# Macro and Micronutrients

## Biochemistry team

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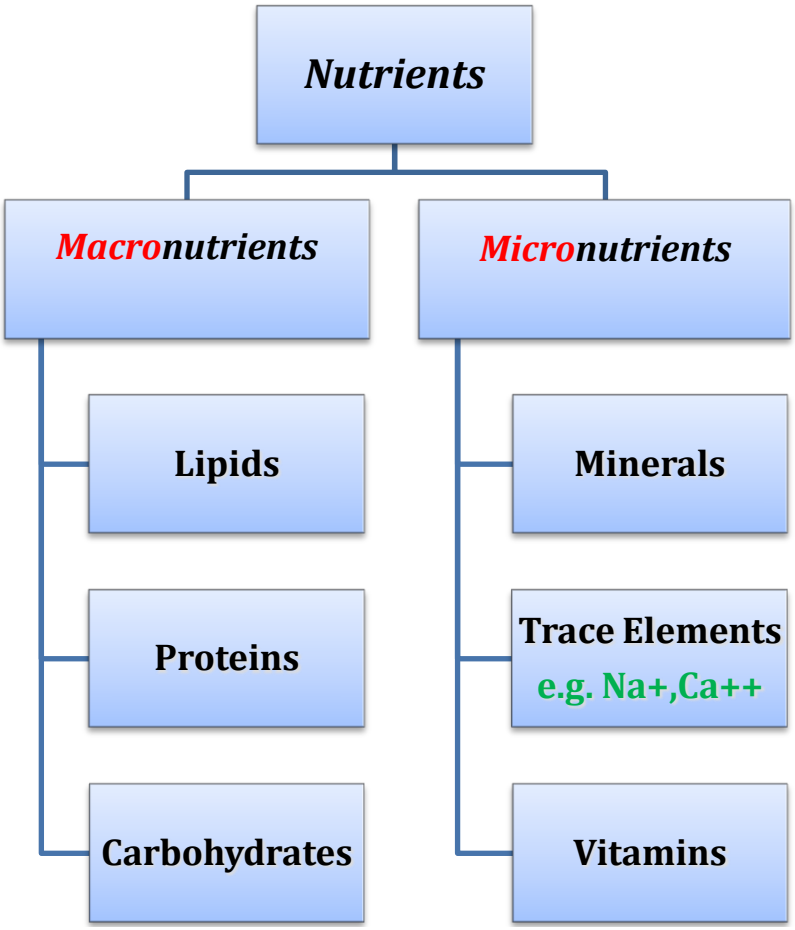



Dr.Othman said that :

1- I may ask you about anything in the ***ma***cronutrients ( RDI , function , related diseases … etc )

2- If I asked you about the ***mi***cronutrients , I will ask about two things : 1 – the function of it . 2- the related diseases .

Dr.sumbl said that :
All numbers in this lecture are NOT important

## *Macronutrients*

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

## *Micronutrients*

- Nutrients needed by the body <u>in small amounts</u> (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
  - Carbohydrates → 4 kcal/gm
  - Fat → 9 kcal/gm

( 1 calorie = 1 kilocalorie)

## *Acceptable Macronutrient Distribution Range (ADMR)*

- Adequate intake of macronutrients to prevent the risk of disease

- AMDR for adults:
- CHOs: 45-65%
- Proteins: 10-35%
- Fats: 20-35%

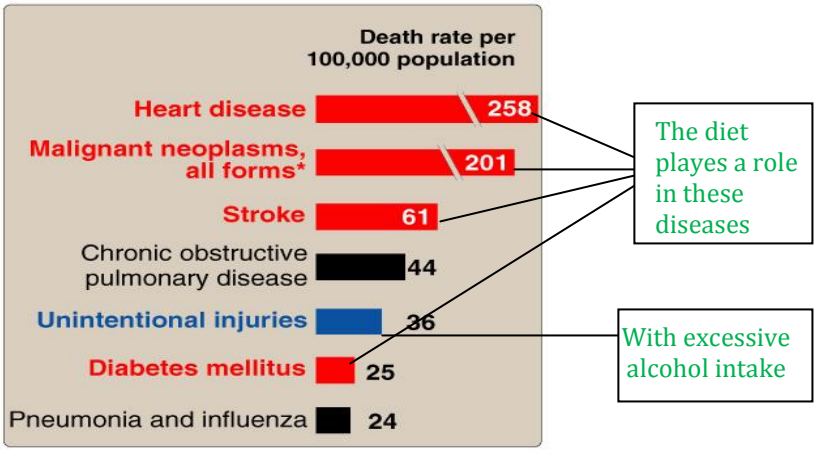



**Figure 27.8**
Influence of nutrition on some common causes of death in the United States in the year 2000. Red indicates causes of death in which the diet plays a significant role. Blue indicates causes of death in which excessive alcohol consumption plays a part. (*Diet plays a role in only some forms of cancer.)

# Nutritional Importance of Proteins

- Proteins supply amino acids and amino nitrogen for the body
- Essential amino acids : Body can't synthesize, must be supplied in the diet
  - PVT TIM HALL: Pheylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Arginine, Lysine, Leucine
- Non-essential: body can synthesize

Dr. sumbl said we have to focus here on requirement and digestibility.

## 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 , minimum score 0)
- Proteins from **animal** sources: 0.82-1.0 "higher sourse than plants"
- Proteins from **plant** sources: 0.4

For example : if the protein that we eat provides all the essential amino acids , we can say that the protein quality is very high ( the quality is 1.0 )

## Sources and RDA

***RDA= recommended daily allowness***

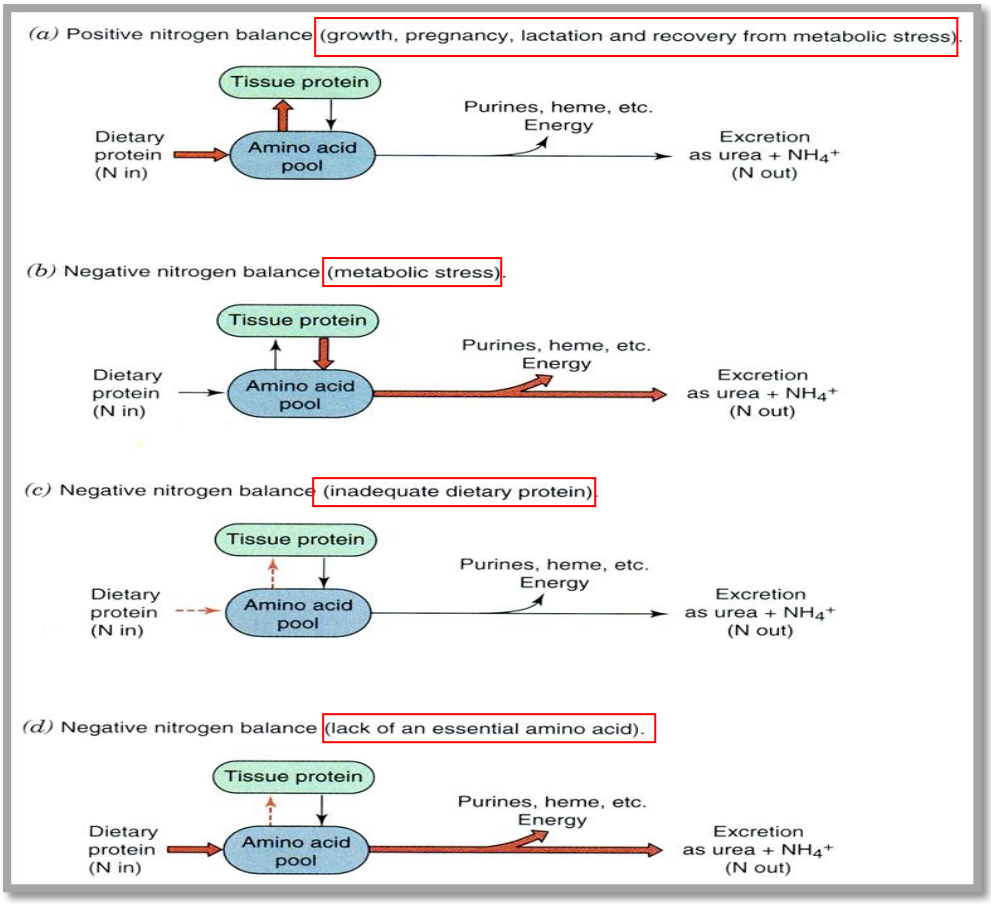
- Meat, poultry, fish, milk( Animal sources ) wheat, corn, beans, nuts ( plant sources )
- RDA (gms/kg body weight)
  - Normal adults: 0.8
  - Athletes: 1.0 ( to maintain their muscle mass)
  - Pregnancy / lactation: upto 30 ( to support the growth of fetus )
  - Children: 2.0 ( helps in growth )

Example 1: If the weight of a normal adult is 70 kg ... the amount of protein intake should be >>> 70 * 0.8 = 56 gms
Example 2: Pregnant women weight : 65 kg >>> 65 * 30 = 1950 gms !!!! .. Because the fetus should get adequate proteins.

## Nitrogen Balance

- ***Normal Nitrogen Balance***
  - In a healthy person, the nitrogen intake is equal to nitrogen loss
- ***Negative nitrogen balance***
  - When nitrogen loss is more than intake
  - Occurs in burns, trauma, illness, metabolic stress
- ***Positive nitrogen balance***
  - When nitrogen intake is more than loss
  - Occurs in growth, pregnancy, lactation, recovery from illness

because the patient already lost more proteins when he/she was ill , so to maintain the balance , the body will gain more protein and loses less for several days.




## *Protein-Energy Malnutrition (PME)*

- 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:
  - Marasmus
  - Kwashiorkor

| | **Marasmus** | **Kwashiorkor** |
|---|---|---|
| **Cause** | Inadequate intake of energy* with adequate protein intake<br>* energy from sources other the proteins e.g. CHO and fats | Inadequate intake of proteins with adequate energy intake |
| **Age and food intake** | • 1-3 year or younger<br>• Mother's milk is supplemented with food (cereals) deficient in calorie | • After weaning (at about 1 year)<br>• Diet mainly contains CHOs |
| **Symptoms** | • Arrested growth<br>• Extreme muscle wasting<br>• Weakness<br>• Weight loss<br>• No edema or changes in plasma proteins | • Edema( due to low plasma protein )<br>• Distended abdomen<br>• Diarrhea<br>• Dermatitis / thin hair<br>• Enlarged fatty liver<br>• Low plasma albumin " with edema " |

Marasmus

**Kwashiorkor**

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

## *Carbohydrates*

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

## *Protein-Sparing Effect*

- Dietary protein requirement and CHO diet are related to each other
- CHO have protein-sparing effect
  - They inhibit gluconeogenesis from amino acids
  - That way 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 proteins will be metabolized
  - more gluconeogenesis will take place

How does the increase in the carbohydrate lead to obesity ?
When the CHO breaks down >> acetyl CoA >> synthesis of FAs >> TGA which then storage in the adipose tissue.

## *Dietary Fiber (= cellulose)*

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

### *Benefits*

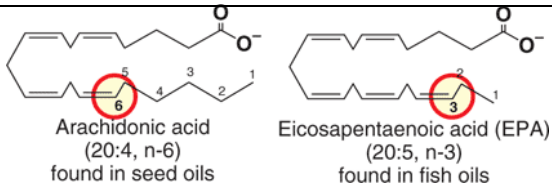
- Lowers serum LDL levels ( reduction in risk for cardiovascular diseases )
- Reduces constipation ( increase bowl motility )
- Promotes feeling of fullness
- Slows gastric emptying (long-term glucose control in patients with diabetes mellitus) ( generates sensation of fullness reduces postprandial – after meal – blood GLUCOSE concentration )
- 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 (coronary heart disease)
  - Obesity

Saturated = no double bounds
Un saturated = has a double bound

## *Essential Fatty Acids = the body can't synthesize it.*




- 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

Reduce the risk of cardiovascular mortality

3 or 6 depends on the position of the first double bound.

## *Omega-3 Fatty Acids*

- Mainly found in cold-water ocean fish such as: albacore, mackerel, salmon, sardines, tuna, whitefish
- Play an important role as:
  - **Structural membrane lipids**
  - **Modulator of ω-6 fatty acid metabolism**

**Sources**

- Plants
- Fish oil containing docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)

**Effects**

- Suppress cardiac arrhythmias
- ↓ Serum triacylglycerols
- ↓ Tendency to thrombosis
- Lower blood pressure
- ↓ Risk of cardiovascular mortality
- Little effect on LDL or HDL levels

| ***Recommendations for Omega-3 Fatty Acid Intake<br>American Heart Association Guidelines*** | |
|---|---|
| ***Population*** | ***Recommendation*** |
| **Patients without coronary heart disease (CHD)** | ➢ Fatty fish twice a week<br>➢ Include oils and foods rich in a-linolenic acid (flaxseed, canola and soybean oils; flaxseed and walnuts) |
| **Patients with CHD** | ➢ 1 gm of EPA+DHA per day from fatty fish<br>➢ EPA+DHA supplements |
| **Patients who need to lower triglycerides (fats)** | ➢ 2 to 4 grams of EPA+DHA per day |

EPA+DHA= Fish oil

DHA = DocosaHexaenoic Acid

EPA = EicosaPentaenoic Acid

## *Omega-6 Fatty acids*

**Sources**

- Nuts
- Avocados
- Olives
- Soybeans
- Oils (sesame, cottonseed, corn oil)

**Effects**

- ↓ Plasma cholesterol
- ↓ LDL
- ↓ HDL

**Plasma LDL are lowered , BUT HDL which protect against CHD are also lowered , the powerful benefits of lowering LDL are only partially offset because of decreased HDL**

## *Trans Fatty Acids*

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

Cys FA is the good one which can be transferred to Trans FA by hydrogenation

## *Micronutrients*

Remember the most important things are:
1- the function
2- related diseases

## *Vitamins*

- 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 - Classified Based on Solubility* | |
|---|---|
| **Fat-Soluble Vitamins** | **Water-Soluble Vitamins** |
| A, D, E, and K (stored in the body)<br><br>A,K,E,D "أكيد" | Ascorbic acid (vitamin C)<br>Thiamin (vitamin $B_1$)<br>Riboflavin (vitamin $B_2$)<br>Niacin (vitamin $B_3$)<br>Pyridoxine (vitamin $B_6$)<br>Biotin<br>Pantothenic acid<br>Folate<br>Cobalamin (vitamin $B_{12}$) |

## *Vitamin D (Calciferol)*

- 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**

Addition of calcium phosphate to the bone to make it hard.

**Sources and RDA (IU)**

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

| *Deficiency of vitamin D* | |
|---|---|
| Rickets | **Osteomalacia** |
| ➢ Insufficient bone mineralization in children<br>➢ Bones become soft and deformed | ➢ Bone demineralization* and increased osteoporosis<br>*ca++ is releasing from the bones to maintain the ca++ deficiency in the blood.<br>➢ Painful bones with frequent fractures |

## *Vitamin E*

- **Antioxidant**: prevents oxidation of cell components by molecular oxygen and free radicals
- May have a role in fertility and anti-aging effect
- 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 $B_1$ (Thiamin)*

- 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)**

- Plants, cereals, meat
- Adults: 1.2, Children: 0.6

| *Disorders of Vitamin $B_1$ (Thiamin) Deficiency* | |
|---|---|
| **Beriberi** | **Wernicke-Korsakoff syndrome** |
| ➢ A type of chronic peripheral neuritis due to severe thiamin deficiency causes weakness, neuropathy, disorderly thinking, paralysis<br>➢ Thiamin has a role in nerve conduction<br>➢ **Neuropathy affects glial cells (astrocytes) of the brain and spinal** cord causing neuron death | ➢ Common in alcoholics due to defective intestinal absorption of thiamin or dietary insufficiency<br>➢ Causes apathy, loss of memory |

## *Functions of Folic Acid*

- 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)**

- Green leafy vegetables, lentils, peas, beans
- Adults: 400, Children: 150-200, Pregnancy: 500-600

| *Disorders of Folic Acid Deficiency* | |
|---|---|
| Megaloblastic anemia<br>**( Deficiency in vitamin B12 OR Folic acid )** | **Neural tube defect**<br>( Spina Bifida ) |
| ➢ Anemia with larger RBCs (Macrocytic anemia )<br>➢ Deficiency in pregnancy and lactation due to increased demand<br>➢ Poor intestinal absorption due to alcoholism or drugs | ➢ Folic acid supplementation in early pregnancy reduces the risk of neural tube defect in fetus |

## *Functions of Vitamin C*

- 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
- Reduces risk of cataract formation

**Sources and RDA (mg/day)**

- Citrus fruits, tomatoes, melon, peppers
- Men: 90, Women: 75, Children: 15-25

**Deficiency:**

- Scurvy
  - 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

## *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

### Calcium deficiency

Rickets, osteomalacia, osteoporosis

## *Iron*

### Functions

- Oxygen transport and metabolism
- Part of hemoglobin, myoglobin, cytochromes
- 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

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

## *Iodine*

- Dietary iodine is stored in thyroid gland for thyroid hormone synthesis
- Tri-iodo-thyronine ($T_3$) and thyroxine ($T_4$)

**Sources and RDA (mg/day)**

- Dairy products, seafood, fortified salt
- Adults: 150, Children: 90

| *Iodine deficiency* | |
|---|---|
| Cretinism " in children " | **Goiter " in adult "** |
| deficiency of thyroid hormones in children causes stunted physical and mental growth | enlargement of thyroid gland due to iodine deficiency affecting thyroid hormone synthesis |

## Test your self:

1- what is the RDA of carbohydrates of normal adult ?

A- 65 gm
B- 130 gm
C- 45 gm
D- 600 gm

2- which one of the following nutrients is the major source of energy ?

A- proteins
B- Fats
C- Carbohydrates
D- Calcium

3- what is the RDA of proteins of an athlete who is 65 kg ?

A- 45 gm
B- 65 gm
C- 52 gm
D- 130 gm

4- which one of the following nutrients has a potent rule in reducing risk factors of CHD ?

A- Omega-3 Fatty acids
B- Omega-6 Fatty acids
C- trans fatty acids
D- Saturated fatty acids

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

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

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

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

Answer: 1- B , 2- C , 3- B , 4- A , 5- D , 6- A