Biochemistry Team 435

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MACRO AND MICRO NUTRIENTS.

* Please check out this link to know if there are any changes or additions.

Important Note:
Dr. Ghani: you don't have to memorize the RDAs neither the Sources. and RDAs.

Revised by
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Color index: Important | Doctors notes | Further explanation.

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 (vitamins, minerals and trace elements) and the diseases due to their deficiencies.

Macro & Macronutrients:

Macronutrients	Micronutrients
Needed by the body in **large amounts** (gram quantities) (proteins, carbohydrates, fats)	Needed by the body in **small amounts** (micro or milli gram quantities) (vitamins, minerals, trace elements).
Note that the body's main source of energy is carbs. -The body utilizes carbohydrates for energy first ,but if they are not present then the body will breakdown fat. If both of the previous energy sources are not present then the body will breakdown protein to meet energy requirements!	Required for **maintaining normal health** and **preventing various diseases**
They **provide energy** and building blocks for proteins, carbohydrates and fats	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:

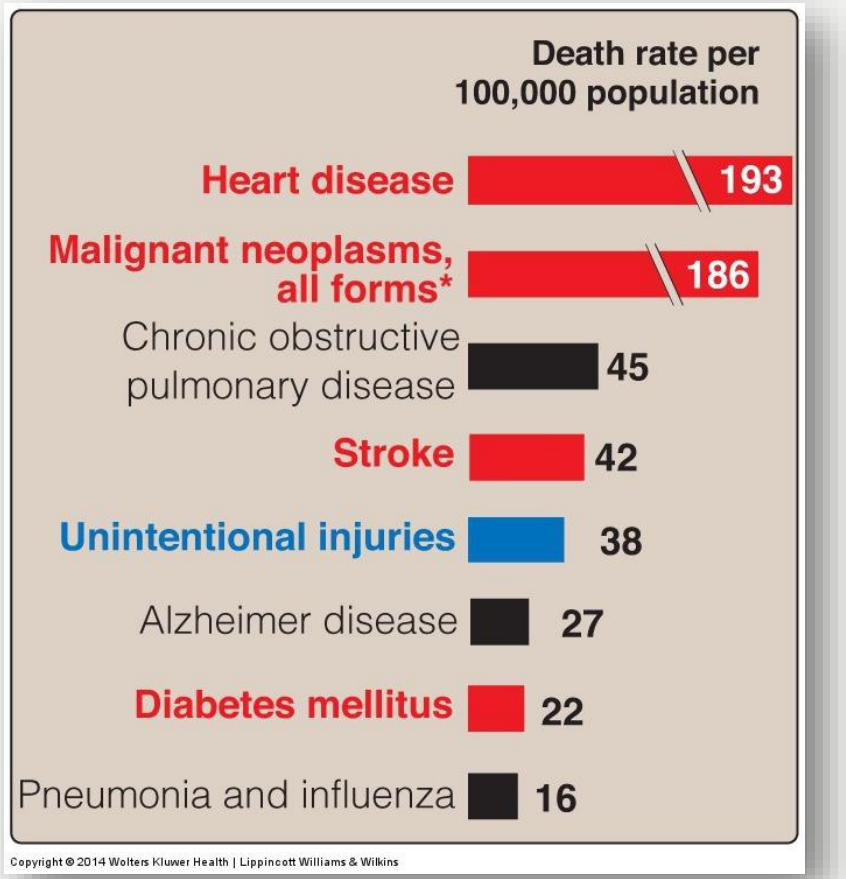
calories (Kilocalories)

- **What is a calorie?**
  - The amount heat required to raise the temperature of 1 gm. of water by 1°C.
    - Proteins → 4 kcal/gm (if you burn 1 gm of protein then it is going to provide 4 kilocalories)
    - Carbohydrates → 4 kcal/gm
    - Fat → 9 kcal/gm "Fat is considered the macronutrient with the **HIGHEST** energy"

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%



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. That is why the knowledge of acceptable range of macronutrients is quite important .

Blue indicates causes of death in which excessive alcohol consumption plays a part.

(*diet plays a role in only some forms of cancer.)

Proteins:

❖ Nutritional Importance of Proteins:

Proteins supply **amino acids** and **amino nitrogen** for the body. Proteins are the only source of nitrogen in the body.

These amino acids are used in the synthesis of different tissues and enzymes.
If you are eating an extra amount of proteins ,then the body can react in two ways:
1- either the excess protein is broken down and used as an energy source .
2- or it will convert into acetyl coA which is used in fat synthesis(so we can conclude that excessive amounts of protein are stored as FAT.)

❖ Types of proteins:

1-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. "you should memorize them"
2-Non-essential:	Body can synthesize them.

❖ Sources and RDA:

- **Sources:** Meat, poultry, fish, milk, wheat, corn, beans, nuts
- **RDA "Recommended dietary intake" (gms/kg body weight)**
  - Normal adults: 0.8
  - Athletes: 1.0
  - Pregnancy / lactation: upto 30
  - Children: 2.0

Proteins:

❖ Nutritional Quality of Proteins:

❖ **What is it?**

A measure of a protein's ability to provide the essential amino acids required for tissue maintenance. "to know which protein is more beneficial than the other"

❖ **Measured in: PDCAAS units** (protein Digestibility-Corrected Amino Acid Scoring) An amino acid score provided for each amino acid present in that protein

- **High value** indicates more digestibility and high quality (**maximum score 1.0**) Why is the score of animal proteins higher than the score of plant proteins? Because the constituents of animal proteins are similar to the requirements of the body ,hence these proteins will have a higher nutritional quality ,and ultimately a higher score.
  - **Proteins from animal sources:** 0.82-1.0
  - **Proteins from plant sources:** 0.4

Why is the knowledge of protein nutritional quality important ? Because if you are eating a type of protein with a low score (meaning it has a low nutritional value),then you can combine it with another protein that has a higher nutritional quality ,hence the body will get its requirements!

The nutritional quality of proteins Depends upon two things : 1-the amount of essential amino acids provided by that protein 2-the digestibility of that protein (Because some proteins are not easily digested such as bean which will affect their nutritional quality)

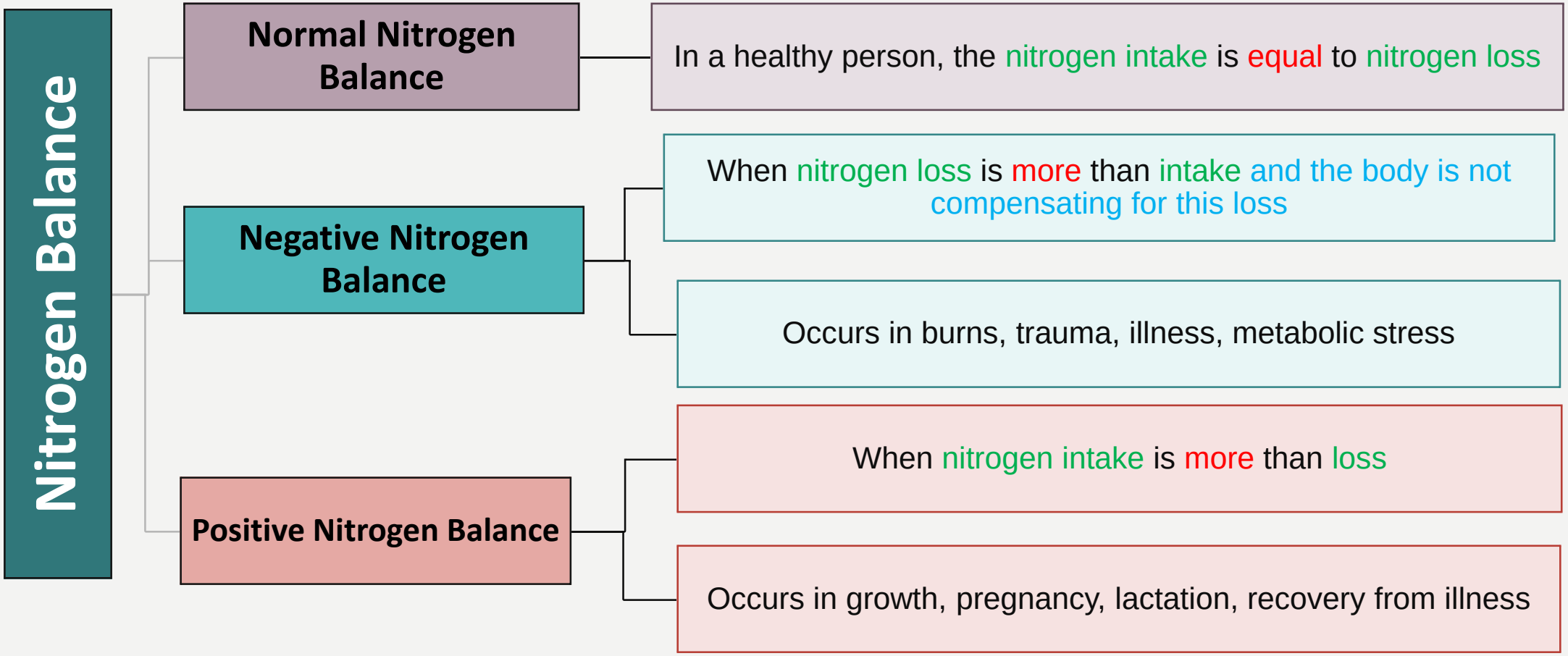
The proteins with the highest nutritional score:

1- Milk protein (casein) it is of good nutritional quality (easily digestible ,provides many essential amino acids) So it has a score of 1

2-egg white

NITROGEN BALANCE

Provided by amino balance



Explanation :

Note that in order for positive nitrogen to occur, two things must happen:
1-intake is more than excretion
2-body keeps on forming more tissue protein(in children during growth , during lactating , metabolic stress) *if only the first condition happens, the proteins will be stored as fat (as mentioned earlier) , so positive nitrogen balance will not happen that is why we specified that positive N balance happens in growth and lactation..and not just by increasing amino acid intake!!!

Image a :

positive nitrogen balance 1-increased amount of Dietary proteins taken in and added to the existing amino acid pool in the body
2-tissue protein is synthesized from said pool
3-the amount of excretion and the amount being used for energy Purine, and heme is normal(not increased) 4-intake more than excretion because your body is taking up more and synthesizing more tissue protein , WITHOUT increased excretion ,then your body is in positive nitrogen balance .

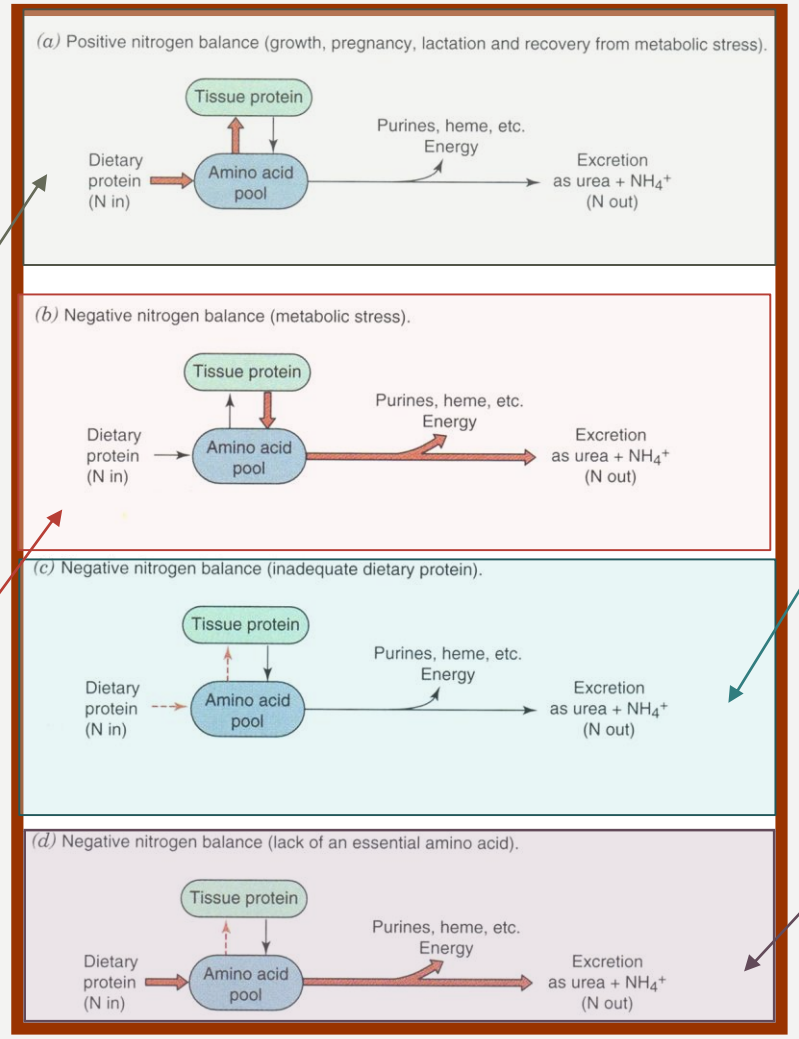


Image b:

Negative nitrogen balance occurred Because the body is in metabolic stress> breakdown is much more > the amount of nitrogen excreted (as urea and ammonia) is much more

Image c:

Negative nitrogen balance occurred due to the following:
1-malnutrition (intake of nitrogen is low)
2- hence the amount of tissue protein being synthesized is low
3-but the breakdown and excretion remain normal (do not decrease proportionately to the decreased intake)
4- hence , person has negative nitrogen balance

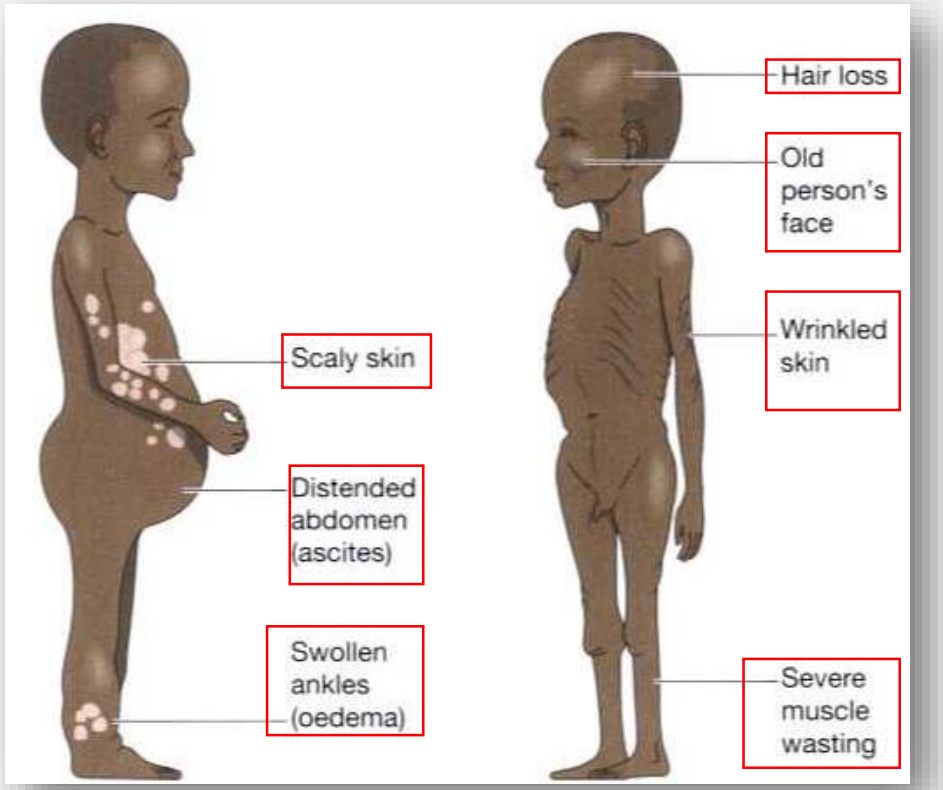
Image d:

1-dietary intake protein is normal But the amount used to synthesize tissue protein is less (why?) due to lack of amino acids from the diet
2- so all other amino acids not being used in synthesis will be degraded and excreted from the body (increased nitrogen loss, hence negative nitrogen balance occurs)

PROTEIN-ENERGY MALNUTRITION

- **What is it ?**
  A condition or disease caused by not eating enough food leading to energy malnutrition or not eating a balanced diet leading to protein malnutrition
- Malnutrition due to **inadequate intake** of proteins or energy

Either the amount of total protein taken Is inadequate Or protein taken in is adequate but the caloric intake is not enough to sustain life



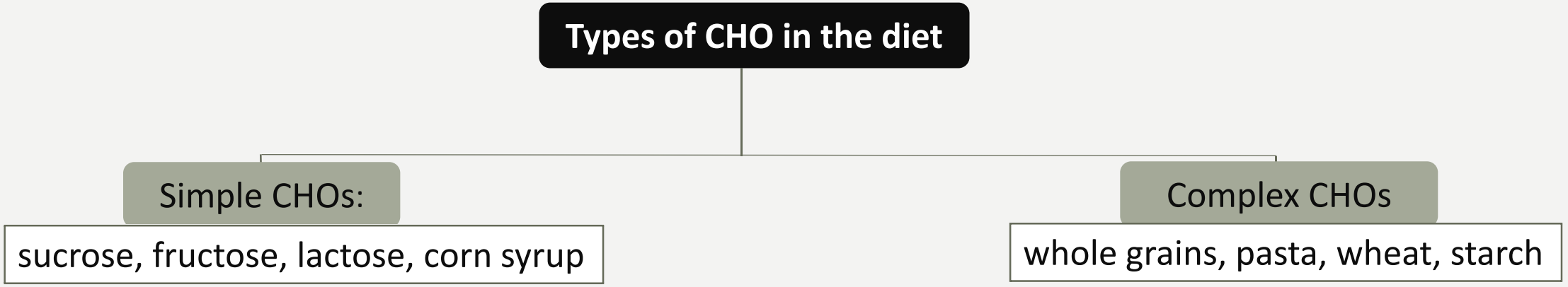
PROTEIN-ENERGY MALNUTRITION

الجدول مهم جدا و غالبا بيجينا على شكل كايس! احفظوه زين!!

disorders	Marasmus	Kwashiorkor
Causes	Inadequate intake of energy with adequate protein intake	Inadequate intake of proteins with adequate energy intake (kwashiorkor is more of an acute state while marasmus is chronic)
Age and food intake	• 1-3 year • **Mother's milk** is supplemented with food (cereals) deficient in calories.	• After weaning (few months to **at about 1 year**). • Diet mainly contains **CHOs.** • Why does kwashiorkor occur? Sometimes mothers wean the babies much earlier than they should (take them off milk) So now the baby's diet is composed of carbs mostly So the amount of blood protein will go down ,hence edema will occur
Symptoms	• Arrested growth • Extreme muscle wastingWhy does this occur even though protein intake is adequate? • Because you are not getting enough energy from carbs, so the proteins will be used as an energy source • Weakness • Weight loss • **No edema or changes in plasma proteins.**	• Edema "due to decreased protein levels" • Distended abdomen • **Diarrhea** • **Dermatitis due to fat loss** / thin hair • Enlarged fatty liver due to decrease in lipoproteins so the lipids will accumulate in the liver. • Low plasma albumin

CARBOHYDRATES

- Their major role in diet is **energy production**.
- **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



What is difference between the simple and complex: carbs?
The body requires more energy to breakdown complex carbs than in simple carbs. One should include more complex carb in his/her diet

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.

As long as you have a good amount of carbs in the body, proteins will NOT be used as an energy source

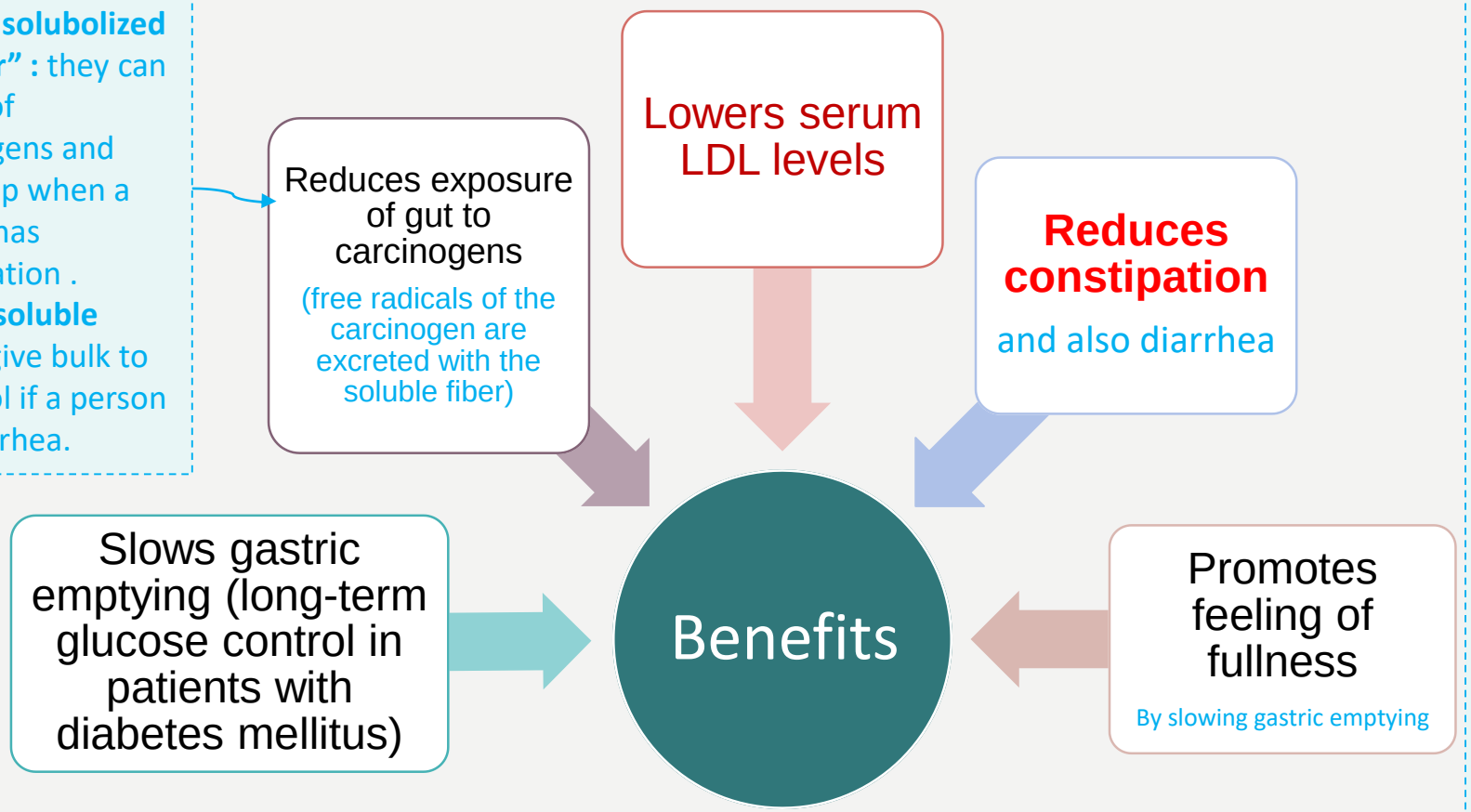
How can proteins provide energy?

First they have to be turned into glucose by gluconeogenesis. The amino acids that can be used in the synthesis of glucose are called : glycogenic amino acids

DIETARY FIBER

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

There are two types of fibers:
- **Soluble fibers: "can be solubolized in water" :** they can get rid of carcinogens and they help when a person has constipation .
- **The insoluble fibers:** give bulk to the stool if a person has diarrhea.



Where are bile salts synthesized? Liver
What is the parent compound of bile salts? cholesterol
How does fiber lower serum LDL?
Because the soluble fibers interfere with the reabsorption of bile salts.
Bile salts that are released into the gut for the digestion and the absorption process will be reabsorbed by a percentage of 90% (normally) .
These bile salts are reabsorbed → then taken to the liver → then to gallbladder.
how do the soluble fibers interfere with this process?
by binding to bile salts!
This binding inhibits the reabsorption of bile salt that normally occurs -so less bile salts are available in the body → the body will synthesize more bile salts by using the cholesterol in the body ? hence depleting serum cholesterol (LDL)

FATS IN THE DIET

- A **concentrated source of energy** (9 kcals/gram).
- **Importance:**
  - 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 "omega-3" fatty acid). It means that the location of first double bond of the fatty acid chain (start counting from methyl group) is at C3. Note that a fatty acid starts with a ethyl group and ends with a carboxy group. **Types of fatty acids :** 1-saturated : no double or triple bonds 2-unsaturated: contains double or triple bond.
  - **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 cardio protective effects.
  - Decrease blood clotting.
  - Decrease blood pressure.

Why are these eicosanoids cardioprotective? Because when taking in these eicosanoids they replace the type of fatty acids present in the membranes of these inflammatory cells and that's how it modifies the property of these inflammatory cells
Hence reduces the ongoing inflammation .

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.

So when you are eating these omega three fatty acids or take them as supplements ,then they will replace the membrane lipids, modifying them.

Modulator of ω-6 (omega-6) fatty acid metabolism.

People with high cholesterol should take omega 6 fatty acids even though they decrease HDL (why?) Because in these patients it is of great importance to lower LDL levels And because HDL can be increased by life style modifications such as exercise.

	Omega-3 Fatty Acids:	Omega-6 Fatty Acids:
Sources :	Plants - Fish oil containing docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA).	Nuts – Olives – Avocados - Soybeans – Oils (sesame , cottonseed , corn oil)
Effects:	• Suppress cardiac arrhythmias. • ↓ **Serum triacylglycerols** (main function) & ↓Tendency to thrombosis. • ↓ blood pressure & ↓ the risk of cardiovascular mortality **Little effect on LDL or HDL levels**	• ↓ Plasma cholesterol • ↓ **LDL** • ↓ **HDL**

Recommendations for Omega-3 Fatty Acid Intake

American Heart Association Guidelines

Population	Recommendation
Patients without CHD But have an increased risk	1- Fatty fish twice a week. 2- Include oils and foods rich in a-linolenic acid (flaxseed, canola and soybean oils; flaxseed and walnuts)
Patients with CHD	1- 1 gm of EPA+DHA per day from fatty fish. 2- EPA+DHA supplements
Patients who need to lower triglycerides (fats)	2 to 4 grams of EPA+DHA per day

CHD : coronary heart disease

Trans Fatty Acids

What are they?

Unsaturated fatty acids chemically, behaving more like saturated fatty acids **in the body**.

Effects:

1- increase serum LDL (but not HDL, they may decrease HDL).

2- Risk of CVD. (cardiovascular diseases).

formed during

They're formed during hydrogenation of liquid vegetable oils. (كما تعرف بالزيوت المهدرجة)

When oil gets hydrogenated , it becomes transfat as in ghee which is used in baked food

Found in

Found in **baked food**: cookies, cakes, deep-fried foods, but they can't be found in plants (animals only).

Vitamins

Organic compounds present in small quantities in different types of food

Help in various **biochemical processes** in cell

Most act as **coenzymes**

Important for **growth** and maintaining **good health**

Essential

Vitamins

Non-caloric, they don't give energy

Required in very **small amounts**

Vitamins are Classified Based on Solubility:

Fat-Soluble Vitamins

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K
- STORED IN THE BODY

ADEK

Water-Soluble Vitamins

1. Ascorbic acid (vitamin C)
2. Thiamin (vitamin B1)
3. Riboflavin (vitamin B2)
4. Niacin (vitman B3)
5. Pyridoxine (vitamin B6)
6. Biotin
7. Pantothenic acid
8. Folate
9. Cobalamin (vitamin B12)

Vitamin E & Vitamin B1

	Vitamin E	Vitamin B1 (Thiamin)
Active form	a-Tocopherol is the most active form in the body	Thiamin pyrophosphate (TPP).
function	Antioxidant (prevents oxidation of cell components by molecular oxygen and free radicals). May have a role in fertility and anti-aging effect.	As a Coenzyme for transketolase in HMP pathway and oxidative decarboxylation reactions In krebs cycle +I inking krebs cycle with glycolysis)
Sources	Vegetable Oil -nuts - Seeds – vegetables	Plants – Cereals - Meat.
RDA	• Adults:15 mg/day. • Children:7 mg/day.	• Adults: 1.2 mg/day • Children: 0.6 mg/day

Deficiency of vitamin E results in:

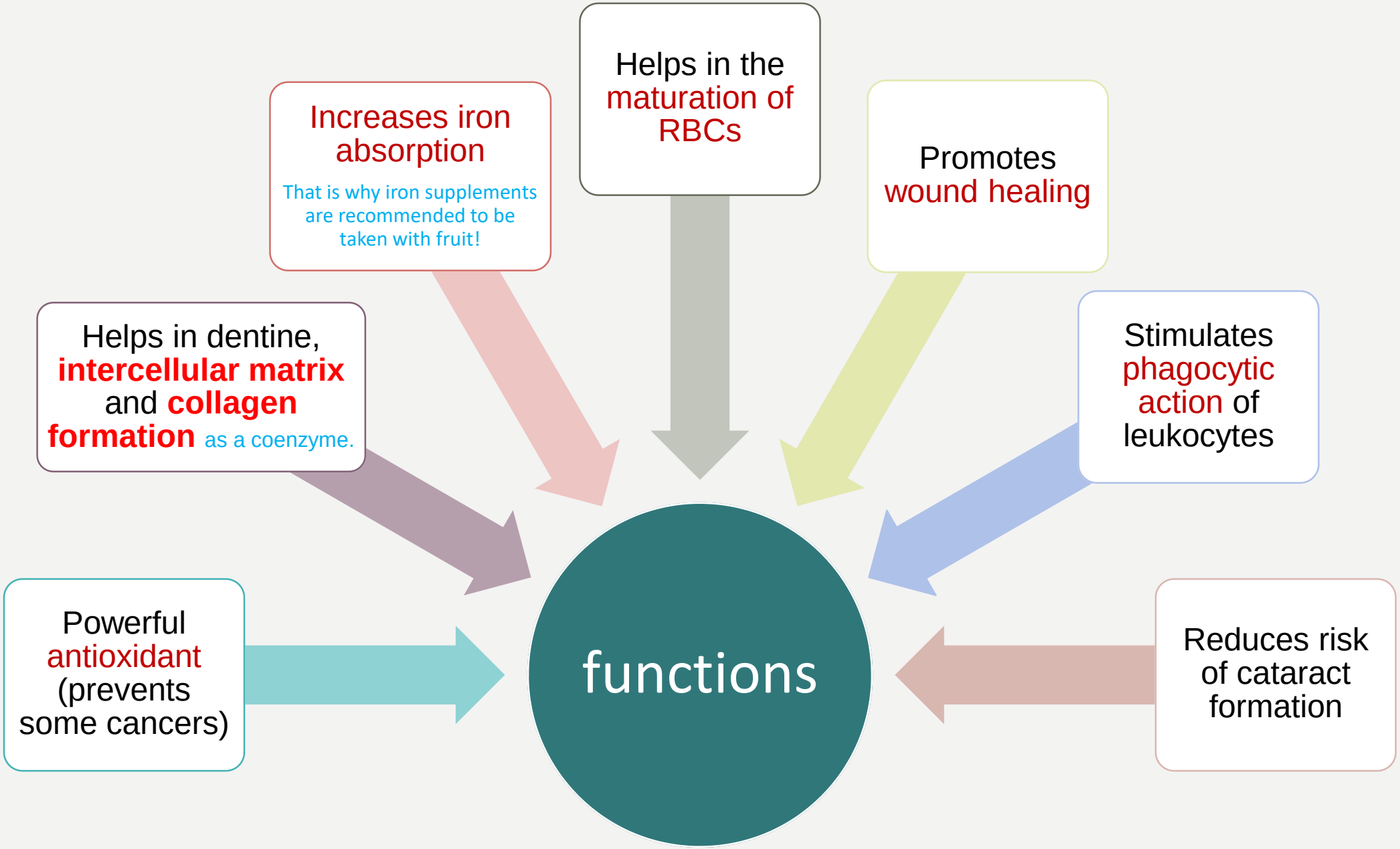
- Defective lipid absorption
- Anemia due to oxidative damage to RBCs
- Neurological problems
- Male infertility

Thiamin Deficiency

- **In thiamin deficiency**:
  - the activity of these two dehydrogenase-catalyzed reactions (transketolase and oxidative decarboxylation reactions) is decreased.
- **Causing**:
  - Low ATP production and, therefore, defective cellular function.

Disorders of Vitamin B_1 (Thiamin) Deficiency		
Disorder :	**Beriberi**	**Wernicke-Korsakoff syndrome**
What is it?	A type of chronic peripheral neuritis due to severe thiamin deficiency.	**Common in alcoholics** due to defective intestinal absorption of thiamin or dietary insufficiency.
Leads to :	weakness, paralysis, neuropathy, disorderly thinking.	apathy, loss of memory
Facts	- Thiamin has a role in nerve conduction. - Neuropathy affects glial cells (astrocytes) of the brain and spinal cord causing neuron death.	

Vitamin C: Functions



Vitamin C

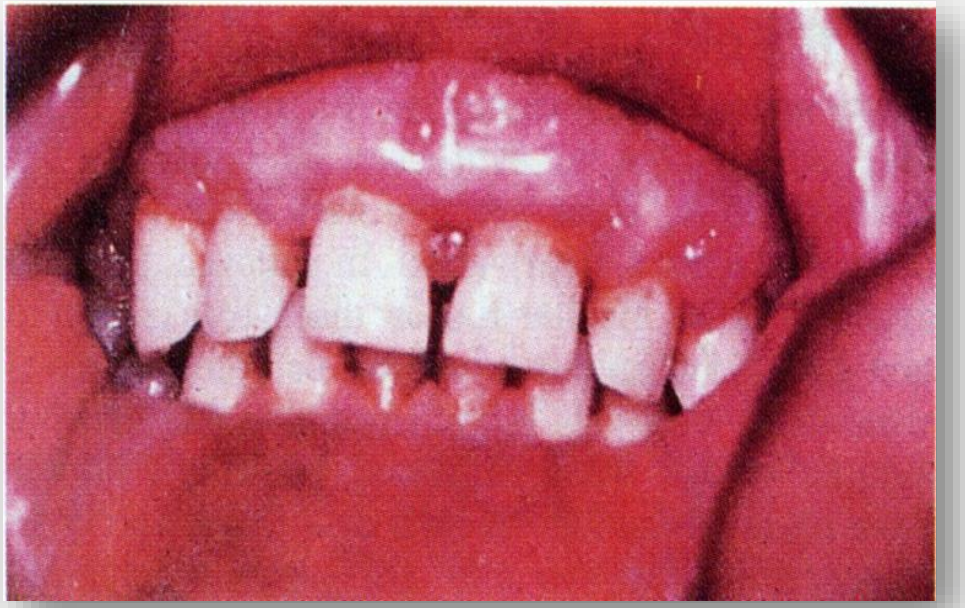
Sources and RDA (mg/day):

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

Deficiency of vitamin C results in a disease called**:**

Scurvy (also called sailor disease)

- It's an **abnormal collagen production**
- Gums become painful, swollen and spongy and bleeding
- 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

Minerals

Macrominerals (>100 mg/day)

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

Microminerals (<100 mg/day)

- Iron
- Iodine.
- Molybdenum
- Copper, selenium
- Manganese, Fluoride
- Zinc, Chromium
- Cobalt, Silicon

- If the minerals are needed more than 100 mg per day = macro
- If the minerals are required less than 100 mg per day then we call them trace elements(microminerals)

❖ Trace elements are metal elements

Iron

Sources and RDA (mg/day):

- **Heme iron:** Animal products (meat, liver), 25% absorption of iron we take from these sources.
- **Nonheme iron:** Plants (spinach, beans), 5% absorption. Note that this decreased absorption explains the iron deficiency that occurs in vegetarians and vegans!
- Men: 8, Women: 18, Children: 7-15

Functions

- Oxygen transport and metabolism.
- Part of **hemoglobin**, **myoglobin**, **cytochromes**.
- Body stores iron as ferritin(In liver), hemosiderin (it is a protein with iron bound to it) and transferrin(in bood).
- Adult women have **much lower iron** storage than men.

Iron deficiency

Iron-related disorders

Iron deficiency anemia

is most common in growing children, pregnant, lactating and menstruating women which 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.

Check your understanding!

Q1: Which of the following are classified as "Macronutrients"?

A. Proteins
B. Fats
C. Vitamins
D. A+B.

Q2: Which of the following is an essential Amino Acid?

A. Arginine
B. Alanine
C. Tyrosine
D. Serine

Q3: Which of the following statements is true?

A. Proteins from plant sources are more digestible than those from animal sources
B. Proteins from animal sources are more digestible than those from plant sources.
C. Proteins from plant sources have equal digestibility as those from animal sources
D. None of the Above

Q4: Normally in a healthy person, Nitrogen intake is….

A. Greater than Nitrogen loss
B. Less than Nitrogen loss
C. Equal to Nitrogen loss.
D. None of the Above

Q5: Marasmus condition arises due to:

A. Inadequate intake of proteins with adequate intake of energy
B. Inadequate intake of energy with adequate intake of proteins.
C. Inadequate intake of proteins with inadequate intake of energy
D. Excess intake of protein with adequate intake of energy

Q6: What will happen if a person's CHO intake is less than required?

A. Proteins will be spared and fats will be metabolized instead
B. Proteins will be metabolized to make up for the energy deficit
C. More Gluconeogenesis will take place
D. B+C.

1.D 2.A 3.B 4.C 5.B 6.D

Check your understanding!

Q1: Which of the following statements is incorrect?

A. Dietary Fibers cannot be broken down by humans
B. Dietary Fibers promote gastric emptying.
C. Dietary Fibers promote a feeling of fullness
D. Dietary Fibers lower serum LDL levels

Q2: What are the effects of Omega-6 Fatty acids on the body?

A. Lower LDL and VLDL only
B. Lower LDL and HDL only
C. Lower plasma cholesterol levels only
D. None of the Above.

Q3: Which of these nutrients helps suppress Cardiac Arrhythmias?

A. Omega-6 Fatty acids
B. Omega-3 Fatty acids
C. α-linolenic acid
D. B+C.

α-linolenic

Q4: What are the fat-soluble vitamins stored in the body?

A. Vitamins K, A, E, D.
B. Vitamins A, D, C, K
C. Vitamins B, D, K , C
D. None of the Above

Q5: Wernicke-Korsakoff Syndrome occurs due to:

A. Vitamin A deficiency
B. Vitamin B_{12} deficiency
C. Vitamin B_1 Deficiency.
D. Vitamin D deficiency

Q6: Iron is stored in the body as:

A. Ferritin
B. Transferrin
C. Hemosiderin
D. All of the Above.

1.B 2.D 3.D 4.A 5.C 6.D

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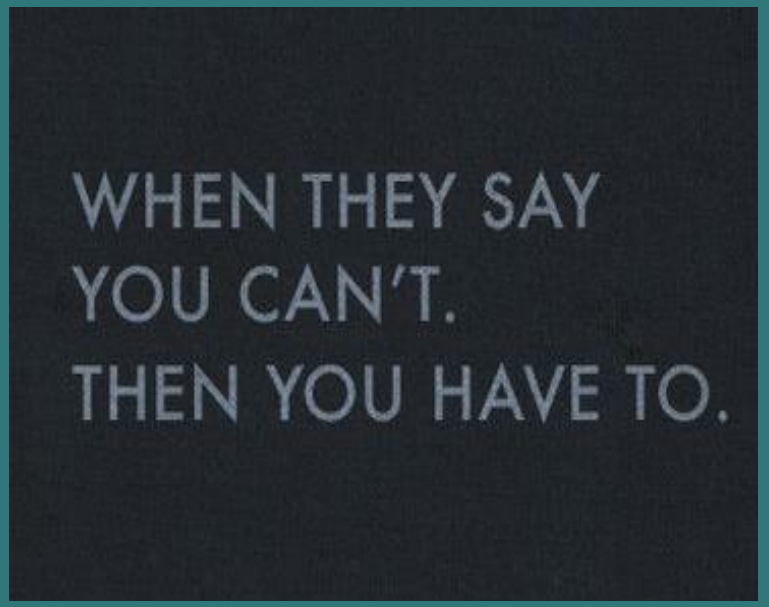

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Resource:

- 435's slides and notes.

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