil
- Iodophors used in food processing

Iodine deficiency

- 1. Endemic goiter
- Cretinism
- Hypothyroidism
- Hyperthyroidism

Selenium

- Component of enzyme glutathione peroxidase (GSH-Px)
- Antioxidant and free radical scavenger
- Role in iodine metabolism
- Interaction with vitamin E

Sources of Selenium

- Brazil nuts
- Seafood
- Kidney, liver
- Meat, poultry

Selenium deficiency

- Keshan disease: heart muscle failure and Cardiomyopathy.

Manganese

- Component of many enzymes, especially in mitochondria
- Activates many other enzymes
- Formation of connective and skeletal tissues
- Growth and reproduction
- Carbohydrate and lipid metabolism

Chromium

- Potentiates insulin action
- Possible glucose tolerance factor
- Possible role in regulation of gene expression

Molybdenum

- Role in enzymes that catalyze oxidation-reduction reactions
- Possible role in response of some asthmatics to sulfites
- Deficiency causes mental changes and abnormalities of sulfur and purine metabolism

Boron

- Essentiality not yet established
- Influences activity of metabolic enzymes and metabolism of several nutrients
- Associated with cell membranes

Cobalt

- Component of vitamin B₁₂ (cobalamin)
- Required for enzyme methionine aminopeptidase
- Macrocytic anemia

Focal Points

- The major nutrients with roles in the human body include energy-containing macronutrients (carbohydrates, lipids, protein and alcohol as well as the micronutrients (vitamins and minerals.)
- The indigestible food component, fiber is essential for health, especially related to the gastrointestinal tract and cardiovascular system, but 80% of Americans do not get enough fiber.
- Alcohol contains calories for heat but not for muscular work, and it impacts health positively in moderation and negatively in excess.
- Changing concepts regarding the structure, function, and utilization of nutrients in the body are important to keep in mind as they determine the impact of nutrient deficiencies or excesses on health and disease management.
- Miscellaneous trace elements exist in human tissues, especially in the skeleton, because of their abundance on the earth's surface; their essentiality in humans is not totally clear.