"اللَّهُمَّ لا سَهْلَ إلاَّ ما جَعَلْتَهُ سَهْلاً، وأنْتَ تَجْعَلُ الحَزْنَ إذَا شِئْتَ سَهْلاً "

Macro & Micro Nutrients

Biochemistry Team 437

Color index:
Doctors slides
Doctor's notes
Extra information
Highlights

GNT block

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 should you know about this lecture:

- Sources are not really important. Will not be asked about.
- You should know the RDA for Carbs, Proteins, and Fats only.
- There will be calculations.
- Functions of Vitamins and diseases related to them are important.

We are talking about quantity.

Macronutrients & Micronutrients

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Macronutrients	Micronutrients
• Nutrients needed by the body in large amounts (proteins, carbohydrates, fats) • They provide energy and building blocks for proteins, carbohydrates and fats.	• 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. • Some act as coenzymes.

Energy Content of Food

ATP breakdown will produce heat. Calorie is a measure to that heat.
How do we measure calorie content? bomb calorie meter.

- Body obtains energy as ATP
- 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^{o}C
  - Proteins (**4** kcal/gm)
  - Carbohydrates (**4** kcal/gm)
  - Fat (**9** kcal/gm)

Acceptable Macronutrient Distribution Range (ADMR)

Adequate intake of macronutrients to prevent the risk of disease

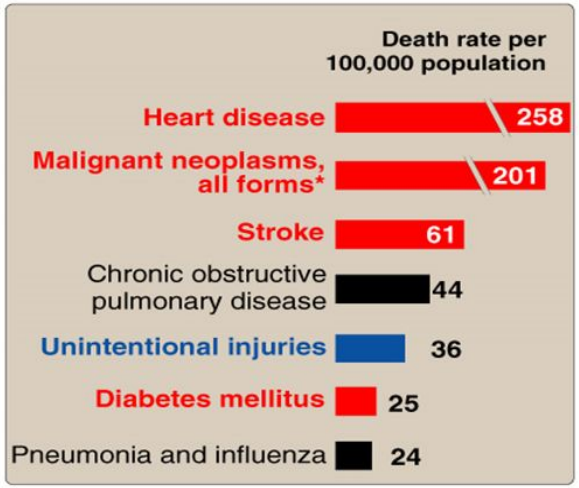

Figure 27.8
Influence of nutrition on some common causes of death in the United States in the year 2000. Red indicates causes of death in which the diet plays a significant role. Blue indicates causes of death in which excessive alcohol consumption plays a part. (*Diet plays a role in only some forms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

AMDR for adults:

CHOs: 45-65%

Proteins: 10-35%

Fats: 20-35%

Diseases like heart disease, malignant neoplasm, strokes, diabetes, have nutrition as a main causative factor.

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.

Proteins are the ONLY source of nitrogen for the body.

Nutritional Quality of Proteins (NQP)

A measure of a protein's ability to provide the essential amino acids required for tissue maintenance and growth.

High quality protein: A protein that can give you all essential amino acids.

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

Factors that are taken into consideration to come up with these numbers:

- Presence of essential amino acids
- Digestibility of proteins

Don’t memorize the RDA
In this lecture.

Sources and RDA of Proteins

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RDA (g/kg body weight):

- NORMAL ADULTS: 0.8
- ATHLETES:1.0
- PREGNANCY/LACTATION: UP TO 30 because the fetus needs protein to grow.
- CHILDREN: 2.0

If your weight is is 70 Kg. How much gram of protein do you need every day?

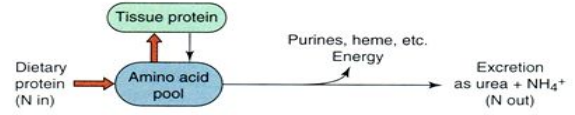
↝ 70 x 0.8 = 56g per day

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

Nitrogen Balance

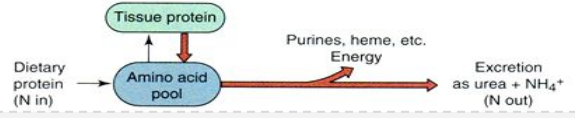
Normal Nitrogen Balance	In a healthy person, the nitrogen intake is equal to nitrogen loss.
Negative nitrogen balance Happens when: • tissue protein is broken down • Amount of dietary intake of protein is down • Normal protein intake but the Essential amino acids are deficient.	When nitrogen loss is more than intake. Occurs in burns, trauma, illness, metabolic stress, malnutrition.
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).



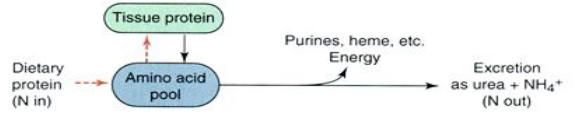
Excretion does not change in proportion to intake because body needs proteins it will enter the tissues.

(b) Negative nitrogen balance (metabolic stress).



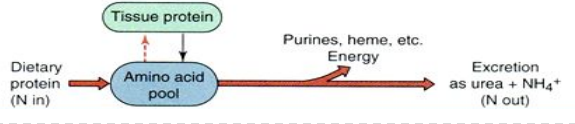
Normal intake and synthesis but tissue proteins are breaking down due to stress so the excretion increases.

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



The intake is decreased, the excretion is normal, but tissue synthesis is decreased

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



Normal intake but the quality is low, protein synthesis decreases and excretion increases (intake and output are normal but the synthesis decreased negative nitrogen balance.)
Example: if person eating a lot of beans which are deficient in methionine body is not getting nutrients that it requires, so the amino acid pool will be excreted and not used in synthesis.

Protein-Energy Malnutrition

- **Malnutrition:** A condition or disease caused by not eating enough food or not eating a balanced diet.
- Malnutrition due to inadequate (either the amount or type) intake of proteins or energy.
- Two conditions: (Infants are usually more susceptible to these diseases because of high demand of protein)

	Marasmus	Kwashiorkor
Cause	Inadequate intake of energy with adequate protein intake.	Inadequate intake of proteins with adequate energy intake.
Age and Food Intake	• 1-3 year • Mother's milk is supplemented with food (cereals) deficient in calories	• After weaning (at about 1 year) • Diet mainly contains CHOs ↗ Example: in some poor countries they give their children rice water instead of milk, it is high in carbs but very low in protein.
Symptoms Because we don't have enough energy and carbs, the body will start breaking down its protein.	• Arrested growth • Extreme muscle wasting because no carbs • Weakness • Weight loss • No edema or changes in plasma proteins • Treatment: eating enough carbohydrates	• Edema • Distended abdomen • Diarrhea • Dermatitis / thin hair (no fat) • Enlarged fatty liver due to excess carbs that are stored as fat • 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 healthier option.
- CHO intake above RDA causes weight gain or obesity due to increased fat storage in adipose tissue.

Carbohydrates are converted to fat if not used.

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 "energy production"
- If CHO intake is less than the RDA (130 g/day)
  - More proteins will be metabolized
  - More gluconeogenesis will take place
- In a normal situation, your body will start burning carbs → fats → proteins
- But if you're not eating enough carbs, energy will be taken from **protein** first, then fats.

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 (Cholesterol makes bile which binds to fibers and is excreted, forcing the liver to use its cholesterol to make more bile salts therefore cholesterol does not enter circulation as LDL)
  - Reduces constipation
  - Promotes feeling of fullness
  - Slows gastric emptying (long-term glucose control in patients with diabetes mellitus)
  - Reduces exposure of gut to carcinogens

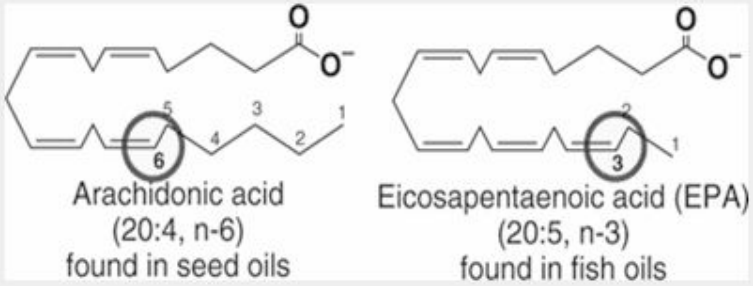
Fats in the Diet

- 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 Acids

- Two essential fatty acids:
  - a-linolenic acid (w-3 fatty acid)
  - linoleic acid (w-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

*Eicosanoids has anti-inflammatory role.



- Can be made from linoleic acid
- Position of first double bond on **6**

- 20 carbon
- Five double bonds
- Position of first double bond is on carbon **3**

Omega-3 Fatty Acids

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- 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 w-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 a-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 + Omega-3 Fatty acids

Omega-6 Fatty acids

Sources:

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

Effects:

- ↓Plasma cholesterol
- ↓LDL
- ↓HDL (Decreased HDL is not healthy, but can be overcome with lifestyle modifications)

Omega-3 Fatty acids

Sources:

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

Effects:

- Suppress cardiac arrhythmias
- Reduce serum triacylglycerols
- Reduce tendency to thrombosis
- Lower blood pressure
- Reduce Risk of cardiovascular mortality
- Little effect on LDL or HDL levels lowered by omega 6

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 (as co-enzymes)
- 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)	**Ascorbic acid (vitamin C)**, **Thiamin (vitamin B_1),** Riboflavin (vitamin B_2), Niacin (vitamin B_3), Pyridoxine (vitamin B_6), Biotin, Pantothenic acid, Folate Cobalamin (vitamin B_{12})

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

Deficiency: (mostly absorbed in premature infants) may lead to:

1- Defective Lipid absorption

2- Anemia due to oxidative damage

3- Neurological problems

4- Male infertility

Antioxidants in cell: Vitamin C,E, and Beta carotene

Sources and RDA (mg/day):

- Vegetable oil, nuts, seeds, vegetables
- Adults:15, children: 7

Vitamin B1 (Thiamin)

- Active form: Thiamin pyrophosphate (TPP) Coenzyme for transketolase and oxidative decarboxylation reactions (reactions linking glycolysis + krebs cycle)
- In thiamin deficiency, the activity of these two dehydrogenases is decreased
- Causing: Low ATP production and defective cellular function

Deficient Vit B1 patients will feel energized after taking supplements.

Sources and RDA (mg/day):
- Plants, cereals, meat
- Adults:1.2, children: 0.7

Disorders of Vitamin B_1 (Thiamin) Deficiency:

Beriberi: It used to be common in the sailors
- A type of chronic peripheral neuritis due to severe thiamine 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 (not reversible)

Vitamin C

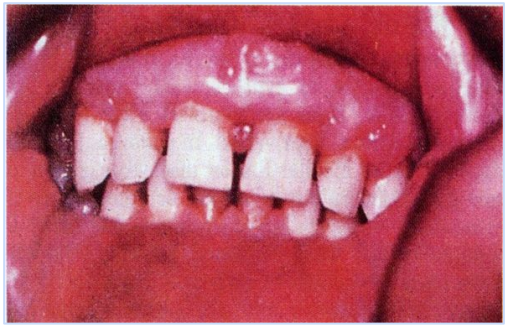
- Powerful antioxidant (prevents some cancers)
- Helps in dentine, intercellular matrix and collagen formation
- Increases iron absorption through conversion of ferric to ferrous
- Helps in the maturation of RBCs
- Promotes wound healing
- Stimulates phagocytic action of leukocytes
- Reduces risk of cataract formation

Sources and RDA (mg/day):

- Citrus Fruits, tomatoes, melon, peppers
- Men: 90, women: 75, children: 15-25

Deficiency causes scurvy sailors disease

- 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 (>100mg/day):

- Calcium
- Phosphorus
- Sodium
- Potassium
- Chloride
- Magnesium

Microminerals (Trace elements) (<100 mg/day):

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

*Ultratrace minerals because the required dose is less than 1 mg/day

Iron:

- 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 because of the physiological loss of blood

Here you have to know which kind is better absorbed

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

Hemosiderosis (iron overload disorder):

- Due to Iron excess (toxicity)
- Hemosiderin[1] (Iron stores in complex with ferritin protein in liver and spleen
- Occurs in people receiving repeated blood transfusion

Iron deficiency anemia is most common in growing children, pregnant, lactating, and menstruating women need more Iron.

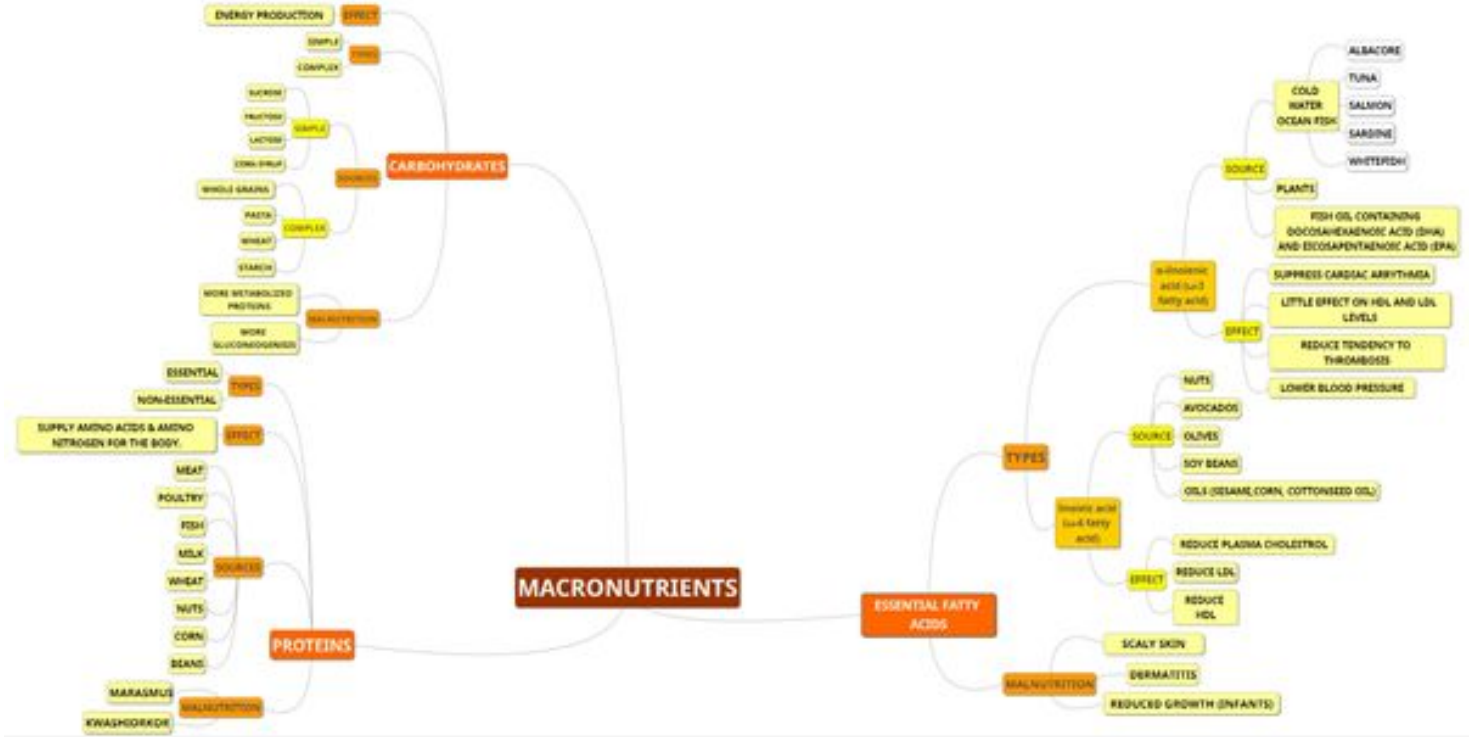
Hemochromatosis: occurs due to genetic mutation or inherited disease.

- Affected gene: HME gene
- Causes: excessive Iron absorption and increase in circulating Iron which causes an increase in ferritin + transferrin

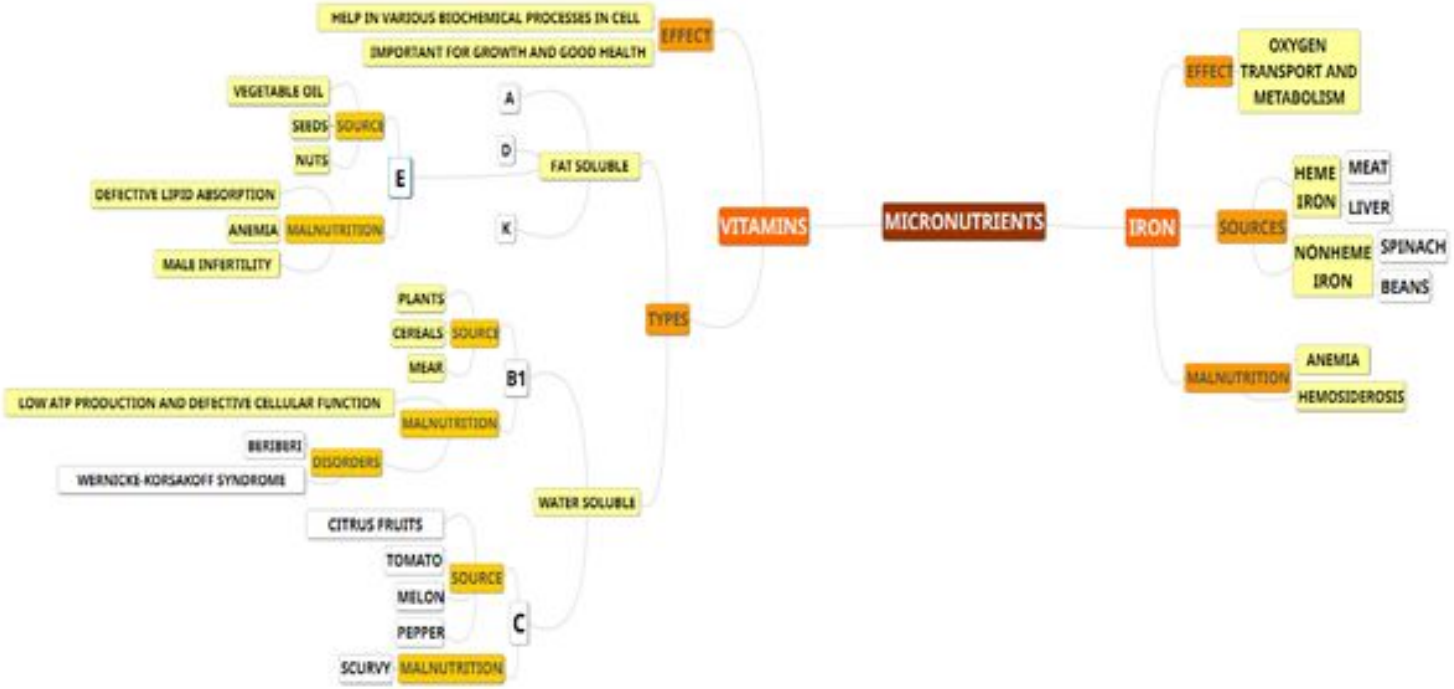
Hemosiderosis: can be secondary form of that condition in which the cause of excess iron is the breaking of RBC.

[1]Hemosiderin is focal, stored in liver and kidney it is composed of Iron, ferritin, degraded ferritin. Iron stored as hemosiderin is not available for the body.

Summary


MACRONUTRIENTS
CARBOHYDRATES
ENERGY PRODUCTION
EFFECT
SIMPLE
COMPLEX
TYPES
SUCROSE
FRUCTOSE
LACTOSE
CORN SYRUP
SIMPLE
WHOLE GRAINS
PASTA
WHEAT
STARCH
COMPLEX
SOURCES
MORE METABOLIZED PROTEINS
MORE GLUCONEOGENESIS
MALNUTRITION
PROTEINS
ESSENTIAL
NON-ESSENTIAL
TYPES
SUPPLY AMINO ACIDS & AMINO NITROGEN FOR THE BODY.
EFFECT
MEAT
POULTRY
FISH
MILK
WHEAT
NUTS
CORN
BEANS
SOURCES
MARASMUS
KWASHIORKOR
MALNUTRITION
ESSENTIAL FATTY ACIDS
TYPES
α-linolenic acid (ω-3 fatty acid)
SOURCE
ALBACORE
TUNA
COLD WATER OCEAN FISH
SALMON
SARDINE
WHITEFISH
PLANTS
FISH OIL CONTAINING DOCOSAHEXAENOIC ACID (DHA) AND EICOSAPENTAENOIC ACID (EPA)
EFFECT
SUPPRESS CARDIAC ARRHYTHMIA
LITTLE EFFECT ON HDL AND LDL LEVELS
REDUCE TENDENCY TO THROMBOSIS
LOWER BLOOD PRESSURE
SOURCE
NUTS
AVOCADOS
OLIVES
SOY BEANS
OILS (SESAME,CORN, COTTONSEED OIL)
linoleic acid (ω-6 fatty acid)
EFFECT
REDUCE PLASMA CHOLESTROL
REDUCE LDL
REDUCE HDL
MALNUTRITION
SCALY SKIN
DERMATITIS
REDUCED GROWTH (INFANTS)

Summary


MICRONUTRIENTS
VITAMINS
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IMPORTANT FOR GROWTH AND GOOD HEALTH
TYPES
FAT SOLUBLE
A
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NUTS
MALNUTRITION
DEFECTIVE LIPID ABSORPTION
ANEMIA
MALE INFERTILITY
WATER SOLUBLE
B1
SOURCE
PLANTS
CEREALS
MEAT
MALNUTRITION
LOW ATP PRODUCTION AND DEFECTIVE CELLULAR FUNCTION
DISORDERS
BERIBERI
WERNICKE-KORSAKOFF SYNDROME
C
SOURCE
CITRUS FRUITS
TOMATO
MELON
PEPPER
MALNUTRITION
SCURVY
IRON
EFFECT
OXYGEN TRANSPORT AND METABOLISM
SOURCES
HEME IRON
MEAT
LIVER
NONHEME IRON
SPINACH
BEANS
MALNUTRITION
ANEMIA
HEMOSIDEROSIS

Take Home Messages

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

MCQs:

Q1: Which of the following nutrients do not provide energy?

A. Protein
B. Fat
C. Vitamins
D. Carbohydrates

Q2: Which of the following amino acids is not an essential amino acid?

A. Threonine
B. Tryptophan
C. Tyrosine
D. Lysine

Q3: Which of the following is not a benefit of dietary fibres?

A. Reduces constipation
B. Promotes feeling of fullness
C. Speeds up gastric emptying
D. Reduces exposure of gut to carcinogens

Q4: 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.

Q5: Iron is stored in the body as?

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

Q6: 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

Q7: 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

1- C
2- C
3- C
4- D
5- D
6- A
7- D

SAQs:

1) What is the effect of carbohydrate on dietary protein?

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

2) name 2 disorder of vitamin B1 (thiamine) deficiency and give quick explanation

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

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Team leaders

- رهام الحلبي
- عبدالحكيم العنيق

Boys team

Girls team

- مجد البراك

@biochemistry437

teambiochem437@gmail.com