

[lecture 1]

Macro and Micronutrients



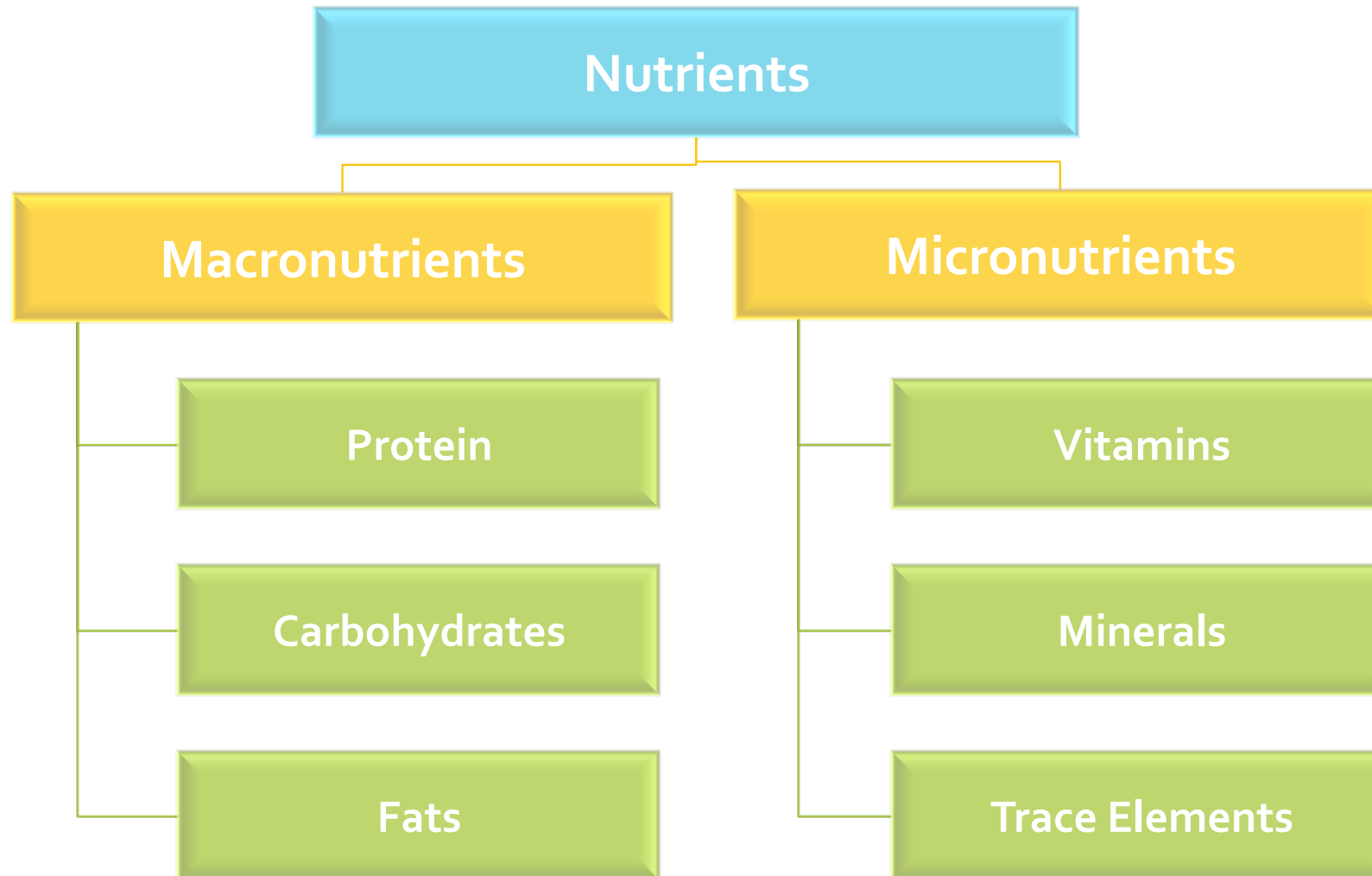
The Objectives

- What are macro and micronutrients?
- Types
- Functions
- Sources and RDAs
- Diseases and conditions due to their deficiency
- Slids Num. 18, 19 & 20 are great summary from our sisters **Eman Al-Bediea** & **Khulood Al-Raddadi**.

Red =
Import-
ant

Blue =
explain

Green =
addition
notes



Macronutrients

- Nutrients needed by the body in large amounts (proteins, carbohydrates, fats)
- They provide energy and building blocks for proteins, carbohydrates and fats

Micronutrients

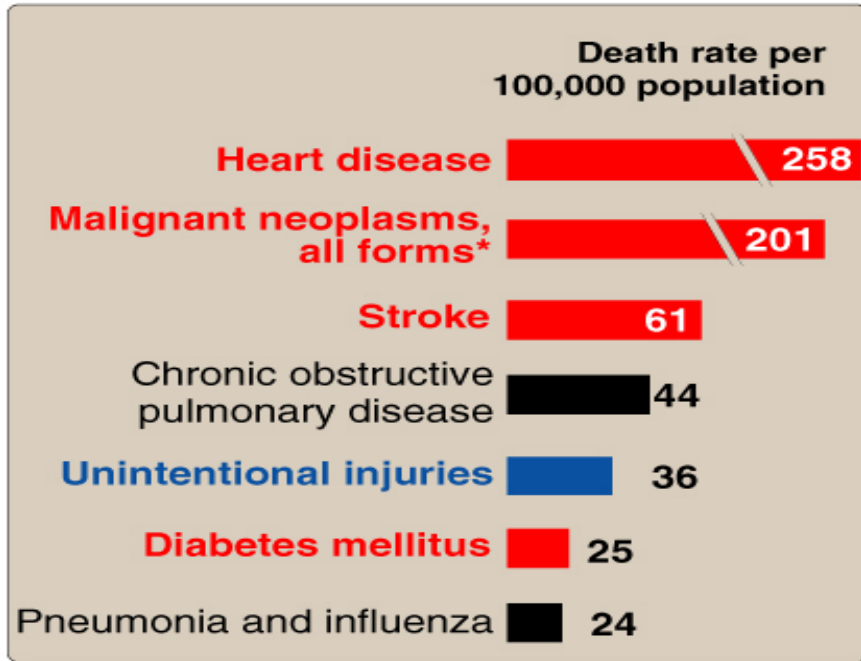
- Nutrients needed by the body in small amounts (vitamins, minerals, trace elements)
- Required for maintaining normal health and preventing various diseases
- They do not provide energy

Energy Content of Food

- Body obtains energy as ATP
- ATP is used for all body functions
- The energy content of food is measured in calories (Kilocalories)
- One calorie is the heat required to raise the temperature of 1 gm. of water by 1°C

- Proteins → 4 kcal/gm
(It means that 1 gm of protein produce 4kcal of energy)
- Carbohydrates → 4 kcal/gm
- Fat → 9 kcal/gm

- Adequate intake of macronutrients to prevent the risk of disease



AMDR for adults:

- CHO: 45-65%
- Proteins: 10-35%
- Fats: 20-35%

we should memorize the numbers

The diet plays a role in the diseases in red

Figure 27.8

Influence of nutrition on some common causes of death in the United States in the year 2000. Red indicates causes of death in which the diet plays a significant role. Blue indicates causes of death in which excessive alcohol consumption plays a part. (*Diet plays a role in only some forms of cancer.)

All RDAs are not important they will be colored in light gray

Nutritional Importance of Proteins

Proteins supply amino acids and amino nitrogen for the body

1- Essential amino acids : Body can't synthesize, must be supplied in the diet

(**PVT TIM HALL**):

Pheylalanine, **V**aline, **T**ryptophan,
Threonine, **I**soleucine, **M**ethionine,
Histidine, **A**rginine, **L**ysine, **L**eucine

"these are the essential and any other aa (amino acid) will be non-essential"

2- Non-essential: body can synthesize

Nutritional Quality of Proteins

- A measure of a protein's ability to provide the essential amino acids required for tissue maintenance
- Measured in **PDCAAS** units (Digestibility-Corrected Amino Acid Scoring)
- High value indicates **more digestibility and high quality** (maximum score 1.0)
- Proteins from animal sources: 0.82-1.0
"higher than plants"
- Proteins from plant sources: 0.4

Sources and RDA

*RDA= recommended daily allowance

Sources

Meat, poultry, fish, milk, wheat, corn, beans, nuts

RDA (gms/kg body weight):

Normal adults: 0.8

Athletes: 1.0

Pregnancy / lactation: upto 30

Children: 2.0

Example 1: If the weight of a normal adult is 70 kg ... the amount of protein intake should be → $70 * 0.8 = 56 \text{ gm}$

It is important to have combination of food to get all essential aa especially for vegetarians.

Nitrogen Balance



How it is calculated? $\text{Intake} - \text{excretion}$
 If the intake is more \rightarrow positive, and if it is less \rightarrow negative

Normal Nitrogen Balance

In a healthy person, the nitrogen intake is equal to nitrogen loss

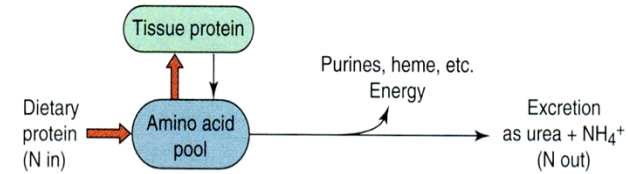
Positive nitrogen balance

When **nitrogen intake is more** than loss
 Occurs in growth, pregnancy, lactation, recovery from illness

Negative nitrogen balance

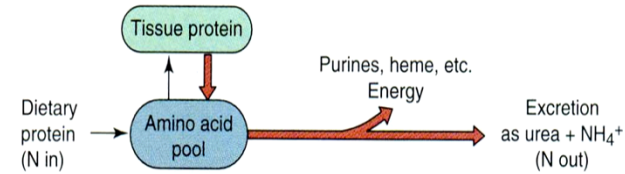
When nitrogen **loss is more** than intake
 Occurs in burns, trauma, illness, metabolic stress

(a) Positive nitrogen balance (growth, pregnancy, lactation and recovery from metabolic stress)



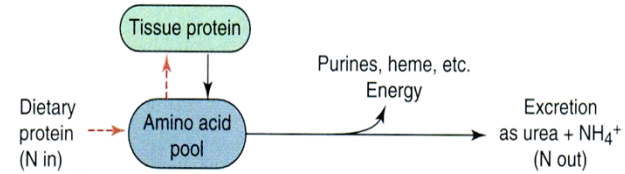
\uparrow Intake \rightarrow +ve

(b) Negative nitrogen balance (metabolic stress)



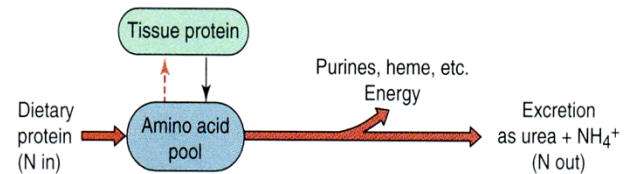
Normal intake but tissue destruction is increased \rightarrow
 \uparrow excretion \rightarrow -ve

(c) Negative nitrogen balance (inadequate dietary protein)



\downarrow Protein intake \rightarrow -ve

(d) Negative nitrogen balance (lack of an essential amino acid)



Essential aa intake is less \rightarrow body take aa needed from tissue protein \rightarrow \uparrow excretion \rightarrow -ve

Malnutrition:

A condition or disease caused by not eating enough food or not eating a balanced diet
Malnutrition due to inadequate intake of proteins or energy

Two conditions:

The disease	Marasmus	Kwashiorkor
Causes	Inadequate intake of energy with adequate protein intake	Inadequate intake of proteins with adequate energy intake
Age	under 1 year of age (when mother's milk is supplemented with native cereals deficient in protein & calories)	after weaning (about one year of age)
Symptoms	<ul style="list-style-type: none"> • Arrested growth • Extreme muscle wasting • Weakness • Anemia <p><u>No edema or changes in plasma proteins</u></p>	<ul style="list-style-type: none"> • Stunted growth • Diarrhea • Dermatitis (inflammation of skin) / thin hair • Anorexia (loss of appetite) • Enlarged fatty liver • ↓↓ plasma albumin • a deceptively plump belly as a result of Edema

- Their major role in diet is energy production.
- **Types** in the diet:
 - 1- **Simple CHOs**: sucrose, fructose, lactose, corn syrup.
 - 2- **Complex CHOs**: whole grains, pasta, wheat, starch.
- RDA:
 - 130 grams/day for adults and children.
 - CHO intake above RDA causes weight gain or obesity due to increased fat storage in adipose tissue.

- Absorbs water → make food heavy → Slows gastric emptying → promote sensation of fullness and maintain blood glucose level (help in obesity and in DM)
- increase motility → reduce constipation
- Help in secretion of bile acid → lowers LDL level (reduction in risk for cardiovascular diseases)

Protein-Sparing Effect

When we do exercises, our body firstly burns Carbohydrates, then fat, and finally the proteins.

- Dietary protein requirement and CHO diet are related to each other
- CHO have protein-sparing effect
 - They inhibit gluconeogenesis from amino acids
 - Amino acids are used for repair and maintenance of tissue protein and not for gluconeogenesis
- If CHO intake is less than the RDA (130 g/day)
 - more protein will be metabolized
 - more gluconeogenesis will take place

Dietary Fiber

- The component of food that **cannot be broken down** by human digestive enzymes
- RDA (gm/day): Men: 38, Women: 25

Benefits:

- Lowers serum LDL levels
- Reduces constipation
- Promotes feelings of fullness
- Slows gastric emptying (**long-term glucose control in patients with diabetes mellitus**)
- Reduces exposure of gut to carcinogens

Fats in the Diet

- A concentrated source of energy (9 kcals/gram)
- Supply essential fatty acids **such as linoleic and linolenic acids**
- Provide phospholipids for membrane function
- Source of fat-soluble vitamins (A, D, E, K) and help in their absorption
- RDA (gm/day): Total fats: 65, Saturated: 20
- Excessive fat intake can cause
 - **Atherosclerosis/heart disease**
 - **Obesity**

Essential Fatty Acids

- Two essential fatty acids:
 - **α -linolenic acid (ω -3 fatty acid)**
 - **linoleic acid (ω -6 fatty acid)**
- Deficiency causes: scaly skin, dermatitis, reduced growth (most common in infants)
- Used for eicosanoids synthesis which appear to have cardioprotective effects
 - decrease blood clotting
 - decrease blood pressure

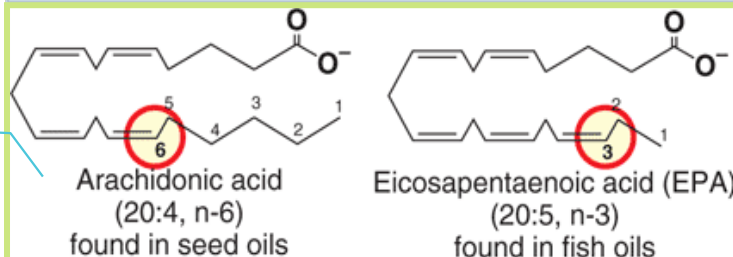
Trans Fatty Acids

- Unsaturated fatty acids, behaving more like saturated fatty acids in the body
 - increase serum LDL (but not HDL)
 - risk of CVD
- Not found in plants (animals only)
- Formed during hydrogenation of liquid vegetable oils
- Found in baked food: cookies, cakes, deep-fried foods

The are called omega 3 and 6 depending on the location of the first double bond.

What does (20:5, n-6) .. (20:4, n-3) mean?

(number of carbon atoms : number of double bonds, first double bond)



Essential Fatty Acids

Essential Fatty Acids	Omega-3 Fatty Acids	Omega-6 Fatty acids
Sources	<ul style="list-style-type: none"> ○ Plants ○ Fish oil containing docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) 	<ul style="list-style-type: none"> ○ Nuts ○ Avocados ○ Olives ○ Soybeans ○ Oils (sesame, cottonseed, corn oil)
Effects	<ul style="list-style-type: none"> ○ Suppress cardiac arrhythmias ○ ↓ Serum triacylglycerol ○ ↓ Tendency to thrombosis ○ Lower blood pressure ○ ↓ Risk of cardiovascular mortality ○ Little effect on LDL or HDL levels 	<ul style="list-style-type: none"> ○ ↓ Plasma cholesterol ○ ↓ LDL ○ ↓ HDL ○ No effect on TG
MORE	<ul style="list-style-type: none"> ○ Mainly found in cold-water ocean fish such as: albacore, mackerel, salmon, sardines, tuna, whitefish ○ Play an important role as: <ul style="list-style-type: none"> - Structural membrane lipids - Modulator of ω-6 fatty acid metabolism 	

American Heart Association Guidelines

The doctor said that this slide is just for your Knowledge

Population	Recommendation
Patients without coronary heart disease (CHD)	<ul style="list-style-type: none"> ○ Fatty fish twice a week ○ Include oils and foods rich in a-linolenic acid (flaxseed, canola and soybean oils; flaxseed and walnuts)
Patients with CHD	<ul style="list-style-type: none"> ○ 1 gm of EPA+DHA per day from fatty fish ○ EPA+DHA supplements
Patients who need to lower triglycerides (fats)	<ul style="list-style-type: none"> ○ 2 to 4 grams of EPA+DHA per day provided as capsules under a physician's care

EPA+DHA= Fish oil
 DHA = DocosaHexaenoic Acid
 EPA = EicosaPentaenoic Acid

- Organic compounds present in small quantities in different types of food
- Help in various biochemical processes in cell
- Important for growth and good health
- Essential
- Noncaloric
- Required in very small amounts

vitamins

Vitamins - Classified Based on Solubility

Water-Soluble Vitamins

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> • thiamin (vitamin B₁) • riboflavin (vitamin B₂) • Niacin (vitamin B₃) • pyridoxine (vitamin B₆) • Biotin (vitamin B₇) | <ul style="list-style-type: none"> • ascorbic acid (vitamin C) • pantothenic acid (vitamine B₅) • Folate (vitamin B₉) • cobalamin (vitamin B₁₂) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Fat-Soluble Vitamins

- A
- D
- E
- K (stored in the body)

Together they form the word
AKED (أكيد)

Vitamin D (Calciferol)

functions

- Synthesized either from 7-dehydrocholesterol or ergosterol by UV light
- Considered a hormone, can be synthesized by the body
- Maintains calcium homeostasis, healthy bones and teeth
- Promotes calcium/phosphorous absorption from the intestine
- Increases bone mineralization

Sources and RDA (mg/day):

- Sunlight, fish, egg yolk, milk
- Adults and Children: 600

deficiency

- Rickets: (in children)**
- Insufficient bone mineralization in children
 - Bones become soft and deformed
- Osteomalacia: (in adults)**
- Bone demineralization and increased osteoporosis
 - Painful bones with frequent fractures

Vitamin E

functions

- Antioxidant: prevents oxidation of cell components by molecular oxygen and free radicals
- May have a role in fertility and anti-aging effect (that's why some creams contain vitamin E)
- α - tocopherol is the most active form in the body

Sources and RDA (mg/day):

- Vegetable Oil, nuts, seeds, vegetables
- Adults: 15, Children: 7

deficiency

- (mostly observed in premature infants)
- Defective lipid absorption
 - Anemia due to oxidative damage to RBCs
 - Neurological problems
 - Male infertility

Functions of Vitamin B1 (Thiamin)	functions	<ul style="list-style-type: none"> ○ Active form: Thiamin pyrophosphate (TPP) ○ Coenzyme for transketolase and oxidative decarboxylation reactions ○ In thiamin deficiency, the activity of these two dehydrogenases is decreased ○ Causing: Low ATP production and defective cellular function
	Sources and RDA (mg/day):	<ul style="list-style-type: none"> ○ Plants, cereals, meat ○ Adults: 1.2, Children: 0.6
	deficiency	<p>Beriberi</p> <ul style="list-style-type: none"> ○ A type of chronic peripheral neuritis due to severe thiamin deficiency causes weakness, neuropathy, disorderly thinking, paralysis ○ Thiamin has a role in nerve conduction ○ Neuropathy affects glial cells (astrocytes) of the brain and spinal cord causing neuron death <p>Wernicke-Korsakoff syndrome</p> <ul style="list-style-type: none"> ○ Common in alcoholics due to defective intestinal absorption of thiamin or dietary insufficiency ○ Causes apathy, loss of memory
Folic Acid Deficiency	functions	<ul style="list-style-type: none"> ○ Folate: natural / Folic acid: synthetic form ○ Essential for synthesis of many compounds ○ Important in one-carbon metabolism ○ Transfers one-carbon units to intermediates, amino acids, purines and thymine ○ Helps prevent cancer and heart disease
	Sources and RDA (mg/day):	<ul style="list-style-type: none"> ○ Green leafy vegetables, lentils, peas, beans ○ Adults: 400, Children: 150-200, Pregnancy: 500-600
	deficiency	<ul style="list-style-type: none"> ○ Deficiency in pregnancy and lactation due to increased demand ○ Poor intestinal absorption due to alcoholism or drugs <div style="display: flex; align-items: center; margin-left: 20px;"> } Leads to → <ul style="list-style-type: none"> ○ Megaloblastic anemia ○ Anemia with larger RBCs ○ Neural tube defect (spine bifida , anencephaly) ○ Folic acid supplementation in early pregnancy reduces the risk of neural tube defect in fetus </div>

Vitamin C

functions	<ul style="list-style-type: none">○ Powerful antioxidant (prevents some cancers)○ Helps in dentine, intercellular matrix and collagen formation○ Increases iron absorption○ Helps in the maturation of RBCs○ Promotes wound healing○ Stimulates phagocytic action of leukocytes (enhance immunity)○ Reduces risk of cataract formation
Sources and RDA (mg/day):	<ul style="list-style-type: none">○ Citrus fruits, tomatoes, melon, peppers○ Men: 90, Women: 75, Children: 15-25
deficiency	<ul style="list-style-type: none">○ Abnormal collagen production○ Gums become painful, swollen and spongy○ The pulp is separated and the teeth are lost

Scorbutic gums in vitamin C deficiency. Gums are swollen, ulcerated, and bleeding due to vitamin C-induced defects in oral epithelial basement membranes and periodontal collagen fiber synthesis.



Minerals and Trace Elements

Macrominerals (>100 mg/day)

- Calcium
- Phosphorous
- Sodium
- Potassium
- Chloride
- Magnesium

Microminerals (<100 mg/day)

- Iron
- Iodine
- Copper
- Manganese
- Zinc
- Cobalt
- Molybdenum
- Selenium
- Fluoride
- Chromium
- Silicon

iodine	functions	<ul style="list-style-type: none"> ○ Dietary iodine is stored in thyroid gland for thyroid hormone synthesis ○ Tri-iodo-thyronine (T₃) and thyroxine (T₄)
	Sources and RDA (mg/day):	<ul style="list-style-type: none"> ○ Dairy products (Milk products), seafood, fortified salt ○ Adults: 150, Children: 90
	deficiency	<ul style="list-style-type: none"> ○ Cretinism: deficiency of thyroid hormones in children causes stunted physical and mental growth ○ Goiter: enlargement of thyroid gland due to iodine deficiency affecting thyroid hormone synthesis

Iron

functions

- Oxygen transport and metabolism
- Part of hemoglobin (in blood) , myoglobin (in muscles) , cytochromes (in redox reactions)
- Body stores iron as ferritin, hemosiderin and transferrin
- Adult women have much lower iron storage than men

Sources and RDA (mg/day):

- **Heme iron:** Animal products (meat, liver), 25% absorption
- **Nonheme iron:** Plants (spinach, beans), 5% absorption
- Men: 8, Women: 18, Children: 7-15

deficiency

- **Iron deficiency anemia** is most common
Growing children, pregnant, lactating and menstruating women need more iron
- **Hemosiderosis (iron overload disorder)**
 - Due to iron excess (toxicity)
 - Hemosiderin (Iron stored in complex with ferritin protein in liver and spleen)
 - Occurs in persons receiving **repeated blood transfusions**

- Iron is transport in plasma in the form of Transferrin
- Iron is stored in two forms
 - Ferritin (apoferritin+iron)
 - Haemosiderin (insoluble complex molecule)

calcium

functions

- Bone growth and teeth formation
- Neurotransmission of nerve impulse / muscle function
- Blood coagulation / activates enzymes

Sources and RDA (mg/day):

- Mainly dairy products (milk, yoghurt, cheese)
- Men: 1000, Women: 1200, Children: 700-1300

deficiency

- Rickets, osteomalacia, osteoporosis

Summary of Macro nutrients

	Proteins	Carbohydrates	Fats
RDA	Normal adults: 0.8 Athletes: 1.0 Pregnancy / lactation: up to 30 Children: 2.0	(Major energy source) 130 grams/day for adults and children	Total fats: 65 Saturated: 20
SOURCES	Meat, poultry, fish, milk, wheat, corn, beans, nuts	1- Simple CHOs: sucrose, fructose, lactose, corn syrup. 2- Complex CHOs: whole grains, pasta, wheat, starch.	-----
FEATURES	Nitrogen balance: Normal : N intake = N loss negative : N intake < N loss positive : N intake > N loss	Protein-sparing effect - They inhibit gluconeogenesis from amino acids. - Amino acids are used for repair and maintenance of tissue protein.	- Supply essential fatty acids such as linoleic and linolenic acids. - Provide phospholipids for membrane function. - Source of fat-soluble vitamins (A, D, E, K) and help in their absorption.
DISORDERS	Deficiency results in: <u>1-Marasmus:</u> - Inadequate energy , adequate protein. - < 1 year of age. - Arrested growth, muscle wasting - Weakness, Anemia. - No edema or changes in plasma proteins. <u>2-Kwashiorkor:</u> - Inadequate protein , adequate energy. - After weaning (about one year of age). - Stunted growth , Skin lesions & depigmented hair. - Anorexia - Enlarged fatty liver and low plasma albumin		Excessive fat intake: - Atherosclerosis/heart disease. - Obesity.

Summary of Micro nutrients

	Sources	RDA	Importance	Deficiency
Vitamin D (Calciferol)	- Sunlight, fish, egg yolk, milk. - Synthesized either from 7-dehydrocholesterol or ergosterol by UV light	Adults and Child: 600 (mg/day)	1-Maintains calcium homeostasis , healthy bones and teeth. 2-Promotes calcium/phosphorous absorption from the intestine. 3-Increases bone mineralization .	<u>1- Rickets:</u> Insufficient bone mineralization in children Bones become soft and deformed. <u>2- Osteomalacia:</u> Bone demineralization and increased osteoporosis Painful bones with frequent fractures.
Vitamin E	Vegetable Oil, nuts, seeds, vegetables.	Adults: 15 Children: 7 (mg/day)	- Antioxidant.. - have a role in fertility . - α - tocopherol is the most active form in the body.	- Mostly observed in premature infants. 1- Defective lipid absorption. 2- Anemia due to oxidative damage to RBCs. 3- Neurological problems. 4- Male infertility.
Vitamin B1 (Thiamin)	Plants, cereals, meat	Adults: 1.2 Child: 0.6	- Active form: Thiamin pyrophosphate (TPP) - Coenzyme for transketolase and oxidative decarboxylation reactions.	<u>1- Beriberi:</u> A type of chronic peripheral neuritis due to severe thiamin deficiency causes weakness, neuropathy, disorderly thinking, paralysis. <u>2- Wernicke-Korsakoff syndrome:</u> Common in alcoholics due to defective intestinal absorption of thiamin or dietary insufficiency Causes apathy, loss of memory
Folic Acid	Green leafy vegetables, lentils, peas, beans	Adults:400 Child: 150-200 Pregnancy: 500-600	- Important in one-carbon metabolism - Transfers one-carbon units to intermediates, amino acids, purines and thymine. - Helps prevent cancer and heart disease .	- Deficiency in pregnancy and lactation due to increased demand -Poor intestinal absorption due to alcoholism or drugs Leads to: <u>1-Megaloblastic anemia:</u> Anemia with larger RBCs. <u>2- Neural tube defect:</u> Folic acid supplementation in early pregnancy reduces the risk of neural tube defect in fetus.
Vitamin C	Citrus fruits, tomatoes, melon, peppers	Men: 90 Wom: 75 Ch: 15-25	- Powerful antioxidant. - Increases iron absorption. - Helps in the maturation of RBCs . - Promotes wound healing.	<u>Scurvy:</u> 1- Abnormal collagen production. 2-Gums become painful, swollen and spongy. 3-The pulp is separated and the teeth are lost.

Summary of Minerals and Trace Elements

	Calcium	Iron	Iodine
Function	<p>1- Bone growth and teeth formation.</p> <p>2- Neurotransmission of nerve impulse/ muscle function.</p> <p>3- Blood coagulation / activates enzymes.</p>	<p>1- Oxygen transport and metabolism.</p> <p>2- Part of hemoglobin, myoglobin, cytochromes.</p> <p>3- Body stores iron as ferritin, hemosiderin and transferrin.</p> <p>4- Adult women have much lower iron storage than men.</p>	<p>Dietary iodine is stored in thyroid gland for thyroid hormones synthesis "Tri-iodo-thyronine (T₃) and thyroxine (T₄)"</p>
Sources	<p>Mainly dairy products (milk, yoghurt, cheese)</p>	<p>1- Heme iron: Animal products (meat, liver), 25% absorption.</p> <p>2- Nonheme iron: Plants (spinach, beans), 5% absorption.</p>	<p>Dairy products, seafood, fortified salt</p>
RDA	<p>Men: 1000 Women: 1200 Children: 700-1300</p>	<p>Men: 8 Women: 18 Children: 7-15</p>	<p>Adults: 150 Children: 90</p>
Deficiency	<p><u>1- Rickets</u> <u>2- osteomalacia</u> <u>3- osteoporosis</u></p>	<p>1- <u>Anemia</u> is most common. Growing children, pregnant, lactating and menstruating women need more iron</p> <p>2- <u>Hemosiderosis</u> (iron overload disorder)>> in hemorrhage.</p> <ul style="list-style-type: none"> - Hemosiderin (Iron stored in complex with ferritin protein in liver and spleen). - Occurs in persons receiving repeated blood transfusions. - Due to iron excess (toxicity) 	<p><u>1- Cretinism</u>: deficiency of thyroid hormones in children causes stunted physical and mental growth.</p> <p><u>2- Goiter</u>: enlargement of thyroid gland due to iodine deficiency affecting thyroid hormone synthesis .</p>

Test your knowledge ...!

1- the amount of energy yielded by 1 gm of protein =

- A- 4 kcal B- 9 kcal C- 7 kcal D- 10 kcal

2- which one of the following lowers the triacylglycerol level in blood?

- A- omega-3 FA B- omega-6 FA C- trans fatty acids D- vitamin E

3- which one of the following conditions is related to Folic acid deficiency ?

- A- megaloblastic Anemia B- osteoporosis C- Beriberi D- Scurvy

4- which one of the following conditions is related to Vitamin C deficiency ?

- A- megaloblastic Anemia B- osteoporosis C- Beriberi D- Scurvy

5- In osteomalacia there is a :

- A- insufficient bone mineralization b- demineralization c- Inadequate intake of proteins



Biochemistry
Team

Thank you ")

If you find any mistake, please contact us:)
Biochemistryteam@gmail.com

*Biochemistry team leaders:
Basil AlSuwaine And Manar AlEid*

