



Biochemistry of the GIT

## *Macro and Micronutrients*

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## Macronutrients

- Nutrients needed by the body in large amounts (proteins, carbohydrates, fats)
- They provide energy and building blocks for proteins, carbohydrates and fats by breaking it down into its building units (e.g. proteins into amino acids, carbohydrates into monosaccharides)

## 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

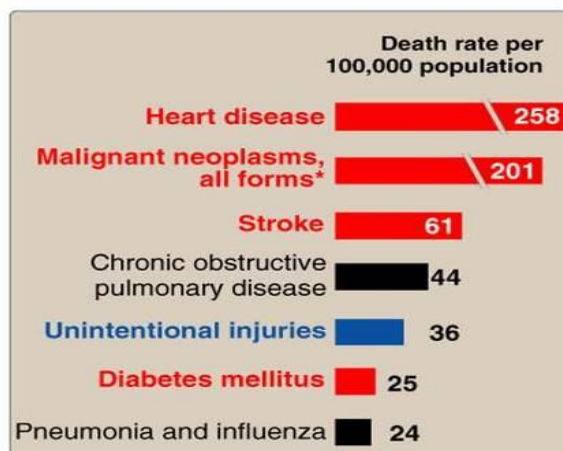
## Energy Content of Food

- Body obtains energy as ATP
- ATP is used for all body functions
- The energy content of food is measured in calories (Kilocalories). We use calorie or KJ but calories are more common
- One calorie is the heat required to raise the temperature of 1 gm. of water by 1°C
  - Proteins → 4 kcal/gm = 4000 cal/gm
  - Carbohydrates → 4 kcal/gm = 4000 cal/gm
  - Fat → 9 kcal/gm = 9000 cal/gm

## 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**: **P**heylalanine, **V**aline, **T**ryptophan, **T**hreonine, **I**soleucine, **M**ethionine, **H**istidine, **A**rginine, **L**ysine, **L**eucine
- 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. Proteins that provide **more essential amino acid** will be **higher** in quality (i.e. the profile of essential amino acid)
- Proteins are not easy to digest (i.e. digestibility)
- Measured in PDCAAS units (Digestibility-Corrected Amino Acid Scoring) which is a complete system that score the amino acids based on their quality (digestibility and essential amino acid profile).
- 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
  - *Proteins from animal sources are **BETTER** than plant sources.*
  - *If the person is vegetarian: we have to combine different vegetables. For example, **wheat** (Methionine rich but deficient in Lysine) + **kidney beans** (Methionine deficient but rich in Lysine) = **good score proteins**.*

## Sources and RDA "recommended daily allowance"

- Meat, poultry, fish, milk, wheat, corn, beans, nuts
  - RDA (gms/kg body weight)
    - Normal adults: 0.8
    - Athletes: 1.0
    - Pregnancy / lactation: up to 30
    - Children: 2.0
- The Numbers aren't important*

**Nitrogen Balance** whatever you should take in your diet = whatever you excrete in urine, feces and sweat.

### Normal Nitrogen Balance

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

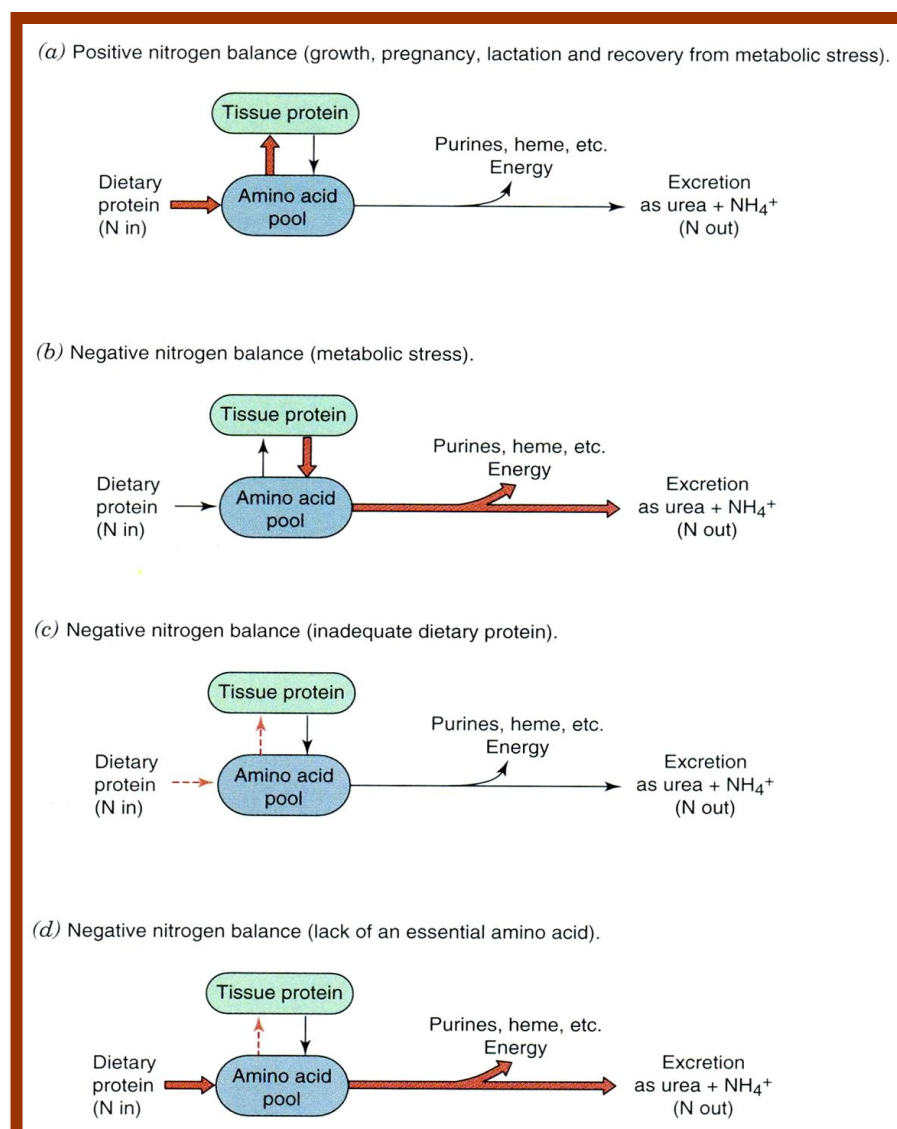
### Negative nitrogen balance

- 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

*Nitrogen is excreted out as **Ammonia**.*



## 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

People who have **PEM** (protein energy malnutrition) they have low immunity and susceptible to secondary infections.

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



## Carbohydrates

- Their major role in diet is energy production
- RDA (**recommended dietary allowance**): 130 grams/day for adults and children. This number is the amount required for the **cellular function** only, we actually need much more.
- 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

There is a relationship between the amount of **carbohydrate** in your diet and the **proteins**; it's called (protein sparing effect). The process in which **amino acids** are getting **deaminated** to produce **glucose** is called **gluconeogenesis**.

- 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

Fibers are **undigestible carbohydrates** because we **DON'T** have the enzyme to digest them (e.g. cellulous).

- 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. They reduce the reabsorption of **bile acid** and increase the excretion of **bile acid** and as a consequence increase **LDL** excretion as well.
- Reduces constipation. They're described to people having either constipation or diarrhea.
- Promotes feelings of fullness. They can absorb 10 to 15 times their own weight grams of water, hence it promotes the feeling of fullness and that's slows gastric emptying.
- Slows gastric emptying (long-term glucose control in patients with diabetes mellitus)
- Reduces exposure of gut to carcinogens

### Fats in the Diet

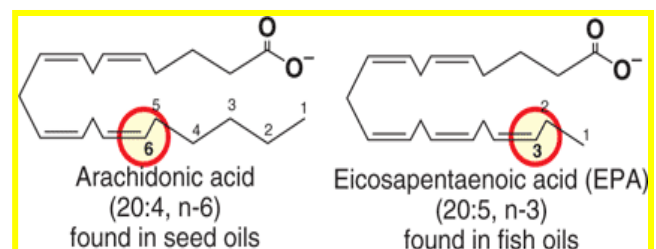
- A concentrated source of energy (9 kcals/gram)
- Supply essential fatty acids such as linoleic and linolenic acids. (parts of the omega-3 and omega-6 fatty acid).
- Provide phospholipids for membrane function
- Source of fat-soluble vitamins (A, D, E, K) and help in their absorption
- RDA (gm/day): Total fats: 65, Saturated: 20
- Excessive fat intake can cause
  - Atherosclerosis/heart disease
  - Obesity

### Essential Fatty Acids

- Two essential fatty acids:
  - $\alpha$ -linolenic acid ( $\omega$ -3 fatty acid)
  - linoleic acid ( $\omega$ -6 fatty acid)

**$\alpha$ -linolenic acid ( $\omega$ -3 fatty acid)** and **Linoleic acid ( $\omega$ -6 fatty acid)** are involved in the production of **eicosanoids**, which are **prostaglandins**, **thromboxanes** and other mediators.

- 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  $\omega$ -6 fatty acid metabolism

## Recommendations for Omega-3 Fatty Acid Intake

### American Heart Association Guidelines

Population	Recommendation
■ Patients without coronary heart disease (CHD)	■ Fatty fish twice a week ■ Include oils and foods rich in $\alpha$ -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

eicosapentaenoic acid (EPA)  
docosahexaenoic acid (DHA)

### Sources

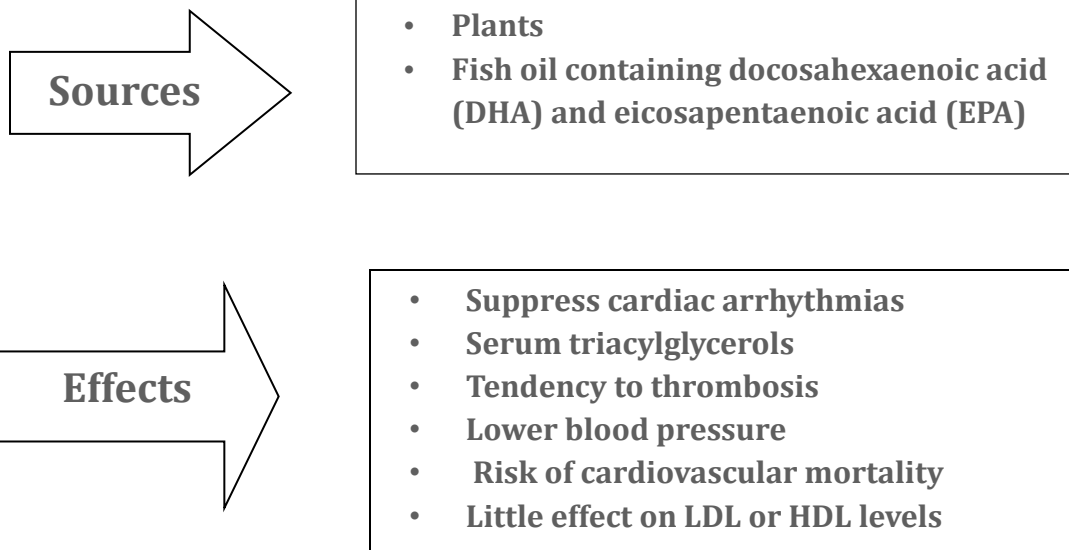
- Nuts
- Avocados
- Olives
- Soybeans
- Oils (sesame, cottonseed, corn oil)

### Effects

- ↓ Plasma cholesterol
- ↓ LDL
- ↓ HDL



## Omega-3 Fatty acids



## 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, **NOT** required for energy

- 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 D (Calciferol)

**Vitamin D (1, 25-dihydroxycholecalciferol)** or simply (**Calciferol**) is synthesized either from **7-dehydrocholesterol** from **derma** (skin) **cells** by **UV light** or **ergosterol** from **plants** (diet).

- 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 (IU)**

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

**Deficiency causes:****Rickets:**

- Insufficient bone mineralization in children
- Bones become soft and deformed

**Osteomalacia:**

**Osteomalacia** is a condition where you don't have enough  $\text{Ca}^{+2}$  and phosphorus because of the improper amount of vitamin D, which lead to bone demineralization

- Bone demineralization and increased osteoporosis
- 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
- $\alpha$  - 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 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
  - Anemia with larger RBCs
- Deficiency in pregnancy and lactation due to increased demand
- Poor intestinal absorption due to alcoholism or drugs
- Neural tube defect. **Spina Bifida and Anencephaly.**
  - 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

**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

**Minerals and Trace Elements****Macrominerals**

(&gt;100 mg/day)

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

**Microminerals**

(&lt;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 like **protein kinases**.

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

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

**Calcium deficiency:** Rickets, osteomalacia, osteoporosis



## Iron

Body stores iron as *ferritin*, *hemosiderin* and *transferring*.

### 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

## Iodine

- Dietary iodine is stored in thyroid gland for thyroid hormone synthesis
  - Tri-iodo-thyronine (T3) and thyroxine (T4)

### Sources and RDA (mg/day):

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

**Iodine deficiency:**

- Cretinism: deficiency of thyroids hormones in children causes stunted physical and mental growth
- Goiter: enlargement of thyroid gland due to iodine deficiency affecting thyroid hormone synthesis