
Macro and Micronutrients

**Carbohydrates / Proteins / Lipids
Vitamins / Minerals / Trace Elements**

GNT Block

Dr. Usman Ghani

Objectives

- Understand the nutritional importance of dietary macro and micronutrients
 - Identify major dietary sources and RDAs of macro and micronutrients
 - Evaluate the nutritional quality of proteins, the types of dietary carbohydrates, fibers and fats and their benefits
 - Discuss the role of macronutrients in causing diseases or conditions such as nitrogen imbalance, diabetes, obesity, atherosclerosis and heart disease
 - Understand the functions of micronutrients and the diseases due to their deficiencies
-

Overview

- What are macro and micronutrients?
 - Types
 - Functions
 - Sources and RDAs
 - Diseases and conditions due to their deficiency
-

Macronutrients

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

Micronutrients

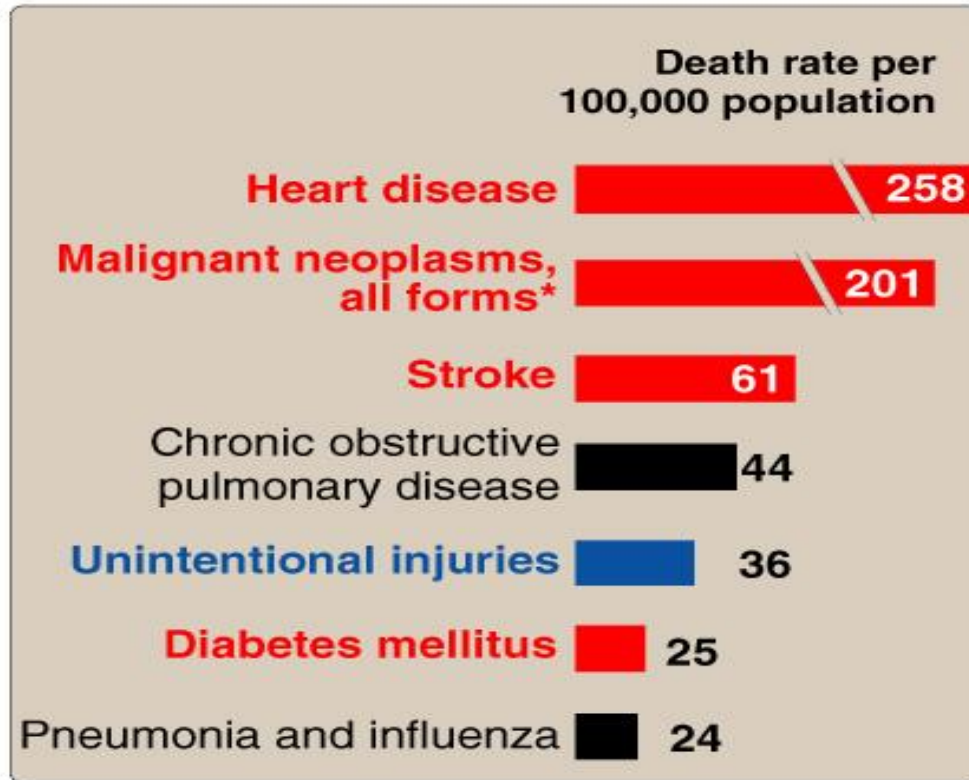
- Nutrients needed by the body in small amounts (vitamins, minerals, trace elements)
 - Required for maintaining normal health and preventing various diseases
 - They do not provide energy
-

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/g
 - Carbohydrates → 4 kcal/g
 - Fat → 9 kcal/g
-

Acceptable Macronutrient Distribution Range (AMDR)

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
-

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
 - Proteins from plant sources: 0.4
-

Sources and RDA

Sources and RDA:

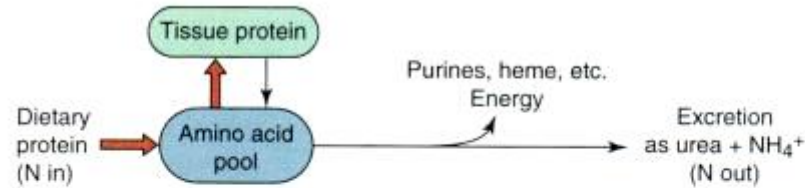
- Meat, poultry, fish, milk, wheat, corn, beans, nuts

 - RDA (g / kg body weight)
 - Normal adults: 0.8
 - Athletes: 1.0
 - Pregnancy / lactation: up to 30
 - Children: 2.0
-

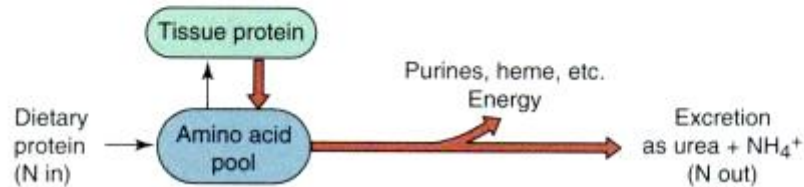
Nitrogen Balance

- *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
-

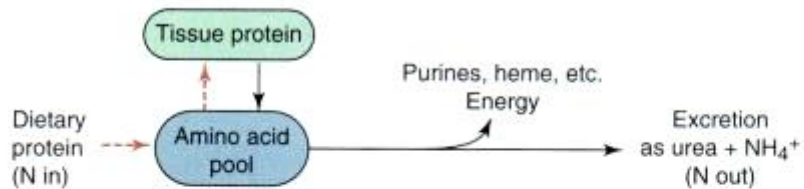
(a) Positive nitrogen balance (growth, pregnancy, lactation and recovery from metabolic stress).



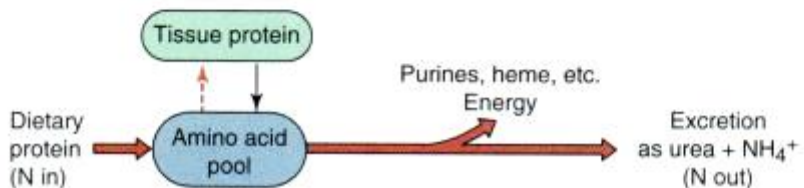
(b) Negative nitrogen balance (metabolic stress).



(c) Negative nitrogen balance (inadequate dietary protein).



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



Protein-Energy Malnutrition

- 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	Inadequate intake of proteins with adequate energy intake
Age and food intake	<ul style="list-style-type: none"> • 1-3 year • Mother's milk is supplemented with food (cereals) deficient in calories 	<ul style="list-style-type: none"> • After weaning (at about 1 year) • Diet mainly contains CHOs
Symptoms	<ul style="list-style-type: none"> • Arrested growth • Extreme muscle wasting • Weakness • Weight loss • No edema or changes in plasma proteins 	<ul style="list-style-type: none"> • Edema • Distended abdomen • Diarrhea • Dermatitis / thin hair • Enlarged fatty liver • Low plasma albumin

Carbohydrates

- Their major role in diet is energy production
 - 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
-

Dietary Fiber

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

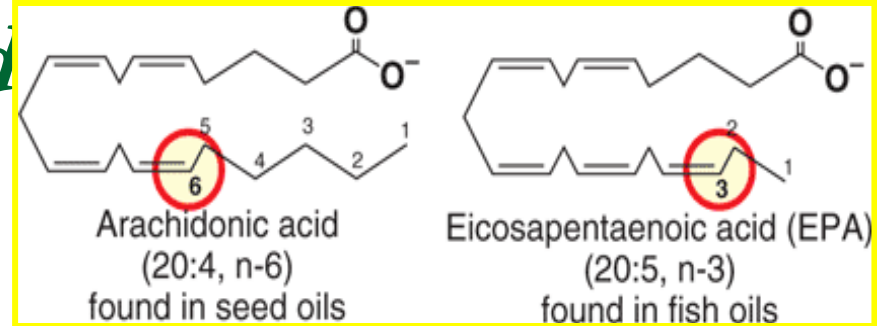
Benefits:

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

Fats in the Diet

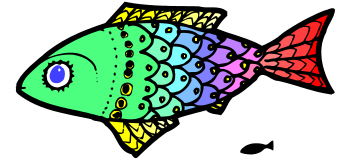
- A concentrated source of energy (9 kcals/gram)
 - Supply essential fatty acids such as **linoleic** and **linolenic** acids
 - Provide phospholipids for membrane function
 - Source of fat-soluble vitamins (A, D, E, K) and help in their absorption
 - RDA (gm/day): Total fats: 65, Saturated: 20
 - Excessive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

Essential Fatty Acid

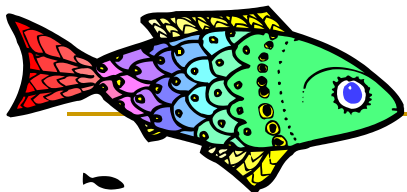
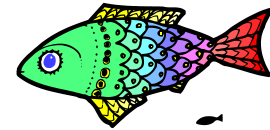


- Two essential fatty acids:
 - α -linolenic acid (ω -3 fatty acid)
 - linoleic acid (ω -6 fatty acid)
- Deficiency causes: scaly skin, dermatitis, reduced growth (most common in infants)
- Used for eicosanoids synthesis which appear to have cardioprotective effects
 - decrease blood clotting
 - decrease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

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



Recommendations for Omega-3 Fatty Acid Intake

American Heart Association Guidelines

Population

- Patients without coronary heart disease (CHD)



Recommendation

- Fatty fish twice a week
- Include oils and foods rich in α -linolenic acid (flaxseed, canola and soybean oils; flaxseed and walnuts)

- Patients with CHD



-
- 1 gm of EPA+DHA per day from fatty fish
 - EPA+DHA supplements

- Patients who need to lower triglycerides (fats)



-
- 2 to 4 grams of EPA+DHA per day

Omega-6 Fatty acids



Sources

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



Effects

- ↓ Plasma cholesterol
 - ↓ LDL
 - ↓ HDL
-

Omega-3 Fatty acids



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**

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
-

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**

- A, D, **E**, and K (stored in the body)

■ **Water-Soluble Vitamins**

- **Ascorbic acid (vitamin C)**
 - **Thiamin (vitamin B₁)**
 - Riboflavin (vitamin B₂)
 - Niacin (vitamin B₃)
 - Pyridoxine (vitamin B₆)
 - Biotin
 - Pantothenic acid
 - Folate
 - Cobalamin (vitamin B₁₂)
-

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 B₁ (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 B₁ (Thiamin) Deficiency

Beriberi

- 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

Wernicke-Korsakoff syndrome

- Common in alcoholics due to defective intestinal absorption of thiamin or dietary insufficiency
 - Causes apathy, loss of memory
-



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
-



Disorders of Vitamin C Deficiency

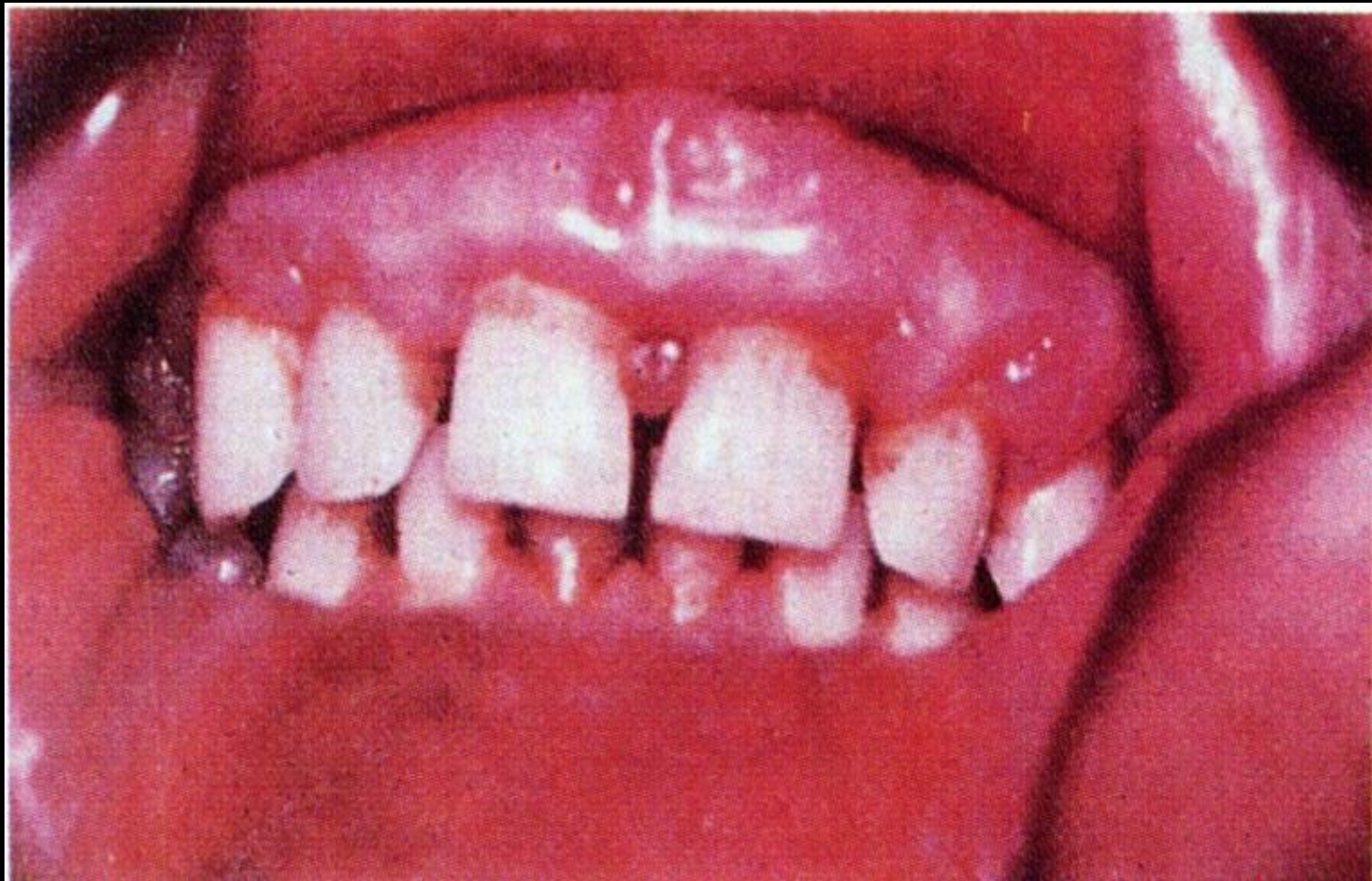
Sources and RDA (mg/day):

- 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

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 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
-

Take home message

- Macro and micronutrients are essential for energy and maintaining good health
 - Various diseases are associated either with malnutrition or excessive intake of these nutrients
-

References

- Lippincott's Biochemistry, 6th Edition, pp. 357-394, Lippincott Williams & Wilkins, New York, USA.
 - Textbook of Biochemistry with Clinical Correlations 6th Edition, pp. 1071-1096, Thomas M. Devlin, Wiley, USA.
-