Food for Mankind

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Fundamentals for human, animal and plant health

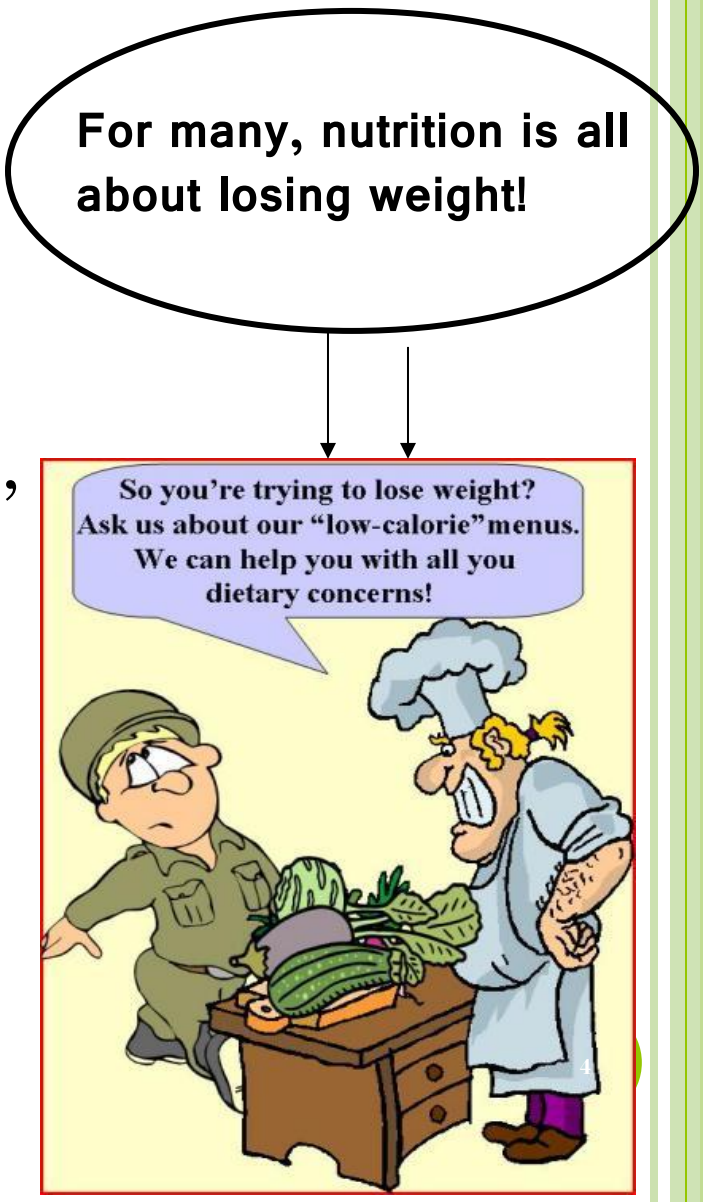
- Genetics
- Nutrition
- Prevention and control of diseases
- Environment

Factors influencing health and quality of life

- Genetics
- Nutrition
- Mental well being
- Physical activity and exercise
- Avoidance of toxicants i.e. smoking, excessive alcoholic consumption etc.

Perspectives on nutrition

- To scientists**, nutrition** is the study of:
  - The nutrients found in **foods**
  - The body's **handling** of nutrients to maintain **health**
- Nutrients (protein,carbohydrate, fat,vtamins, minerals and water)are substances that can promote:
  - **Growth**
  - **Maintenance**
  - **Repair**



CLASSIFICATION OF FOODS

- ***Classification by origin:***

- Foods of animal origin

- Foods of vegetable origin

- ***Classification by chemical composition*:**

There are only **six classes of nutrients** namely:

- **Fats**
- **Proteins**
- **Carbohydrates**
- **Vitamins**
- **Minerals**
- **Water**

NUTRIENTS

- **Organic and inorganic complexes contained in food are called nutrients. They are broadly divided in to:**
- **Macronutrients:**
- **-proteins**
- **-fats**
- **-carbohydrates**
- **Micronutrients:**
- **-vitamins**
- **-minerals**

Food Choices

- Personal preference
- Habit
- Ethnic heritage or tradition
- Social interactions ,food culture
- Availability, convenience, economy
- Positive and negative associations
- Emotional comfort

Food Choices

- Values
- Body weight and image
- Nutrition and health benefits
- Functional foods
- Provide health benefits beyond their nutrient contributions ex. Whole foods, fortified food

Food provides nutrients

We have already established that we eat food to get nutrients.

Food is eaten and digested in the body to allow the absorption of energy and nutrients.

Usually, more than one class of nutrients with different amount is represented in a food (e.g., an apple composes of CHO, water, vitamin C,minerals [e.g., Ca]while milk composes of more fats, and proteins.)

CLASSIFICATION BY PREDOMINANT FUNCTION

- **Body building foods:**
- **-meat, milk, poultry, fish, eggs, pulses etc**

- **Energy giving foods:**
- **-cereals, sugars, fats, oils etc.**

- **Protective foods:**
- **-vegetables, fruits, milk, etc**

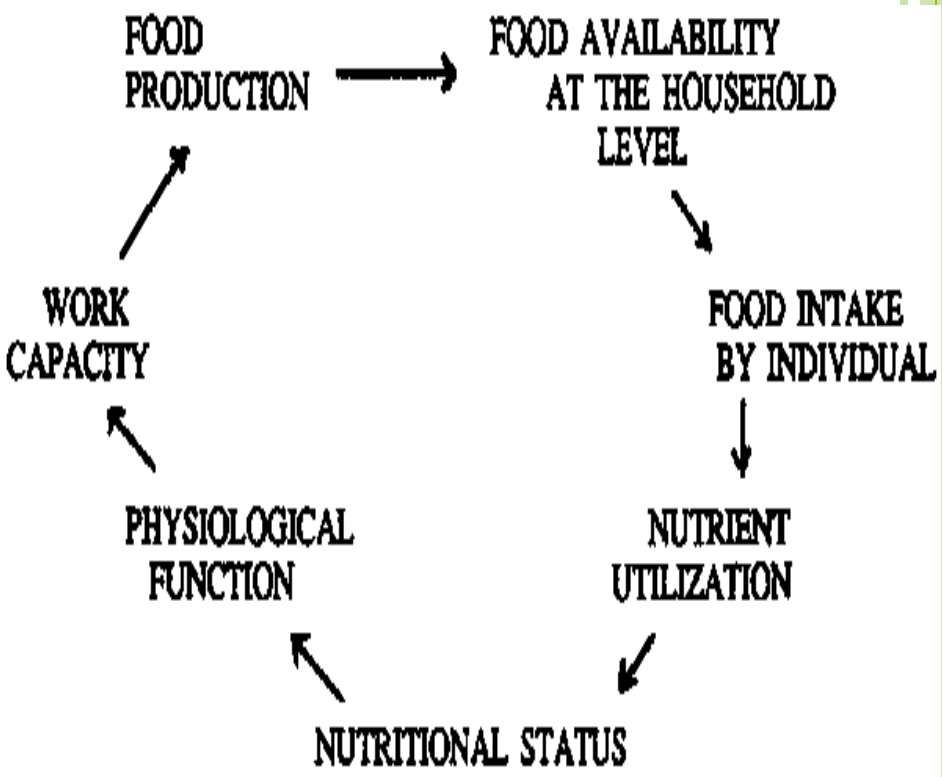
Body Composition

The Importance of Good Nutrition

Good nutrition enhances your quality of life and helps you prevent disease.
It provides you with the calories and nutrients your body needs for maximum energy and wellness.

You are what you eat.

Nutrition – a link between food and health enabling



NUTRITION – A LINK BETWEEN FOOD AND HEALTH ENABLING

- Availability, access consumption and utilization of food of adequate quality, quantity & safety

- Meeting human nutrient and non-nutritient requirements during the life cycle

Macronutrients

There are ***three macronutrients*** that are essential for health. These are:

- carbohydrate;
- protein;
- fat

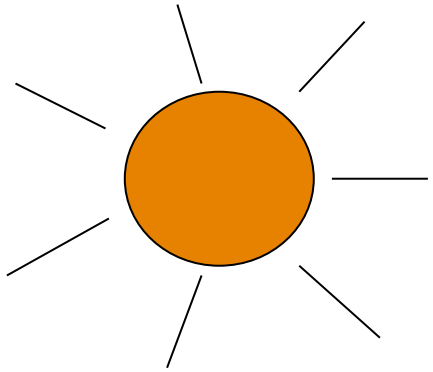
Macronutrients are measured in grams (g).

Carbohydrate

- Major **energy source**: 4 calories/gram
- Types
  - Monosaccharides
  - Disaccharides
  - Polysaccharides
- **Recommended intake: 45-65% of total calories from carbohydrates**

<u>Photosynthesis:</u> Sun's energy becomes part of glucose molecule

$6\ CO_2 + 6\ H_2O + \text{energy (sun)} \longrightarrow C_6H_{12}O_6 + 6\ O_2$



energy

Carbon dioxide
Water
Chlorophyll

→ GLUCOSE

Carbohydrate

Carbohydrates: are the starches, sugars ,and cellulose present in food.

They are classified as either simple or complex

- **Simple carbohydrates:** are sugars

Examples include: glucose, fructose, lactose

- **Complex carbohydrates** are starches.

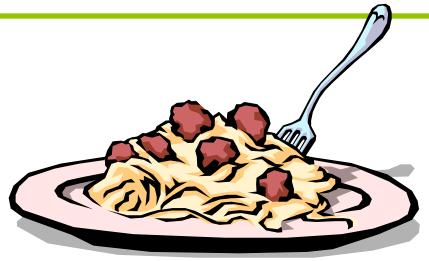
Examples include: whole grains, seeds, legumes

Fiber is an indigestible complex carbohydrate that helps move waste through the digestive system.

Functions

Carbohydrate provides an important source of **energy** for the body, providing 4 Kcals per one gram. Carbohydrate is also essential for the oxidation of fats (preventing ketosis from fat oxidation) and for the synthesis of certain non-essential amino acids

- Body converts all carbohydrates to glucose, a simple sugar.
- Glucose is not used right away and it is stored as glycogen in liver & muscle.
- Too many carbohydrates will cause the body to store the excess as fat.



Function

- Some cells (RBC, brain) can use only CHO until starvation sets in
- **120 grams of glucose / day = 480 Calories needed for brain function.**

- Spares protein from use for energy

- The carbohydrate reserve (glycogen) of a human adult is about 500g. This reserve is rapidly exhausted when a man is fasting. If the dietary carbohydrates do not meet the energy needs of the body, protein and glycerol from dietary and endogenous sources are used by the body to maintain glucose homeostasis.
- Dietary fibre which is mainly non-starch polysaccharide is a physiological important component of the diet. It is found in vegetables, fruits and grains. It may be divided broadly into cellulose and non-cellulose polysaccharides which include hemi-cellulose pectin, storage polysaccharides like inulin, and the plant gums and mucilage. These are all degraded to a greater of lesser extend by the micro flora in the human colon

Where is carbohydrate found?

Some examples of **sugar sources** (carbohydrate) are sucrose (found in table sugar), lactose (found in milk), and fructose (found in fruit).

Eg. Simple sugar-- sugar, syrup,

honey, candy, bakery and processed goods

Some examples of food sources for **starchy carbohydrates** are rice, bread, pasta, and cereal.

Fiber

- Cellulose-based plant material that **cannot be digested**
- **Provides no energy: 0 calories/gram**
- **Types:**
  - Soluble (gel-forming)
  - Insoluble (absorbs water)
- **Benefits**
  - Moves stool through digestive tract: I
  - Lowers blood cholesterol levels: S
  - Steadies blood sugar levels: S
- **Recommended: 25-30 grams/day**

Fiber's Forms Insoluble Fiber

- There are two forms of fiber:
  - **Insoluble Fiber**
  - **Soluble Fiber**

- Insoluble Fiber
- Insoluble fibers do not dissolve in water.
- These fibers increase fecal bulk, improve digestion and help prevent cancer and conditions of the colon.
- Sources of soluble fiber include:
  - Whole wheat flour
  - Legumes
  - Nuts
  - Many vegetables - especially those with a skin (zucchini, potatoes, corn, etc.)
  - Wheat bran

How Insoluble Fiber Works

- The fiber pulls water into and speeds digestion through the large intestines, which helps to maintain bowel regularity.
- As the fiber moves through the large intestines, it collects waste and is excreted from the body.
- This action may decrease the risk of developing a number of conditions that affect the large intestines such as colon cancer and diverticulitis, among others.

Soluble Fiber

- Soluble fibers dissolve in water and are fermentable in the body.
- These may improve cholesterol and help support healthy blood sugar levels.
- Soluble fiber is found in:
  - Apples
  - Oats
  - Beans (especially black beans, kidney beans, and navy beans)
  - Barley
  - Citrus fruits

How Soluble Fiber Works- Cholesterol

- These fibers combine with water in the intestines to form gels.
- The gels bind with bile in the gut.
- Bile is made from the cholesterol found in the body.
- This cholesterol comes from our diet but is also created by the body.
- As the fiber is indigestible, it is excreted and takes the cholesterol out with it.

How Soluble Fiber Works – Digestion and Absorption

- Slows digestion through small intestine, which slows glucose absorption.
- Is completely fermentable in the gut, supporting healthy intestinal flora. (prebiotic function).
- Delays emptying of the stomach to help us feel full longer.

How to Eat More Fiber

- Adding more whole plant based foods to one's diet will add more dietary fiber without the addition of supplements.
- Be sure to drink plenty of water - 8 glasses with 8 oz of water every day.
- Add fiber slowly. All those improvements to one's digestion can be overwhelming if done all at once so add little more everyday.

Fiber Facts

Soluble	Insoluble
Dissolves in water.	Does not dissolve in water
May help reduce cholesterol to improve or maintain heart health.	May help reduce risk for conditions of the colon including cancer, diverticulitis and others.
Slows digestion in stomach and small intestine to help us feel fuller longer.	Helps maintain bowel regularity.

Is One Type of Fiber More Important than the other?

- **No**

- Soluble and Insoluble fiber have different benefits to our health but are both important to a healthy diet.
- A combination of the is easily attained with a diet that includes plenty of different plant based foods.
- Many fiber rich foods contain both soluble and insoluble fiber, which provide use with all previously mentioned health benefits in one item.

Fiber Benefits

- **Fiber has a number of important potential health benefits:**
- Improved digestion
- Improved cholesterol levels
- Reduced risk for colon cancer
- Slows nutrient absorption and helps people feel fuller longer, which may enhance weight loss.

Chemical classification of CHO

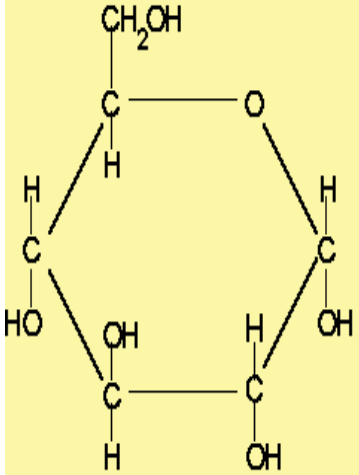
1. **Simple carbohydrate**
   - **monosaccharide or simple sugar**
     - **glucose 70-110 mg%**
     - **galactose**
     - **fructose**
   - **disaccharide**
     - *** sucrose → glucose + fructose**
     - *** lactose → glucose + galactose**
     - *** maltose → glucose + glucose**

- **2. Complex Carbohydrate**
  (Polysaccharides)
  - **2.1 starch**
  - **2.2 dietary fiber**
    - **2.2.1 insoluble dietary fiber ; cellulose hemicellulose lignin**
    - **2.2.2 soluble dietary fiber ; pectin gum mucilage**

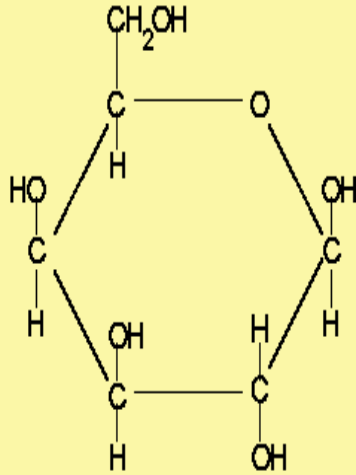
MONOSACCHARIDES

- **Glucose (Glu) - most abundant CHO; part of table sugar; "blood" sugar**
- **Fructose (Fru) - found in fruit & honey; part of table sugar**
- **Galactose (Gal) - part of milk sugar; generally not found free in nature**

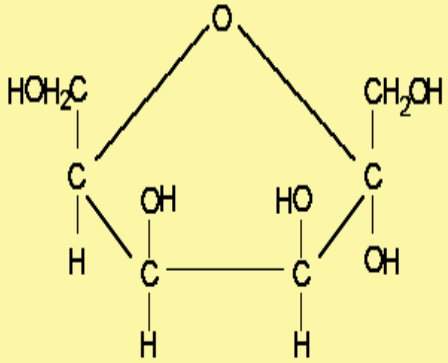
Structures of Common Monosaccharides



Glucose

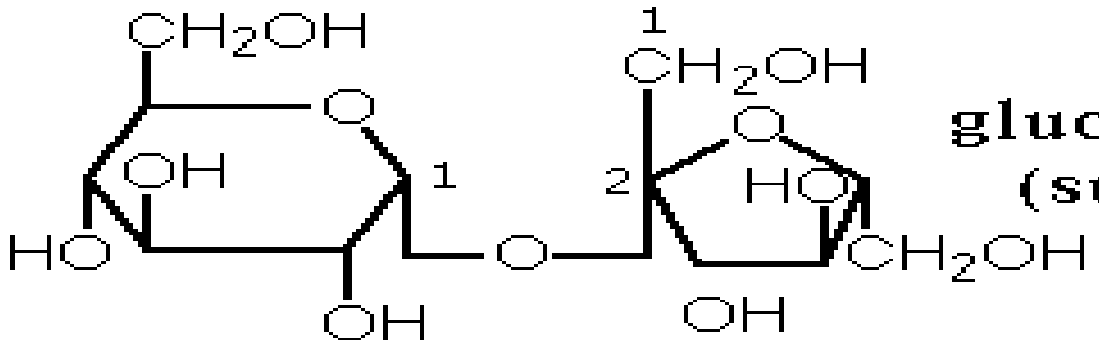


Galactose

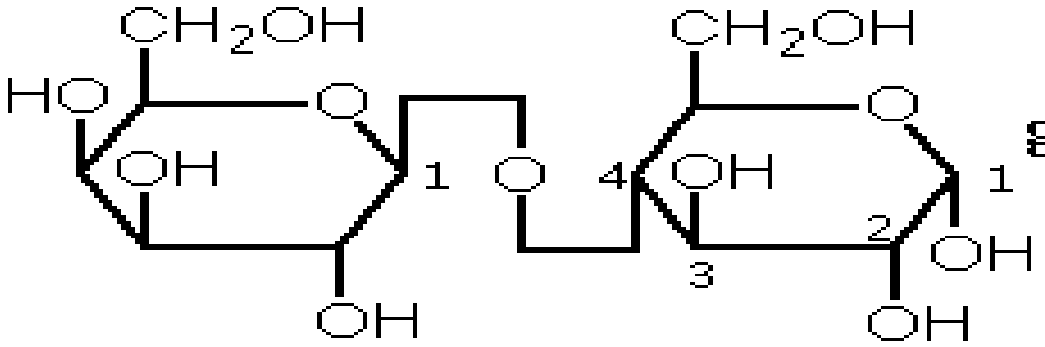


Fructose

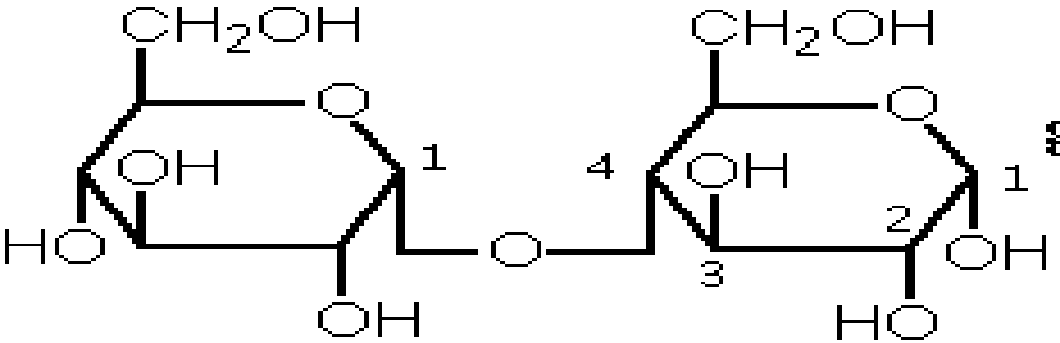
Disacharides



glucose α 1-2 fructose
(sucrose)



galactose β 1-4 glucose
(lactose)



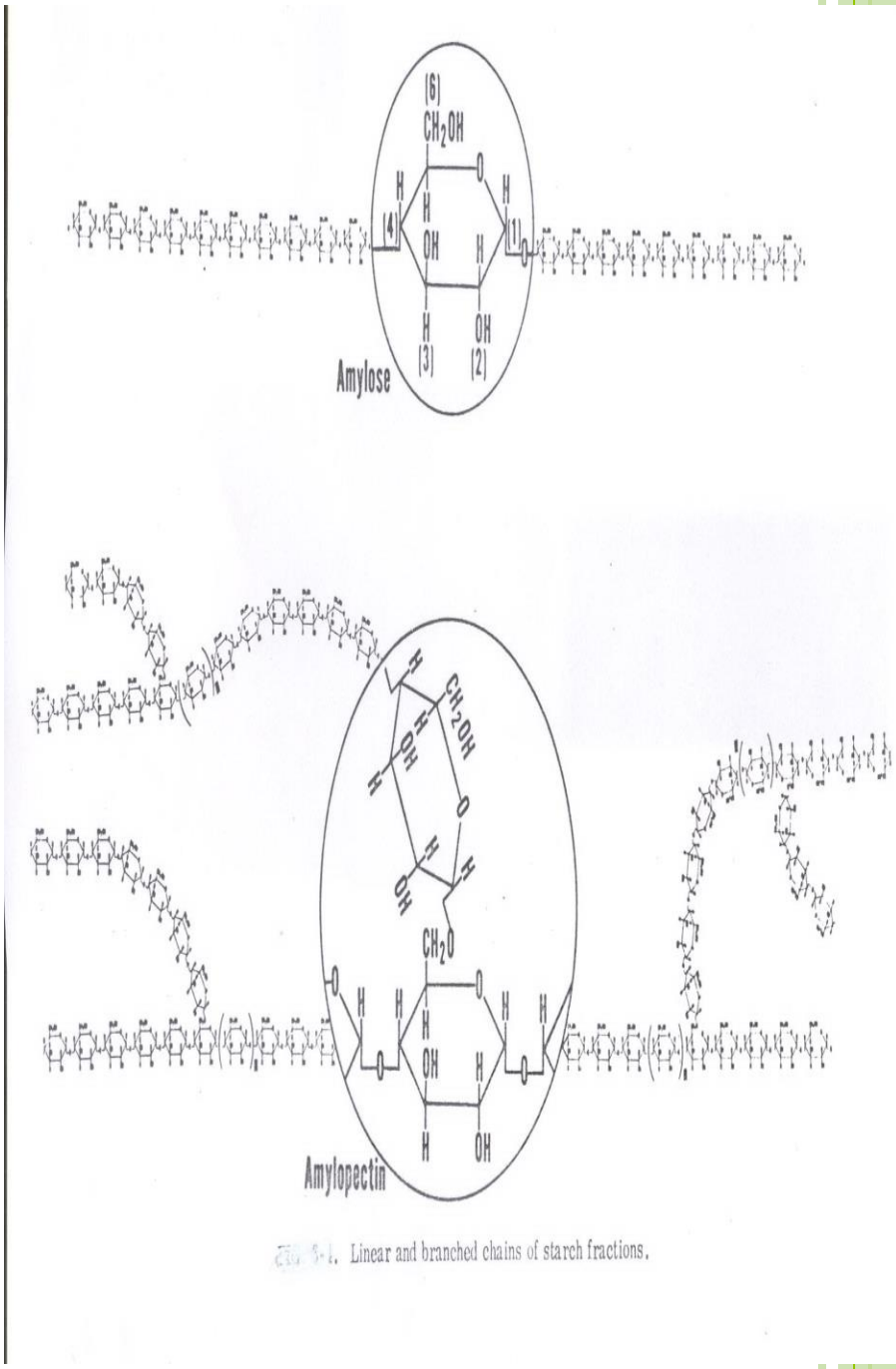
glucose α 1-4 glucose
(maltose)

Complex carbohydrates

- **Oligosaccharides**
- **Polysaccharides**
  - **Starch**
  - **Glycogen**
  - **Dietary fiber**

Starch

- Major storage carbohydrate in higher plants
- Amylose – long straight glucose chains (α1-4)
- Amylopectin – branched every 24-30 glucose residues (α 1-6)
- Provides 80% of dietary calories in humans worldwide

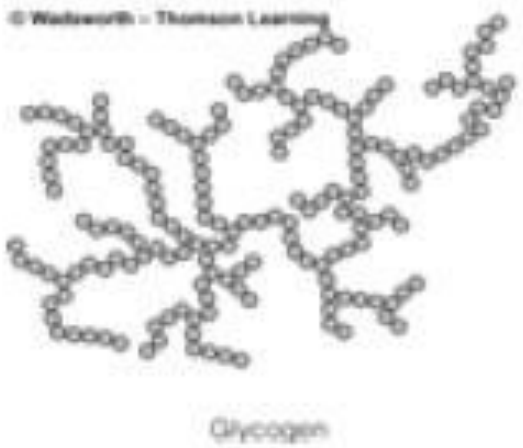


Linear and branched chains of starch fractions.

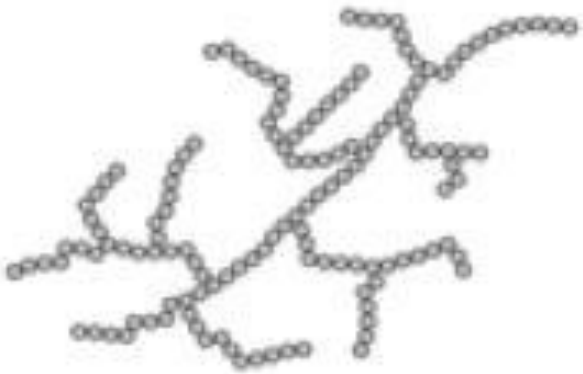
POLYSACCHARIDE STRUCTURE
Glycogen and Starch

HIGHLY BRANCHED STUCTURE ⟹ Many points Of glucose release

- Glycogen: Hundreds Of glucose units-Highly Branched chains
- Starch: Hundreds Of glucose units- Occasionally branched
- Starch: Hundreds Of glucose units- Unbranched chains



Glycogen



Starch (amylopectin)

Starch (amylose)

Enzymes digest starch to glucose

- **Enzymes in stomach : amylase**

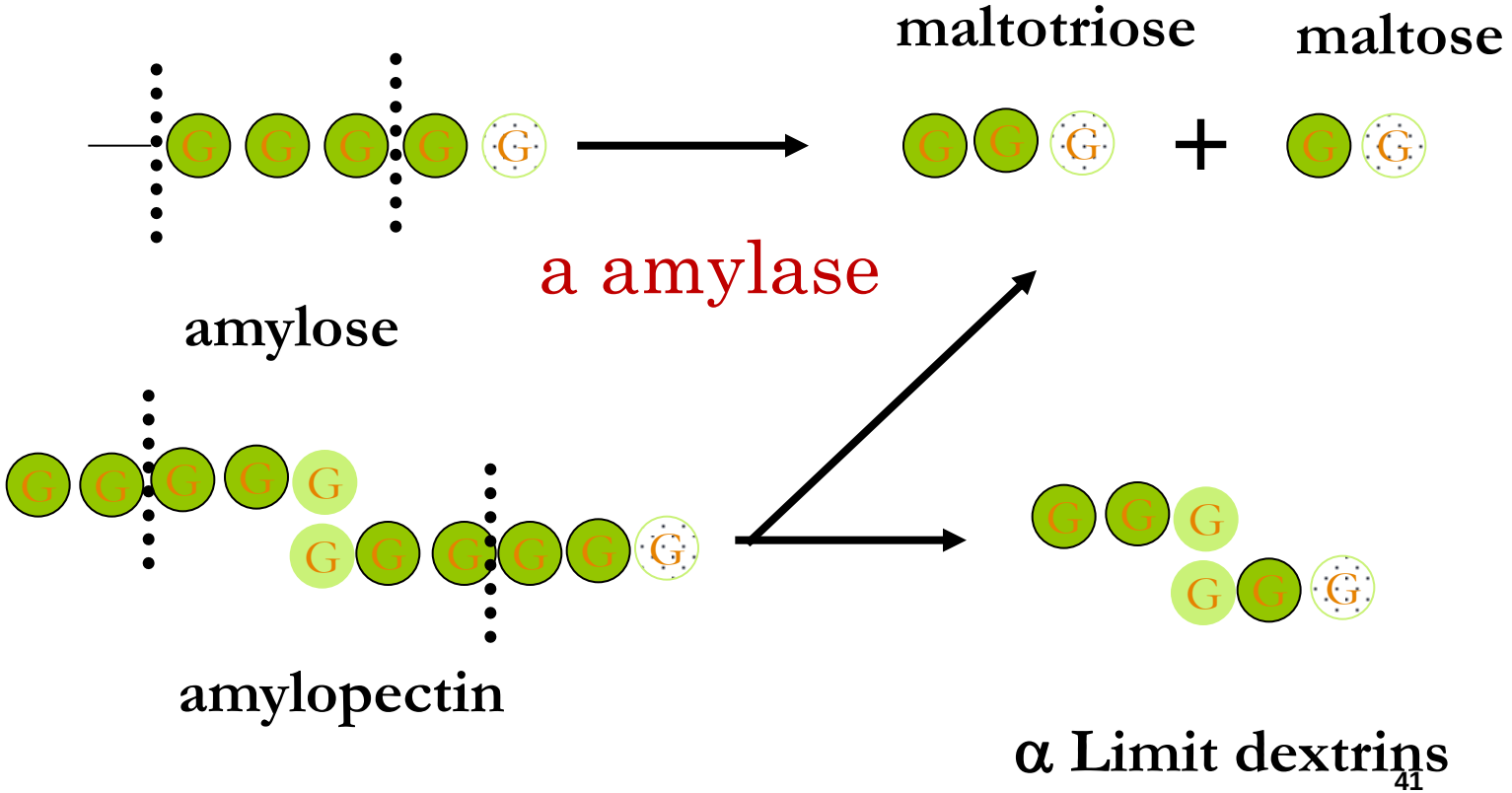
- **Enzymes associated with intestinal surface membranes**

i. **Sucrase**
ıı. **α dextrinase**
iii. **Glucoamylase (maltase)**
iv. **Lactase**
v. **peptidases**

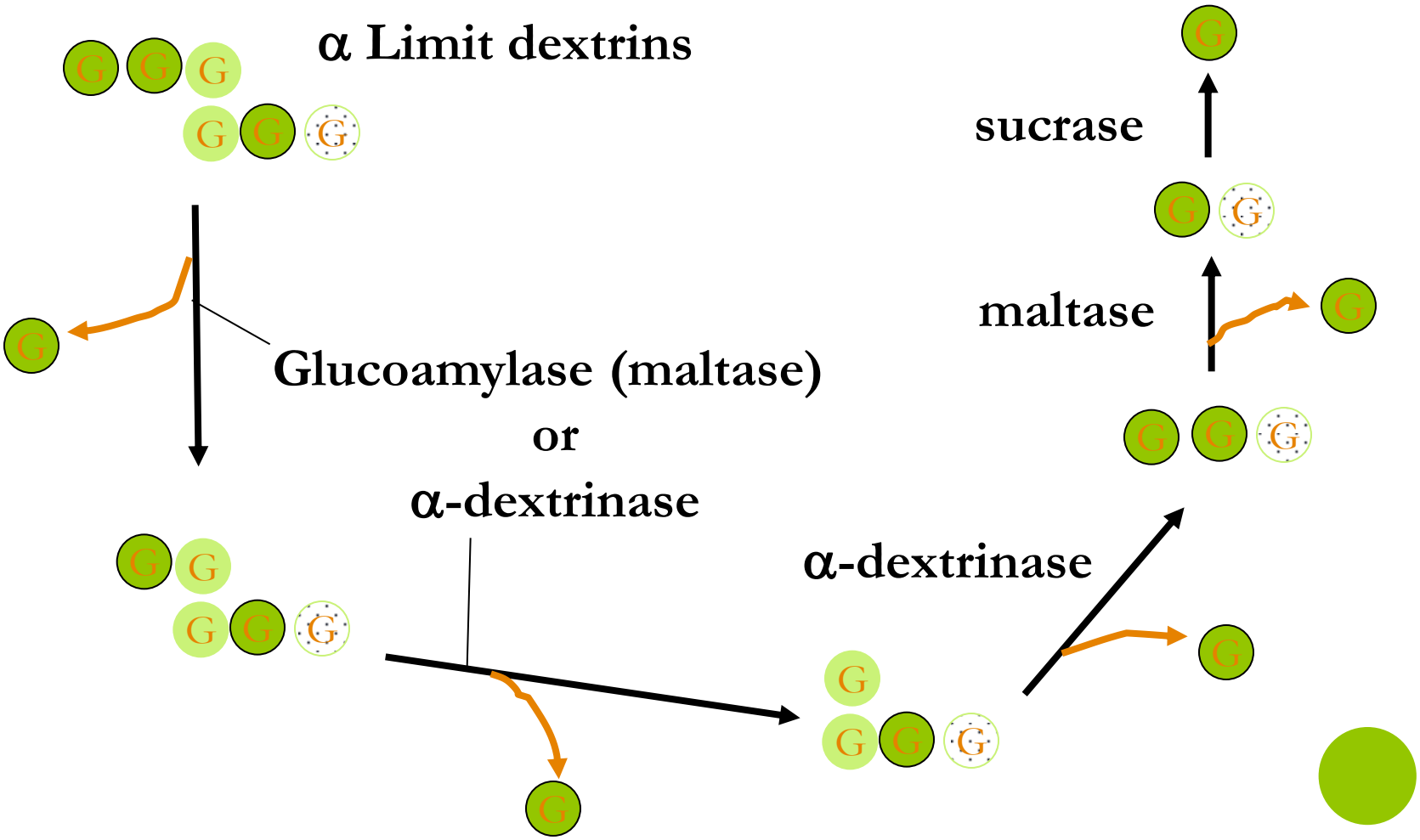
Small Intestine

- **Pancreatic enzymes**

a-amylase



OLIGOSACCHARIDE DIGESTION.CONT



Protein

- Energy source: 4 kilocalories/gram
- **Recommended intake: 15-20% of total calories from protein**
- Protein are complex organic nitrogenous compounds.
- They also contain sulfur and some cases phosphorus and iron
- Proteins are made of monomers called amino acids.
- They are about 20 different amino acids which are found in human body. Of this 8 AA are termed " Essential AA."
  - ***Essential* amino acids** must be obtained from food
  - ***Nonessential* amino acids** can be built by the body

.

Protein

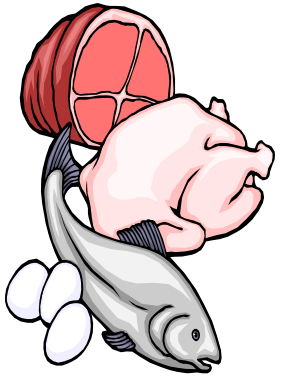
Proteins are nutrients that help build and maintain body cells and tissues.

Proteins are classified into two groups:

- **Complete proteins** contain amounts of all nine essential amino acids.

SOURCES INCLUDE:

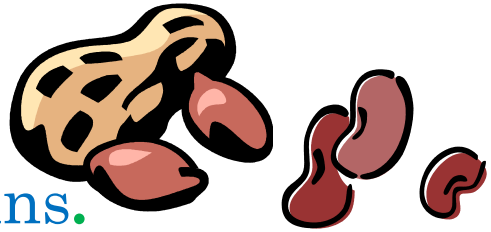
*Fish, meat, poultry, eggs, milk, cheese, yogurt, and many soybean products.



- **Incomplete proteins** lack one or more essential amino acids.

SOURCES INCLUDE:

*Beans, peas, nuts, and whole grains.



Amino Acids in Animal Protein

In-Dispensable

Histidine,	HIS
Isoleucine,	ILE
Leucine,	LEU
Lysine,	LYS
Methionine,	MET
Phenylalanine,	PHE
Threonine,	THR
Tryptophan,	TRP
Valine,	VAL

Semi-dispensable

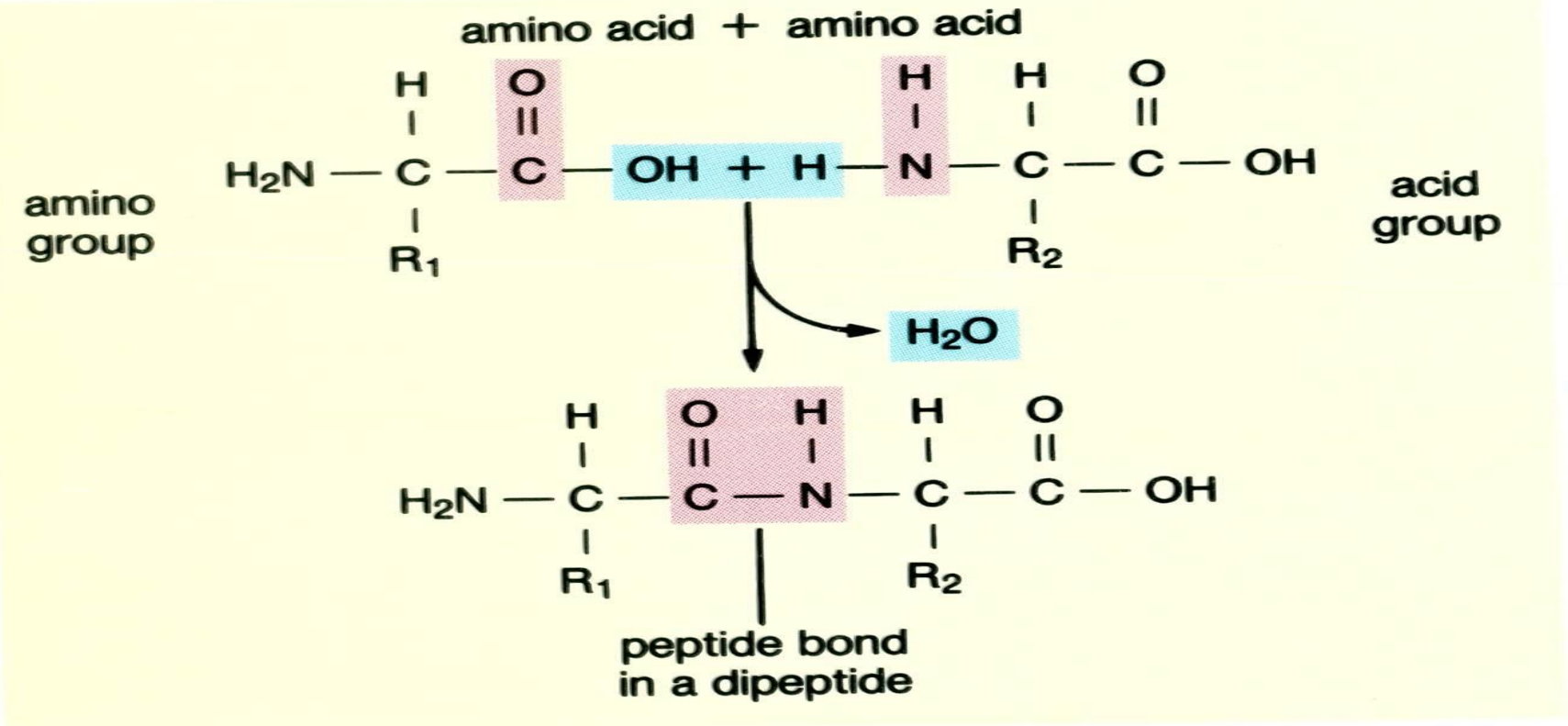
Arginine,	ARG
Glutamine	GLN
Proline,	PRO

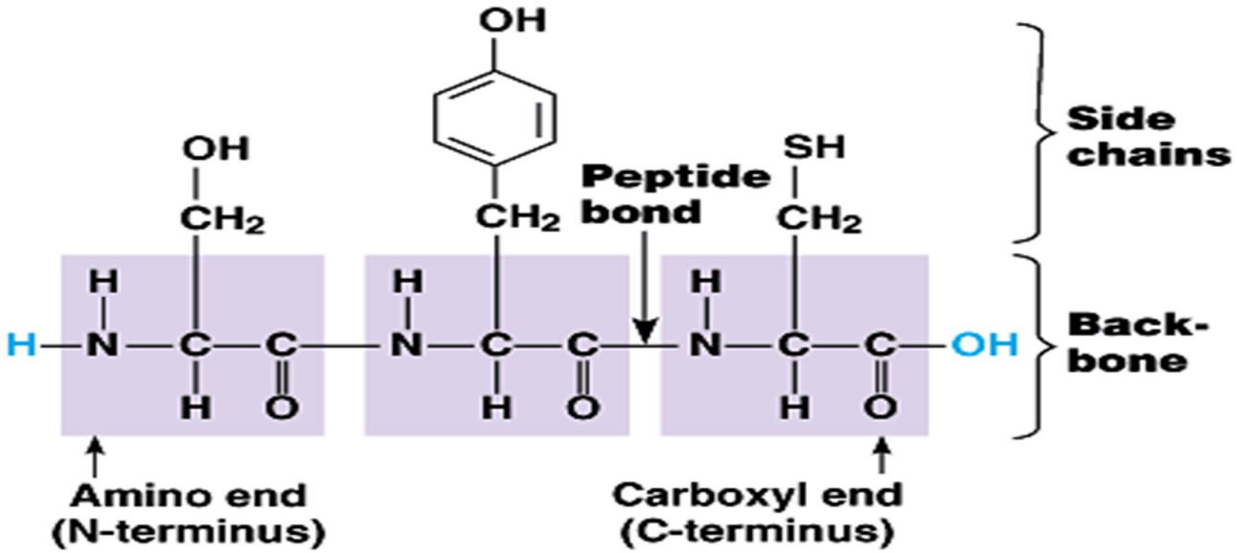
Dispensable

Alanine,	ALA
Asparagine,	ASN
Aspartate,	ASP
Cysteine,	CYS
Glutamate,	GLU
Glycine,	GLY
Serine,	SER
Tyrosine,	TYR

Amino Acids

- Composed of central C bonded to 4 groups
  - Amino group: -NH2
  - Carboxyl group: -COOH
  - Hydrogen: -H
  - R group: completes amino acid, variable in structure
- Essential AAs(Indispensable AA)- AAs that cannot be synthesized from other AAs in humans, must be consumed
- Non-essential Aas(Dispensable AA)- AAs that can be synthesized from other AAs in humans

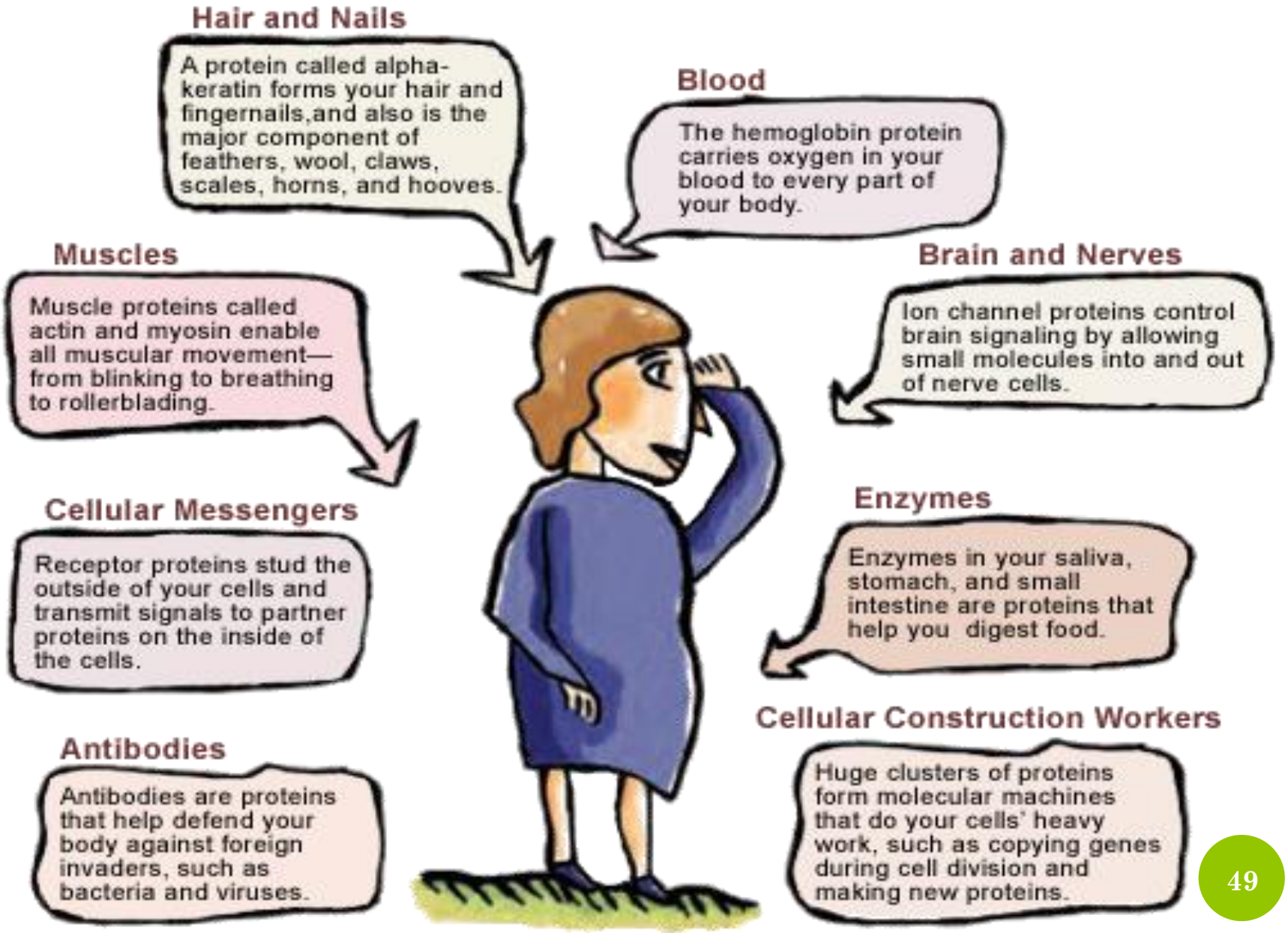

amino acid + amino acid
amino group
acid group
H_2O
peptide bond in a dipeptide


Peptide bond
Side chains
Back-bone
Amino end (N-terminus)
Carboxyl end (C-terminus)

Functions

Functions: Growth and maintenance of tissue, acid-base balance

- Builds and repairs muscles and cell tissues
- Repair and maintenance of body tissues
- Synthesis of bioactive substances and other vital molecules eg. enzymes, hormones, and antibodies
- Regulates body processes eg. Maintenance of osmotic pressure
- Supplies energy (4Kcal/g)


Hair and Nails
A protein called alpha-keratin forms your hair and fingernails,and also is the major component of feathers, wool, claws, scales, horns, and hooves.
Blood
The hemoglobin protein carries oxygen in your blood to every part of your body.
Muscles
Muscle proteins called actin and myosin enable all muscular movement—from blinking to breathing to rollerblading.
Brain and Nerves
Ion channel proteins control brain signaling by allowing small molecules into and out of nerve cells.
Cellular Messengers
Receptor proteins stud the outside of your cells and transmit signals to partner proteins on the inside of the cells.
Enzymes
Enzymes in your saliva, stomach, and small intestine are proteins that help you digest food.
Antibodies
Antibodies are proteins that help defend your body against foreign invaders, such as bacteria and viruses.
Cellular Construction Workers
Huge clusters of proteins form molecular machines that do your cells' heavy work, such as copying genes during cell division and making new proteins.

Fats

- Energy source: 9 kilocalories/gram
- Lipids or Fat- nonpolar compound with long chains of carbon atoms
- **Recommended intake: 20-30% of total calories intake.**

Lipid Classes

- **Simple lipid : Triglycerides**
  - made of 3 fatty acids (fa) & 1 glycerol
  - fa 4-22 Carbons long; mostly 16-20 C atoms
  - 95% of dietary lipids (fats & oils)
- **Compound lipid: compose with other comp.**
- **1. Lipoprotein**
- **2. Phospholipids**
  - 1 fa replaced by a phosphate group
- **3. Sterols**
  - complex ringed structures; noncaloric
  - ex. cholesterol & Vit D

Fatty Acids

Types of fatty acids include:

- **saturated;**
- **unsaturated;**
  - **monounsaturated;**
  - **polyunsaturated;**
- **Trans**

Fat is needed for health, but only in moderate amounts.

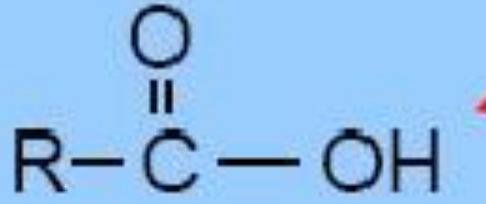
Fatty acids can differ by 1) degree of saturation or 2) length (# carbons) BUT NOT by calories (all 9 kcals/g)

Fatty acids

Fatty acids have carboxylic acid functional group- most often even number of C atoms

In cells and tissues fatty acids occur in large amounts in complex lipids, but only as traces in the free form.

All contain a long *hydrocarbon chain* and a terminal *carboxyl* group.



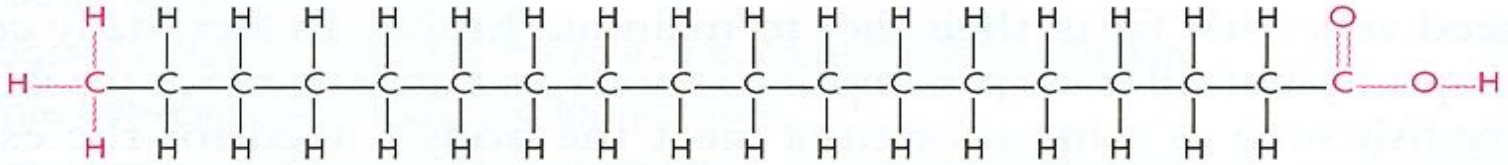
This is the general structure of a fatty acid.

(Methyl group)

Saturated fatty acid (stearic acid; C18:0)

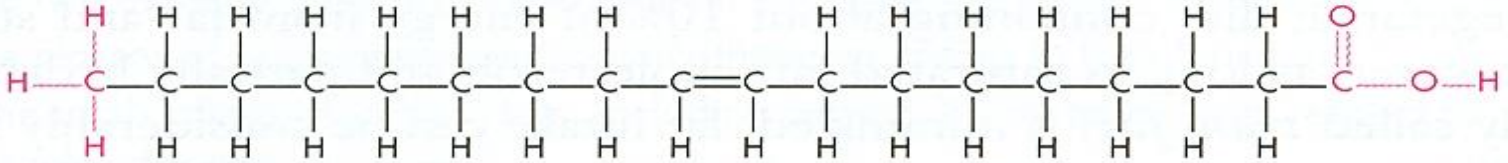
(Acid group)

A



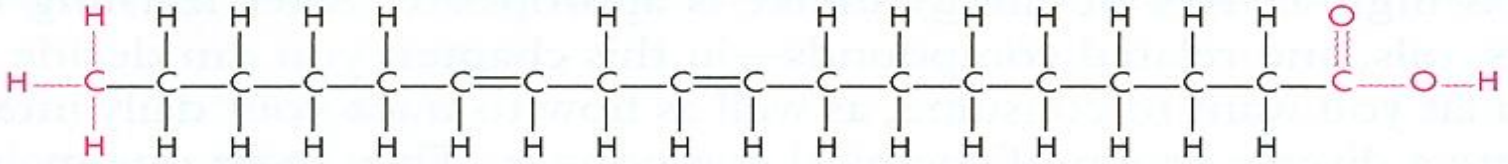
Monounsaturated fatty acid (oleic acid; ω-9; C18:1)

B



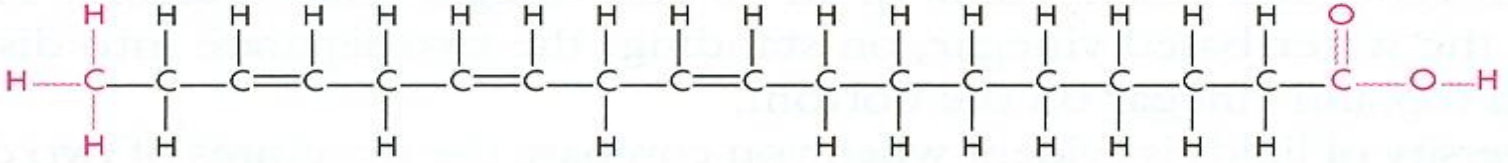
Polyunsaturated fatty acid (linoleic acid; ω-6; C18:2)

C



Polyunsaturated fatty acid (alpha-linolenic acid; ω-3; C18:3)

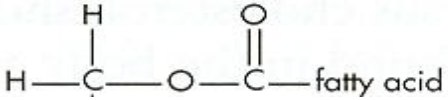
D



Triglyceride

E

G



Lecithin, a phospholipid

Saturated Fats

- Saturated fats-- contain only single covalent bonds
- maximum # of Hydrogen atoms
- usually solid at room temp.
- mostly from animal sources
- Exceptions - tropical oils (palm, coconut) are very saturated
- raise blood cholesterol

Unsaturated Fats

- Unsaturated fats--contain one or more double covalent bonds
- fewer H atoms; double bonds b/t Carbons
- usually liquid at room temp.
- mostly plant and fish sources
- more chemically active (turn rancid faster)
- lower blood cholesterol
- **Monounsaturated fat acid (MUFA)** - 1 double bond (minus 2 H)
- **Polyunsaturated fat acid (PUFA)** - 2 or more double bonds

Essential Fatty Acids

- Location of carbon double bonds has big effect on how FA is metabolized
  - If first C=C is 3 C from methyl end, it is omega-3 FA (alpha-linolenic acid)
  - If first C=C is 6 C from methyl end, it is omega-6 FA (linoleic acid)
  - If first C=C is 9 C from methyl end, it is omega-9 FA
- Alpha-linolenic acid and linoleic acid are only obtained from foods we eat
  - These FAs play important role in forming membranes, in vision, immune system, and create eicosanoids
  - Humans cannot synthesize omega-3 or omega-6 FAs, only omega-9 or further

FATTY ACID FAMILY

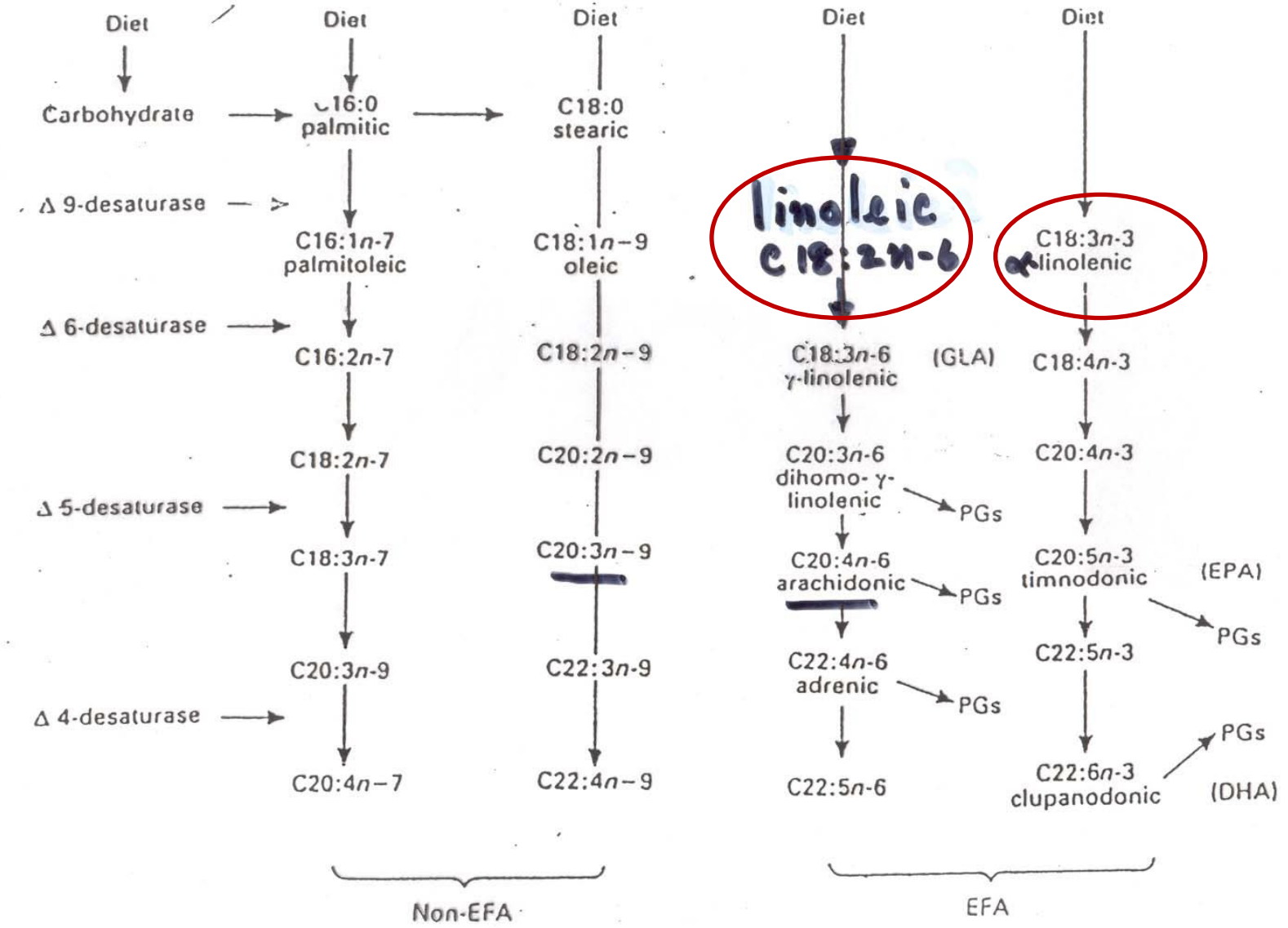
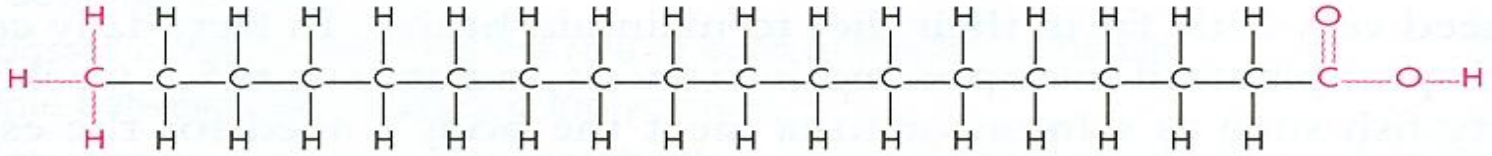


Fig. Metabolism of the various classes of dietary fatty acids. (EFA, essential fatty acid; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; GLA, gamma linolenic acid; PG, prostanoids.)

Saturated fatty acid (stearic acid; C18:0)

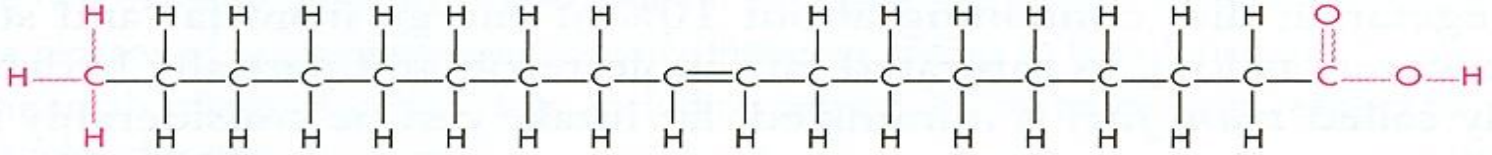
(Methyl group) (Acid group)

A



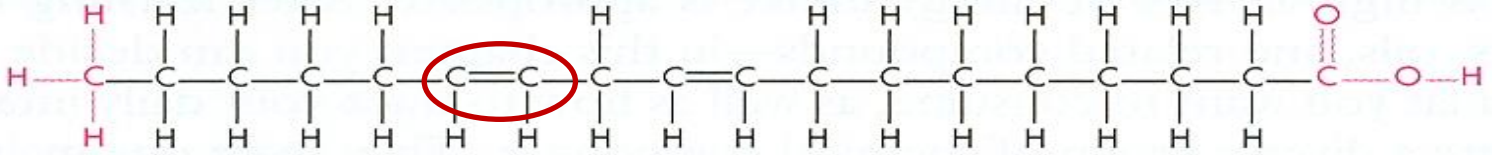
Monounsaturated fatty acid (oleic acid; ω-9; C18:1)

B



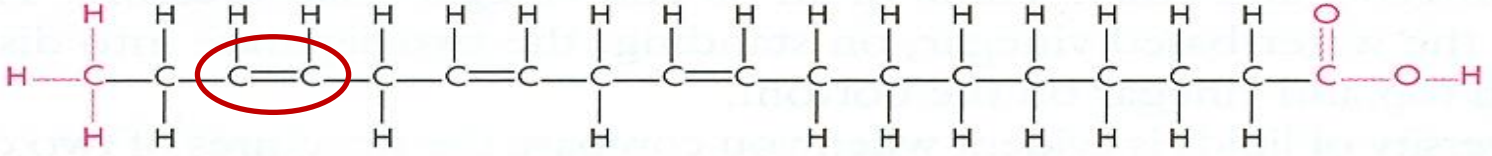
Polyunsaturated fatty acid (linoleic acid; ω-6; C18:2)

C



Polyunsaturated fatty acid (alpha-linolenic acid; ω-3; C18:3)

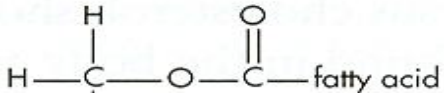
D



Triglyceride

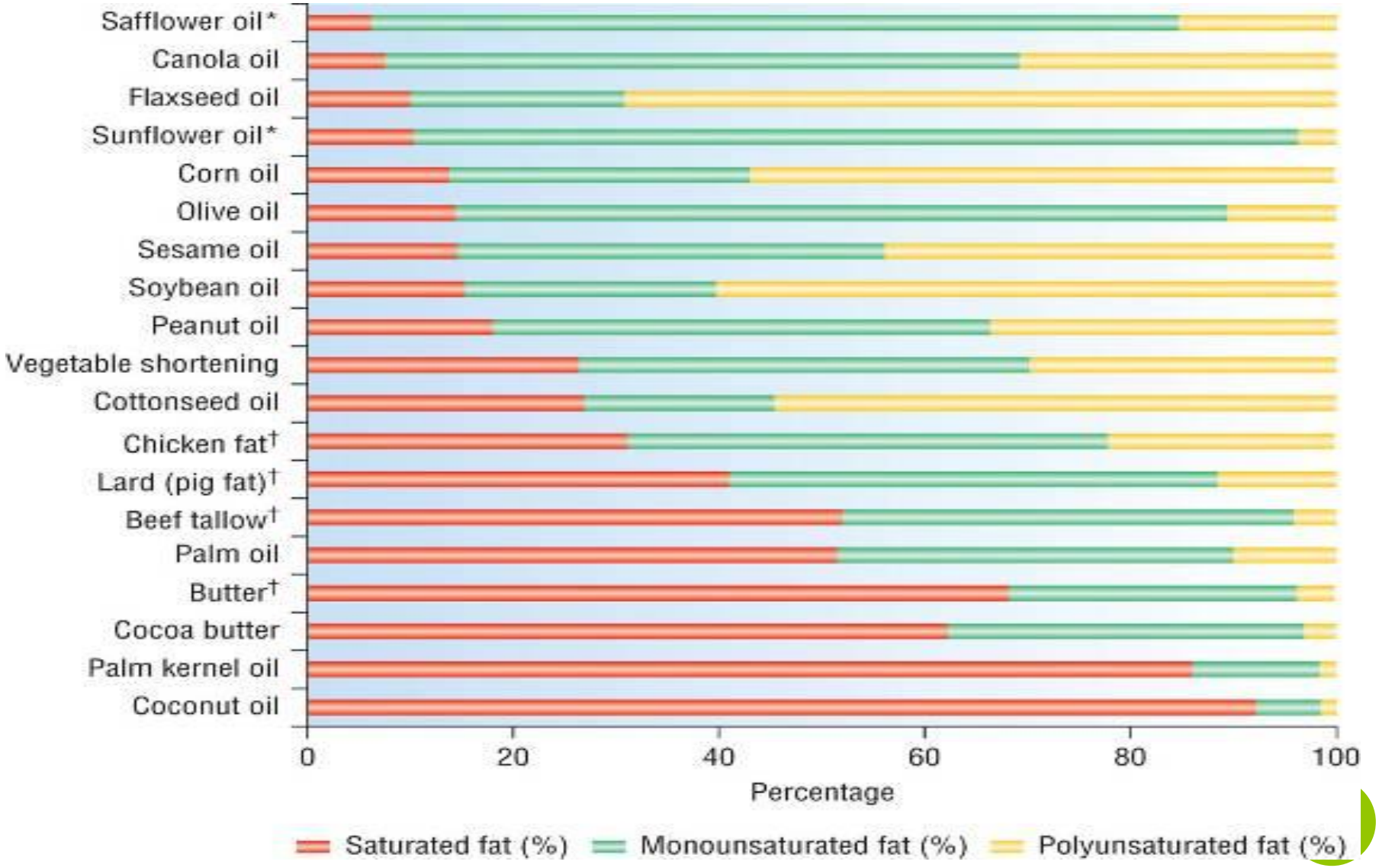
E

G



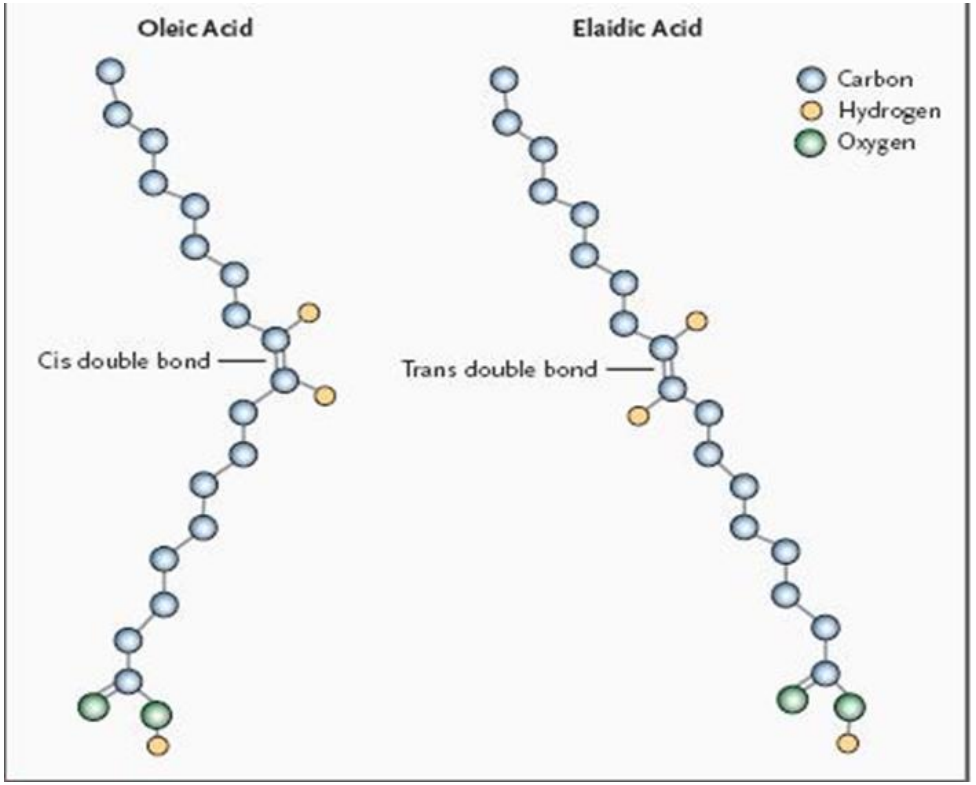
Lecithin, a phospholipid

Composition of Dietary Fats



Trans fats

- Altered form of unsaturated fat (hydrogen added)
- Associated with unhealthy changes in cell membranes
- Raises levels of "bad" cholesterol and lowers levels of "good" cholesterol
- Found in margarine, snack foods, and some deep fried fast foods
  - ***Check food labels***



Fats

Fats are a type of lipid, a fatty substance that do not dissolve in water.

Saturated fats

Animal fat: milk, meat, eggs, butter, and cheese; lard (pork fat), tallow (beef and lamb fat),

Tropical oils: coconut and palm oil

Monounsaturated fats

Olive oil

Polyunsaturated fats

Omega 6: Vegetable oils (soybean, safflower, sunflower, corn, cottenseed, peanut, Canola)

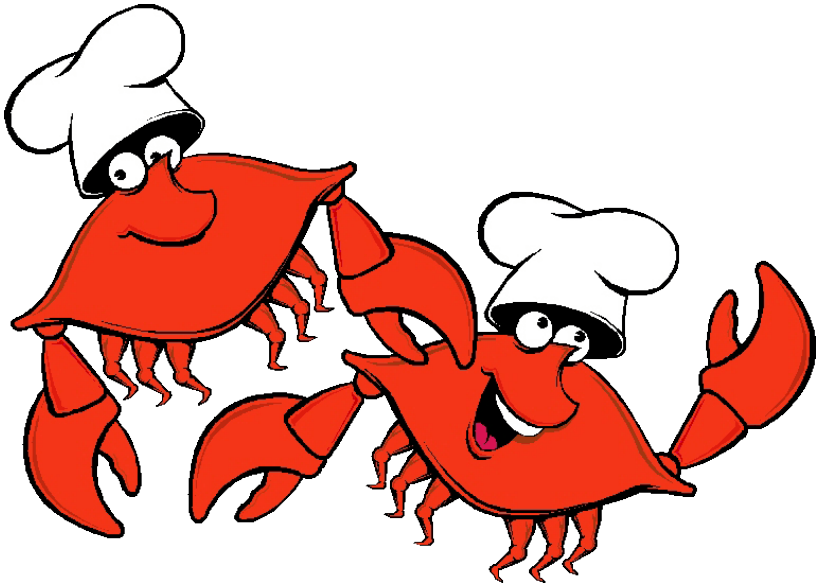
Omega 3: Fish oils

Trans fats

Margarine; in bakery products, snack chips, imitation cheese, and other processed foods.

Types of Fats: Cholesterol

- White fat like substance found in cells of animal origin
- **Functions:** Synthesizes cell membranes; starting material in formation of hormones and bile
- The liver can synthesize cholesterol
- Excess cholesterol in the body can clog arteries and increase risk of cardiovascular disease



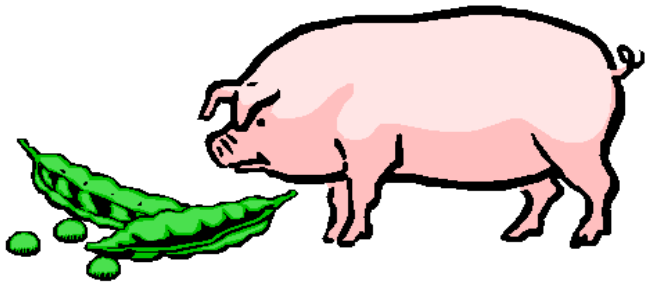
Functions

- Fatty acids that the body needs, but is unable to make are called essential fatty acids, linoleic acid which is needed for growth and healthy skin
- Fats serve as vehicles for fat-soluble vitamins A, D, E, and K
- Fats in the body support viscera such as heart, kidney and intestine; and fat beneath the skin provides insulation against cold.
- High intake of saturated fats is linked to increased cholesterol production and excess cholesterol can lead to an increased risk of heart disease
- Providing high energy as much as 9 kcal for every gram.

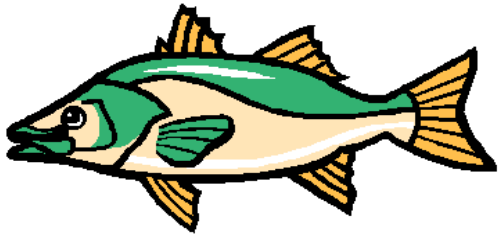
Function

- Fats provide flavor
- Contribute to satiety
- Are essential for completion of development of central nervous system
- Generally fat intake should not be restricted in children under 5 years of age
- Act as emulsifiers (thickeners for foods and suspend fats)

n-6/n-3 on Platelet Aggregation & Inflammation



n-6 PUFAs



n-3 PUFAs

AA

EPA

PGE-2, TXA-2, LTB-4

PGE-3, TXA-3, LTB-5

+++

+

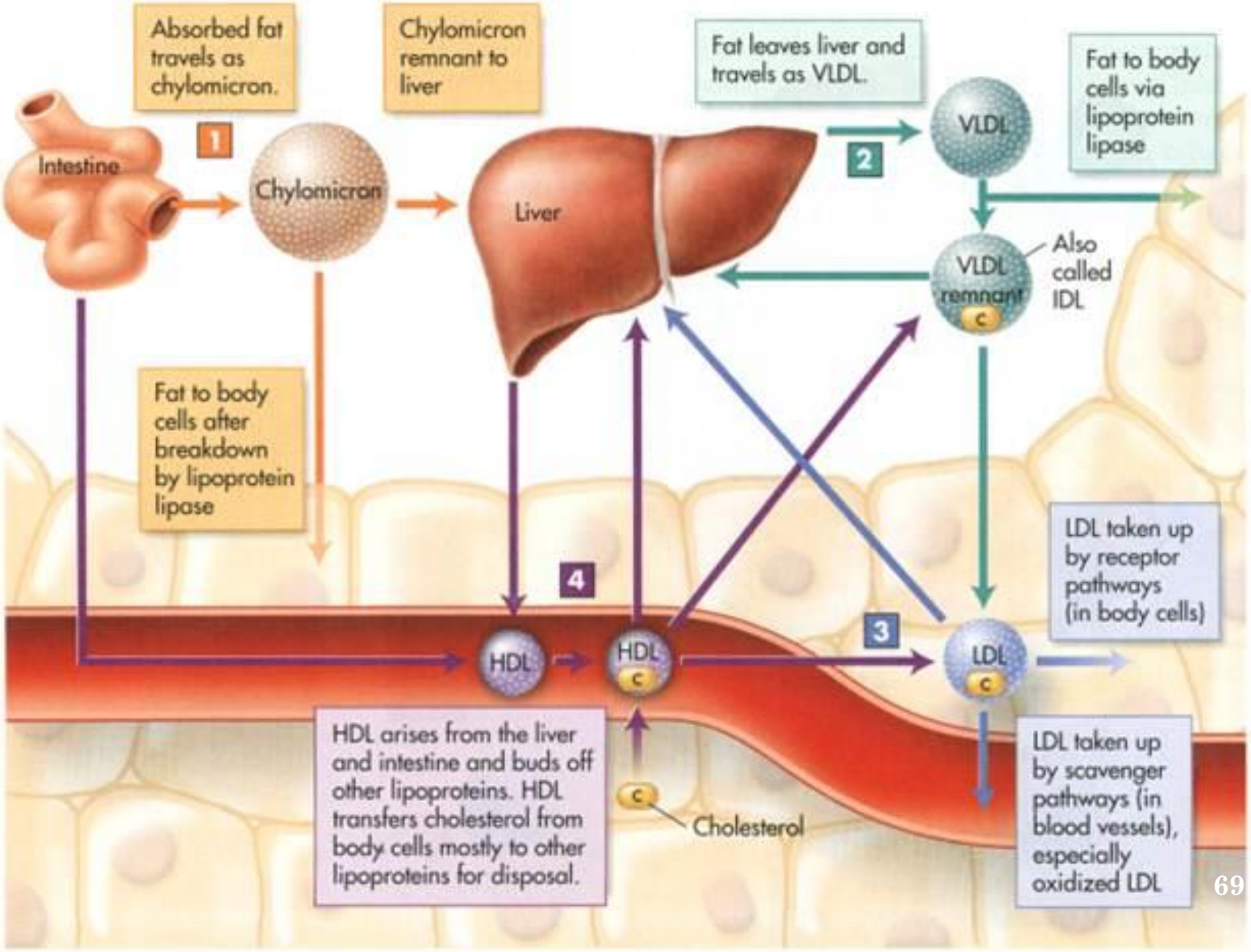
Platelet Aggregation
Inflammation

Cholesterol Functions

- Cell membranes
- Precursor for Vitamin D & some hormones (estrogen, testosterone)
- Major component of bile
- ONLY FOUND IN ANIMALS; NEVER FOUND IN PLANTS
- not an essential nutrient since man makes

Fats: General Recommendations

- 20-30% of total daily calories from fat
- Less than 10% of calories from saturated fat
- Less than 300 mg/day of cholesterol
- The **World Health Organization** recommends an omega-6 fatty acid intake of 5–8% of energy and an omega-3 fatty acid intake of 1–2% of energy Keep trans-fatty acid consumption as low as possible
- Get most fats from sources of unsaturated fats
  - Fish
  - Nuts
  - Vegetable oils


Absorbed fat travels as chylomicron.
Chylomicron remnant to liver
Fat leaves liver and travels as VLDL.
Fat to body cells via lipoprotein lipase
Intestine
1
Chylomicron
Liver
2
VLDL
VLDL remnant
C
Also called IDL
Fat to body cells after breakdown by lipoprotein lipase
4
3
HDL
HDL
C
LDL
C
LDL taken up by receptor pathways (in body cells)
HDL arises from the liver and intestine and buds off other lipoproteins. HDL transfers cholesterol from body cells mostly to other lipoproteins for disposal.
C
Cholesterol
LDL taken up by scavenger pathways (in blood vessels), especially oxidized LDL

Excessive Fat Intake

- High sat fat (higher than 10% of total caloric intake) increase blood LDL and cholesterol deposits in vasculature, and impair immune system function
- Moderate omega-3 FA intake (8 ounces of fish/week) can reduce blood clotting abilities and regulate heart rate, reducing heart attack risk
  - 4-8 ounces of fish/day can reduce blood triglycerides
  - Excess omega-3s can impair immune system, cause uncontrolled bleeding, and increase risk of hemorrhagic stroke
- Omega-3 and omega-6 FAs use same metabolic pathways and can compete with each other
  - o much omega-6 can cause buildup of arachidonic acid, which can produce inflammation causing prostaglandins
  - Low omega-3 can also make inflammatory diseases worse, like arthritis

Excessive Fat Intake

- Rancid fats contain peroxides and aldehydes that damage cells
  - Polyunsat fats go rancid easily because double bonds are damaged easily by oxygen, heat, metals, and light- then they decompose
  - Sat trans fats are resistant to this
  - Highest risk in fish and vegetable oils, packaged fried foods
  - Prevent rancidity by breaking double bonds and adding hydrogen (hydrogenation), using airtight packaging, or adding antoxidants (vitamin E, vitamin C)
- Hydrogenated fat excess (trans fats) raises blood cholesterol levels, lower HDL, increase inflammatory responses, raise body weight stored in abdomen in visceral fat (increases type 2 diabetes risk)

Excessive Fat Intake

- In general, diets high in fat (esp sat fats) increase risk of colon, prostate, and breast cancer
  - Colon cancer risk might be due to excess bile salt secretion may irritate intestinal cells and damage them, leading to increased rate of mitosis and possible tumor development
  - High fat diets elevate blood lipid levels, which in turn raise blood estrogen levels (low fat diets lower blood estrogen)
    - This in turn causes higher risk of breast and prostate cancer

Micronutrients

The micronutrients are divided into:

- **vitamins;**
- **minerals.**

Vitamins are needed in much smaller amounts than macronutrients.

Amounts are measured in milligrams(1mg = 0.001g)and micrograms (1µg = 0.001mg).

Vitamins

- Organic compounds needed in small amounts for normal growth, reproduction, and maintenance of health
- Serve as co-enzymes
- **Provide no energy: 0 calories/gram**
- They cannot be synthesized by the body. Must be obtained by outside sources like diet, rumen bacteria & sun.

Vitamins

Vitamins are compounds that help regulate many vital body processes that include:

1. Digestion 2. Absorption 3. Metabolism 4. Circulation

Vitamins are classified into two groups:

- **Water-soluble vitamins** dissolve in water and pass easily into the blood during digestion. The body does not store these so they need to be replenished regularly. Includes vitamins C, B_1 ,B_2, Niacin(B_3), B_6, Folic acid (B_9), and B_{12}
- **Fat-soluble vitamins** are absorbed, stored, and transported in fat. Your body stores these vitamins in your fatty tissue, liver, and kidneys. Excess buildup can be toxic. These include vitamins A, D, E, and K.

Class of Vitamins

Fat Soluble Vitamins:

stored in tissues

Examples

A

D

E

K

Water Soluble Vitamins:

not stored in tissues, must have constant supply

Examples

B, B1, B2, B6 & B12

Niacin

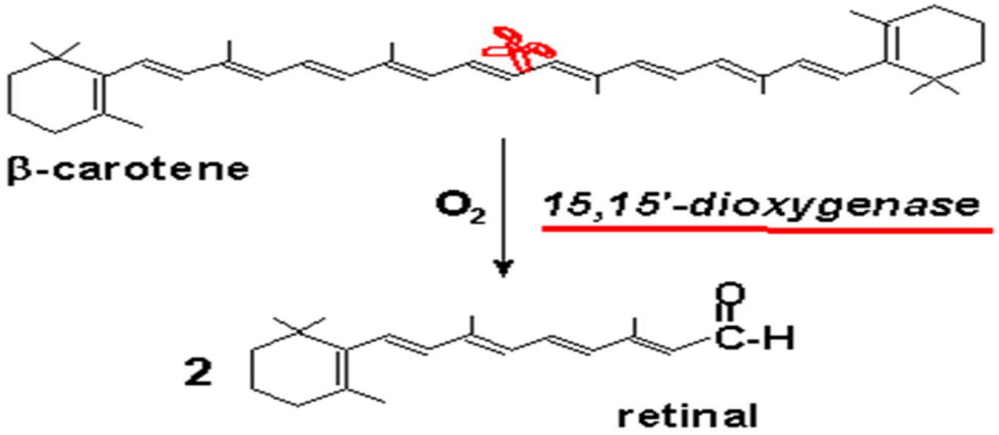
Folic Acid

C

VITAMIN A

- Vitamin A» covers both a pre-formed vitamin, retinol, and a pro-vitamin, beta carotene, some of which is converted to retinol in the intestinal mucosa.
- The international unit (IU) of vitamin A is equivalent to 0,2 microgram of retinol (or 0,55 microgram of retinal palmitate).

Vitamin A
initial metabolism:

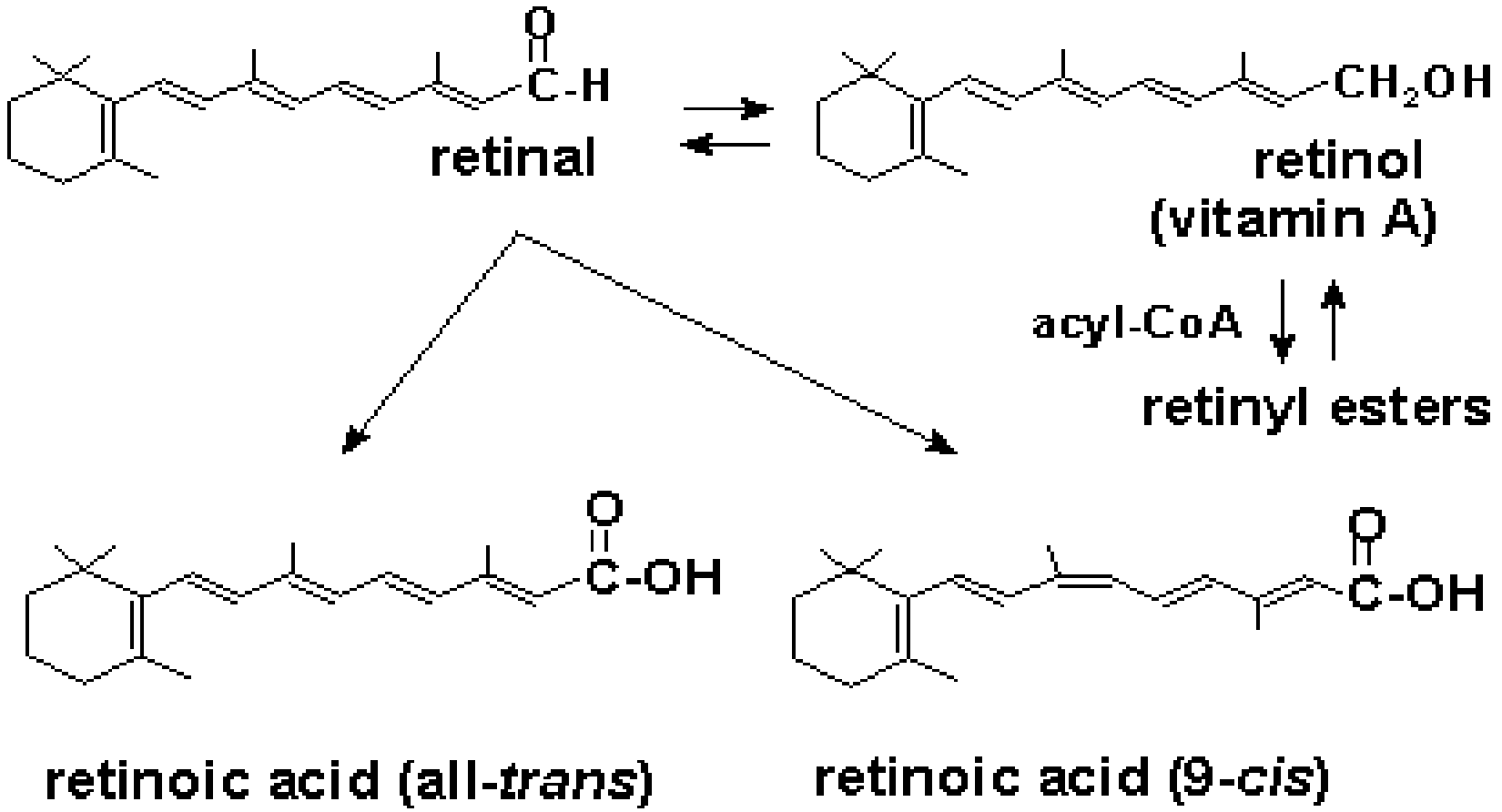


Functions of Vitamin A

- Role in vision = visual transduction process. It contributes to the production of retinal pigments which are needed for vision lights.
- Role as antioxidant.
  - Protection against oxygen free radicals.
  - Studies as to its prevention against cancer, heart disease and blindness.
- Role in normal epithelial cell growth and differentiation. It is necessary for maintaining the integrity and the normal functioning of glandular and epithelial issue which lines intestinal , respiratory and urinary tracts as well as the skin and eyes.
  - Prevention against tumors from epithelial cells = carcinoma such as bronchial cancers.

Vitamin A

reduction or oxidation:

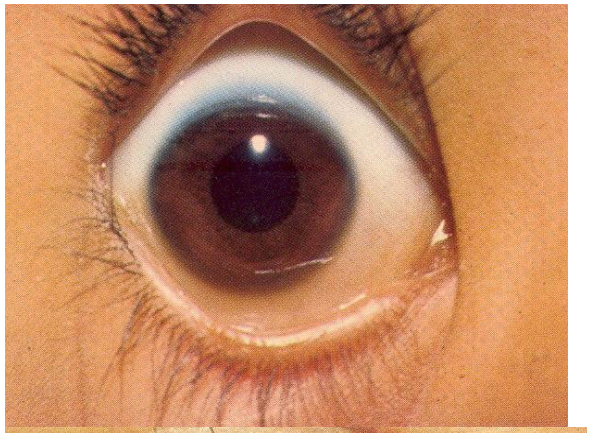


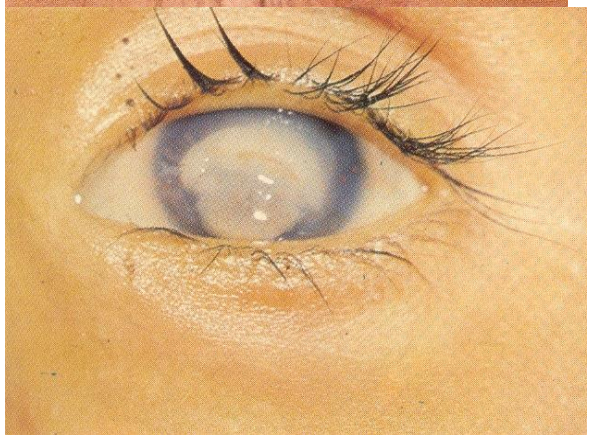
Deficiency of vitamin A

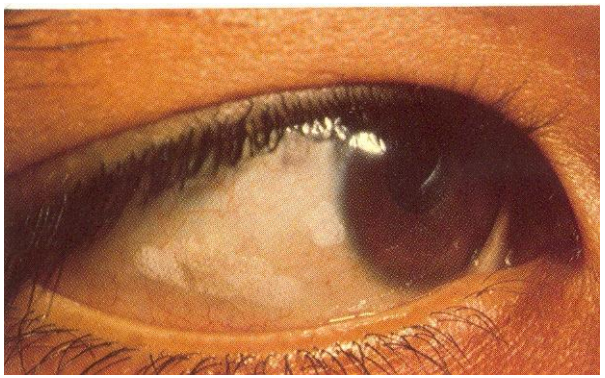
- **The signs of vitamin A deficiency are predominantly ocular. They are:**

- **Nightblindness**
- **Conjunctival xerosis**
- **Bigot's spots**
- **Corneal xerosis**
- **Keratomalacia**

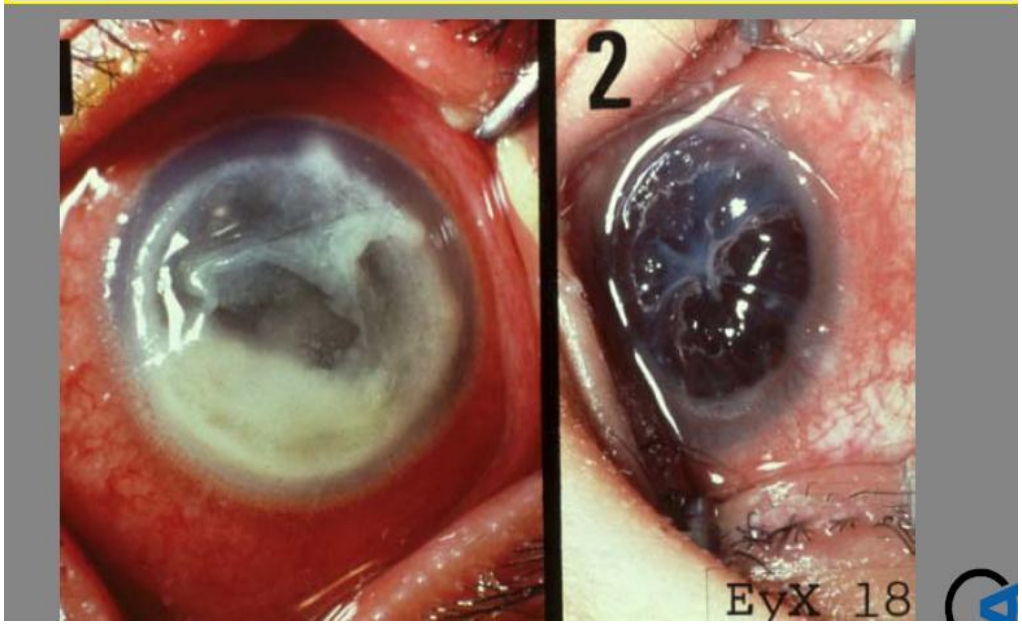
XEROPHTHALMIA



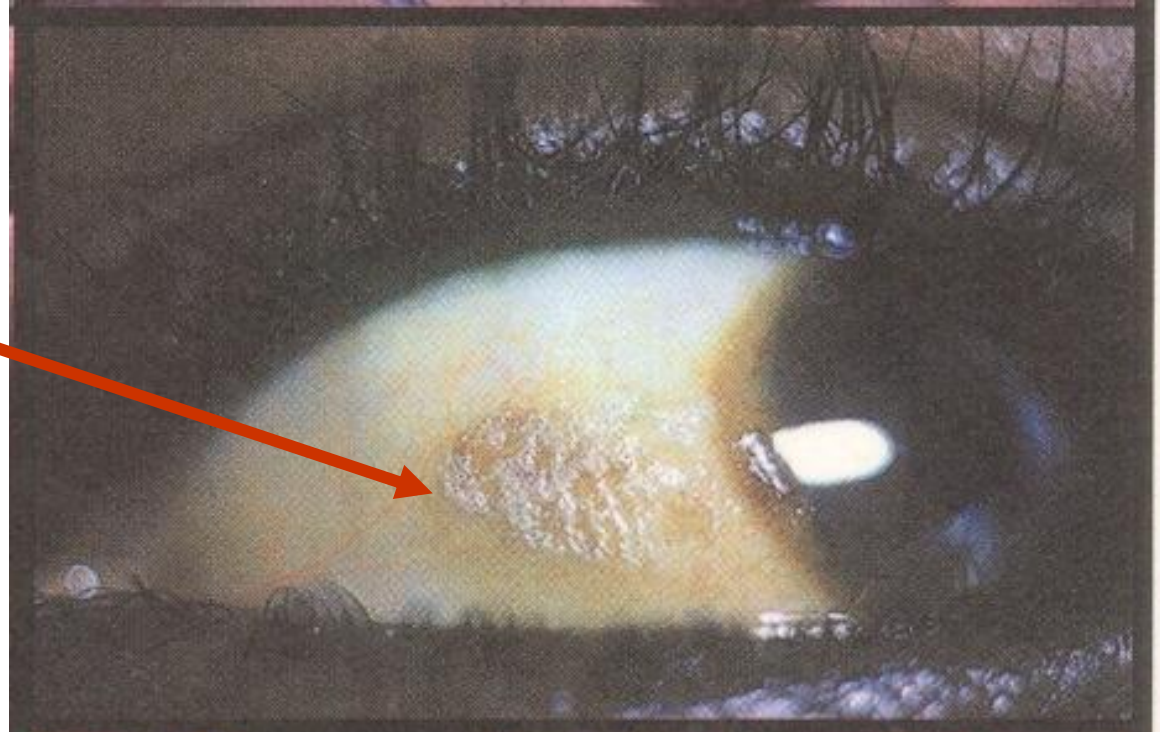




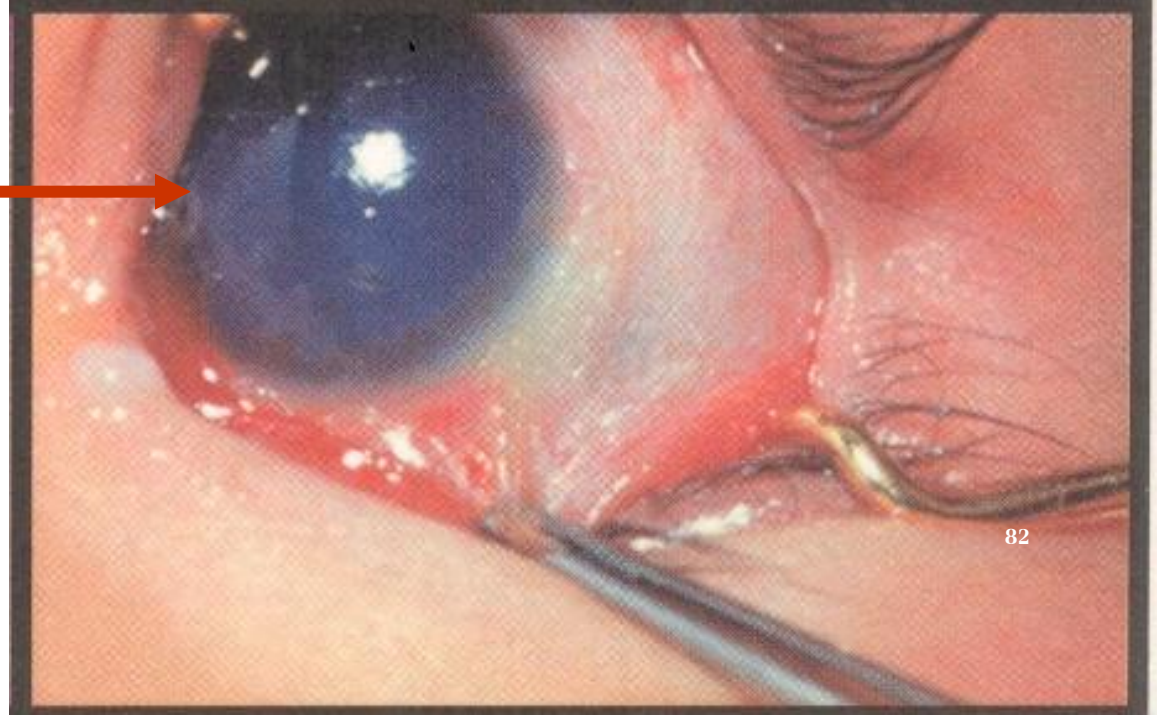
Keratomalacia leading to blindness



Bitot's spot



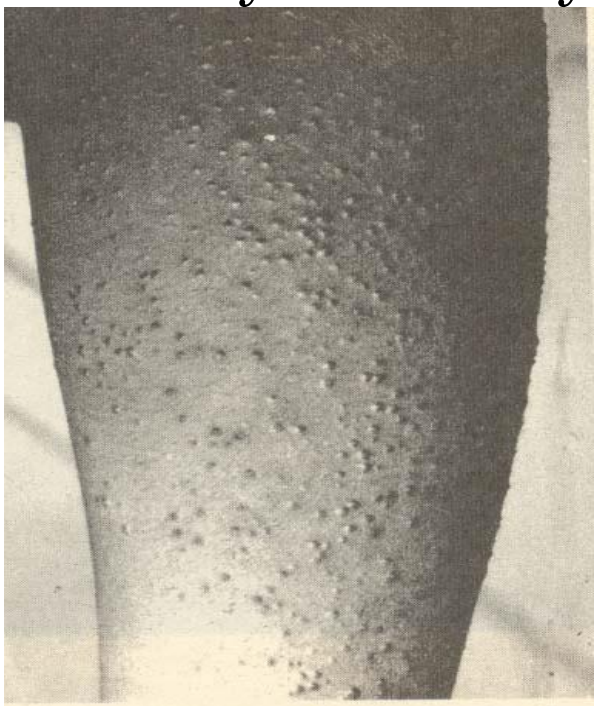
xeropthalmia



Vitamin A

Function: development healthy skin and nerve tissue. Aids in building up resistance to infection. Functions in eyesight and bone formation. **ALL ANIMALS require a source of Vitamin A.** It is important in the ration of pregnant females.

Sources: whole milk, carotene, animal body oils (cod fish and tuna), legume forages and can be synthetically produced.



A. Follicular hyperkeratosis

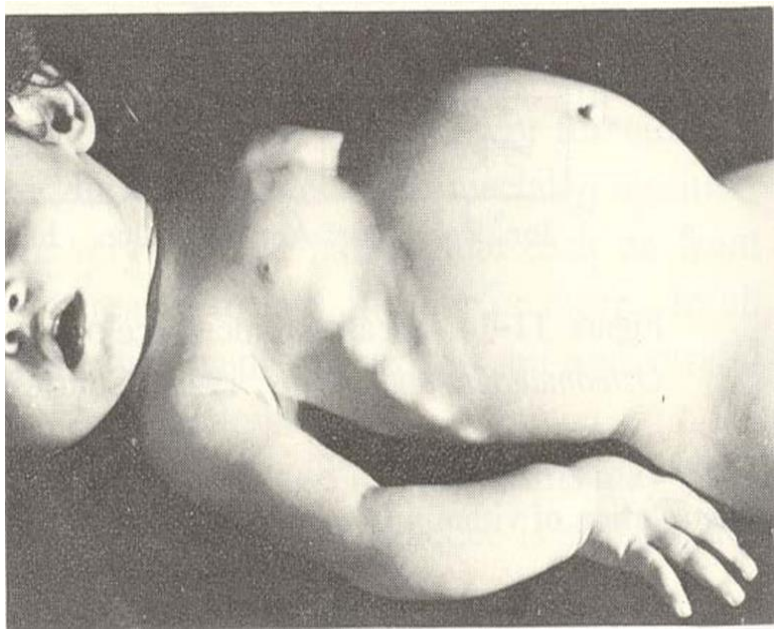
Vitamin D

- The nutritionally important forms of Vitamin D in man are Calciferol (Vitamin D2) and Cholecalciferol (Vitamin D3).
- Function: is essential for the proper utilization of calcium and phosphorus to produce normal, healthy bones.
- Intestine: Promotes intestinal absorption of calcium and phosphorus
- Bone: Stimulates normal mineralization, Enhances bone reabsorption, Affects collagen maturation
- Kidney: Increases tubular reabsorption of phosphate

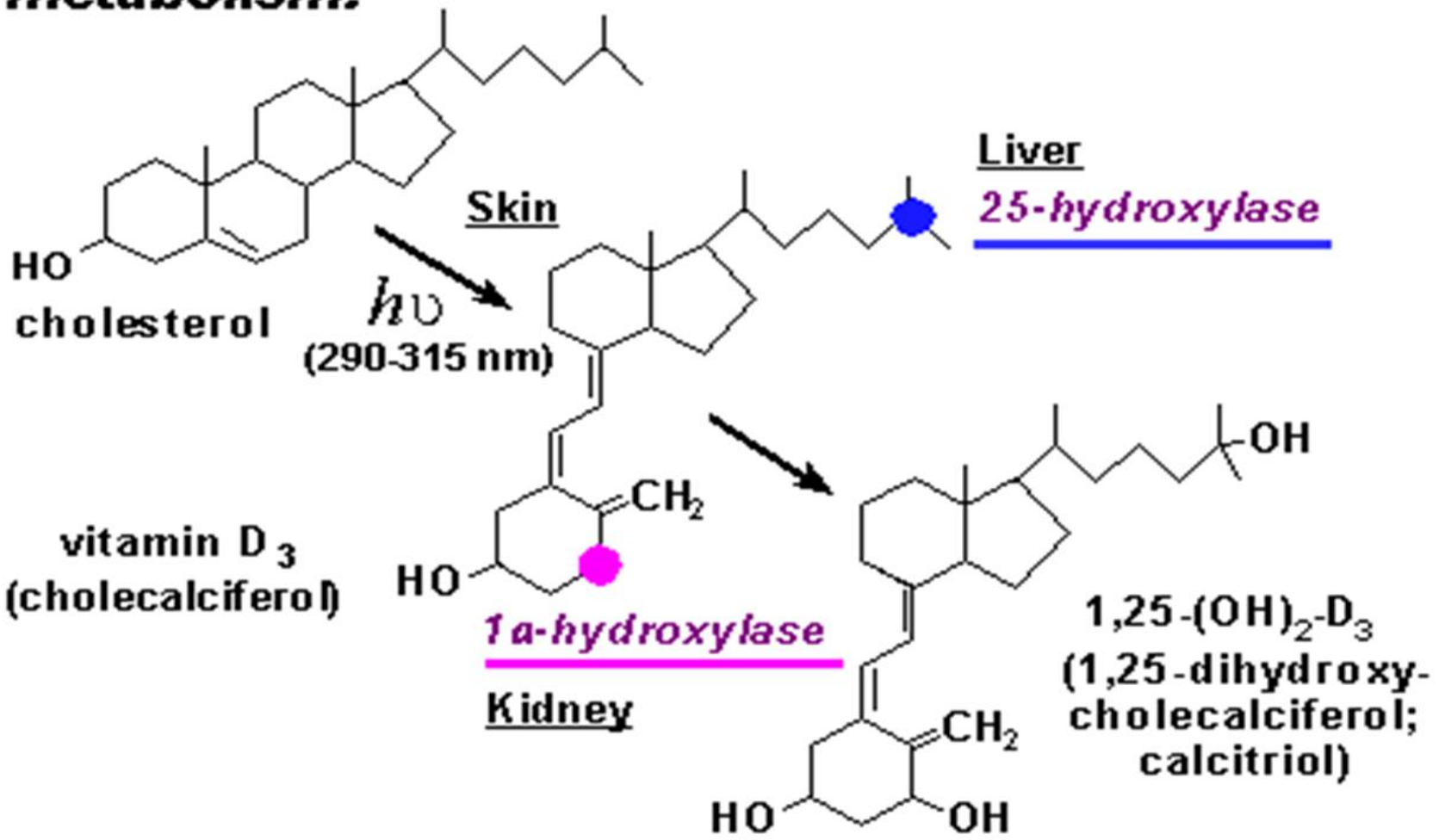
- Vitamin D.
  - Only vitamin not usually required in the diet.
  - A group of sterols produced by action of UV light on certain provitamins.
    - 7-dehydrocholesterol – animals.
      - Synthesized in the liver.
      - Found in skin.
    - Photolytic products in skin yield:
      - Vitamin D_2.
      - Vitamin D_3.
    - Further hydroxylated to yield the active compound 1,25- dihydroxyvitamin D_3 by actions at the :
      - 25 position = liver.
      - 1 position = kidney.

Deficiency signs: retarded growth, misshapen bones (rickets), lameness and osteoporosis.

Sources: Whole milk, sun-cured hays, forage crops, fish liver oils, irradiated yeast.



Vitamin D *metabolism:*



- Vitamin D deficiency.
  - Children = rickets (bowing of legs).
    - Defective bone mineralization.
    - < Ca^{++} levels.
  - Adults = osteomalacia.
    - > fractures.
    - < Ca++ levels.
  - Toxicity = 10x RDA.
    - > Ca^{++} adsorption.
      - Hypercalcemia.
      - Metastatic Ca^{++} deposition.
    - > Kidney stones.

Vitamin E

Function: normal reproduction.

Deficiency signs: poor growth, "crazy chick" disease, Muscular Dystrophy, "white muscle" disease in ruminants and swine and "stiff lamb" disease (affects the nerves and muscles).

Sources: synthetic for poultry and swine, cereal grains and wheat germ oil, green forages, protein concentrates, oil seeds (peanut and soybean oil).

Vitamin E rapidly destroyed in rancid or spoiled fats. That is why these may cause white muscle disease. Utilization of Vitamin E is dependent on adequate selenium.

Vitamin K

Function: necessary for the maintenance of normal blood coagulation.

Deficiency signs: blood loses its power to clot or the time needed for clotting is longer and serious hemorrhages can result from slight wounds or bruises.

Sources: green leafy forages, fish meal, liver, soybeans, rumen and intestinal synthesis, and the synthetic compounds.

Fat-Soluble Vitamins

Nutrient	Functions	Sources
Vitamin A	Keeps skin and mucus membranes healthy Prevents night blindness Promotes growth	Butter, dark green and yellow fruits and vegetables, egg yolk, liver, whole and fortified milk
Vitamin D	Builds strong bones and teeth	Egg yolk; fortified butter, margarine, and milk; the sun
Vitamin E	Acts as an antioxidant to protect cell membranes	Eggs, liver, salad oils, whole grain cereals
Vitamin K	Helps blood clot	Cauliflower, egg yolk, organ meats

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Water-Soluble Vitamins

Nutrient	Functions	Sources
Vitamin C (ascorbic acid)	Helps wounds heal Helps fight infection Helps promote healthy gums and tissues Promote absorption of iron	Oranges, grapefruits, tangerines (citrus fruits), cantaloupe, broccoli, tomatoes and raw cabbage
B-Complex	Keeps nervous system healthy Releases energy from food	Meats, whole grain breads and cereals, dried beans and peas

Water-Soluble Vitamins

- Vitamins Bs and C
- Eight B vitamins:
  - Thiamin (B-1)
  - Riboflavin (B-2)
  - Niacin (B-3)
  - Pyridoxine (B-4)
  - Cobalamin (B-12)
  - Folic acid
  - Pantothenic acid
  - Biotin

B Complex Vitamins

- **General function**
- Co-enzymes (activate enzymes)
- Found in the same foods
  - Single deficiency rare
- Act together in metabolism
  - Metabolic pathways used by protein, carbohydrate, and fat

Thiamin or B-1

- Thiamine (vitamin B1) is a water soluble vitamin. It is essential for the utilization of carbohydrates. Thiamine pyrophosphate (TPP), the coenzyme of cocarboxylase plays a part in activating transkelolase, an enzyme involved in the direct oxidative pathway for glucose Helps to convert carbohydrates to energy

- Foods:
  - Pork, beef, liver, peas, seeds, legumes, whole-grain products, and oatmeal

Deficiency of thiamine

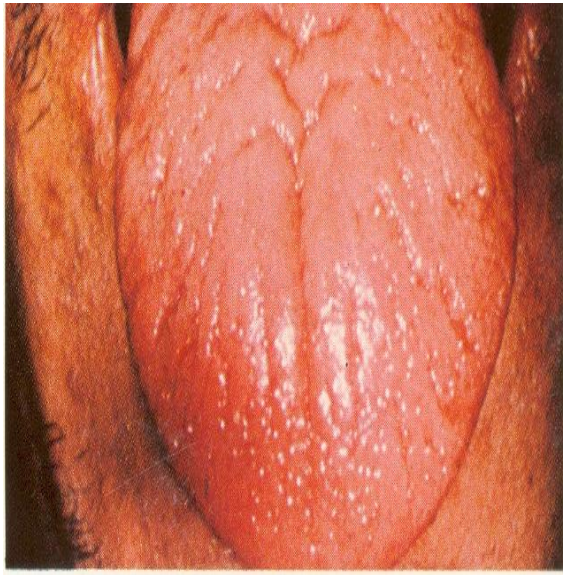
- The two principal deficiency diseases are beriberi and Wernick 's encephalopathy.
- Beriberi may occur in three main forms:
- peripheral neuritis,
- cardiac beriberi
- infantile beriberi, seen in infants between 2 and 4 months of life. The affected baby is usually breast-fed by a thiamine-deficient mother who commonly shows signs of peripheral neuropathy.
- Symptom:
  - Fatigue, nausea, depression, nerve damage

- Wernick's encephalopathy is characterized by ophthalmoplegia, polyneuritis, ataxia and mental deterioration

Riboflavin or B-2

- Is required for the formation of flavin adenine nucleotide (FAD) and flavin mononucleotide (FMN).Key to metabolism and red blood cells.
- Are also required for fatty acid breakdown (beta-oxidation) acetly-CoA (fatty acyl dehydrogenase)
- FAD needed for formation of niacin from tryptophan
- FMN needed for formation of active version of B-6 coenzyme (pyridoxal phosphate)
- Riboflavin participates in folate metabolism
- Synthesis of antioxidant compound gluthionince depends on FAD- containing enzyme gluthionine reductase

VITAMIN B2 DEFICIENCY :CHEILOSIS



Deficiency: Cheilosis: Dry, scaly skin

RDA: 1.3 mg/day in men, 1.1 mg/day in women Avg intake is 2.1 mg/day in men, 1.5 mg/day in women

Foods:

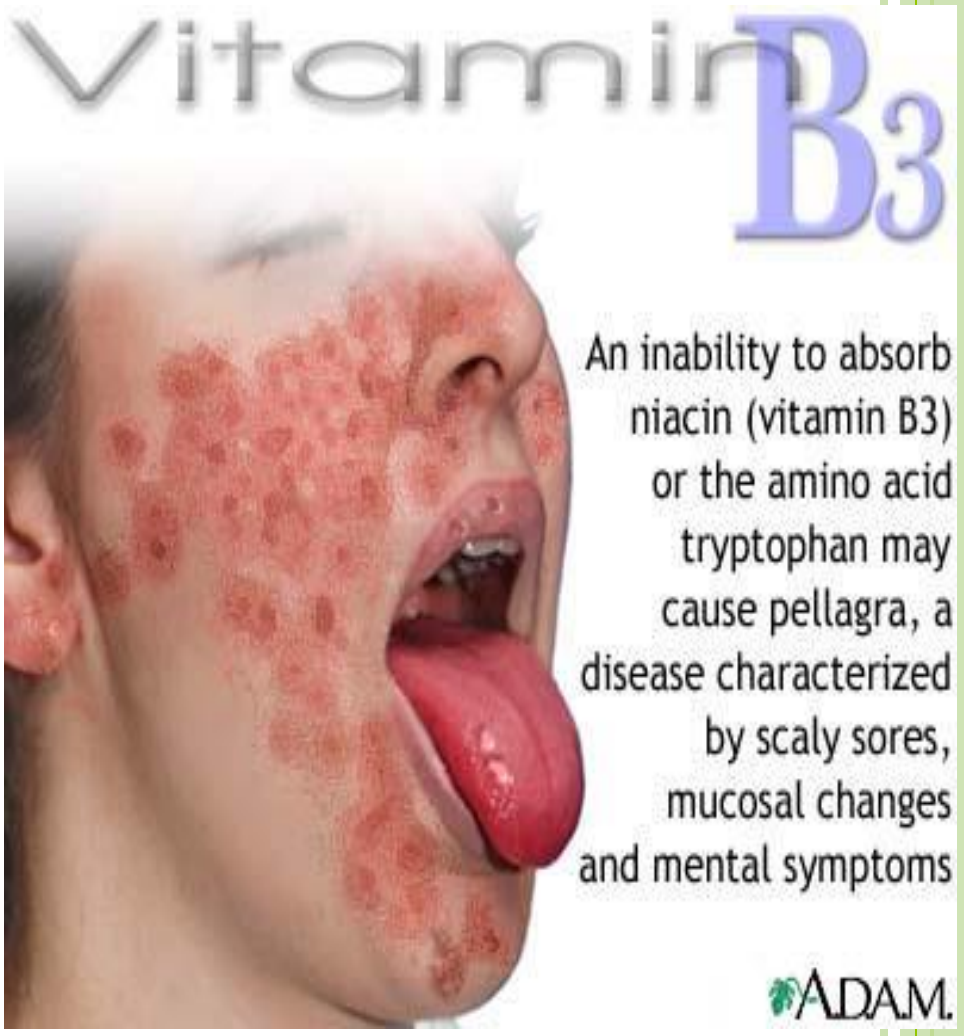
Milk, yogurt, cheese, whole-grain breads, green leafy vegetables, meat, and eggs

Riboflavin Deficiency

- Ariboflavinosis (develops 2 months after cessation of riboflavin)
- Symptoms:
  - Inflammation of the tongue
  - Cracking of tissues at corners of the mouth (angluar cheilitis)
  - Seborrheic dermatitis
  - Nervous system disorders (anemia, fatigue, confusion, headaches)
  - Tiredness
- Diabetes, cancer and cardiovascular disease can make symptom worse

Niacin or B-3

- Two forms Nicotinic Acid and nicotinamide
- Both are readily absorbed from stomach and intestine by active transport or simple diffusion
- Can be synthesized from tryptophan
- Transported to liver and made into NAD and NA
- Foods:
  - Meat, poultry, liver, eggs, brown rice, baked potatoes, fish, milk, and whole-grain foods



Niacin Functions

- Also involved with energy production
- Also helps with skin, nerves and digestive system
- NAD is a coenzyme for many redox reactions in catabolic pathways- is key in the process of oxidative phosphorylation
- NADP is a coenzyme for redox reactions in anabolic pathways
- NAD & NADPH are used in over 200 reactions as coenzymes
- RDA: 16 mg/day in men, 14 mg/day in women
  - Avg intake: 2-3 times RDA due to tryptophan

Niacin toxicity

- Mega doses of niacin can be used to slow or reverse atherosclerosis, lower LDL, raise HDL
- UL is 35 mg/day,but 1 to 2 g is given in time-release form
- Must be given in time release form or can cause side effects:
  - Flushing of skin
  - Itching
  - GI upsets
  - Liver damage

Niacin deficiency → pellagra

Figure 12–12. Hands of a pellagra patient on admission to a hospital, and after three weeks of treatment with nicotinic acid. (From Ruffin and Smith, in *Southern Medical Journal*, 1939. Courtesy of the publishers.)

Deficiency :Pellagra (4 D's Disease)

Rare but causes: diarrhea, dermatitis, dementia and death

Pyridoxine or B-6

- Pyridoxine (vitamin B6) exists in three forms pyridoxine, piridoxal and pyridoxamine. It plays an important role in the metabolism of amino acids, fats and carbohydrate.
- The requirement of adults vary directly with protein intake. Adults may need 2 mg/day, during pregnancy and lactation, 2.5 mg/day. Balanced diets usually contain pyridoxine, therefore deficiency is rare.
- Deficiency:
  - Skin changes, dementia, nervous system disorders and anemia
- Foods:
  - Lean meats, fish, legumes, green leafy vegetables, raisins, corn, bananas, mangos

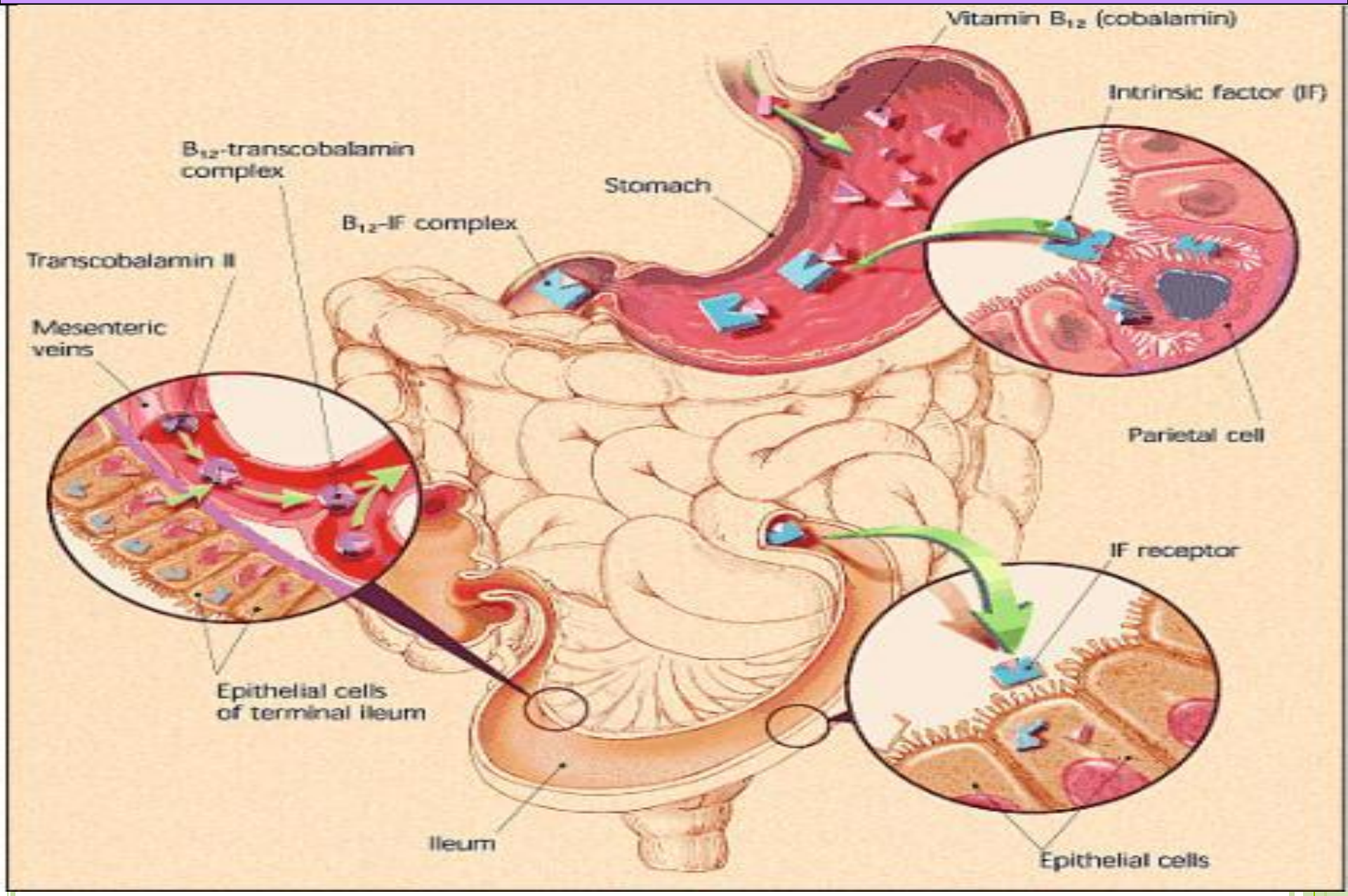
Cobalamin or B-12

- Vitamin B12 is a complex organo-metallic compound with a cobalt atom. The preparation which is therapeutically used is cyanocobalamine.
- Vitamin B 12 cooperates with folate in the synthesis of DNA.
- Vitamin B 12 has a separate biochemical role, unrelated to folate, in synthesis of fatty acids in myelin
- **Helps with nervous system, red blood cells and DNA synthesis**
- Deficiency:
  - Nervous system disorders and pernicious anemia
- Foods:
  - Only found in animal products
    - Meat, fish, poultry, eggs, milk products and clams

B12 Deficiency

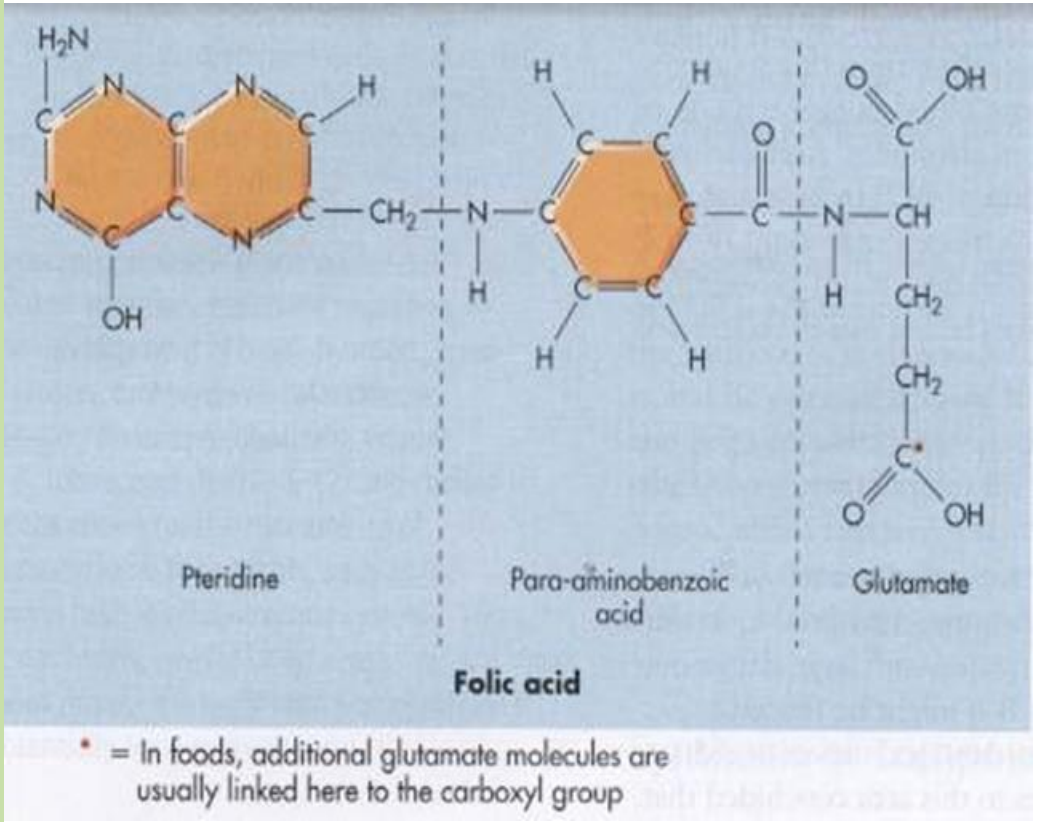
- Vitamin B12 deficiency is associated with megaloblastic anaemia (pernicous anaemia), demyelinating neurological lesions in the spinal cord and infertility (in animal species). Dietary deficiency of B12 may arise the subjects who are strict vegetarians and eat no animal product. At the present time there is little evidence that vitamin B12 deficiency anaemia represents an important public health proble
- symptom:
  - Nervous system disorders and pernicious anemia

Cobalamin absorption :needs Intrinsic Factor



Folic acid (Folacin, Folate)

- Has several forms (see fig- only one glutamate is folic acid)
  - 90% of foods have 3+ glutamates attached to carboxyl group (polyglutamates)
- In order to be absorbed it must be digested into folate monoglutamate by folate conjugate enzymes in the intestinal tract
- Folate monoglytamate actively transported across the membranes of the absorptive cells
- Key role in red blood cell formation and cell division
- Deficiency:
  - Anemia, digestive disorders
- Foods:
  - Leafy, dark green vegetables
  - Also found in liver, beans, peas, asparagus, oranges, avocados

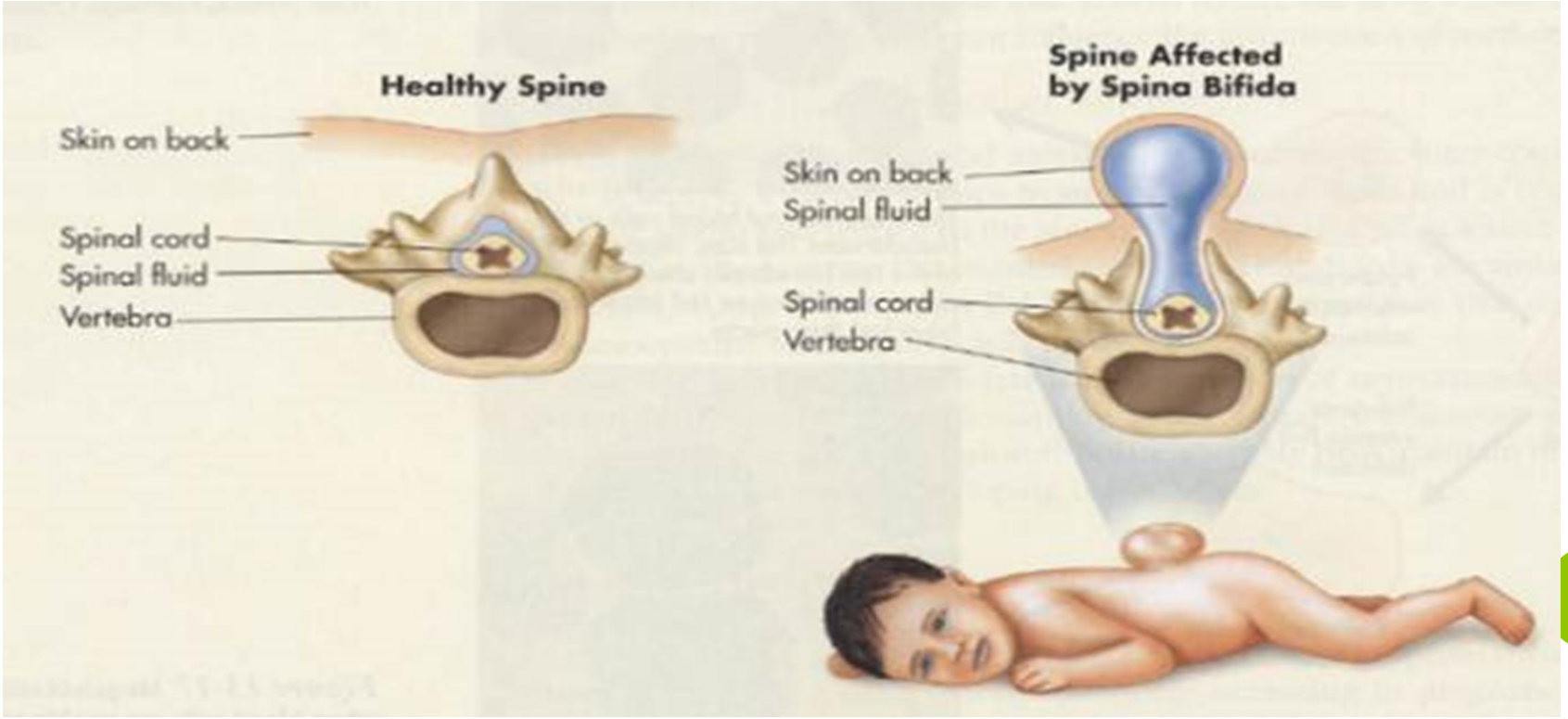


- The functional coenzyme form of folate is called tetrahydrofolic acid (THFA)
- It is required for:
  - Formation of adenine and guanine for DNA, thymine for DNA by adding methylene (CH2) to uracil
  - Amino acid metabolism (converts glycine to serine)
  - Synthesis of neurotransmitters

RDA is 400 ug/day
UL for synthetic folic acid is 1000 ug/day
Higher than this may mask a vitamin B-12 deficiency
Food processing can destroy 50-90% of folate (heat, oxidation, UV light)

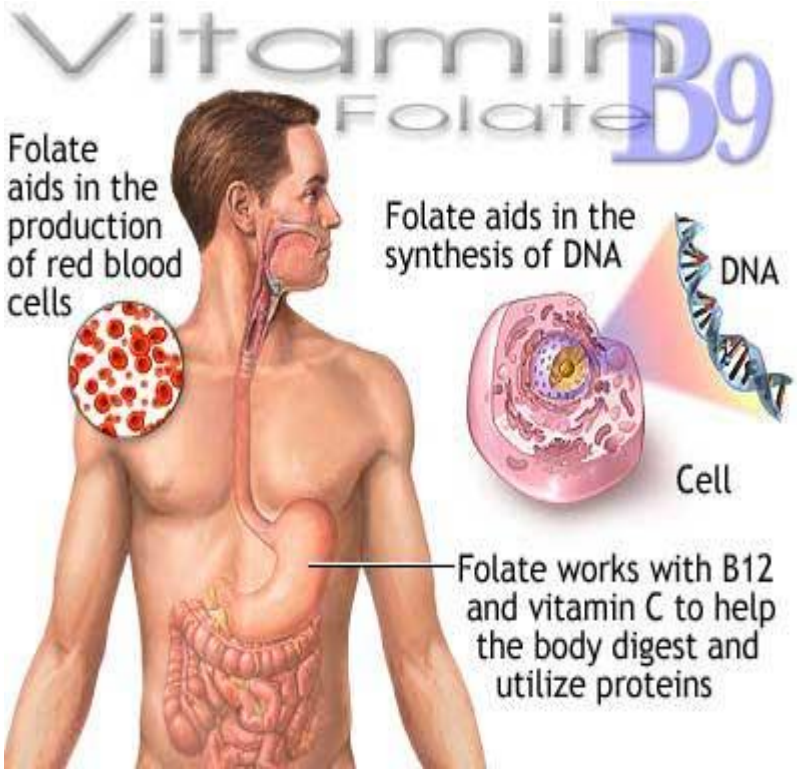
Folate Deficiency

- Also impairs functioning of immune system
- In developing embryos can cause neural tube defects
- Important pre-natal vitamin



Neural Tube Defects
(Folate or vitamin B9 deficiency)

- Neural tube closes first 28 days of pregnancy
- Forms brain and spinal cord
- By the time pregnancy is confirmed, damage is done



B Complex Digestion

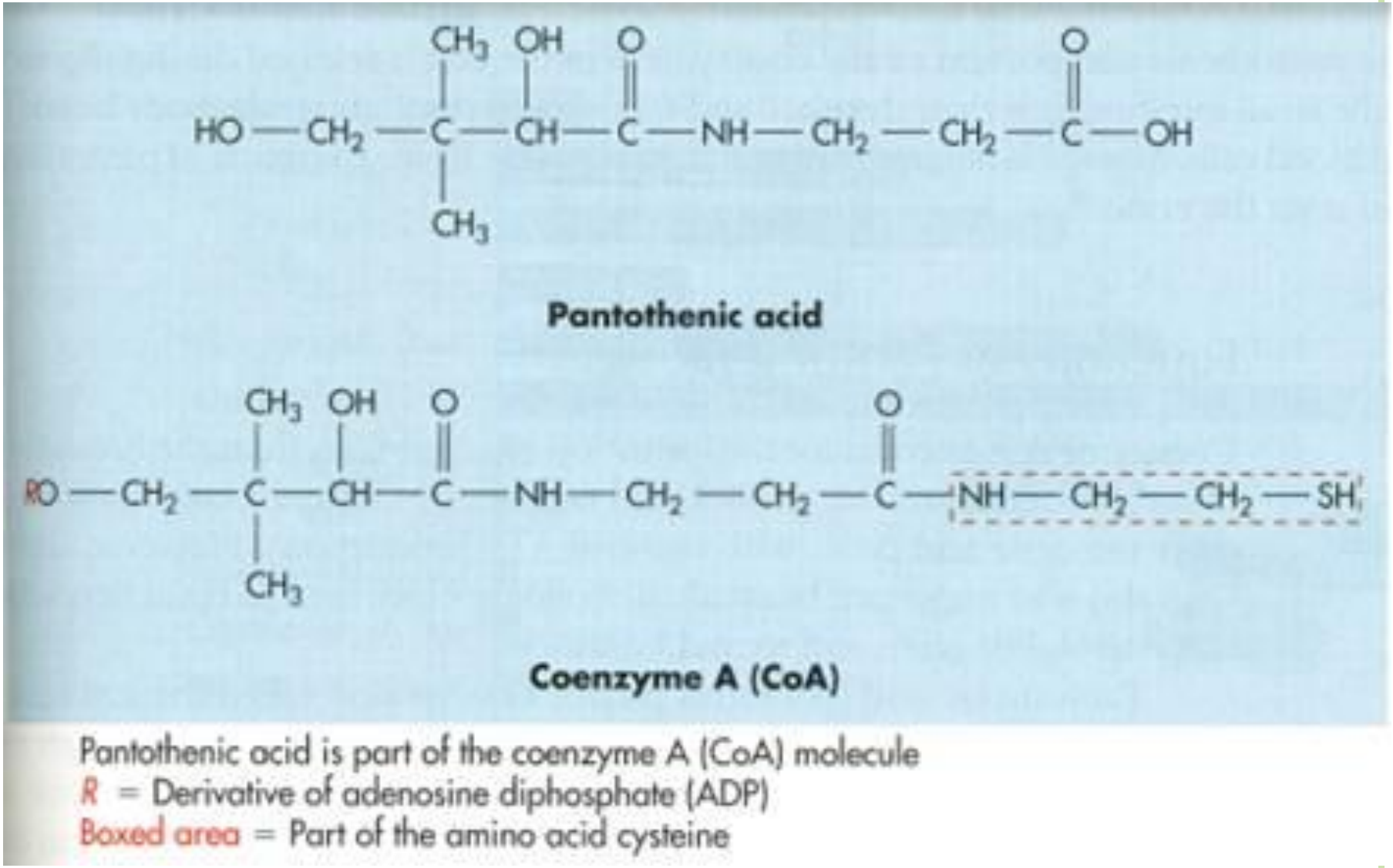
- Broken down from coenzyme form into free vitamins in the stomach and small intestine
- Absorbed, primarily in the small intestine (50%-90%)
- Once inside cells, coenzyme forms are resynthesized
  - No need to ingest coenzyme forms; we can make them

B Complex Primary Functions

- Energy metabolism
  - Thiamin (B-1), Riboflavin (B-2), Niacin (B-3), Pyridoxine (B-6), Biotin, Pantothenic Acid
- Red blood cell synthesis
  - Folate, B12
- Homocysteine metabolism
  - Folate, B12, B6

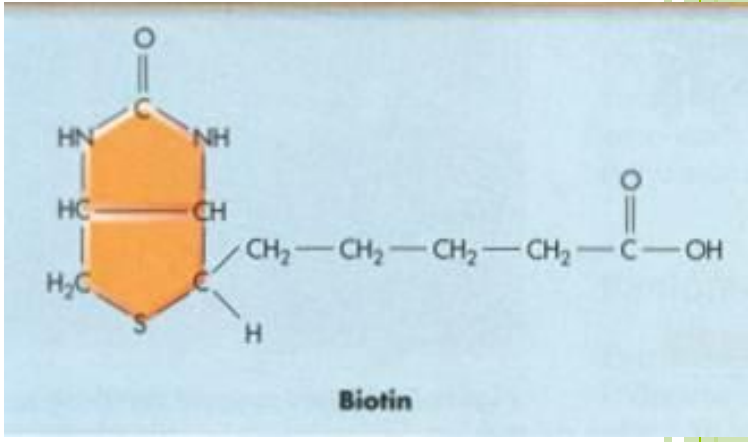
Pantothenic Acid

- Pantothenic acid is part of Acetyl coenzyme A which is required for:
  - Krebs's cycle
  - Fatty acid synthesis
- Coenzyme A is formed when combine pantothenic acid with a derivative of ADP and a portion of the amino acid cysteine (provides sulfur)
- Pantothenic acid also used to form the Acyl carrier protein- used in the synthesis of fatty acids
- AI is 5 mg/day Help with metabolism and formation of some hormones
- Foods:
  - Almost any food, plant-based or animal-based



- Deficiencies are rare , Symptoms: headache, fatigue, impaired muscle coordination, GI tract disturbances

Biotin



- Primarily absorbed in upper part of the small intestine
- Can be taken in the diet as free vitamin or with the vitamin bound to a protein (biocytin)
- In the second case the biotin must be cleaved from the protein before it can be absorbed
  - In Small Intestine, enz biotinidase releases biotin from biocytin & other biotin-dependent enzymes in foods
  - Free biotin absorbed in small intestine via Na-dependent carrier
- We excrete more biotin than we consume, so bacteria in the large intestine must produce some
- AI is 30 ug/day

Functions of Biotin

- Biotin is a coenzyme for several carboxylase enzymes that add CO2 to various compounds
  - Required for metabolism of carbs, proteins, fats
  - Needed for carboxylation of pyruvate to form oxaloacetate
  - Needed for breakdown of AAs threonine, leucine, methionine, and isoleucine
  - Needed for carboxylation of acetyl-CoA to form malonyl CoA, so FAs can be synthesized
- Can be found in:
  - Whole grains
  - Eggs
  - Nuts
  - Legumes
- Also made by intestinal bacteria

Biotin Deficiency

- Rarely from eating raw eggs- eggs contain protein avidin which binds biotin, reducing absorption
- If infants do not posses the enzyme needed (biotinidase) to remove biotin from protein can lead to deficiency (rare, 1 in 112,000)
  - Skin rash
  - Hair loss
  - Neurological disorders (convulsions)
  - Impaired growth

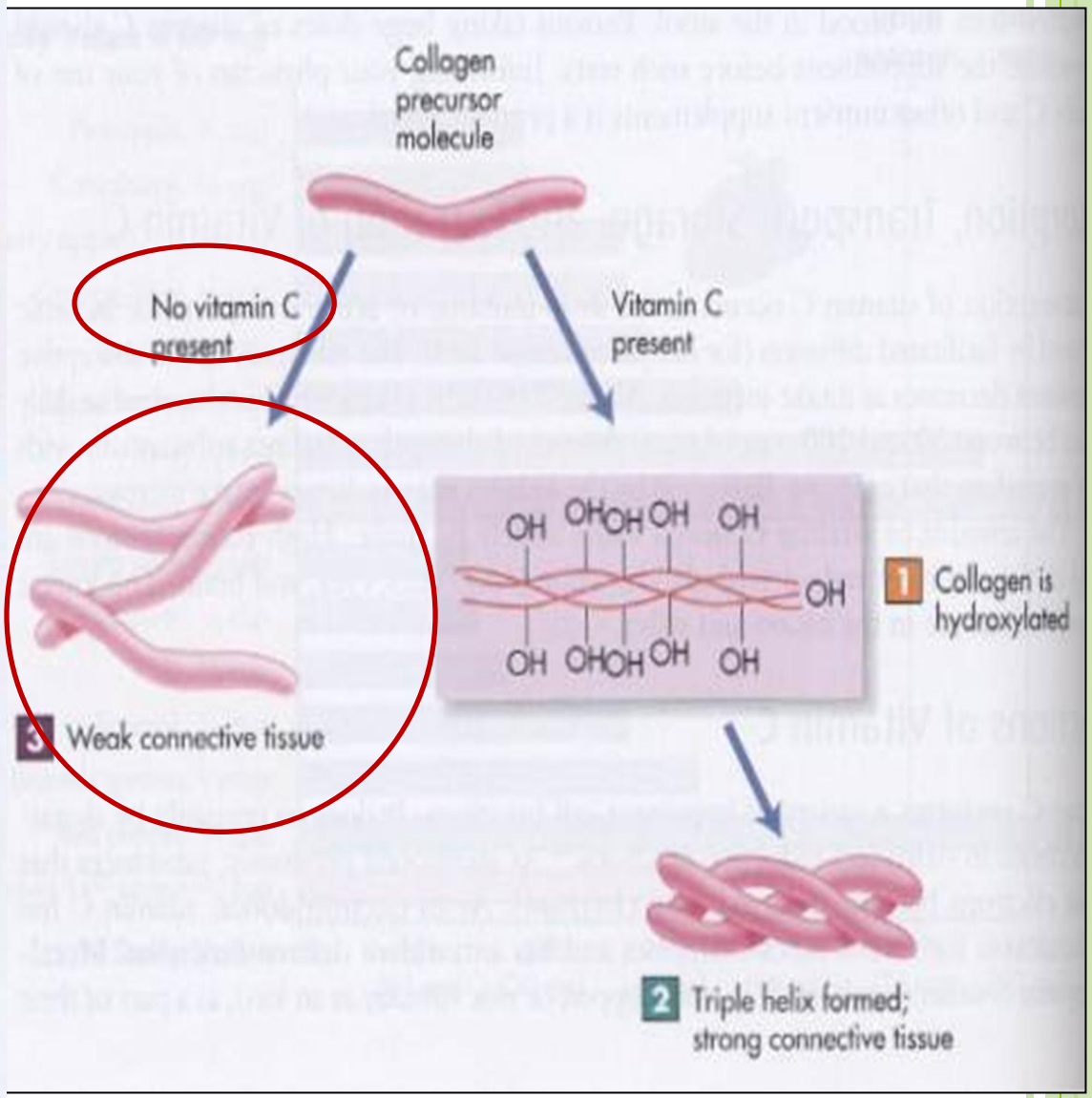
Vitamin C

- Important to bone health, blood vessel health, cell structure and absorption of iron
- Deficiency:Scurvy :Rare
- Scurvy– degeneration of connective tissues leading to:
  - Hemorrhages of small blood vessels
  - Damage to gums resulting in tooth loss
  - Poor wound healing
  - Bone pain & fractures
  - diarrhea
- Too much vitamin C
- Foods:
  - Melons, berries, tomatoes, potatoes, broccoli, fortified juices, kiwi, mangos, yellow peppers and citrus fruits

Function of Vitamin C

- It is a redox agent
- Acts as a cofactor for metalloenzymes (which contain Cu, Zn, Fe) as part of their structure
  - When metalloenzyme catalyzes a reaction, it becomes oxidized- ascorbic acid can donate an e- to oxidized metal, allowing reaction to continue
- Required for:
  - Collagen synthesis
  - Aids in iron absorption
  - Synthesis of carnitine (needed for fatty acid synthesis)
  - Aids functioning of the immune system through its antioxidant activity

Figure 13-25 Pinpoint hemorrhages of the skin—an early symptom of scurvy. The spots on the skin are caused by slight bleeding. The person may experience poor wound healing. These are all signs of defective collagen synthesis.



Vitamins: Should I Take a Supplement?

- Following dietary recommendations would allow people to meet their nutrient needs without supplements
  - Many people eat too many nutrient-deficient foods
- **Caution with using supplements**
  - *Hypervitaminosis* = toxicity
  - Megadoses of any vitamin can be harmful
- Recommendations for certain groups
  - Folic acid, vitamin B-12, vitamin D

Phytochemicals

- **Phytochemicals** = physiologically active components of foods that may deactivate carcinogens
- **Many phytochemicals function as antioxidants**
  - May protect cells from damage caused by unstable molecules **("free radicals")**
- **Examples**
  - Carotenoids
  - Polyphenols
  - Flavonoids

Minerals

Minerals are substances that the body cannot manufacture but are needed for forming healthy bones and teeth and regulating many vital body processes.

Minerals

- **Inorganic materials** that act as structural elements and regulators of numerous body processes
- **Provide no energy: 0 calories/gram**
- **"Trace elements"** found in small amounts in the body

Minerals

- 22 minerals are needed by the body
- Two categories:
  - Major or macrominerals
    - Include calcium, chloride, magnesium, phosphorus, potassium, sodium, and sulfur
  - Trace
    - Include iron, zinc, iodine, selenium, copper, manganese, fluoride, chromium, molybdenum, arsenic, nickel, silicon, boron and cobalt

Minerals

- Percent of Body weight
  - Calcium 2%
  - Phosphorus 1%
  - Potassium 0.3%
  - Sulfur 0.2%
  - Sodium 0.1%
  - Chloride 0.1%
  - Magnesium 0.05%
  - Iron 0.04%

Main roles of minerals

- Building strong bones and teeth:Ca,P, F,Mg,Mn, Fe
- Controlling body fluids inside and outside cells(osmotic pressure): Na, K. Cl
- Helping to generate energy :Bind with enzymes or other organic molecules: Mg, Mn,Zn,
- Maintaining immune function :Zn

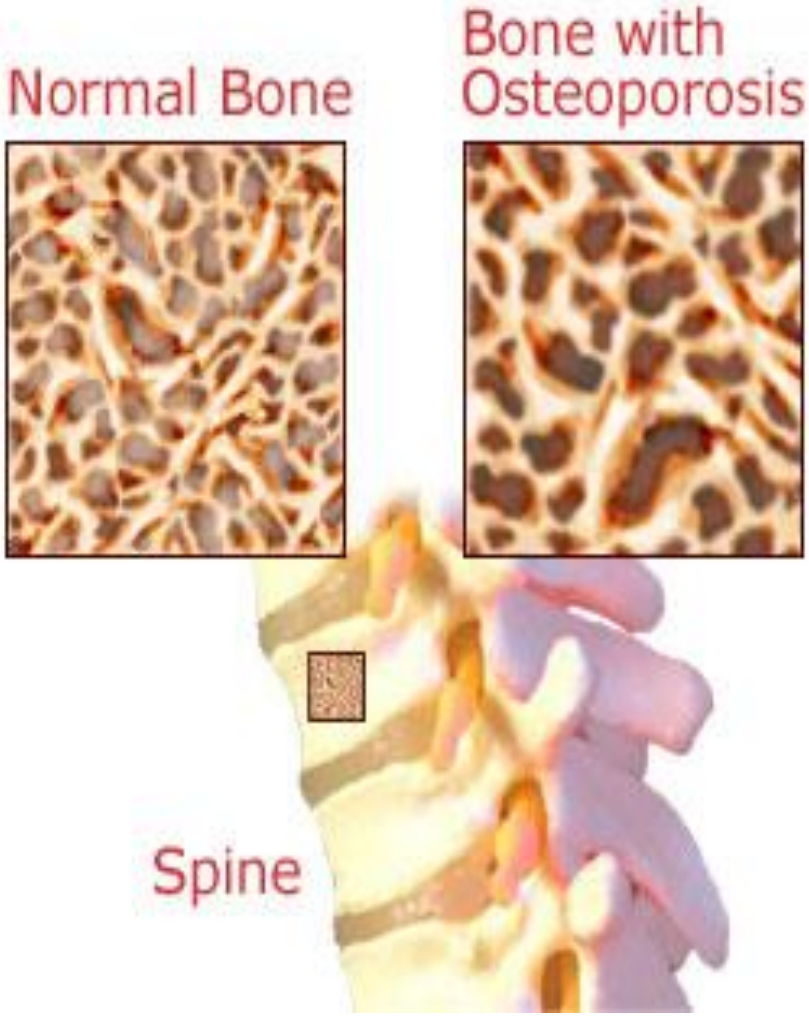
Main roles of minerals

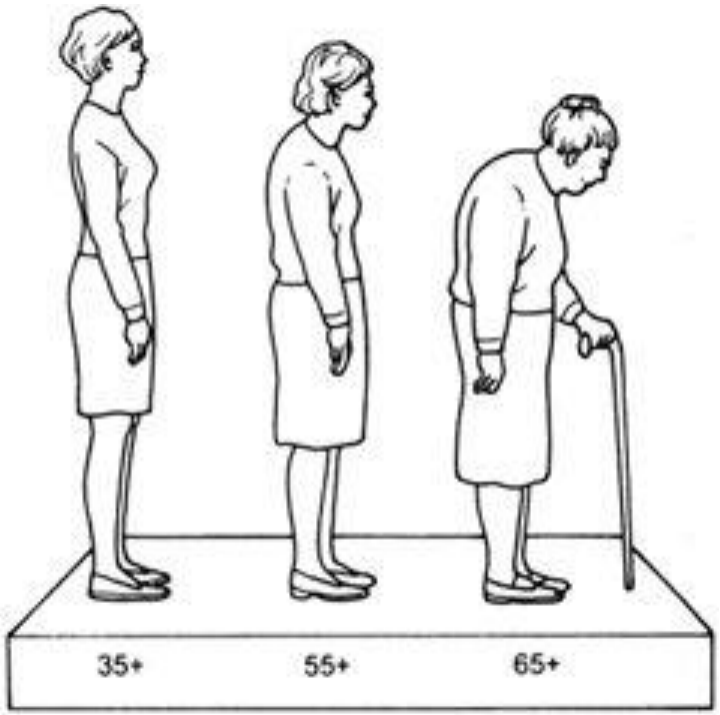
- Muscle and nerve function :Na,K,Ca,Mg
- Blood clotting :Ca
- Help to regulate many body functions: essential compounds in the body: I in Thyroxine ,Fe in Hemoglobin

The Macrominerals

- Calcium Ca
- Phosphorous P
- Potassium K
- Sulfur S
- Sodium Na
- Chlorine Cl
- Magnesium Mg

Calcuim

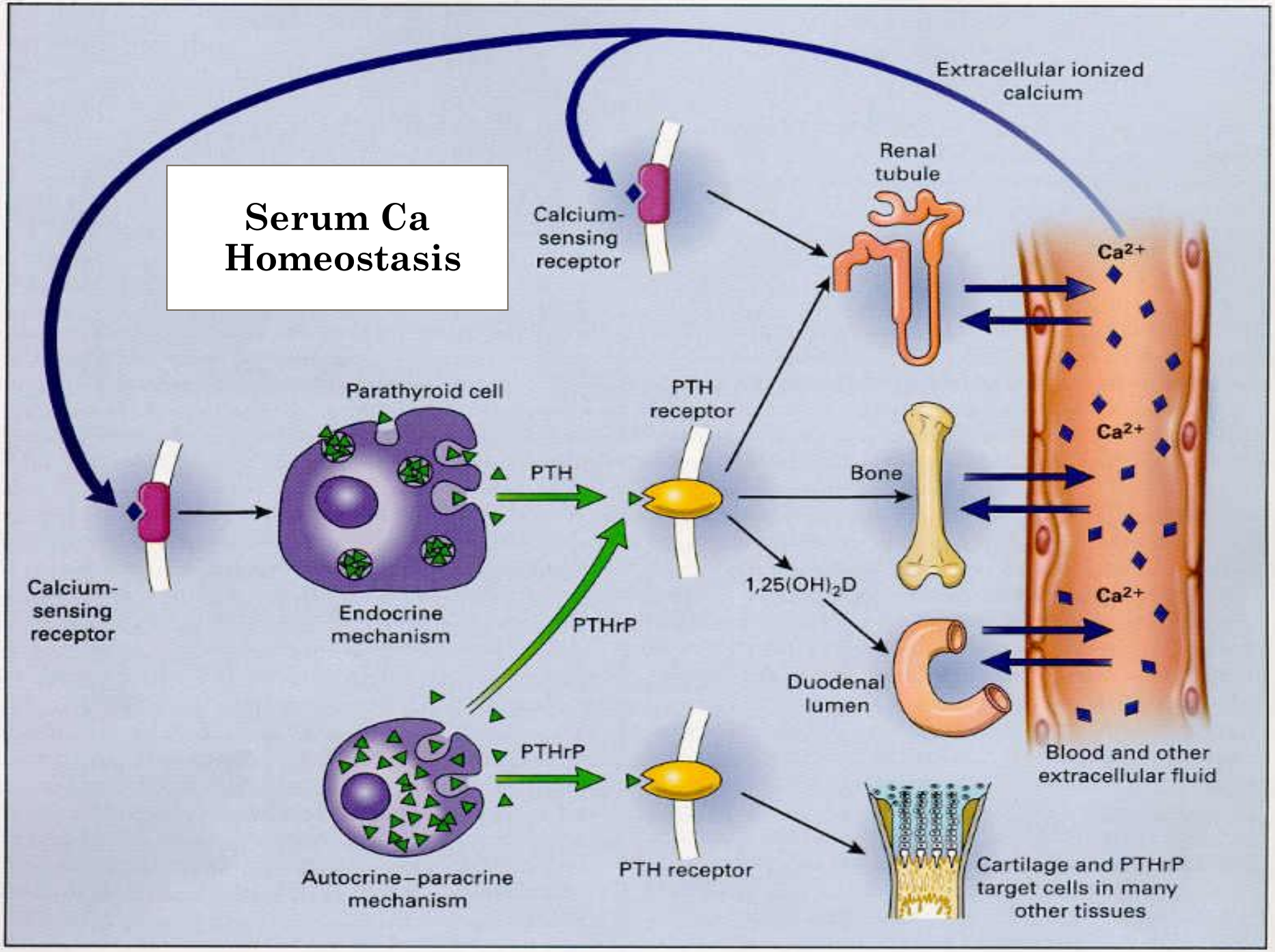




Calcium

- 99% of body calcium in skeleton and teeth
- Miscible Pool(Caในพลาสมา):40% bound to protein, 13% complexed w/ anions,47% free ionized form
- PTH: Increased Ca, Decreased PO4, Increased Vitamin D
- Vitamin D: Increased Ca, Increased PO4, Decreased PTH (slow)
- Ca in plasma from GI Tract≈**0.4mg/Kg/hr**,Bones, ≈0.1mg/Kg/hr. and excrete via Kidney

- How much do you need?
  - Males 19-50 years old: 1,000 mg / day
  - Females 19-50 years old: 1,000 mg / day

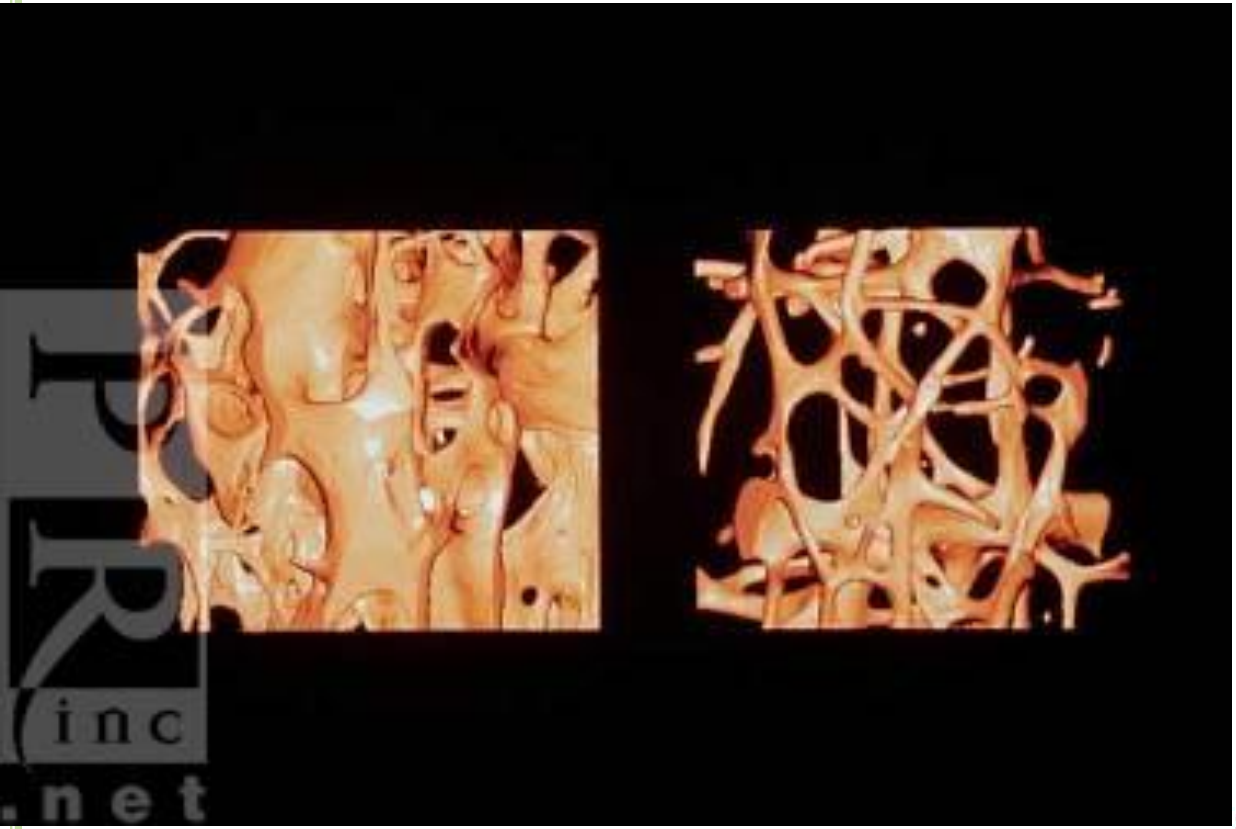

Serum Ca Homeostasis
Extracellular ionized calcium
Calcium-sensing receptor
Renal tubule
Parathyroid cell
PTH receptor
PTH
Bone
Calcium-sensing receptor
Endocrine mechanism
1,25(OH)2D
PTHrP
Duodenal lumen
Ca2+
Ca2+
Ca2+
Blood and other extracellular fluid
PTHrP
Autocrine–paracrine mechanism
PTH receptor
Cartilage and PTHrP target cells in many other tissues

Calcium (Ca)

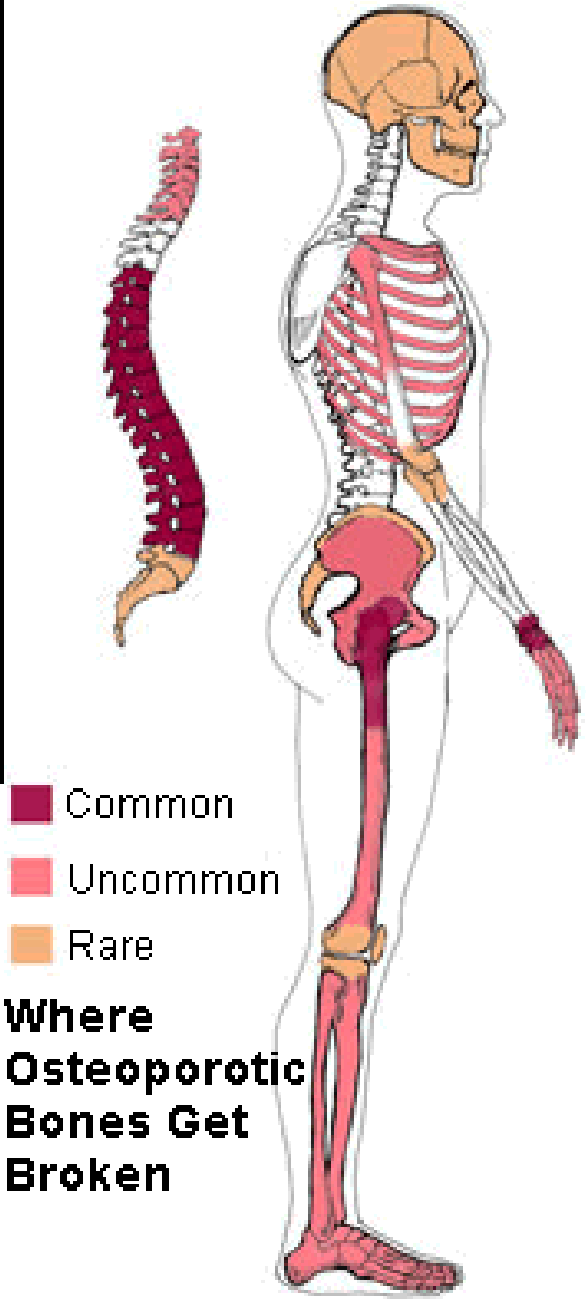
Function: major component of bones and teeth and essential in blood coagulation, nerve and muscle function and milk and egg production.

Deficiency signs: retarded growth, deformed bones in young animals (rickets), and soft shelled eggs and osteoporosis in older animals.

Sources: milk, oyster shells and limestone.



3D Visualization of data obtained by x-ray microtomography of the bone structure of the vertebrae of a 50 year old (left) and a 70 year old (right)



An illustration of the consequence of osteoporosis on the spinal column.

Prevention of Osteoporosis

- Exercise
- Dietary Calcium
- "Rule of 300"
  - 300 mg/d from plant sources
  - 300 mg/d from each serving of dairy
- Bone Loss (Osteoporosis)
  - High sodium intake is associated with calcium excretion.
  - Phosphorus, fluoride and magnesium and several vitamins also all have significant roles in maintaining bone health

Prevention of Osteoporosis

- **<u>Other factors that may increase calcium loss</u>**
  - high caffeine intake
  - high protein intake
  - high alcohol intake
  - cigarette smoking

Calcium & Foods

- Dairy products, fortified juices, sardines

Food	Calcium
Yogurt, plain (low-fat) Yogurt, flavored (low-fat)	1 cup - 415 mg 1 cup – 345 mg
Milk, skim Milk, 1-2%	1 cup – 302 mg 1 cup – 300 mg
Ice cream	½ cup – 88 mg
Broccoli, cooked	½ cup – 68 mg
Salmon, canned	3 oz – 165 mg
Fortified orange juice	8 oz – 300 mg

Enriching Foods to Achieve A “Good Source”

Cow’s milk

310 mg calcium/cup

Soy milk

13 mg calcium/cup

Calcium-fortified soy beverage

295 mg calcium/cup

soy beans

53mg calcium/100g

Sodium

- Na+ is major positive ion in ECF and for maintaining electrical gradients across membrane
- Na+ also used for glucose and AA transporters in intestine
- As Na+ and K+ move across membranes, they create an electrical potential charge
- Na+ also high in blood, used to maintain osmolarity
- What does sodium do for you?
  - Helps maintain fluid balance
  - Helps transmit nerve impulses
  - Influences contraction and relaxation of muscles

Sodium chloride

Considered together because of a close biochemical relationship and are provided as common salt (NaCl)

Function: required for the formation and retention, concentration and pH of body fluids, such as protoplasm, blood. Important in the formation of digestive juices and functions in nerve and muscle activity.

Deficiency signs: poor condition and depressed appetite. Most farm produced feeds are deficient in these two minerals.

Sources: salt supplements and injectable products.

Sodium & Health

- Only about 200 mg of Na is needed per day for normal physiological functions
- AI is 51-1500 mg/day
- UL is around 2400 mg/day
- Under FDA labeling rules, 2400 mg per day is assumed in the diet
- Too much sodium
  - Causes high blood pressure
  - May lead to fluid retention

Where are you getting sodium?

Sodium & Food

- On food labels:
  - Monosodium glutamate (MSG)
  - Baking soda
  - Baking powder
  - Disodium phosphate
  - Sodium alginate
  - Sodium nitrate or nitrite

Sodium Savvy

- The human body requires about 500 mg of sodium per day, while the average American usually ingests between 2,300-6,900 mg each day.

- It is recommended to stay in a range of 1,500 to 2,400 mg / day.

Reducing sodium in your diet

- Eat more fresh foods
- Eat less processed foods
- Look for low-sodium products
- Limit the salt you add to foods
- Experiment with other seasonings
- Use salt substitutes with caution

Phosphorus (P)

Function: essential for the formation of bones, teeth, and body fluids. Required for metabolism, cell respiration and normal reproduction.

Deficiency signs: similar to calcium deficiency, lack of appetite, poor reproduction and unthrifty appearance.

Sources: dicalcium phosphate, bone meal, and low fluorine phosphates.

Potassium (K)

Function: retention and formation of body fluids, pH concentration of body fluid and rumen digestion.

Deficiency signs: nonspecific and unlikely under most conditions but may have decreased feed consumption and efficiency.

Sources: roughages. Grains are less than roughages .

Manganese (Mn)

Function: Fetal development, udder development, milk production and skeleton development.

Deficiency signs: Abortions, reduced fertility, deformed young and poor growth.

Sources: Most use trace mineralized salt.

The Microminerals

Iodine (I)

Copper (Cu)

Iron (Fe)

Selenium (Se)

Manganese (Mn)

Molybedenum (Mo)

Zinc (Zn)

Copper (Cu)

Function: should be present in animal tissues for iron to be properly utilized, hemoglobin formation and synthesis of keratin for fair and wool growth.

Deficiency signs: poor pigmentation of feathers, stringy wool, sway back lambs, lack of muscle coordination and anemia.

Sources: forages and copper salts.

Copper Toxicity

- UL is 10 mg/day
- Caused by:
  - Wilson's disease-genetic disorder
- Copper accumulates in brain, cornea, liver and kidneys

Figure 15-12 Individuals with Wilson's disease deposit copper in the outer edges of the cornea. The ring is a golden to greenish-brown color.

Iodine

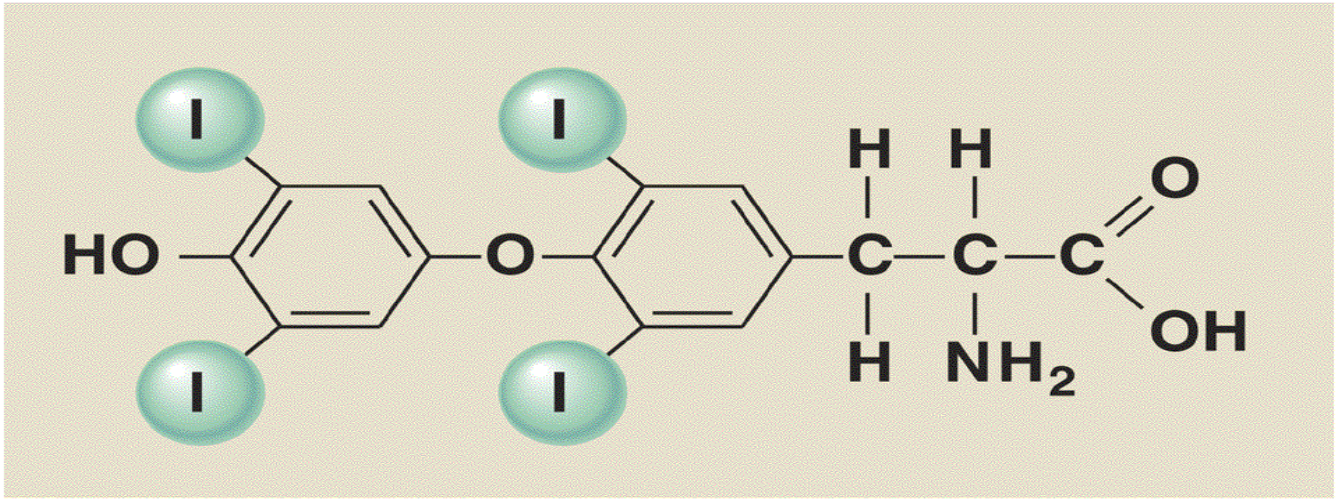
- **Iodine** is needed for the synthesis of thyroid hormones.
  - Regulates metabolic activites of all cells
- Like selenium, its availability depends on soil concentrations; it is also abundant in seawater and hence in seafood and seaweed.
- Lack of iodine causes enlargement of the thyroid glands (**goiter**).
- Chronically high intakes of iodine can cause impaired thyroid function.

Iodine

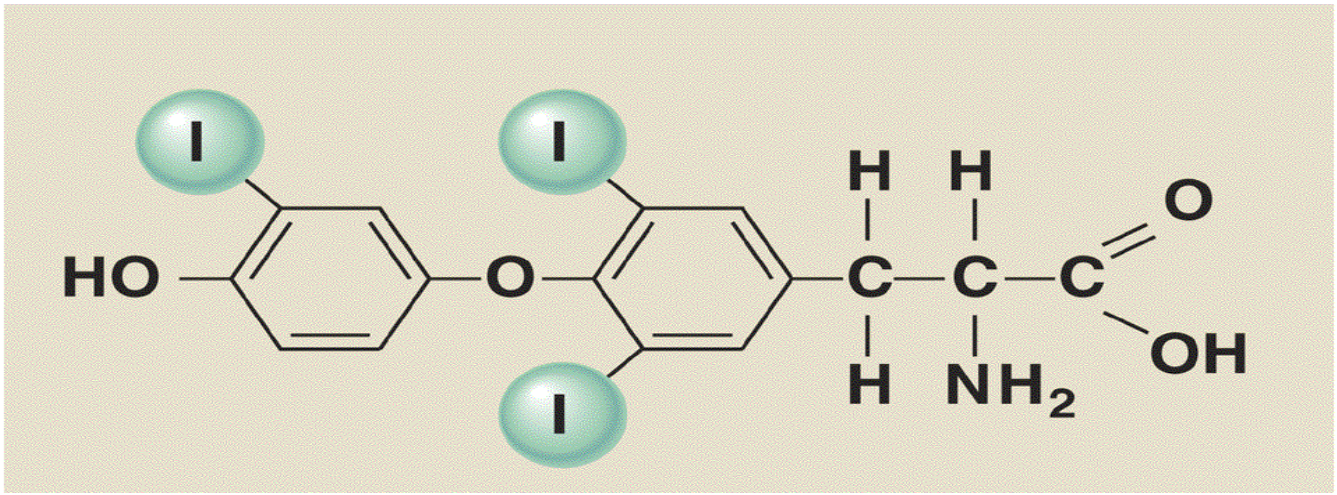
- Goiter and its complications
- Hypothyroidism
- Impaired mental function
- Plays a key role in cell replication
  - Especially relevant for the brain
    - Neural cells multiply mainly in utero and during the first 2 years of life
  - Fetal deficiency leads to
    - Increased rates of spontaneous abortion
    - Stillbirths
    - Congenital anomalies
    - Cretinism
    - Psychomotor deficits
    - Neonatal mortality

Thyroid Hormones Contain 3-4 Atoms of Iodine

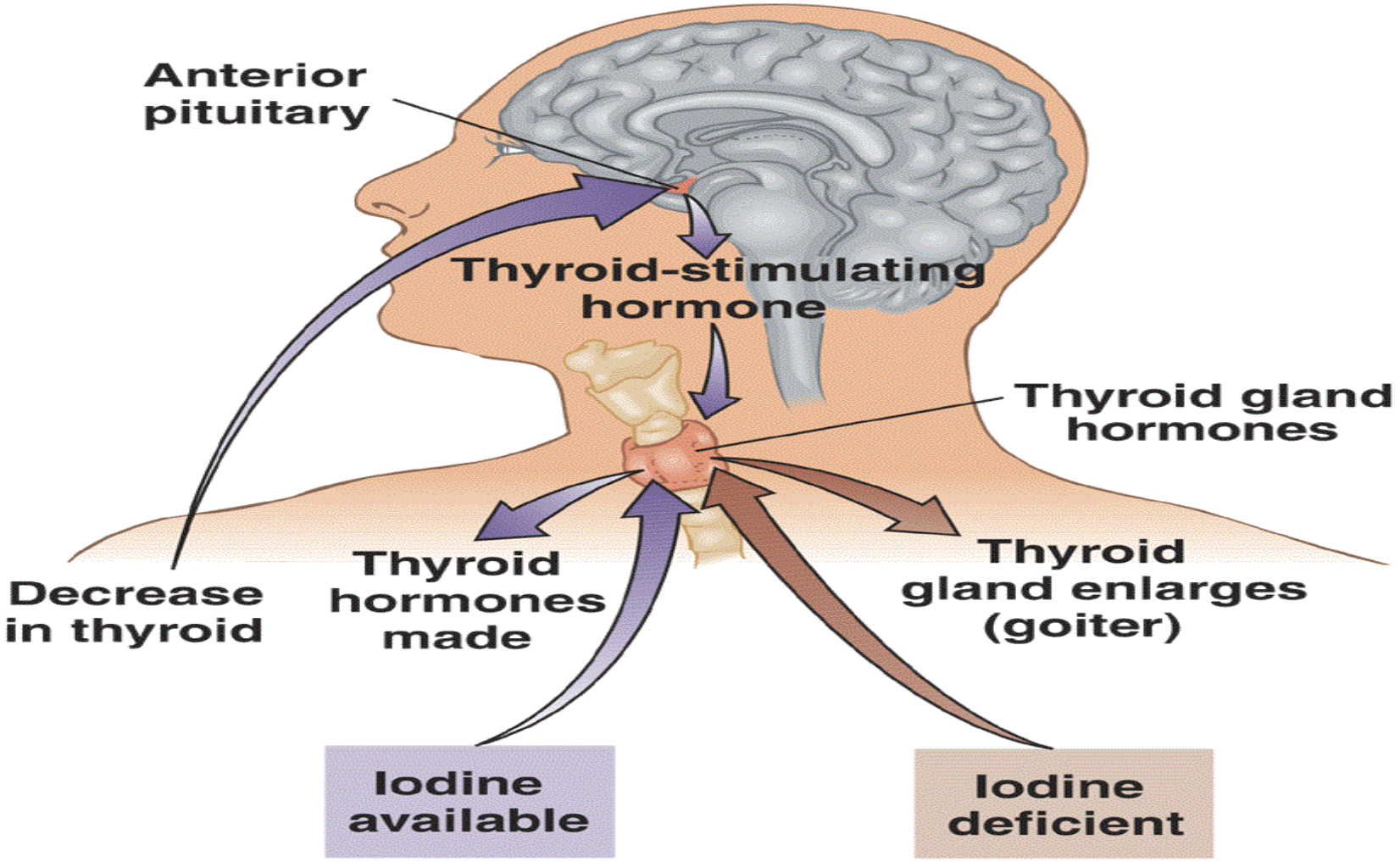
T_4

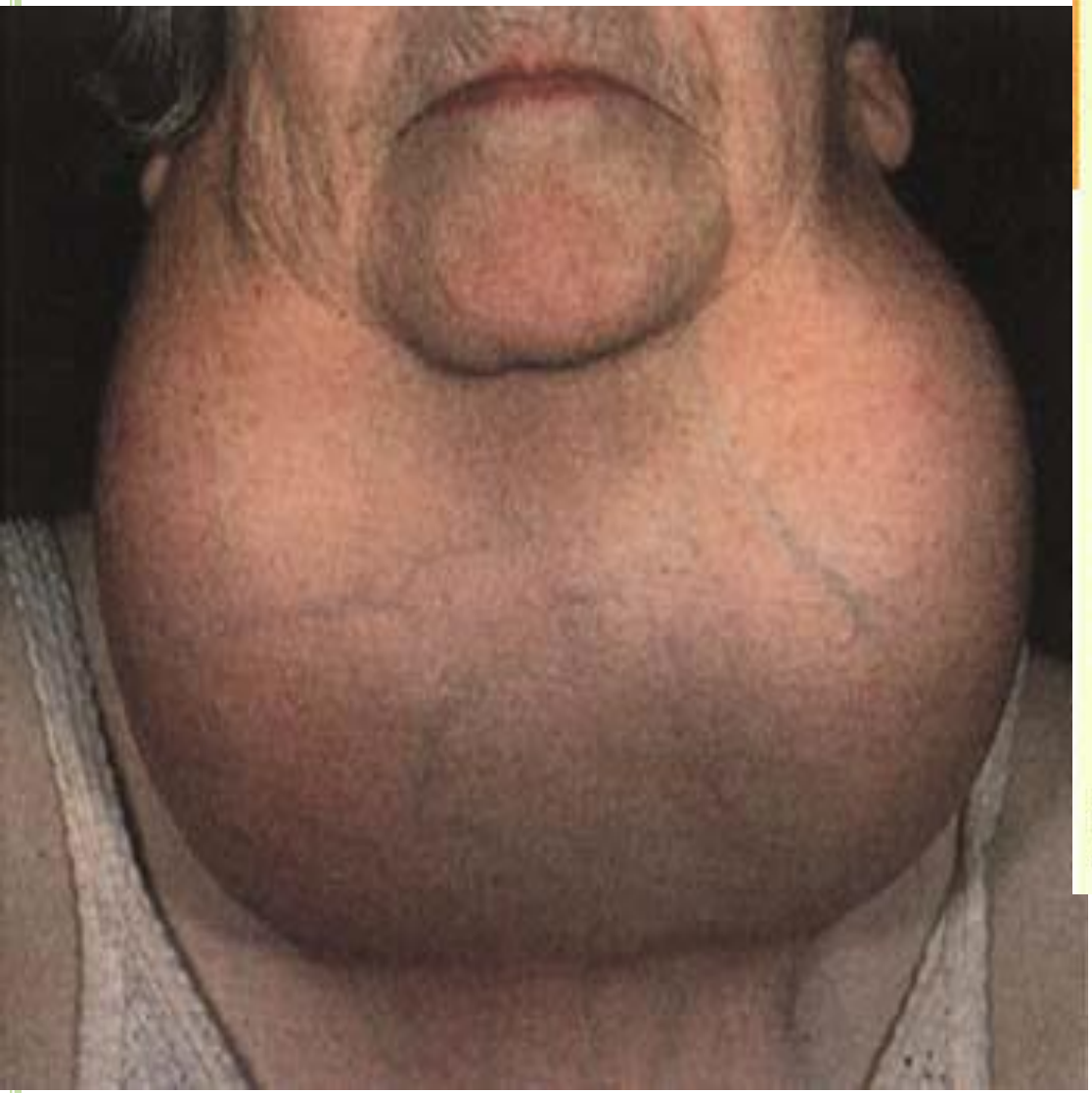


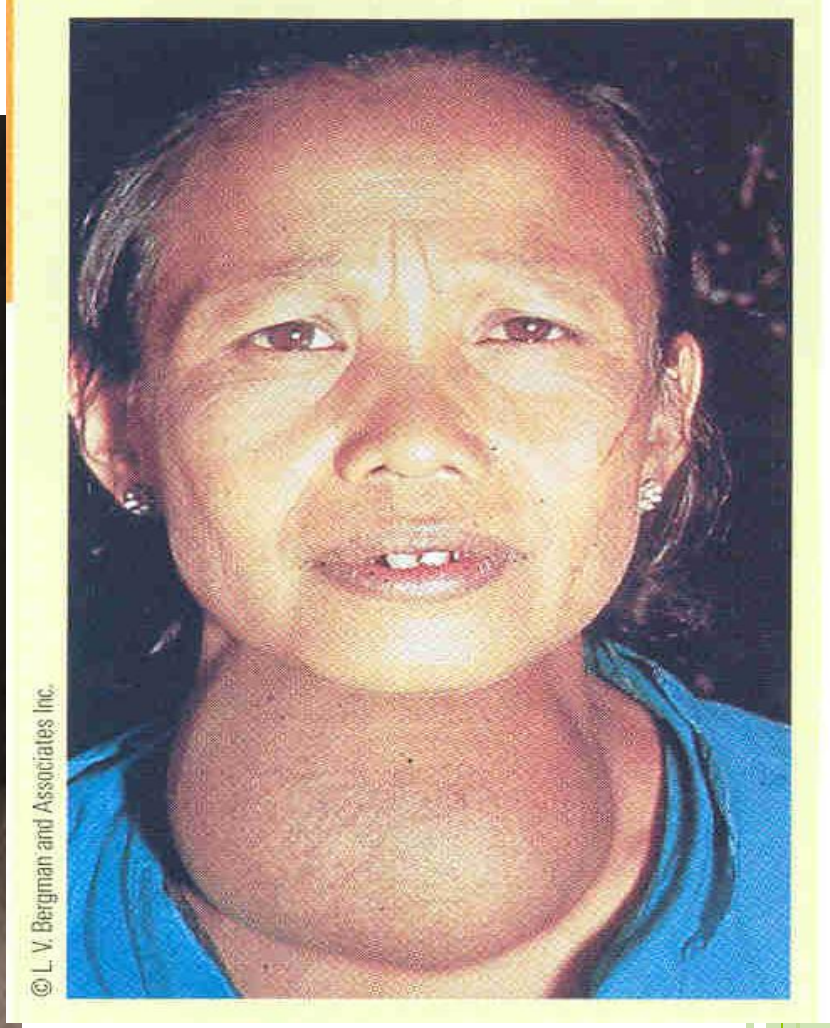
T_3



Goiter Develops When Iodine Is Lacking







Courtesy CNRI/Phototake

A DEFICIENCY OF IODINE CAN LEAD TO AN ENLARGEMENT OF THE THYROID GLAND, A CONDITION KNOWN AS *GOITER*.

Thyroid cartilage
Normal size of thyroid gland
Goiter
Trachea

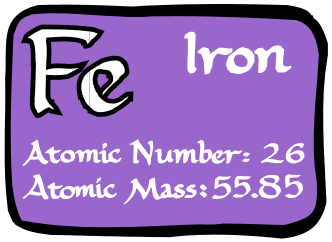
Iron (Fe):

- Function: essential for the function of every organ and tissue of the body (Hemoglobin to carries oxygen molecules)
- Myoglobin – a protein similar to hemoglobin found in the cytoplasm of muscle cells
- Enzymes and electron carrier molecules in the energy metabolism pathway
- Proteins involved in drug metabolism, the immune system, and protection against free radicals

Deficiency signs: seldom occurs in older animals, nutritional anemia, labored breathing and pale eyelids, ears and nose.

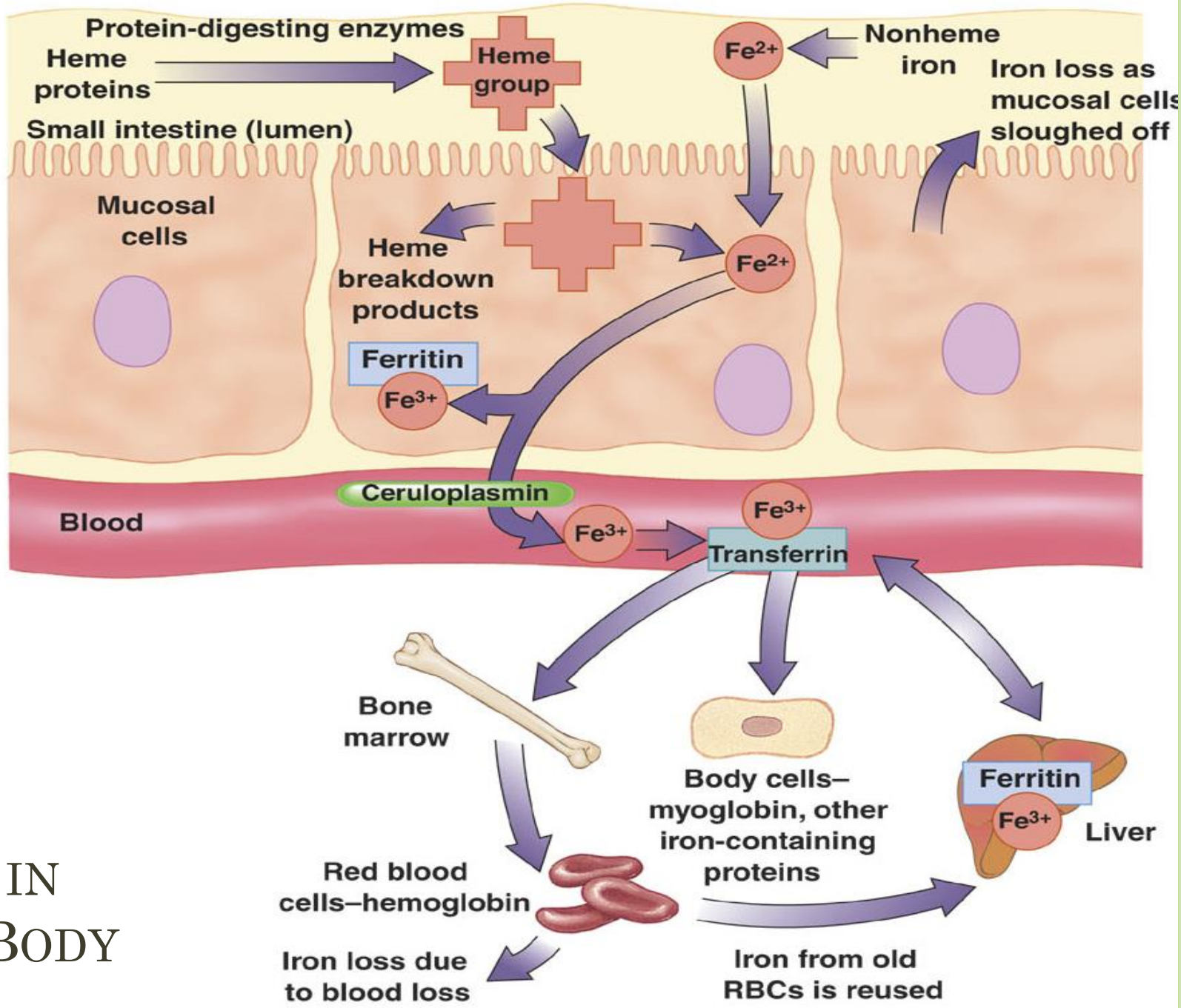
Sources: forages and copper or trace mineral salts.

Iron



- Heme iron:
  - Found in animal products
    - Red meats, liver, poultry and eggs
- Non-heme iron:
  - Found in plant products
    - Beans, nuts, seeds, dried fruits, fortified breads and cereals
- Iron deficiency is the most widespread vitamin or mineral deficiency in the world.
  - 70% of your body's iron is in your hemoglobin
  - Too little iron = too little oxygen

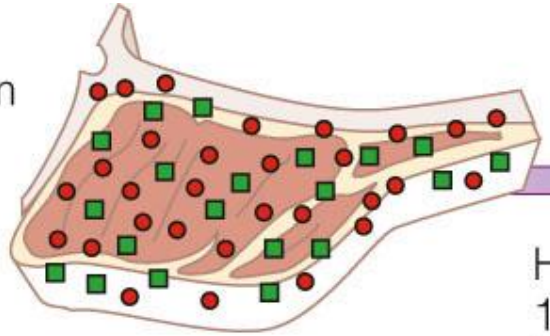
Iron in the Body



best = heme iron (animal sources of iron)

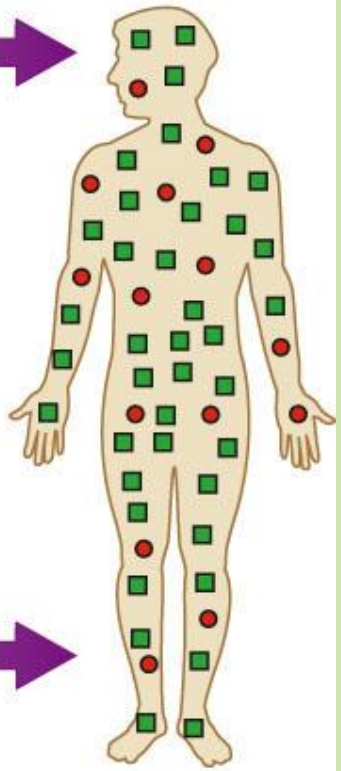
~25% absorbed

Only foods derived from animal flesh provide heme, but they also contain nonheme iron.



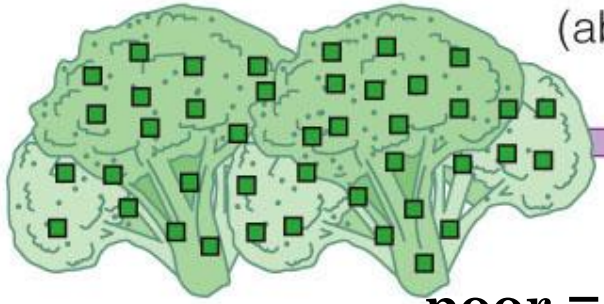
Heme accounts for about 10% of the average daily iron intake, but it is well absorbed (about 25%).

Nonheme iron accounts for the remaining 90%, but it is less well absorbed (about 17%).



Key:
- Heme
- Nonheme

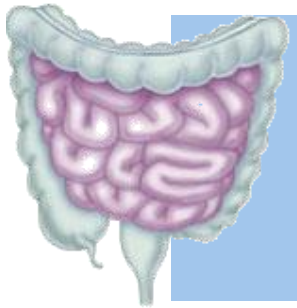
All of the iron in foods derived from plants is nonheme iron.



poor = non-haem iron (vegetative sources)

~17% absorbed

Iron in food



Mucosal cells in the intestine store excess iron in mucosal ferritin (a storage protein).

If the body does not need iron

Iron is not absorbed and is excreted in shed intestinal cells instead. Thus, iron absorption is reduced when the body does not need iron.

If the body needs iron

Mucosal ferritin releases iron to mucosal transferrin (a transport protein), which hands off iron to another transferrin that travels through the blood to the rest of the body.

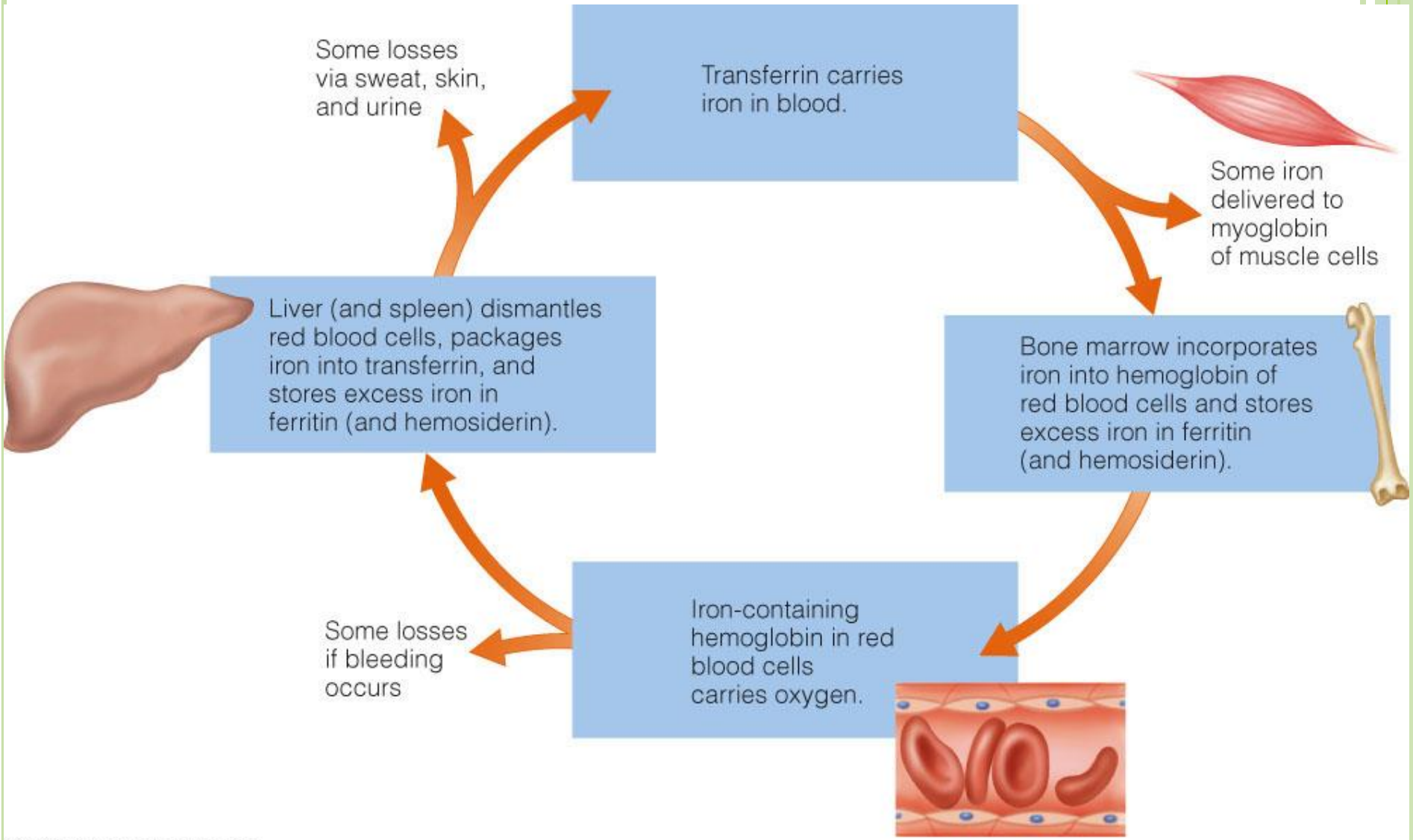
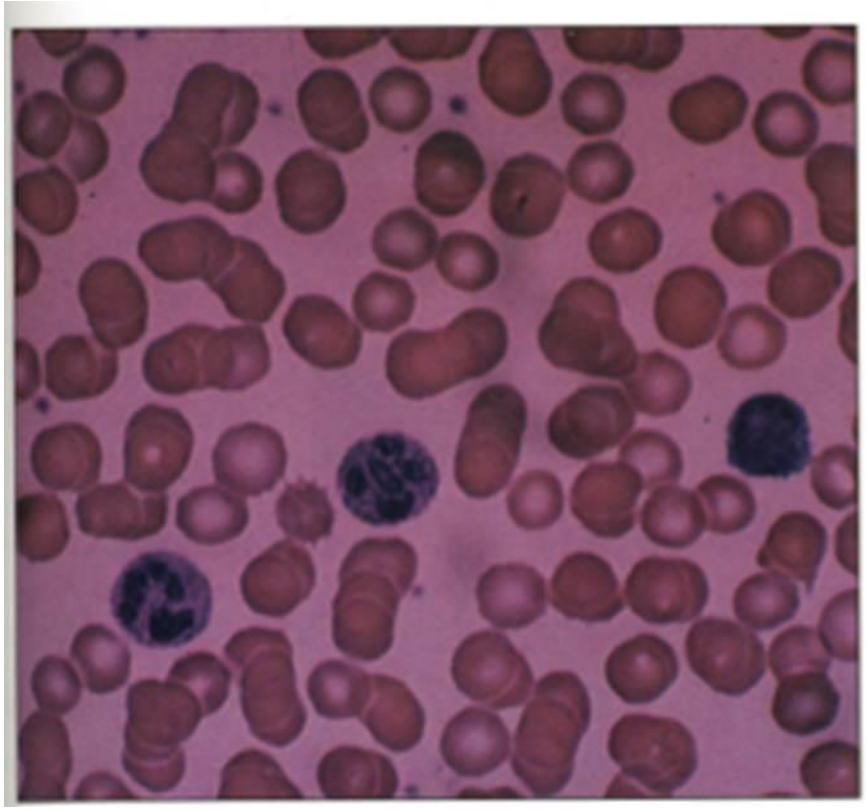
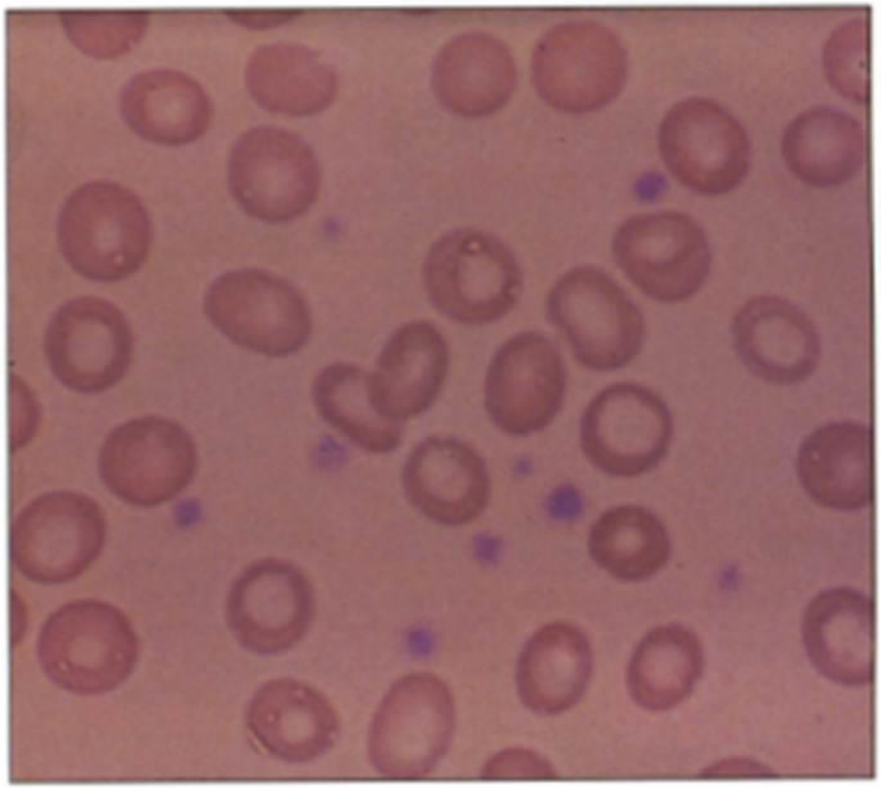


Fig. 13-3





Fe deficiency

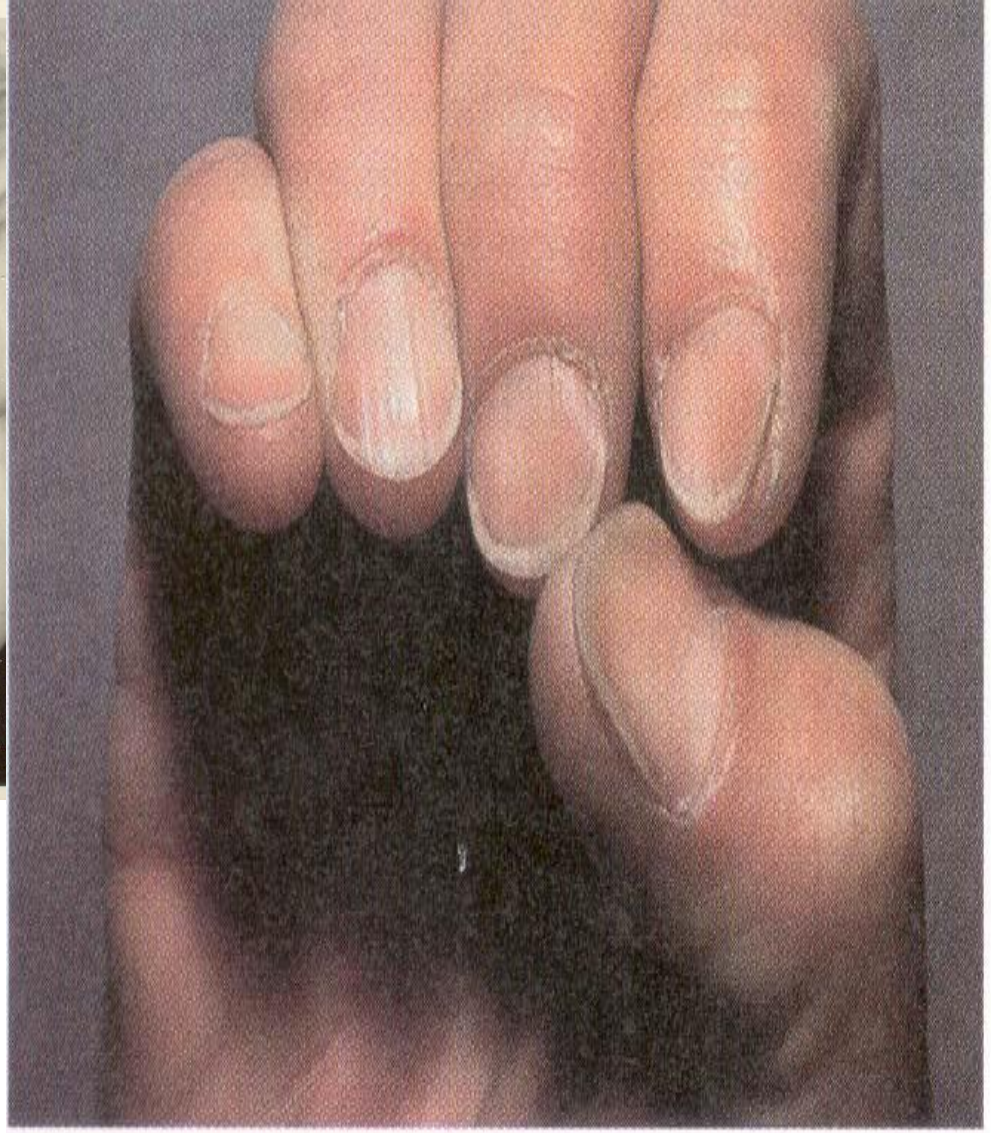


FIGURE 5-10 • Koilonychia—thin, concave nails with raised edges—may be seen on people with iron deficiency anemia. (From Callen WBS et al: *Color atlas of dermatology,* Philadelphia, 1993, WB Saunders.)

Iron

- **Absorption-Enhancing Factors**
  - MFP factor enhances the absorption of nonheme iron.
  - When nonheme iron is consumed with vitamin C at the same meal, absorption of iron increases.
  - Citric acid and lactic acid from foods, HCl from the stomach, and sugars enhance nonheme iron absorption.

- **Absorption-Inhibiting Factors**
  - Phytates and fibers from legumes, grains, and rice
  - Vegetable proteins in soybeans, legumes, and nuts
  - Calcium in milk
  - Tannic acid and other polyphenols in tea, coffee, grains, oregano, and red wine

Iron supplements

- Check with your doctor first.
- High risk groups:
  - Strict vegetarians
  - Those who do not eat a balanced diet
  - Those who are over 60
  - Smokers and those who regularly drink alcohol
  - Chronic dieters
  - Those who suffer from food allergies, intolerances

Cobalt (Co)

Function: required as a nutrient for the microorganisms in ruminants and thereby aids in rumen synthesis of Vitamin B_{12}. Because swine cannot manufacture B_{12} from cobalt, the diets are supplemental with vitamin B_{12} instead.

Deficiency signs: lack of appetite, loss of weight, rough hair coat, anemia, decreased milk and wool production and death in extreme cases.

Sources: legume forages and salt containing cobalt.

Magnesium (Mg)

Function: similar to calcium and phosphorus.

Deficiency signs: Animals are irritable, their heart beat is irregular and there is severe kidney damage.

Sources: mineral supplements and ordinary feeds.

Minerals

Nutrient	Functions	Sources
Calcium	Builds bones and teeth Helps muscles and nerves work	Milk, yogurt, cheese, broccoli, salmon, dark veggies, esp. leafy greens, turnip and mustard greens, tofu, almonds and broccoli.
Fluoride	A mineral that is important to dental and bone health. Greatly improves resistance to cavitites	fluoridated water, foods cooked in or containing fluoridated water, fish with bones that are eaten, and tea
Chromium	A mineral important in regulating blood glucose.	brewer's yeast, whole grains and meats
Copper	A mineral that is important for nerve function, bone maintenance, growth, blood formation and utilization of glucose.	organ meats, sea foods, nuts and seeds
Manganese	A mineral that is important for growth, reproduction, formation of bone, and carbohydrate metabolism.	whole grains, fruits, vegetables and tea.

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Minerals

Nutrient	Functions	Sources
Iron	Combines with protein to make hemoglobin. A mineral that is an essential constituent of blood and muscle and important for the transport of oxygen. Helps cells use oxygen.	liver, red meat, egg yolk, legumes, whole or enriched grains and dark green vegetables.
Zinc	A mineral involved in wound healing, taste sensation, growth and sexual maturation and part of many enzymes regulating metabolism	meat, liver, eggs and seafood (oysters)
Iodine	Promotes normal functioning of the thyroid gland	Iodized salt and salt water fish
Magnesium	A mineral found mainly inside muscles, soft tissues and bone. It functions in many enzyme processes.	nuts, legumes, whole grains and green vegetables

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Minerals

Nutrient	Functions	Sources
Sodium	Helps nerves and muscle function. A mineral that regulates body fluid volume, concentration and acid-base.	Salt, soy sauce, processed foods or foods processed with table salt
Chloride	A mineral that regulates body fluid volume, concentration and acid-base balance. Balance intertwined with that of sodium	fluoridated water, foods cooked in or containing fluoridated water, fish with bones that are eaten, and tea
Potassium	Helps nerve function and muscle contraction, and maintenance of normal blood pressure. Balances body water	Potatoes, bananas, prune juice and tomato products
Phosphorus	A mineral essential to bone formation and maintenance, energy metabolism, nerve function and acid balance.	meat, poultry, fish, eggs, dairy products and cereal products.

Water

Water helps to maintain many bodily functions.

- Lubricates your joints and mucous membranes.
- Enables you to swallow and digest foods.
- Absorb other nutrients, and eliminate wastes.
- Perspiration helps maintain normal body temperature.

Water makes up around 65% of the body. It's important to drink at least 8-10 cups of water a day to maintain health.

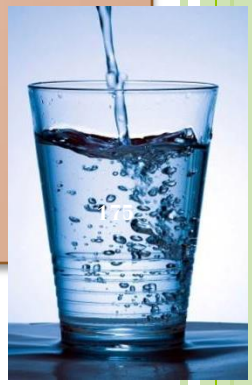


Table 2 Composition of Human Body and Fat-Free Tissue as Influenced by Growth, Malnutrition and Obesity

Components	Fetus (20–25 wk)	Premature baby	Full-term baby	Infant (1 year)	Adult man	Malnutritioned infant	Obese
Body weight (kg)	0.3	1.5	3.5	20	70	5	100
Water %	88	83	69	62	60	74	47
Protein %	9.5	11.5	12	14	17	14	13
Fat %	0.5	3.5	16	20	17	10	35
Remainder %	2.0	2.0	3	4	6	2	5
Fat-free weight (kg)	0.30	1.45	2.94	8	58	4.5	65
Water %	88	85	82	76	72	82	73
Protein %	9.4	11.9	14.4	18	21	15	21
Na (mmol/kg)	100	100	82	81	80	88	82
K (mmol/kg)	43	50	53	60	66	48	82
Ca (g/kg)	4.2	7.0	9.6	14.5	22.4	9.0	64
Mg (g/kg)	0.18	0.24	0.26	3.5	0.5	0.25	0.5
P (g/kg)	3.0	3.8	5.6	9.0	12.0	5.0	12.0

Body Water Content

Obese 40%

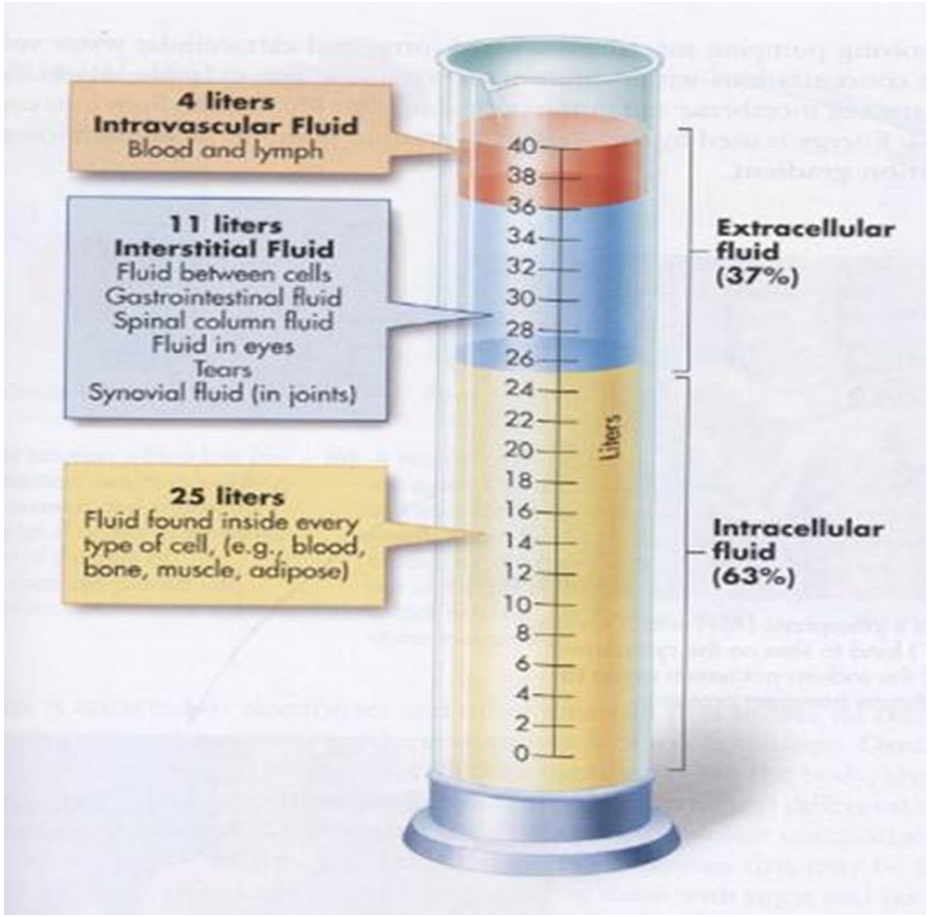
Normal 60%

Muscular 70%

ไขมันเป็นส่วนที่ไม่มีน้ำ
คนที่มีไขมันน้อยจะมีน้ำในตัว
มากกว่าคนที่มีไขมันมากเมื่อ
มีน้ำหนักตัวเท่ากัน

Water

- Essential for life
  - It is possible to live without food than without water.
- Water makes up about 45-75% of your body weight



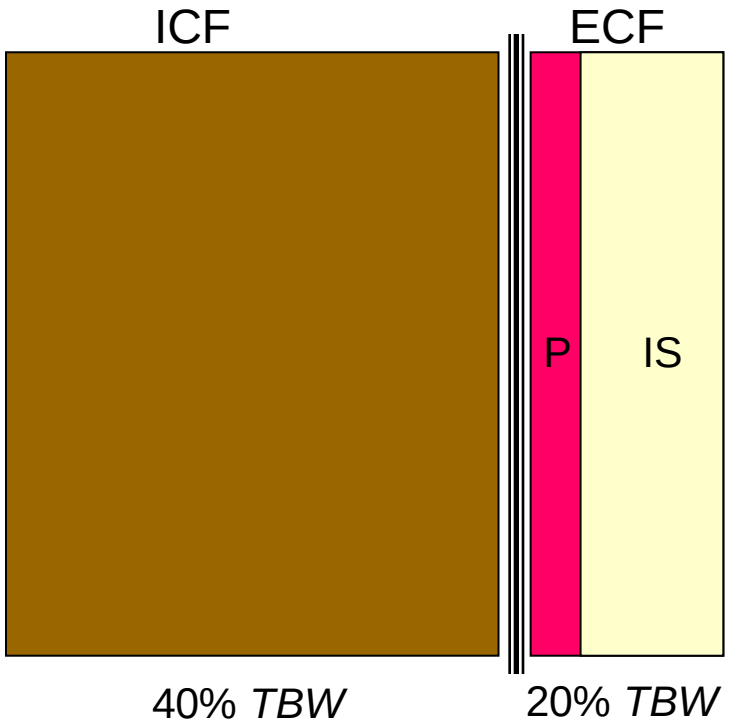
Functions


Represents 75% of the brain
Transports nutrients & oxygen to the cells
Regulates body temperature
Production of oxygen for breathing
Represents 92% of the blood
Helps transform nutrients into energy
Eliminates toxins
Protects and hydrates the organs
Represents 22% of the bones
Helps the body to absorb nutrients
Protects and lubricates the joints
Represents 75% of the muscles
Illustration by Seth Larson

BODY FLUIDS

Distribution of Body Fluids – 50-70% of total body weight;

infant [70-80%], elderly [45-50%]



60-kg man
TBW = 0.6 x 60 kg = 36 L

ICF = 0.4 x 60 kg = 24 L

ECF = 12 L

3L **9L**

BODY FLUIDS

Factors that Dictate Body Water Requirement

1) Amount needed to give the proper osmotic concentration
2) Amount needed to replace water lost excretion

Normal Routes of water gain and loss

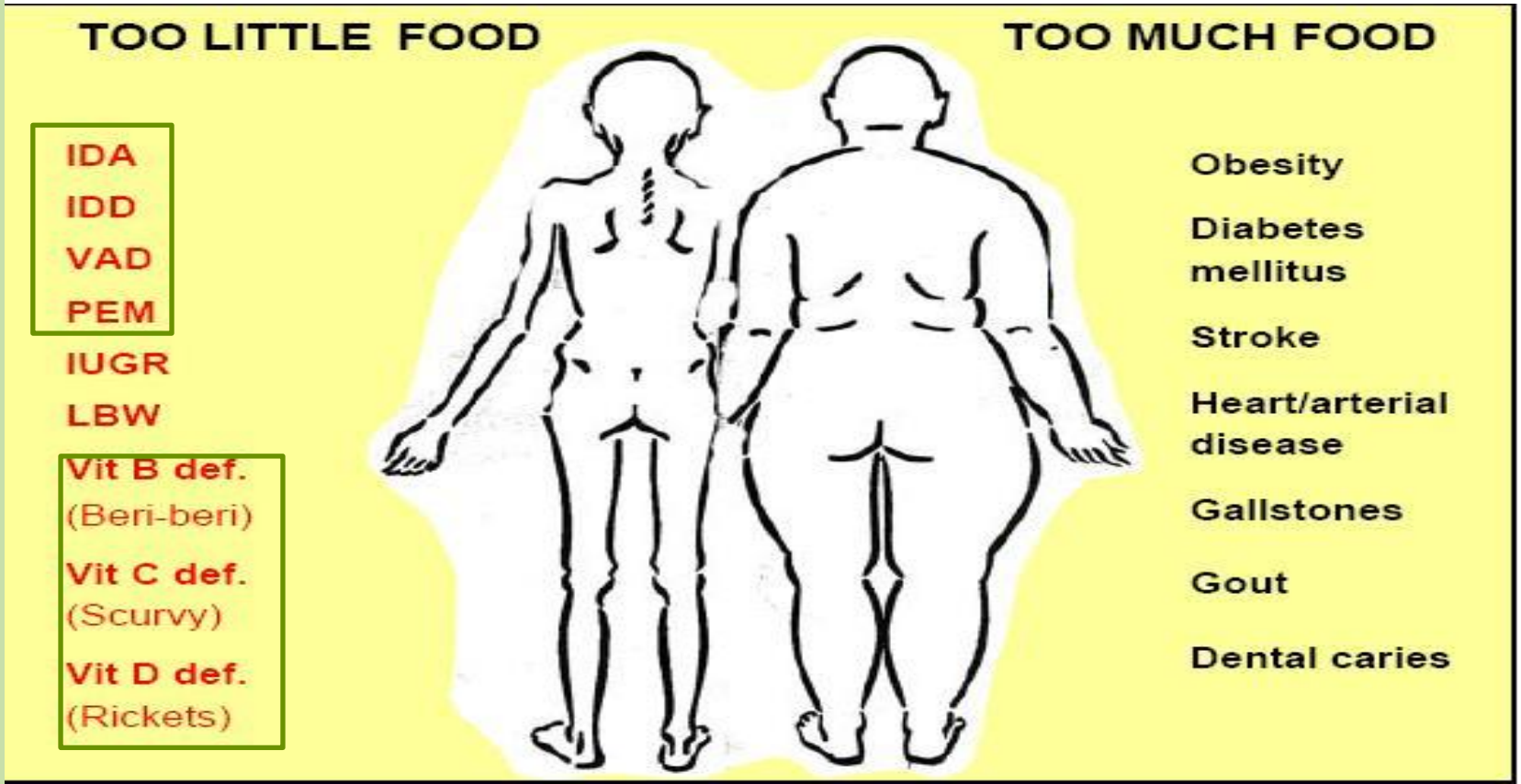
INTAKE	*ml/day*	OUTPUT	*ml/day*
Fluid intake	1,200	Insensible loss	700
Food	1,000	Sweat	100
Metabolic water	300	Feces	200
TOTAL	2,500	Urine	1,500
		TOTAL	2,500

Why is water important?

- Aids with transport
- Mechanical functions
- Helps to break substances down (Hydrolysis ≡)
- Helps to maintain body temperature/pH/osmotic pressure

NUTRITIONAL PROBLEMS

- Malnutrition
  - * Undernutrition: lack or less amount of nutrients
  - * Overnutrition :too much nutrients or energy
- Food unsafety



Getting too Many Nutrients

- Poor nutrition can also result from getting too many nutrients
  - Example: too much fat can lead to heart disease and other problems
- Excess amounts of vitamins and minerals can cause serious harm to your body
  - Example: too much vitamin A can damage your liver
    - Taking too many vitamin and mineral supplements can cause this

Nutrient Deficiencies

- **A Nutrient Deficiency is a shortage of a nutrient**
  - If you do not get enough of a nutrient a deficiency will result and poor health or lack of energy may be the result
    - The effects of some deficiencies take a long time to show
      - **Example:** Not enough calcium in the teen years may not show until the elderly years (less dense bones)

Protein Energy Deficiency

Protein deficiency is rare, but there is a condition called PEM – protein energy malnutrition. This can be seen in infants with stunted growth or thin arms and legs, and large distended abdomens.

Marasmus - this condition mainly affects infants causing them to become thin and weak. The body adapts to the shortage of energy and nutrients. *(All energy stores are depleted as it is used to supply vital organs.)*

Kwashiorkor - this condition is known to be the body's adaption to shortage of energy and nutrients.

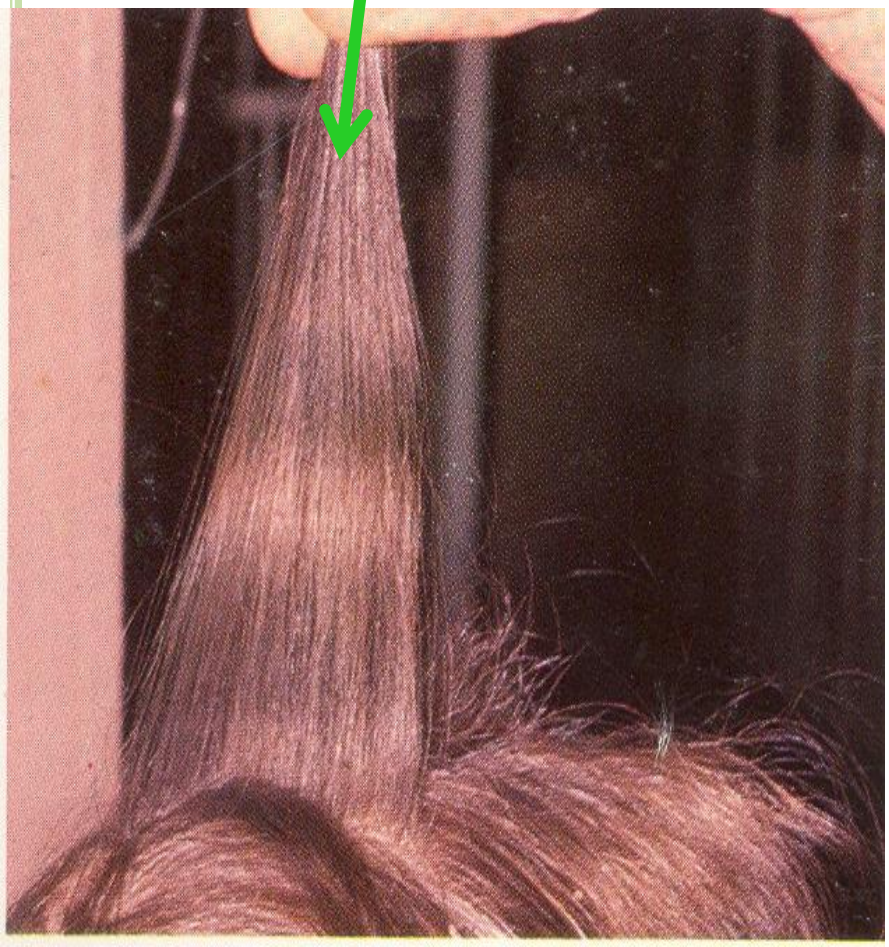
Protein Energy Deficiency

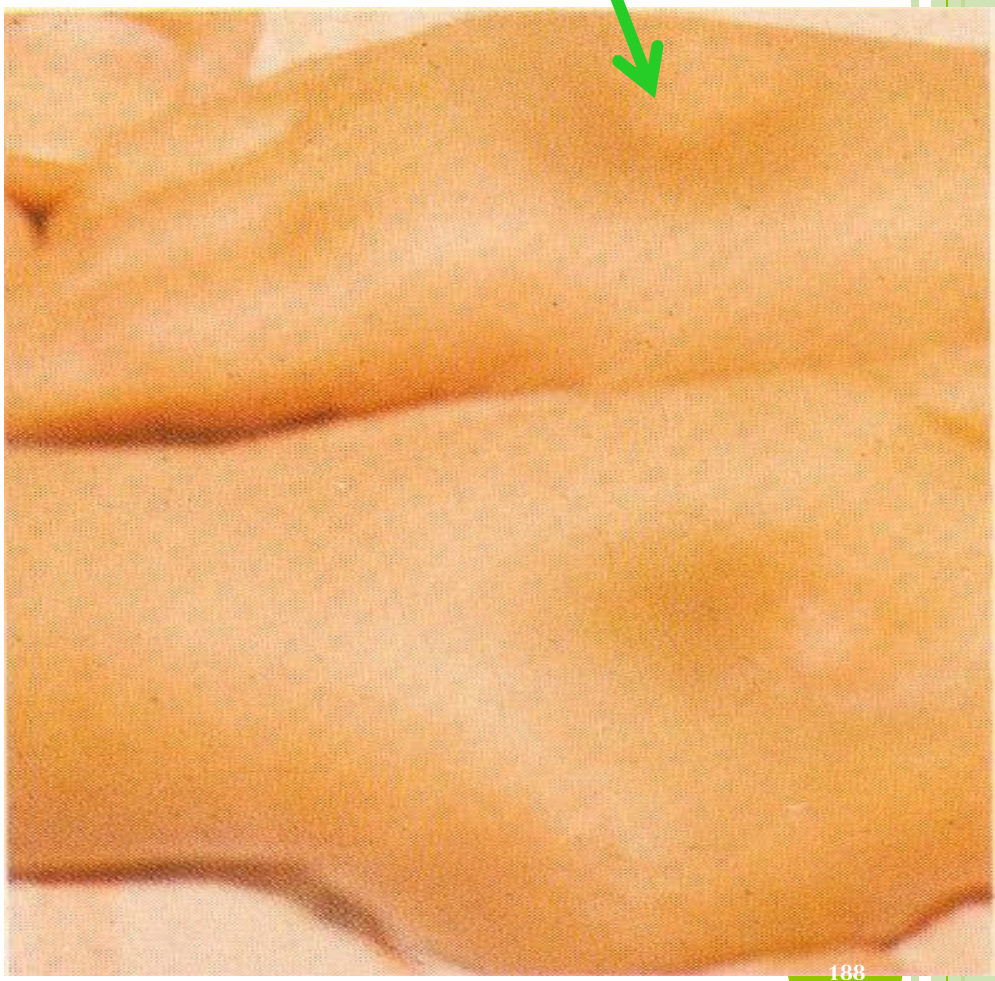
- Parameters for classication
- STUNTING determine from height
- WASTING –assess by weight for height
- UNDERWEIGHT assess by weight

KWASHIORKOR

THE FACE OF "PROTEIN-ENERGY" MALNUTRITION

Flag sign of kwashiorkor and edaema





USUALLY PRESENT SIGNS

- MOON FACE
- HAIR CHANGES(Depigmentation,Flag sign)
- SKIN DEPIGMENTATION
- ANAEMIA
- OEDEMA
- PSYCHOMOTOR CHANGES
- GROWTH RETARDATION
- MUSCLE WASTING

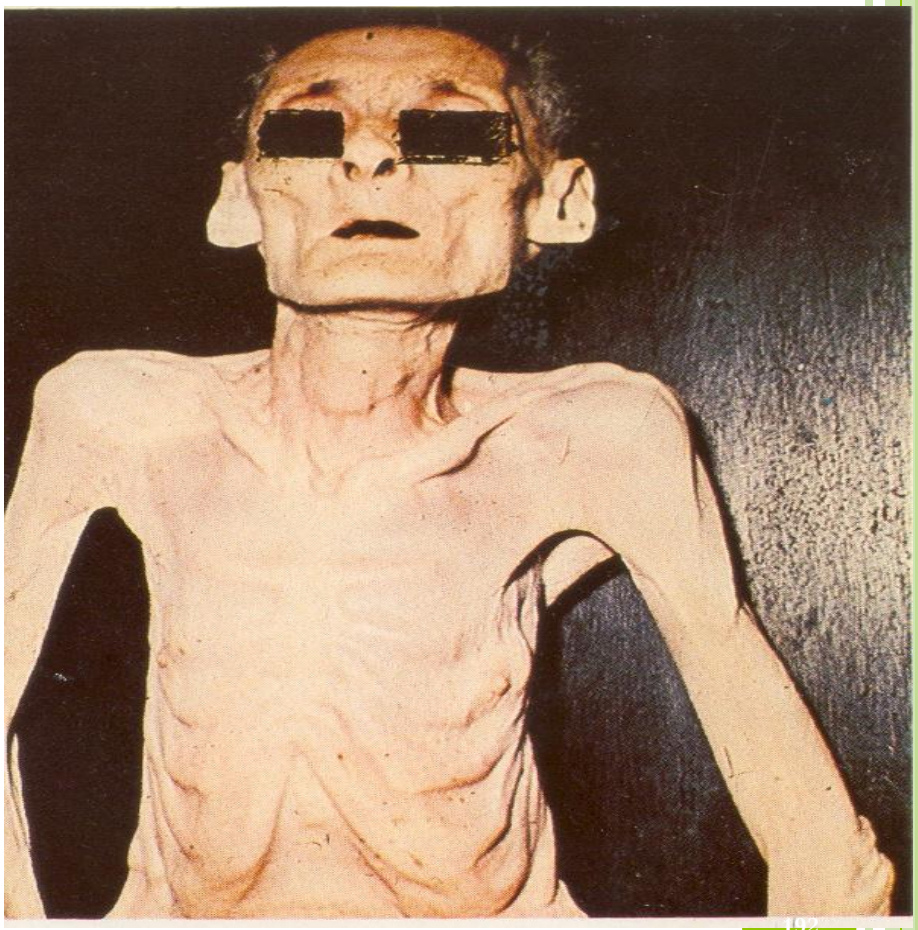
OCCASIONALLY PRESENT SIGNS

- **HEPATOMEGALY**
- **FLAKY PAINT DERMATITIS**
- **CARDIOMYOPATHY & FAILURE**
- **DEHYDRATION (Diarrh. & Vomiting)**
- **SIGNS OF VITAMIN DEFICIENCIES**
- **SIGNS OF INFECTIONS**

MARASMUS

- **The term marasmus is derived from the Greek *marasmos*, which means wasting.**
- **Marasmus involves inadequate intake of protein and calories and is characterized by emaciation.**
- **Marasmus represents the end result of starvation where both proteins and calories are deficient.**
- **Marasmus represents an adaptive response to starvation, whereas kwashiorkor represents a maladaptive response to starvation**
- **In Marasmus the body utilizes all fat stores before using muscles.**

Marasmus



Marasmus

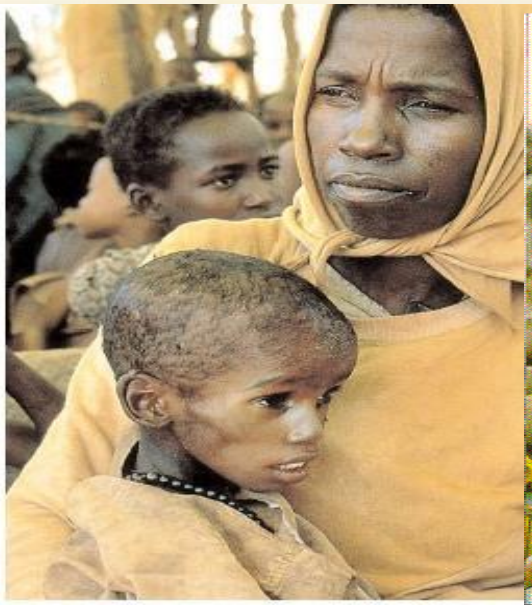
From "Fundamentals of Clinical Nutrition" by R. L. Weinsier copyright 1993 by Mosby-Year Books N.Y.

Fig. 9-2 (A–E) Losses of subcutaneous fat reserves and muscle mass in patients with marasmus.

DERMATITIS

Clinical Features of Marasmus

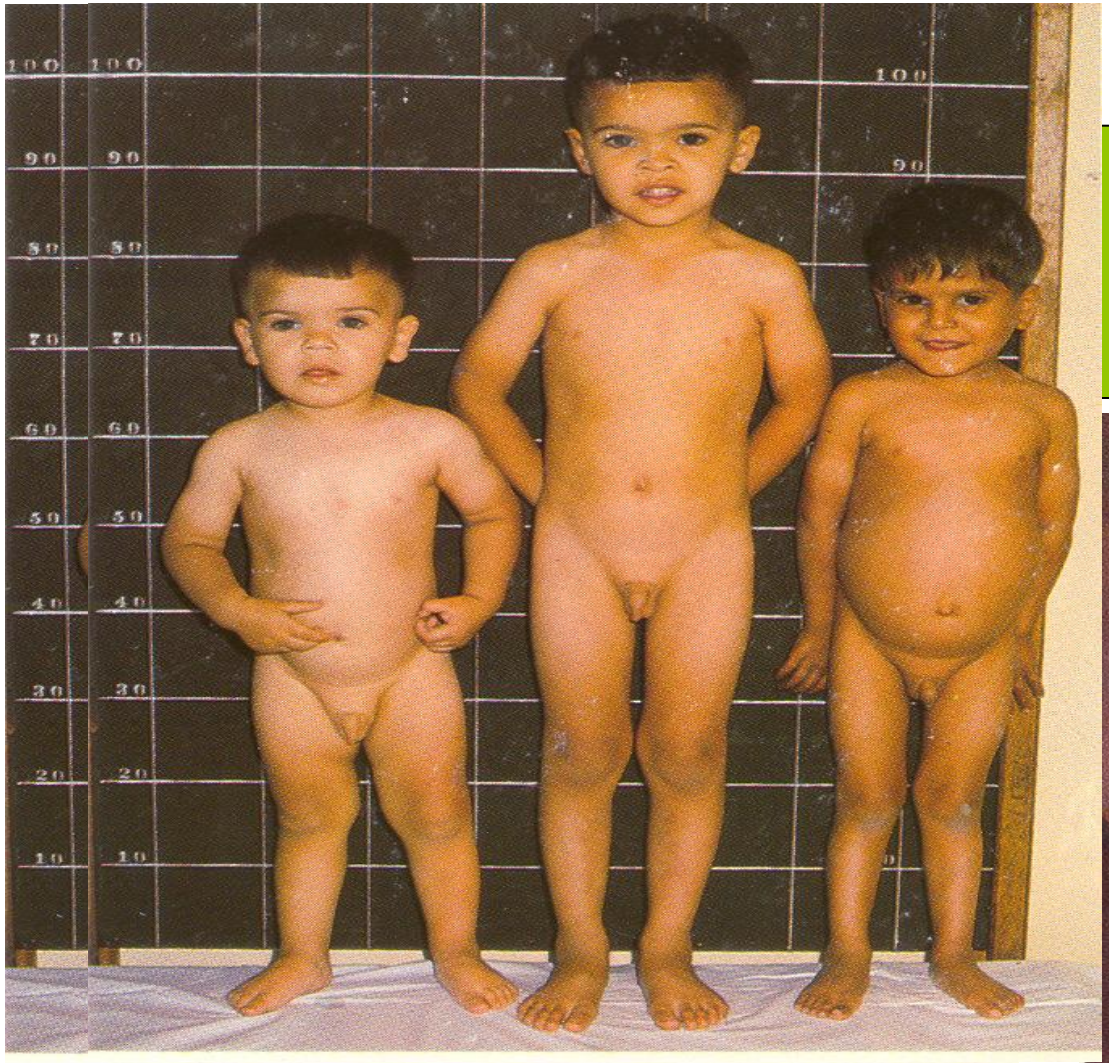
- Severe wasting of muscle & subcutaneous fats
- Severe growth retardation
- Child looks older than his age(monkey face)
- No edema or hair changes
- Alert but miserable
- Hungry
- Diarrhoea & Dehydration



Marasmus

PEM Classification

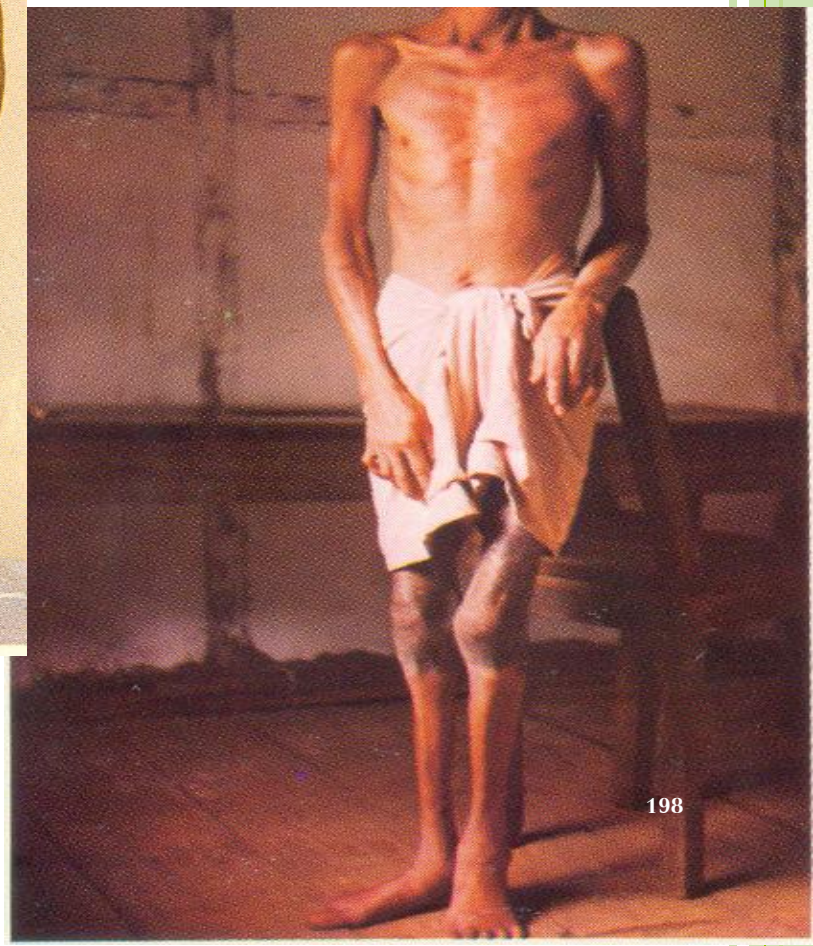
% Standard Wt	w/ Edema	W/O Edema
80-60	kwashiorkor	underweight
<60	Marasmic kwashiorkor	marasmus



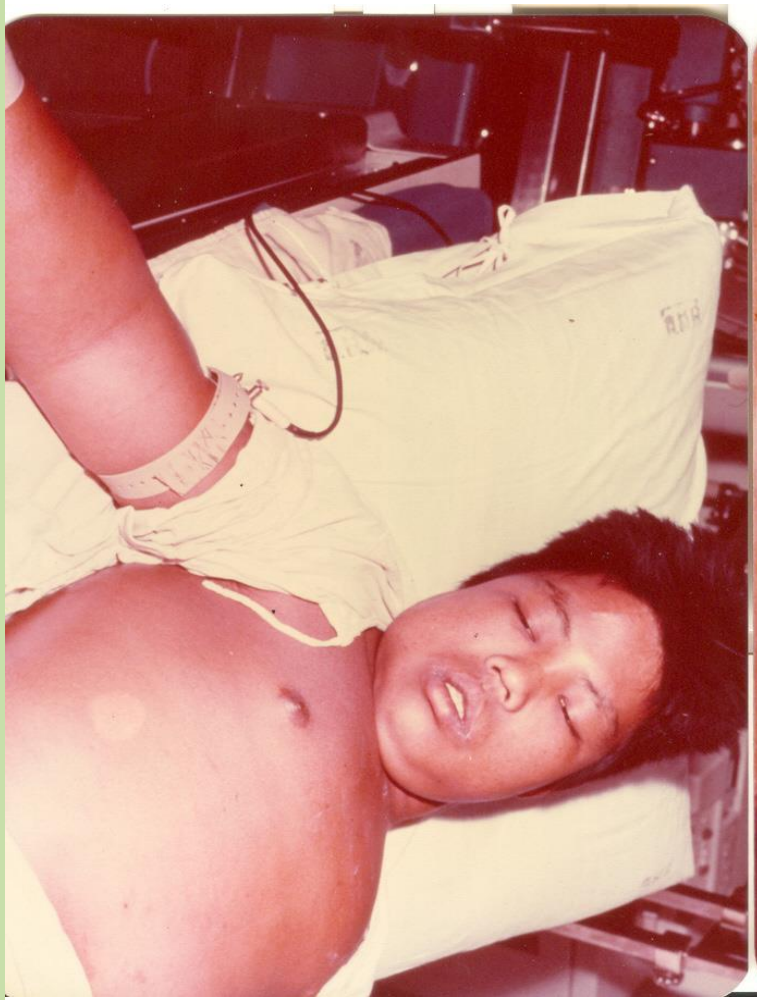
Stunt

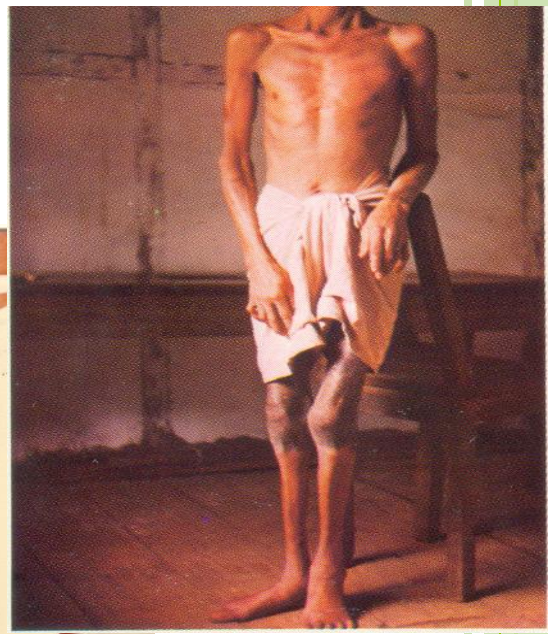
B1 def .

⟶ Beri-beri



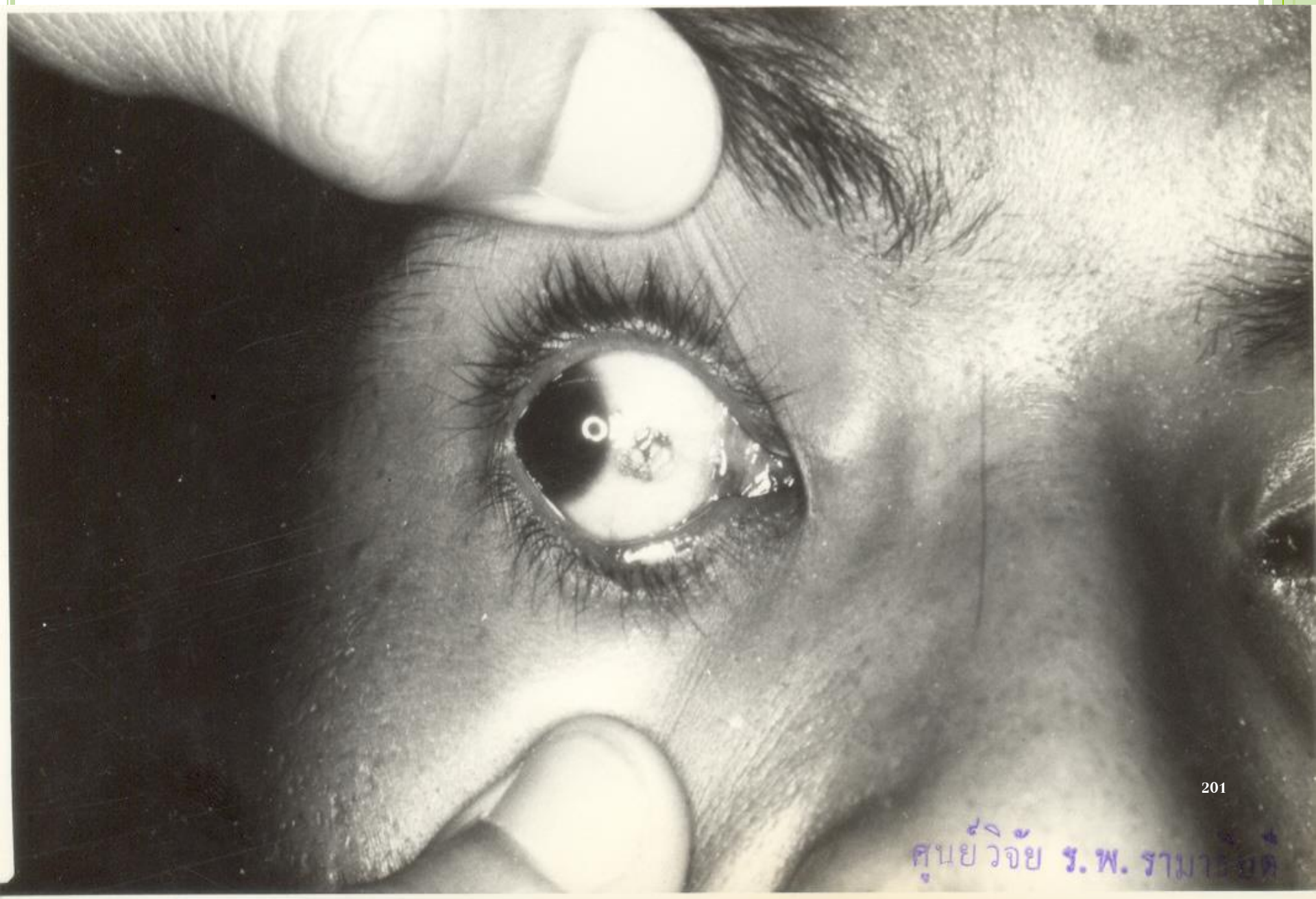
Wet and dry beriberi





Vitamin A deficiency

Night blindness
Xeropthalmia
Toad skin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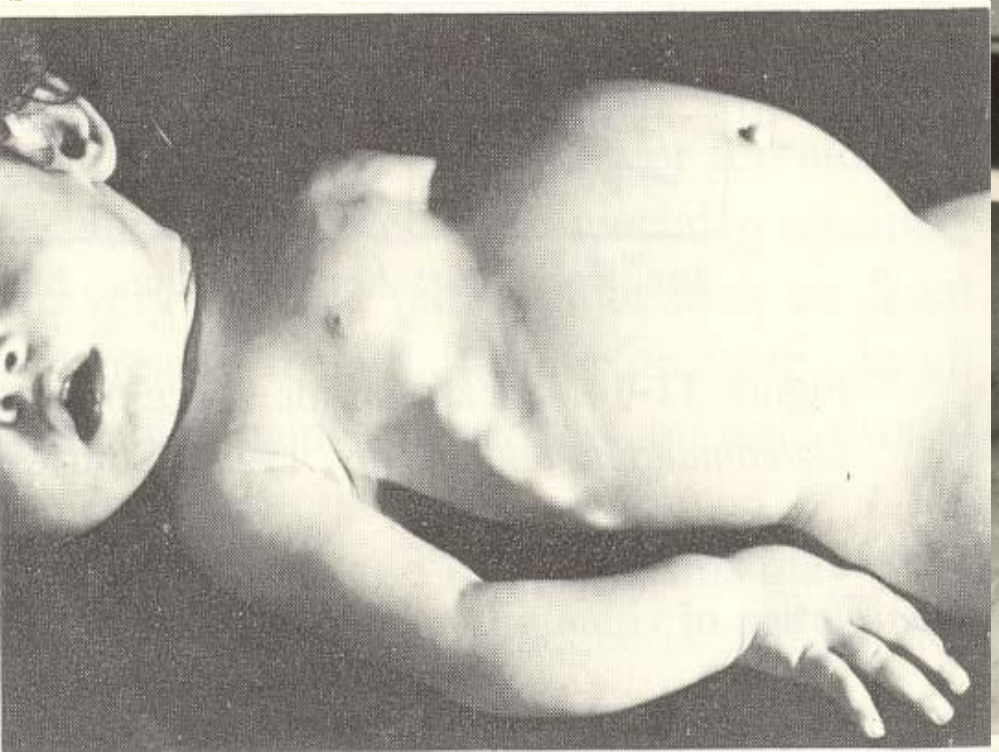
Vitamin D deficiency

ricket

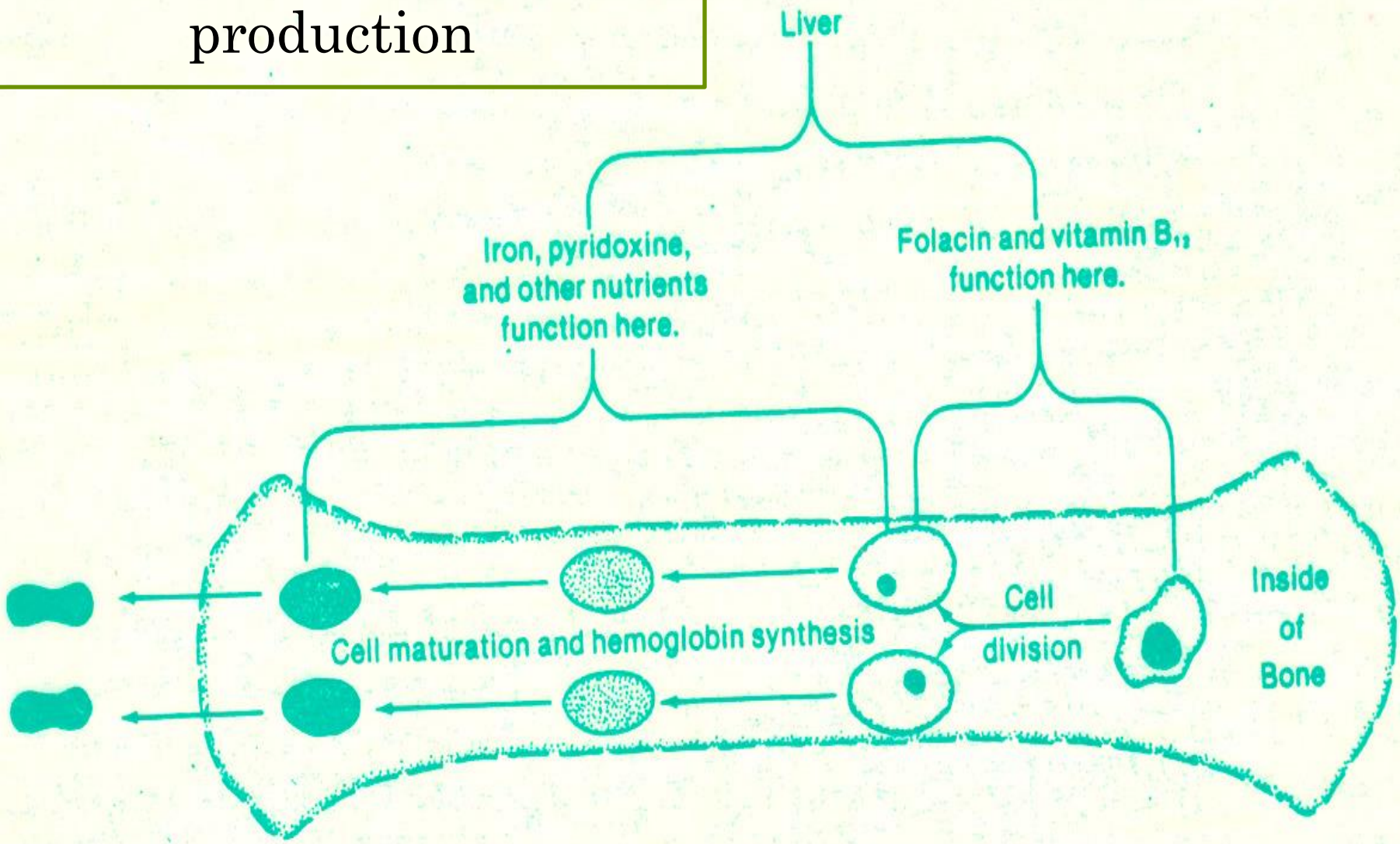
โรคกระดูกอ่อน จากการขาดแคลเซียม วิตามิน ดี



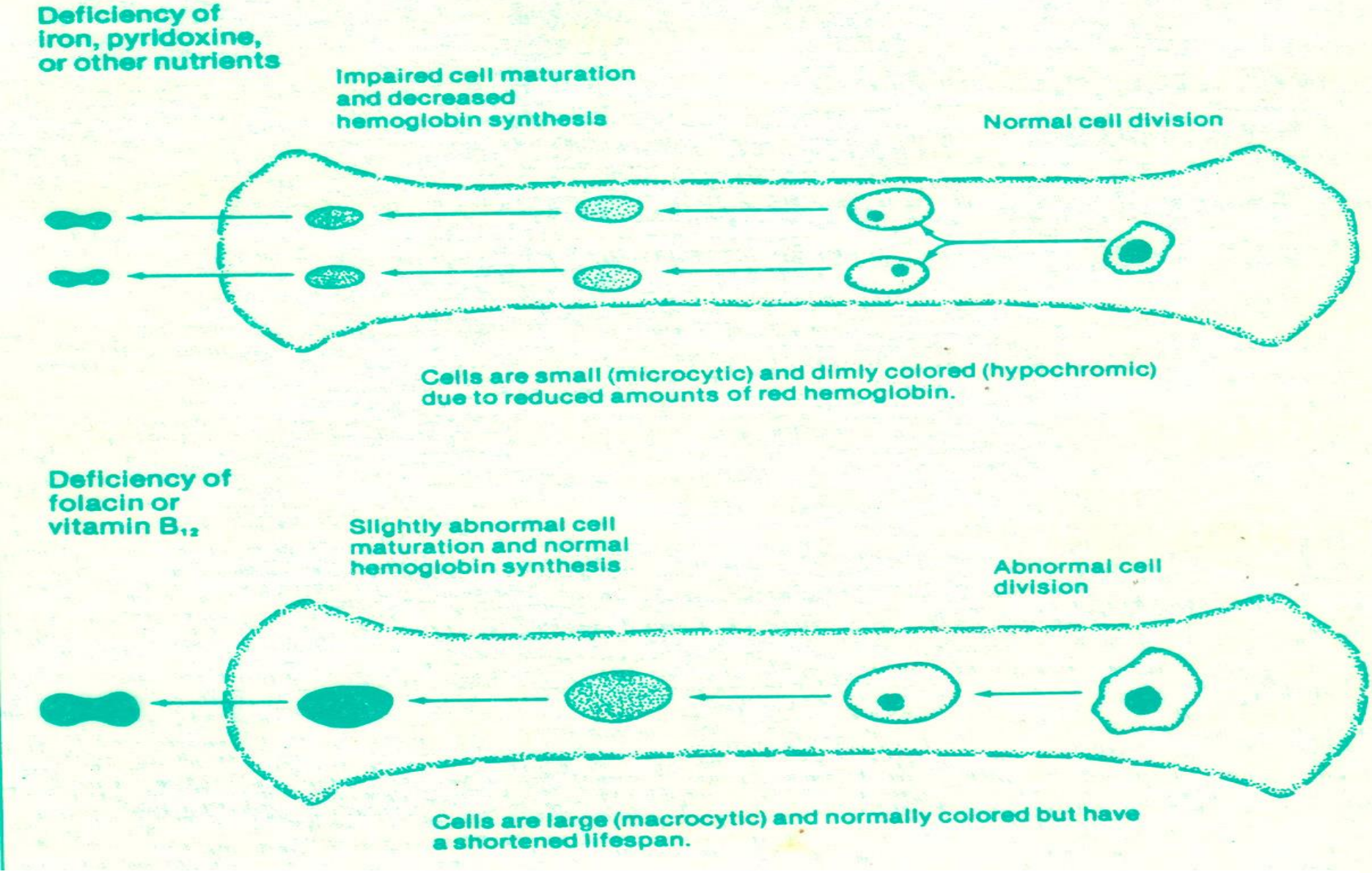
ANAEMIA ⇒ RBC↓ → HYPOXIA

Microcytic anaemia	B_6 **(vit C)**	Small diameter of RBC
Macrocytic (megaloblastic)	Folic acid	Large RBC,immature, Hb↓
Microcytic hypochromic	Fe	Small RBC, Hb↓
Pernicious anaemia	**B_{12} ,Co**	Large RBC immature ,abnormal shape

Mechanism of RBC production



Normal production of RBC



Abnormal production of RBC due to lack of nutrients

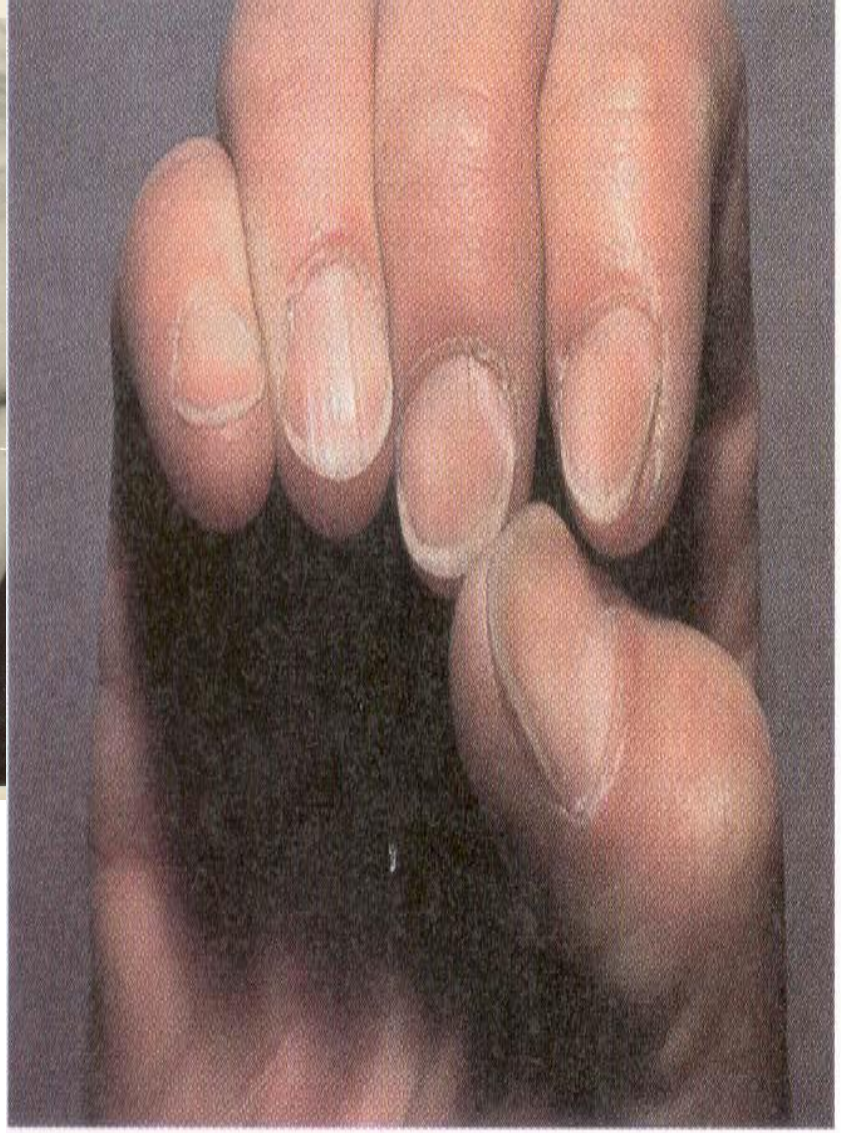
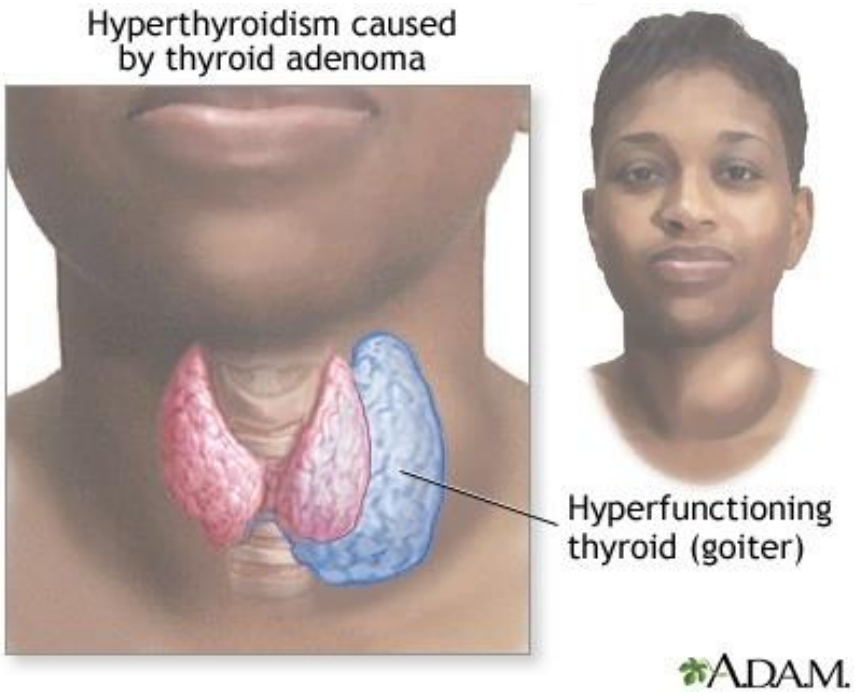


FIGURE 5-10 • Koilonychia—thin, concave nails with raised edges—may be seen on people with iron deficiency anemia. (From Callen WBS et al: *Color atlas of dermatology,* Philadelphia, 1993, WB Saunders.)

Fe deficiency

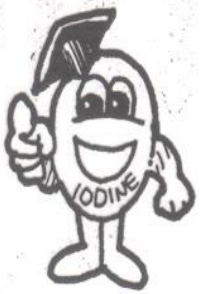
IODINE: Goiter



- Lack of iodine can cause your thyroid to enlarge and then produce a goiter
- These can be painful and uncomfortable

IODINE DEFICIENCY DISORDERS

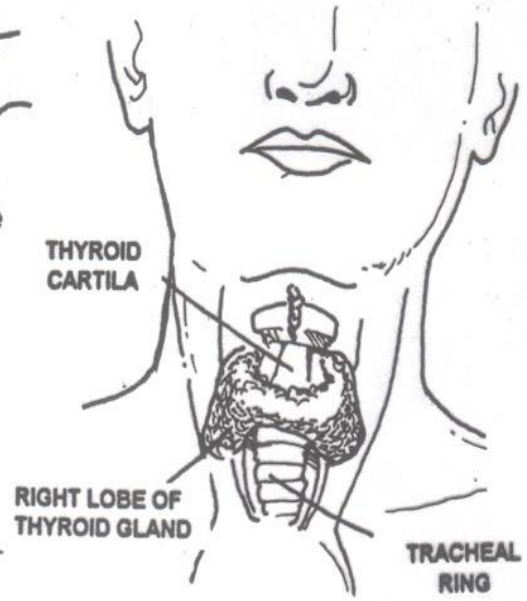
HOW DO WE DETECT GOITER?



Goiter may be detected by palpation of the thyroid gland.

How to palpate at the back?

How to palpate in front?

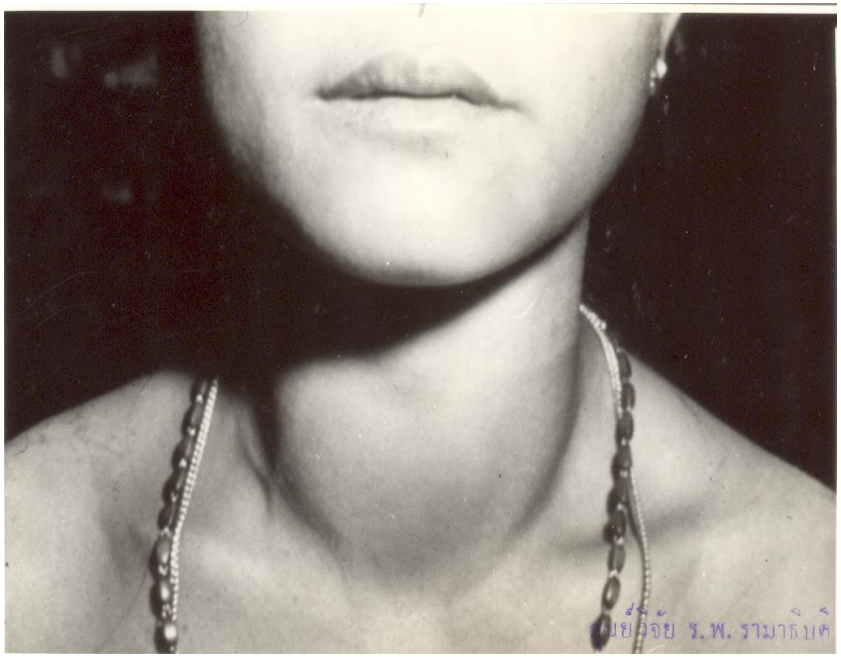


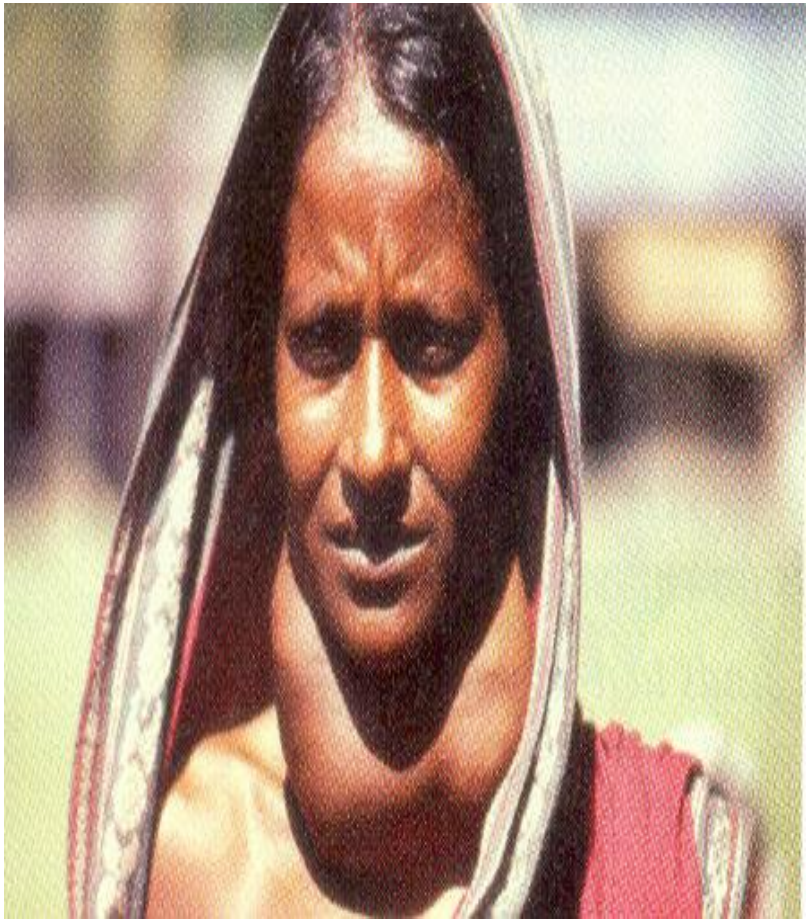
NORMAL THYROID

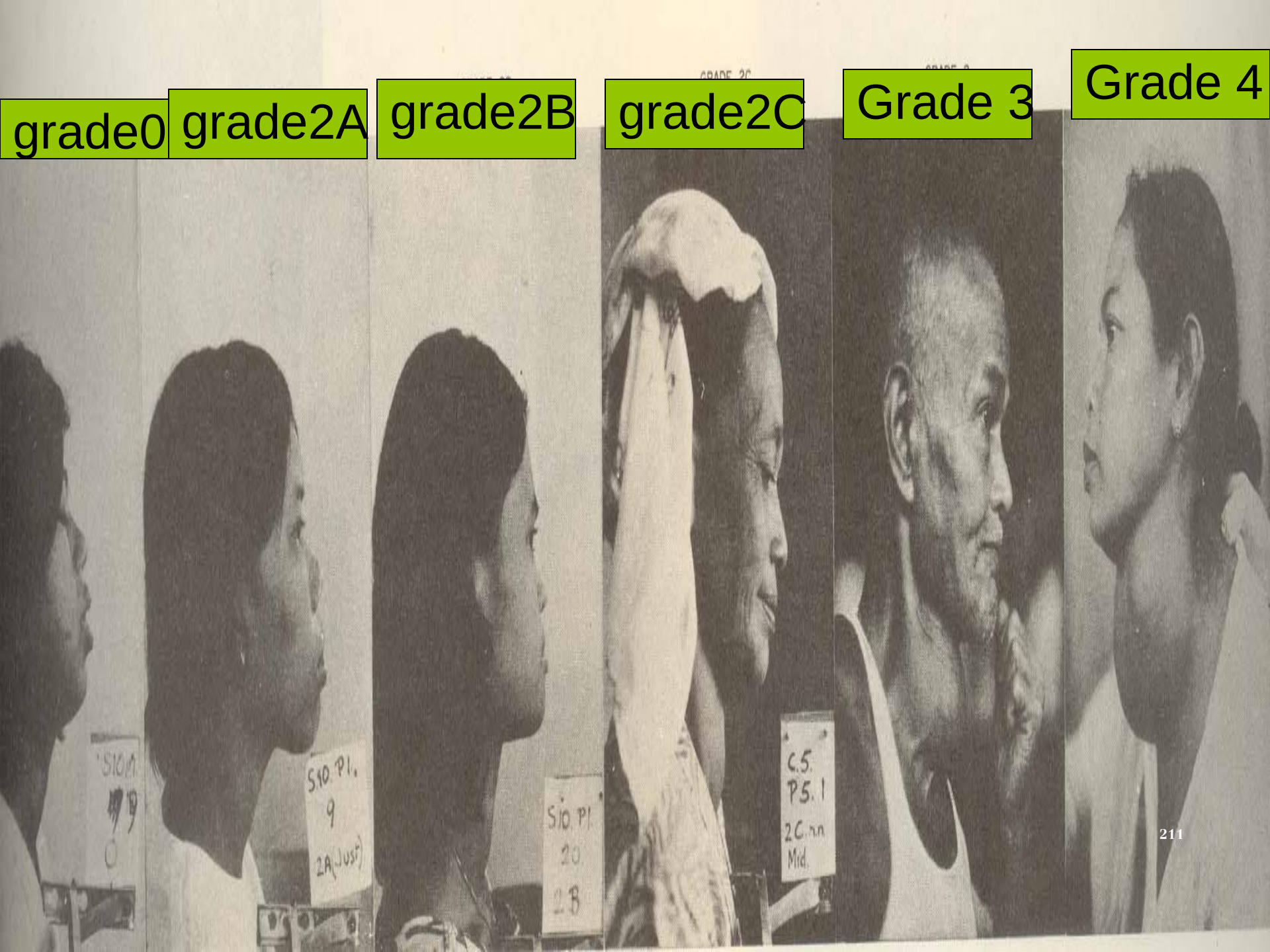
STEPS IN EXAMINING THE THYROID GLAND

1. Stand in front of the patient in normal position.
2. Look at the patient's lower part of the neck to note any mass or enlargement.
3. Ask the patient to swallow. An enlargement in this area which moves up and down as the patient swallows is a visible goiter.
4. Stand behind the patient in normal position.
5. Use the tips of the index and middle fingers to feel the lower front part of the neck just above the notch of the breastbone.
6. Feel for the horizontal rings of the trachea or windpipe through a thin ribbon of tissue. This fleshy mass that can hardly be felt is the thyroid gland. The thyroid has lobes which extend to either side of the trachea.
7. Ask the patient to swallow while your fingers gently palpate the thyroid. If the mass on the neck is a goiter, it will go up and down while swallowing.

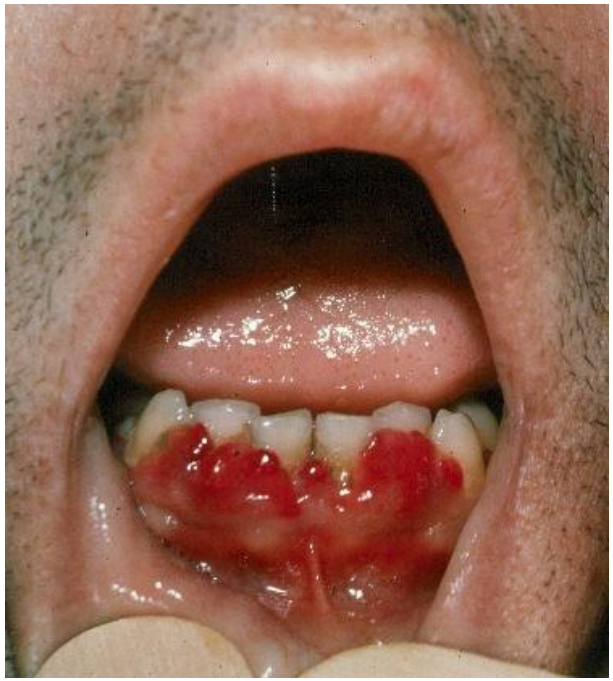
Goiter(lack of iodine)






grade0
grade2A
grade2B
grade2C
Grade 3
Grade 4
S10. P1.
9
2A (Just)
S10. P1
20
2B
C.5.
P5. 1
2C. rn
Mid.

VITAMIN C: Scurvy



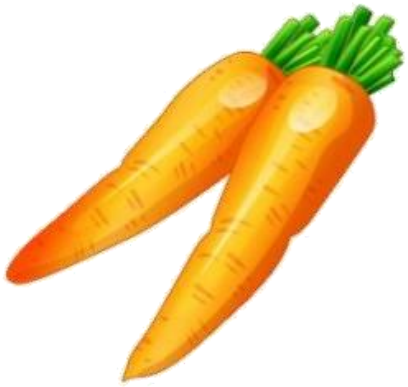
- **Scurvy** can cause bleeding gums, swollen gums, they get soft and start to bleed easy "cork screw" hairs or bleeding follicles, and bleeding fingernails

VITAMIN C: Scurvy

Scorbutic gums. Unlike other lesions of the mouth, scurvy presents a symmetrical appearance without infection.

Pinpoint hemorrhages. Small red spots appear in the skin, indicating spontaneous bleeding internally.

Vitamin A: Night Blindness

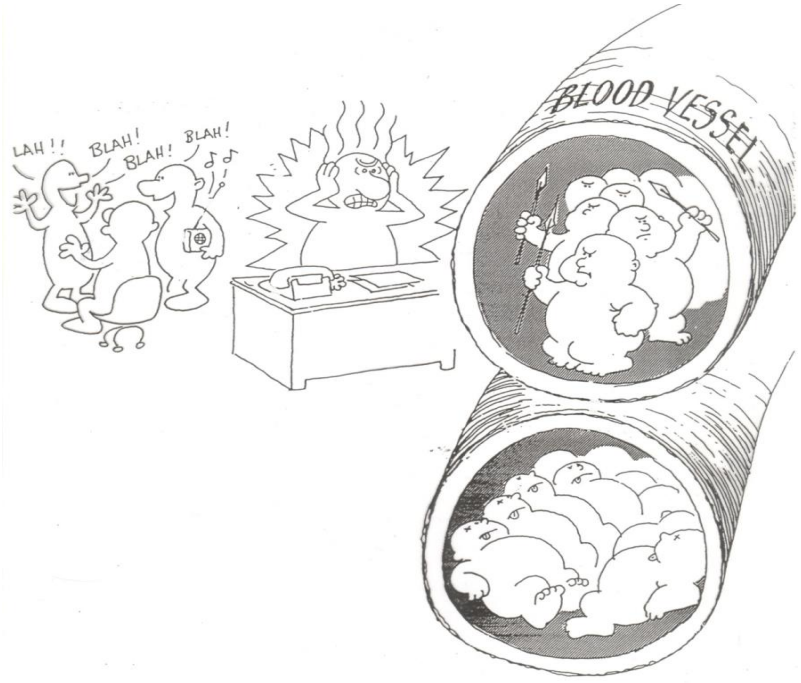


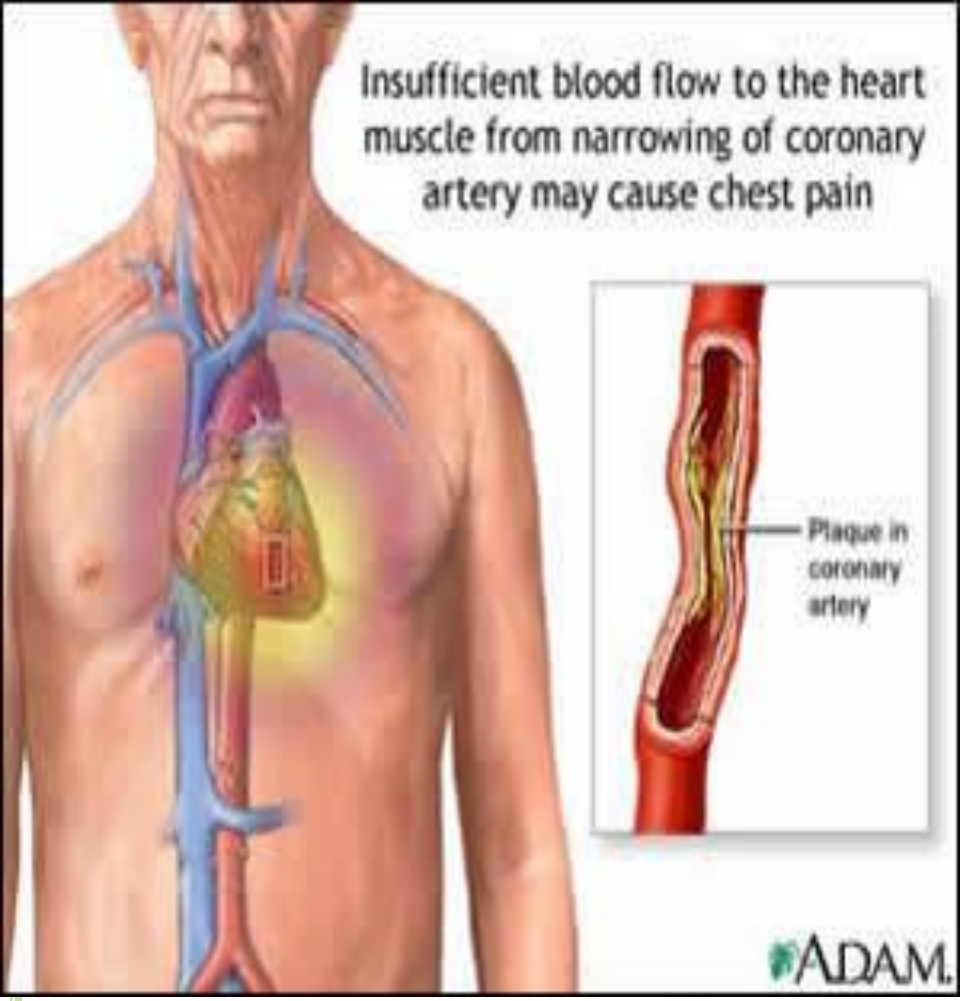
- Unable to see properly at night
- Things are viewed darker than they really are
- The middle of this picture would be what someone with night blindness would see

Vitamin D: Rickets

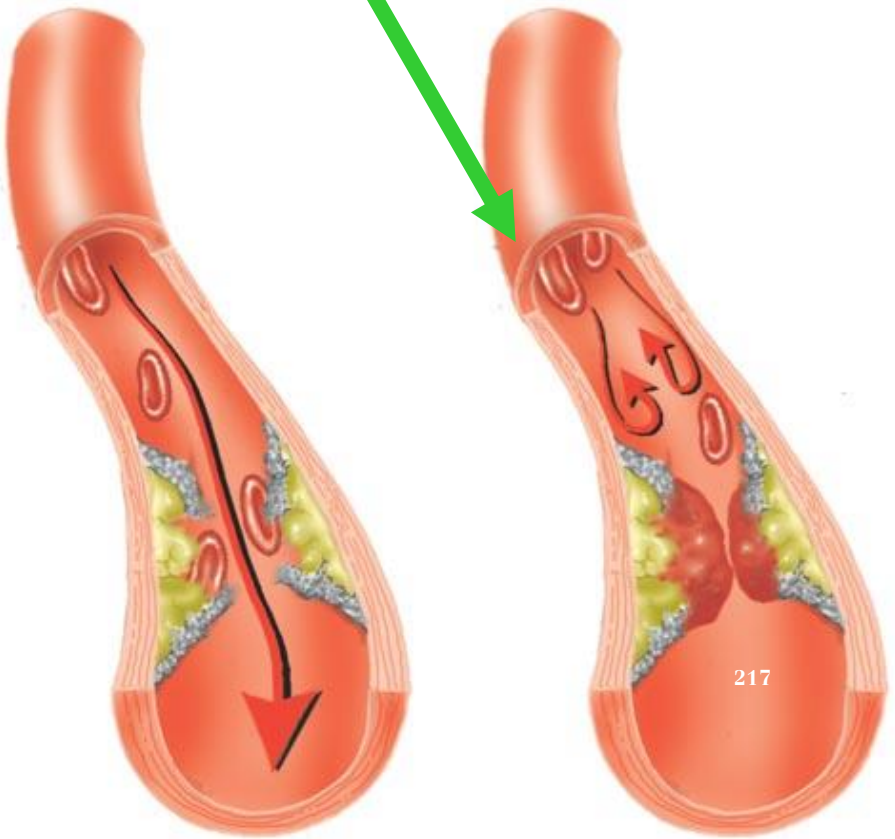
- Rickets is characterized by bowed legs and bones
- This is usually found in third world countries

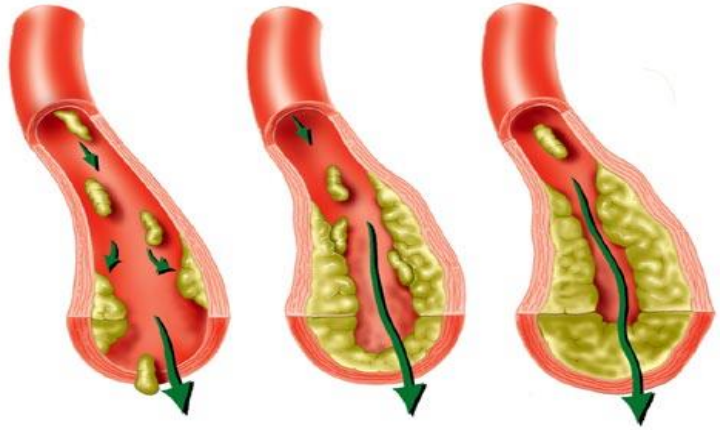
Overnutrition
-Atherosclerosis
-Obesity
-Diabetes



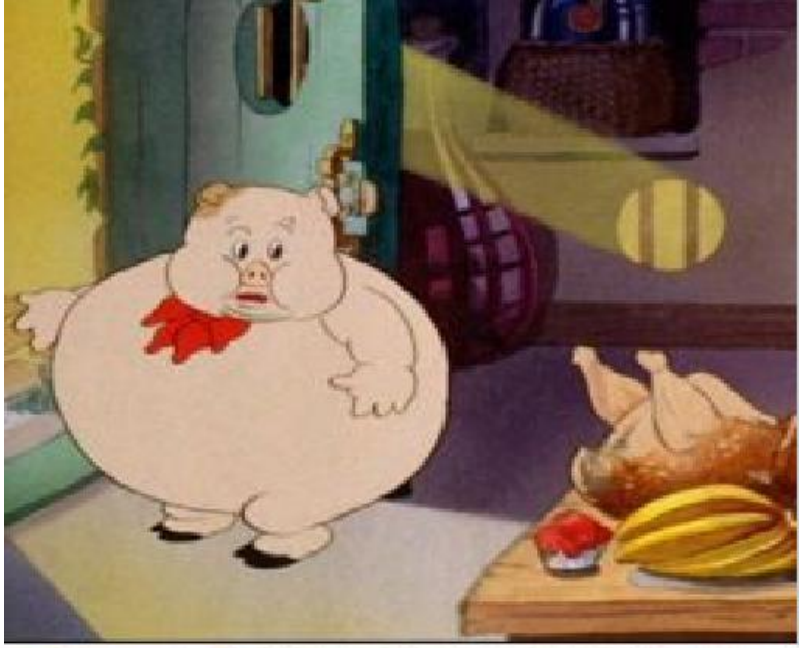


Blood flow is obstructed



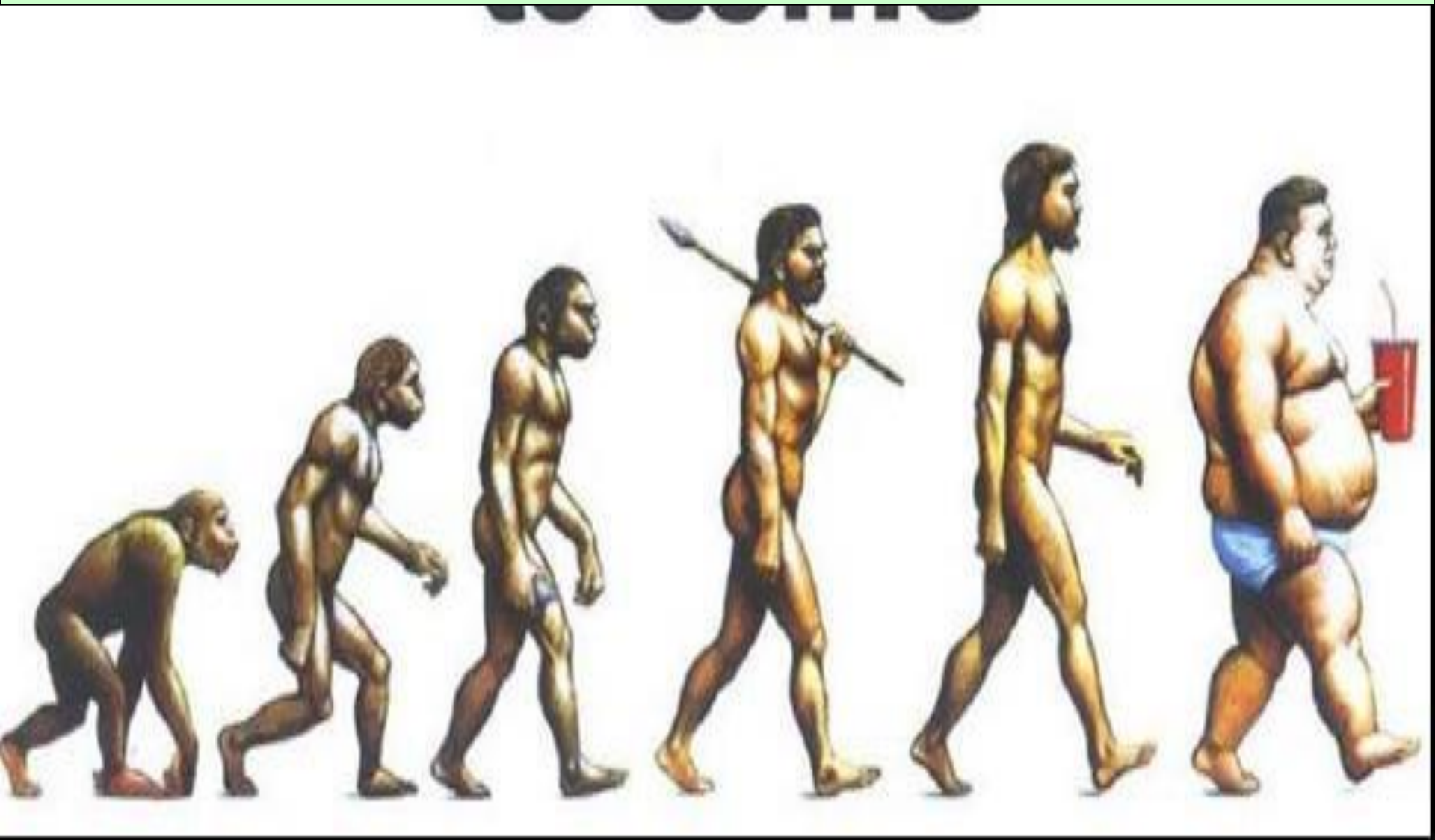


2. OBESITY

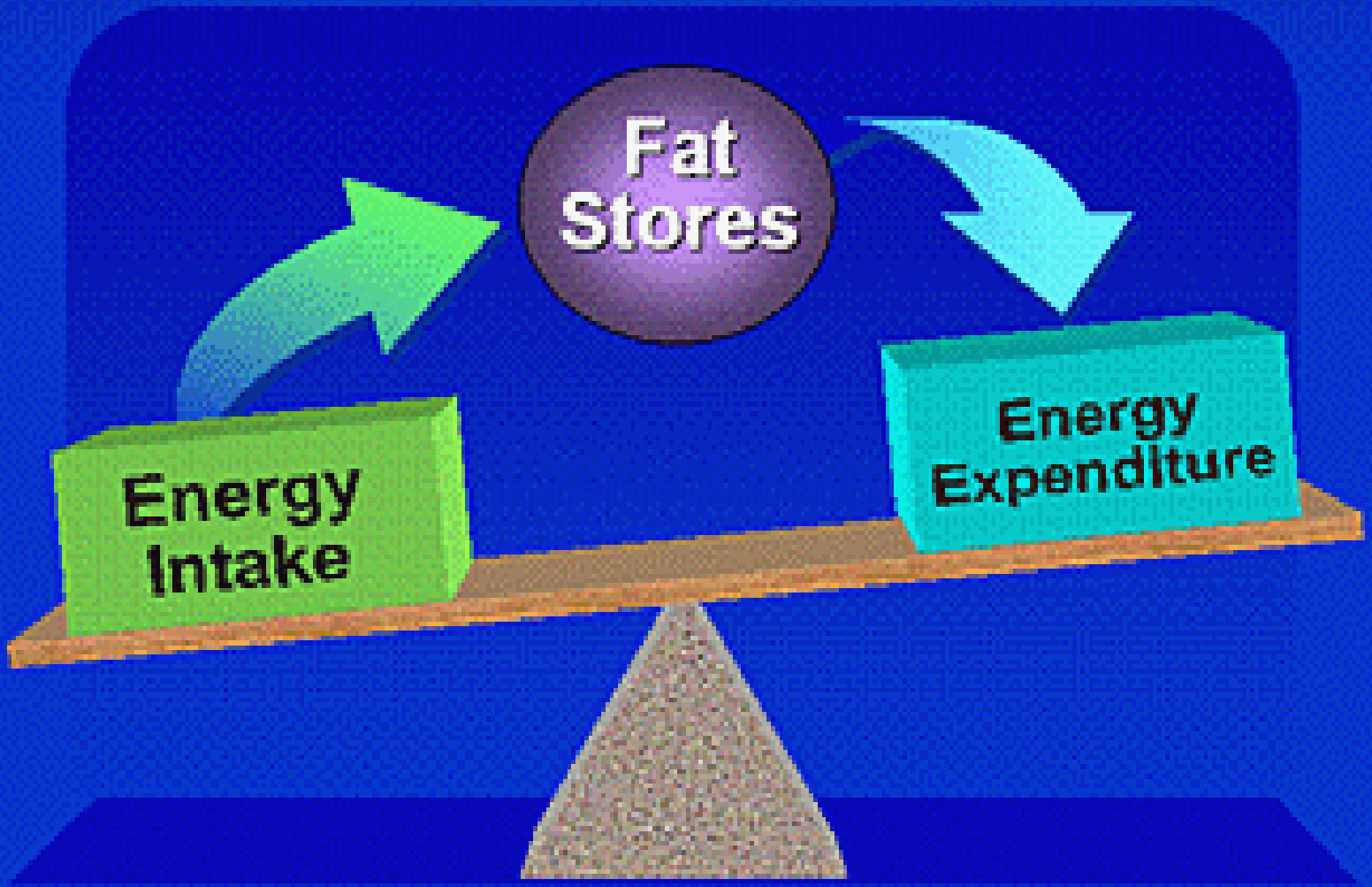


Manuel (Mexican)

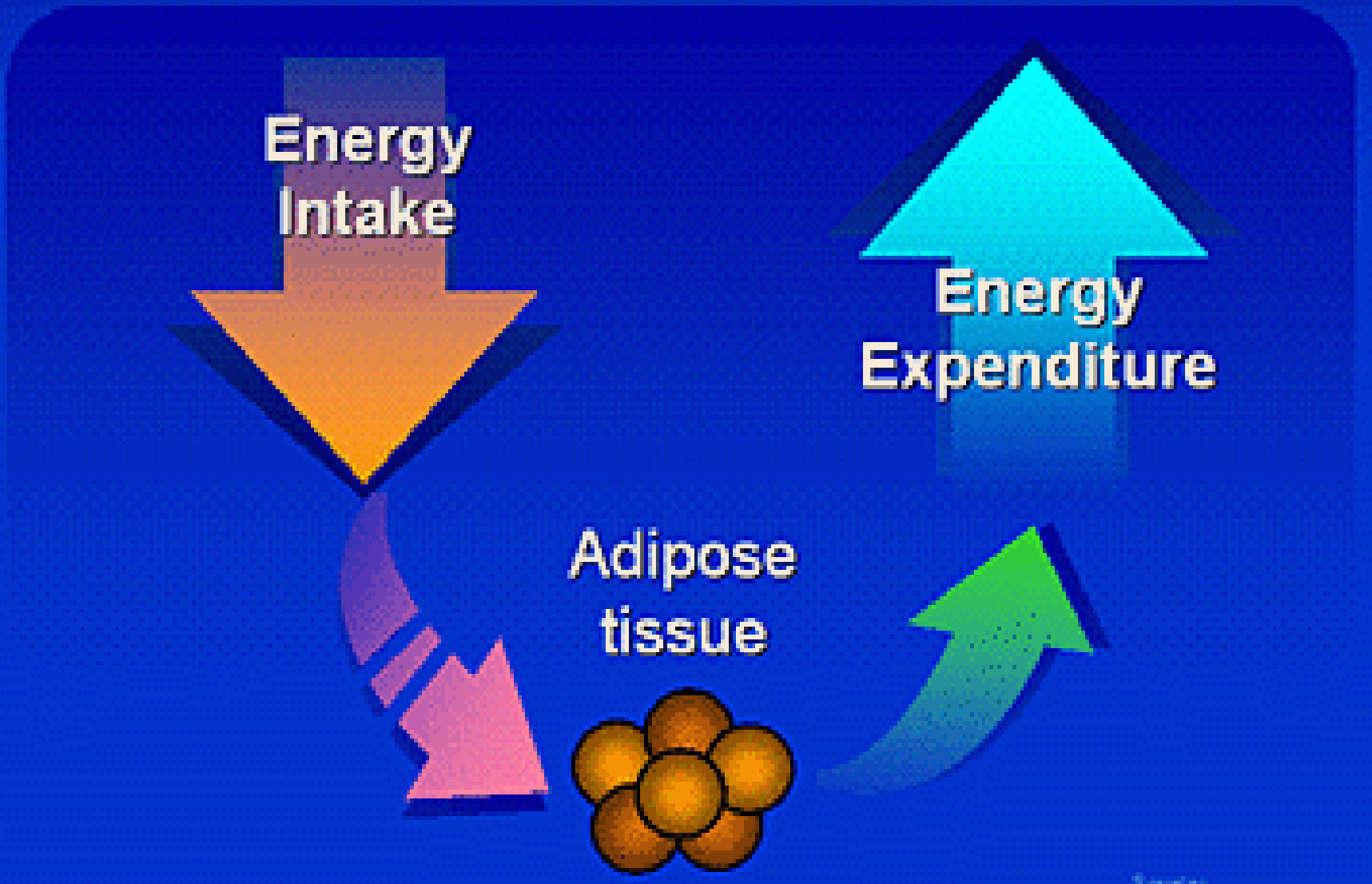
Human development



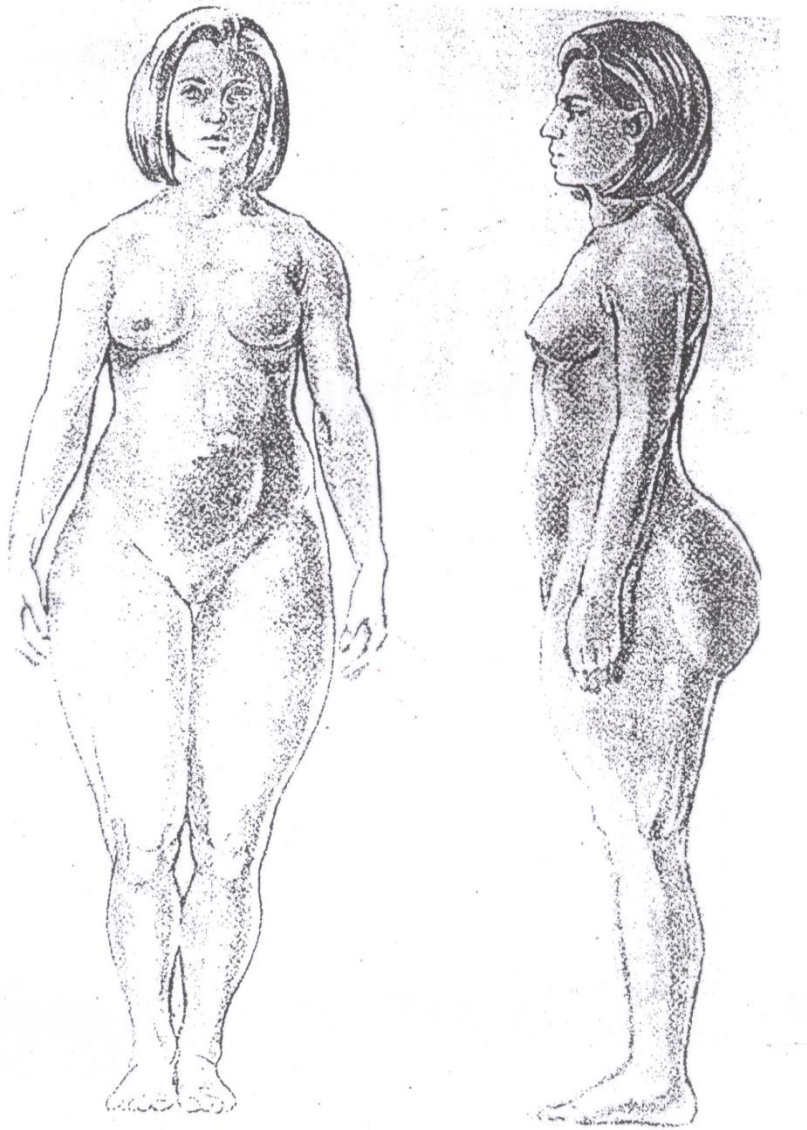
Obesity Is Caused by Long-Term Positive Energy Balance

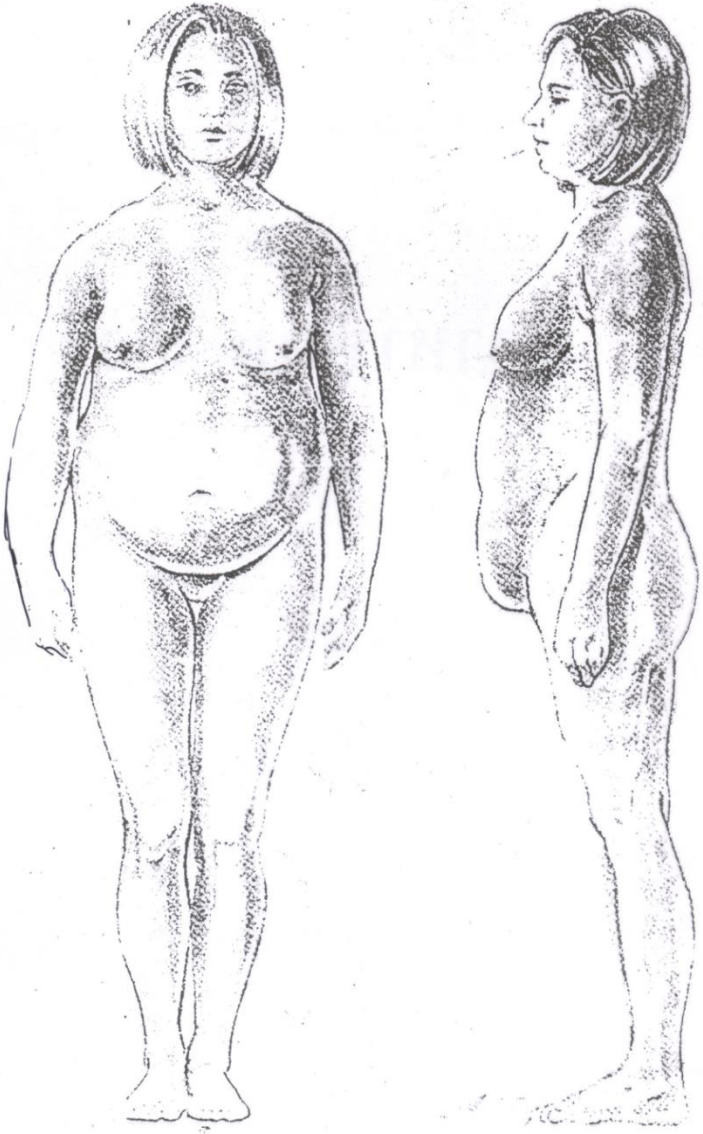


Obesity Therapy



Gynecoid(pear shape) **android(apple shape)**





FIGUR
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(android)
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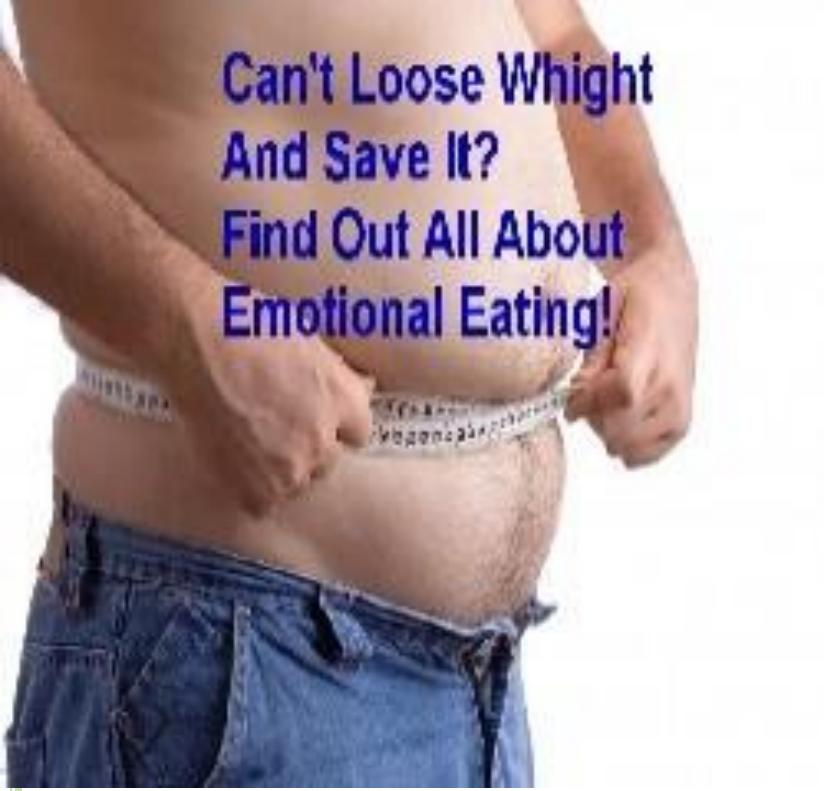
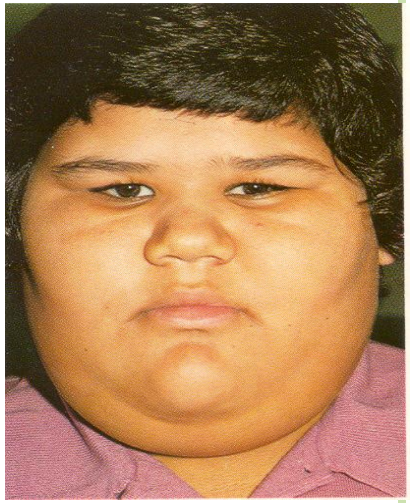
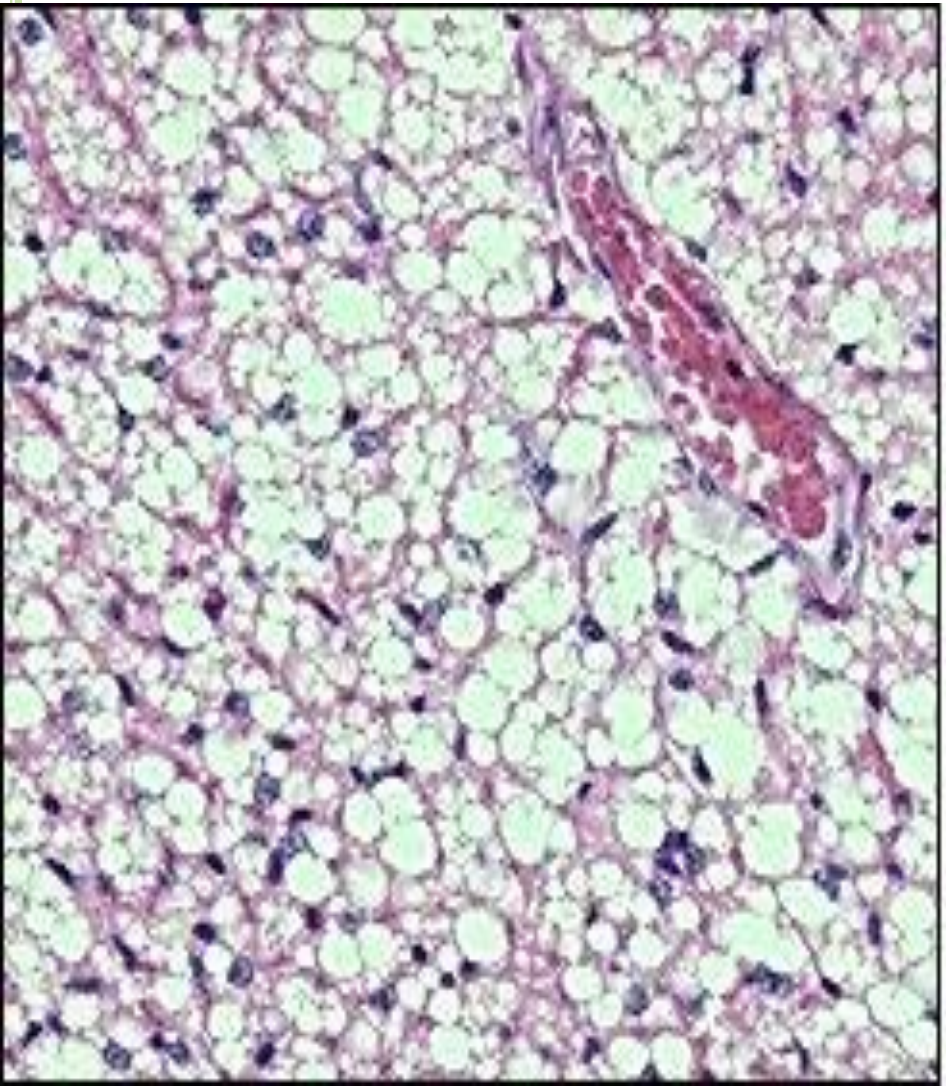

Can't Loose Whight
And Save It?
Find Out All About
Emotional Eating!



Fat (TG) deposits in adipose tissue



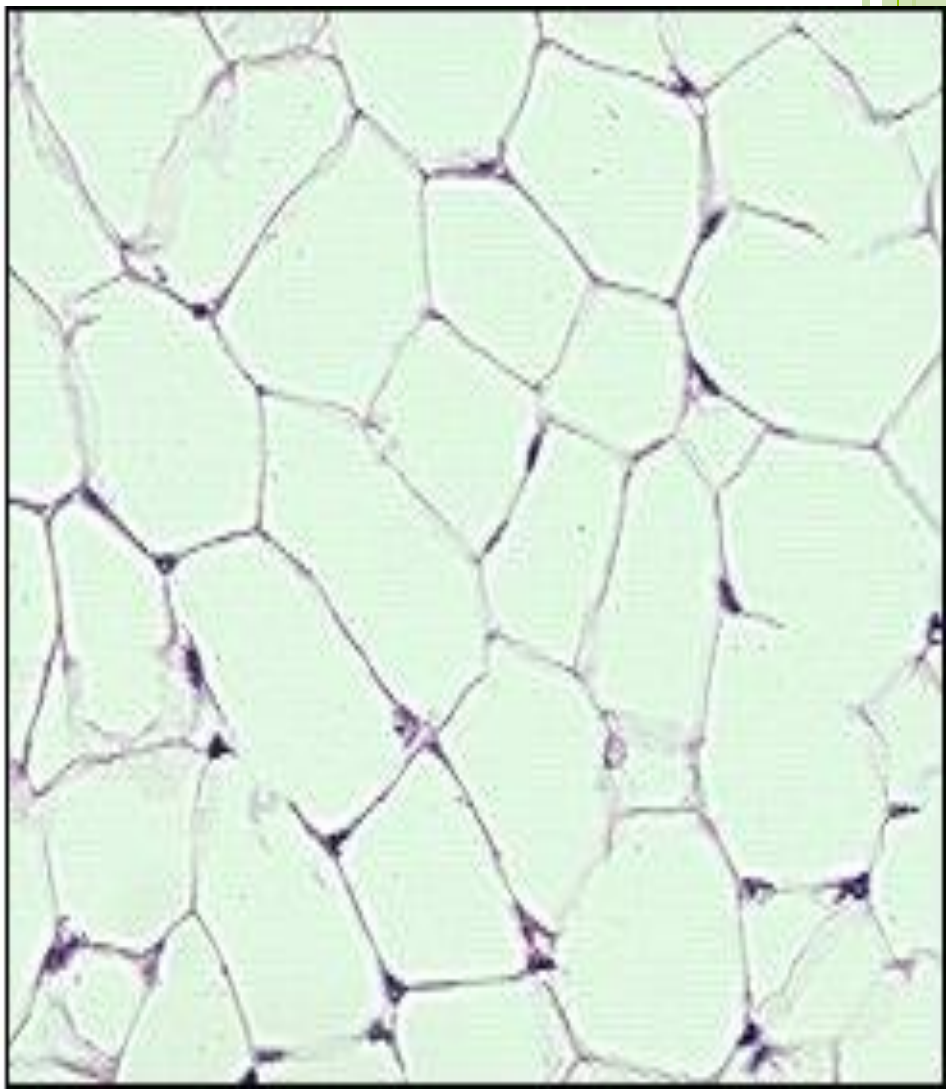
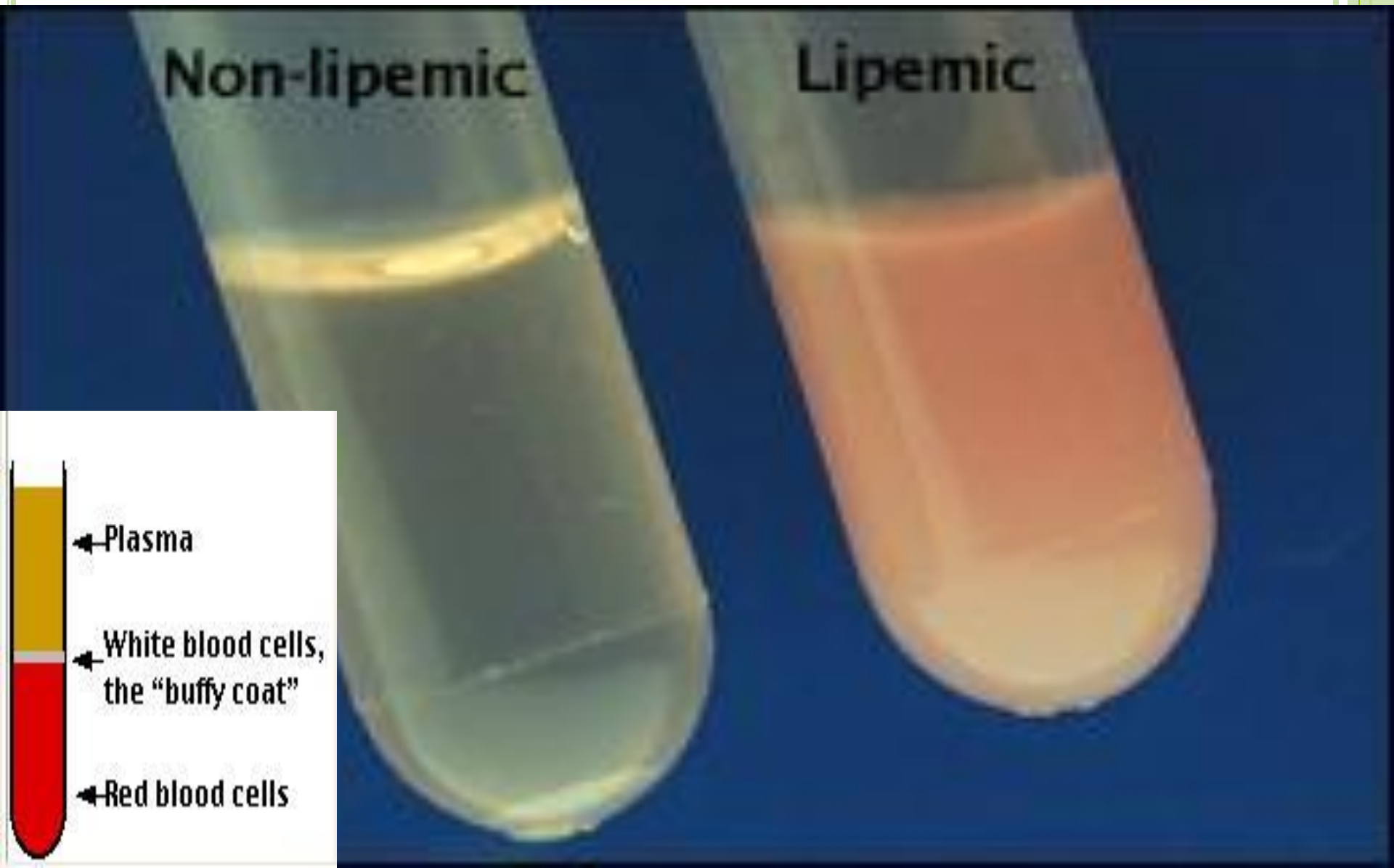


FIGURE 7.8 *Adipocytes contain droplets of fat surrounded by other cell components. As body fat is gained, the size of the fat droplets increases.* (Ed Reschke/ Peter Arnold, Inc.)

Hypertrophy= increase of fat cell size

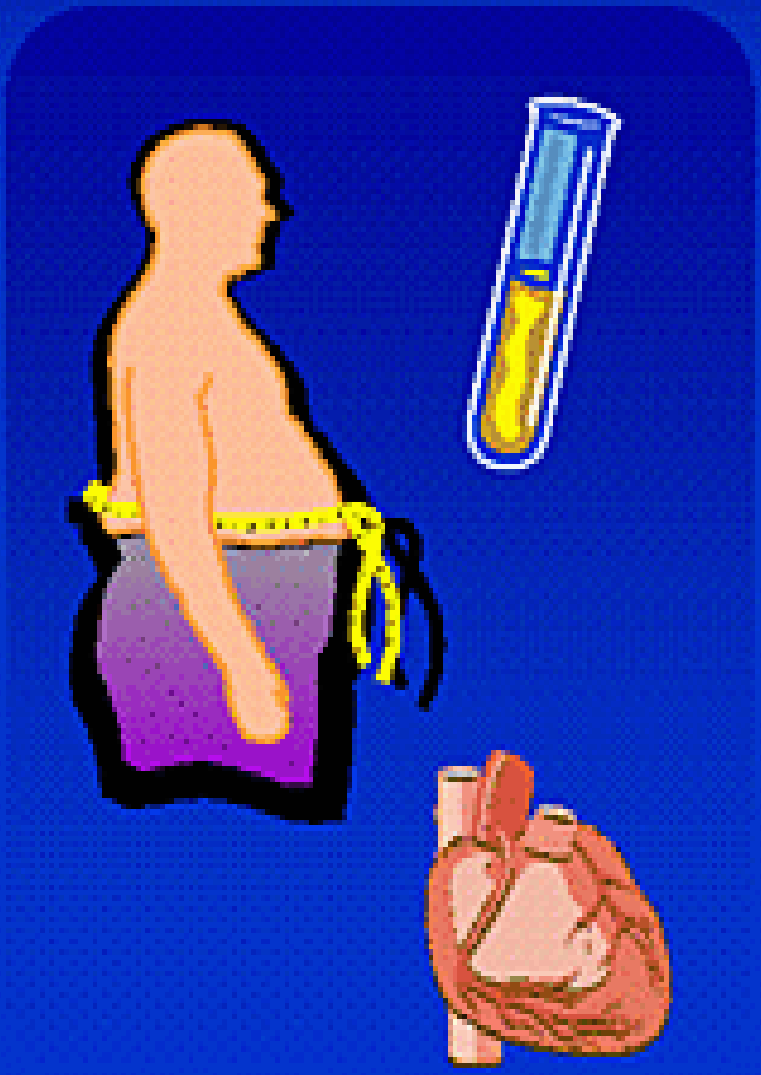
Hyperplasia= increase of fat cell number

Plasma lipid



Xantomata (hyperlipidaemia)

Metabolic Syndrome



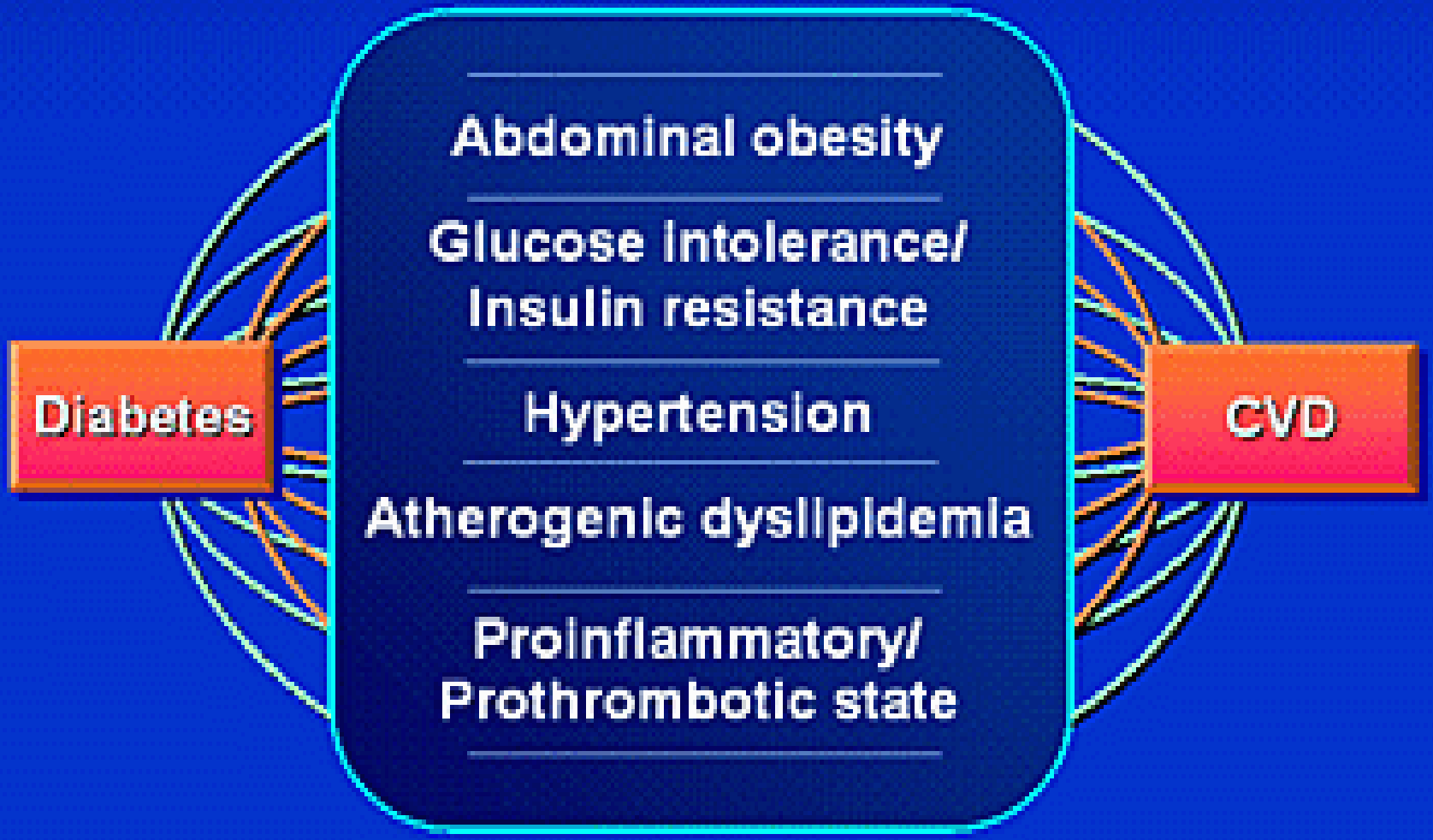
- Abdominal obesity
- Hyperinsulinemia

- High fasting plasma glucose
- Impaired glucose tolerance

- Hypertriglyceridemia
- Low HDL-cholesterol

- Hypertension

Consequence of metabolic syndrome



National Cholesterol Educational Program (NCEP), Adult Treatment Panel (ATP) III; 2001.

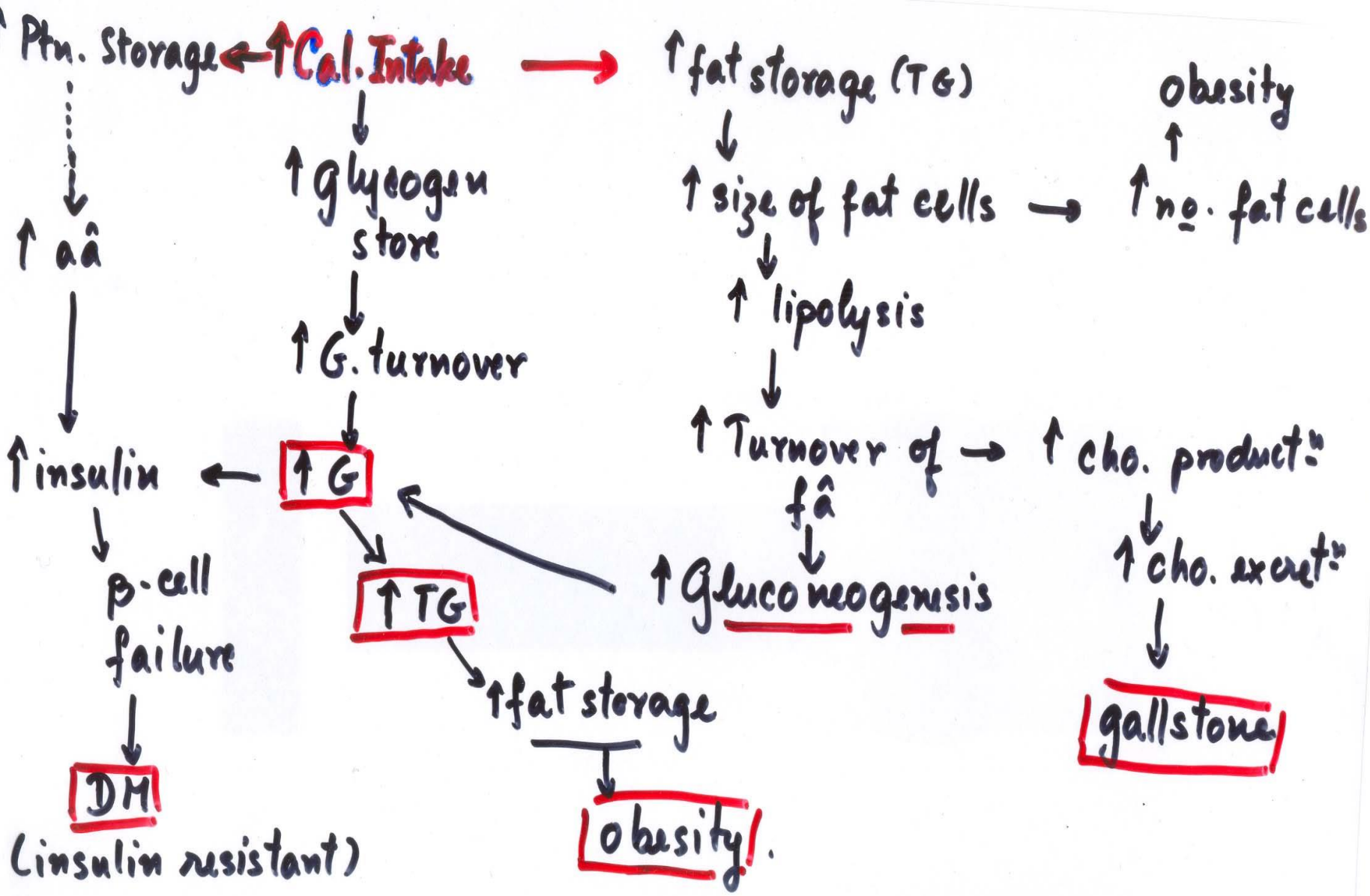


figure: metabolic consequences of excess caloric intake

Clinical Identification of the Metabolic Syndrome*: NCEP-ATP III

*Diagnosis is established when ≥3 of these risk factors are present

Risk Factor	Defining Level
Abdominal obesity (Waist circumference)	
Men	>102 cm (>40 in)
Women	>88 cm (>35 in)
TG	≥150 mg/dL
HDL-C	
Men	<40 mg/dL
Women	<50 mg/dL
Blood pressure	≥130 / ≥85 mm Hg
Fasting glucose	>110 (≥100**) mg/dL

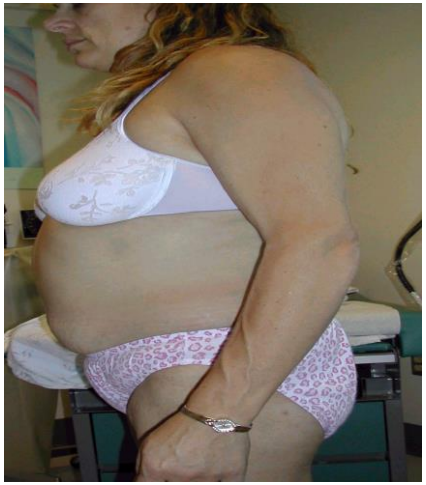
** 2003 New ADA IFG criteria (Diabetes Care)

Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. *JAMA*. 2001;285:2486-2497.

Slide Source: www.obesityonline.org

Asian Body Mass Index

- kg/m^2
- **normal** **18.5 -22.9**
- **overweight** **23.0- 29.9**
- **obesity** **>30.0**
- **Additional risks:**
- **Large waist circumference: Males > 40 and Females > 35 increased risk of disease**
- **Poor aerobic fitness,**
- **Specific races and ethnic groups**



5 Parental Fatness Combinations

Lean Lean

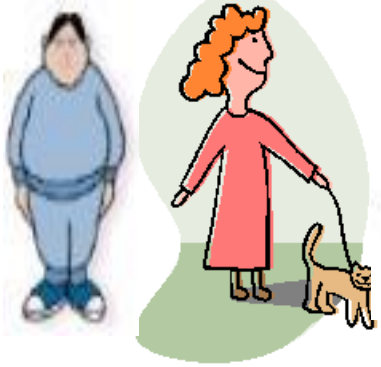
L-L

Medium Lean

M-L

Medium Medium

M-M



Obese Medium

O-M

40%

Obese Obese

O-O

80%

Results of the Study

Tricep Skinfold in Girls