Macro & Micronutrients

Color Index:

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Editing File

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.** Functions are important.
- **Sources and RDAs.** We will not ask you about sources in the exam. We might ask you about RDA of macronutrients not micro.
- **Diseases and conditions due to their deficiency.** diseases are important.

Macro and Micro Nutrients

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

Macronutrients | **Micronutrients**

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

Energy Content of Food

Body obtain energy as ATP.

ATP is used for all body function.

The energy content of food is measured in calories (kilocalories).

One calorie: The heat required to raise the temperature of 1gram of water by 1°C:

- proteins → 4 kcal/g
- Carbohydrate → 4 kcal/g
- Fats → 9 kcal/g

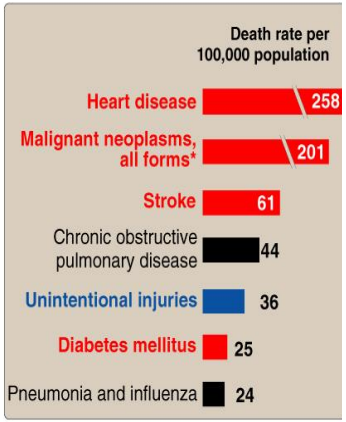
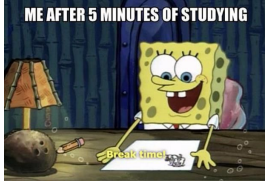


Figure 27.8
Influence of nutrition on some common causes of death in the United States in the year 2000. Red indicates causes of death in which the diet plays a significant role. Blue indicates causes of death in which excessive alcohol consumption plays a part. (*Diet plays a role in only some forms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

Acceptable macronutrient distribution range (AMDR)
Adequate intake of macronutrient to prevent the risk of disease

AMDR for adults:
CHOs: 45-65%
Proteins: 10-35%
Fats: 20-35%
Fibers > 25 g

Nutritional Importance of Proteins



- Proteins supply amino acids and amino nitrogen to the body.[1]

amino acids

Essential amino acids: Body can't synthesize, must be supplied in the diet.

Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Arginine[1], Leucin , Lysine.
"PVT TIM HALL"

Non-Essential amino acids: body can synthesize.

1. No longer considered as an essential, it's a conditionally essential amino acid.
Except in the preterm infants where they can't synthesize them due to the lack of enzymes.

Nutritional Quality of Proteins

1. A measure of protein ability to provide the essential amino acids required for tissue maintenance
2. Measured in PDCAAS units (Digestibility-Corrected Amino Acid Scoring)
3. High value indicate more digestibility and high quality (maximum score 1.0)[2]
4. Proteins from animal sources: (0.82 – 1.0)
5. Proteins from plant sources: (0.4)[3]

1: Main importance of proteins is providing essential amino acids to the body and they provide amino nitrogen to maintain normal nitrogen balance.
2: protein score = 1 this mean the protein can provide all essential amino acids.
3: this why vegetarians are usually amino acid deficient, however when combined with different types of food it gets higher.

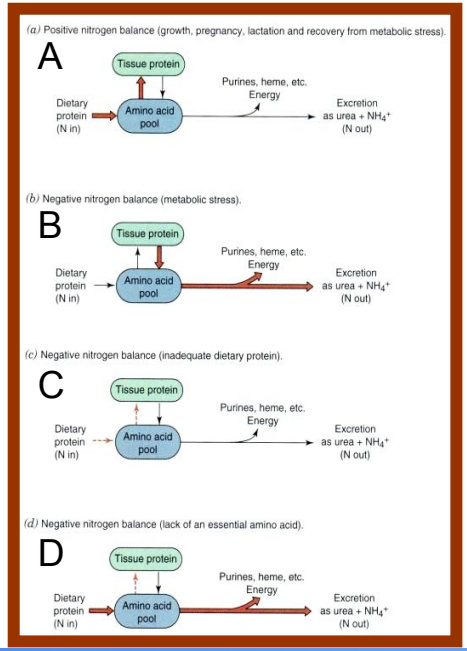
Sources and RDA[1] of Proteins:

- 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 additional 30g per day
  - Children: 2.0

Nitrogen Balance

Normal Nitrogen Balance	• In a healthy person, nitrogen intake = nitrogen loss.
Negative Nitrogen Balance	• When nitrogen intake < loss. • Occurs in burns, trauma, illness[2] and metabolic stress.
Positive Nitrogen Balance	• Nitrogen intake > loss. • Occurs in growth, pregnancy, lactation and recovery of illness[2]



Description of the picture:
A positive nitrogen balance where intake is more than loss.
B: normal nitrogen intake but metabolic stress causes breakdown of tissue protein increasing its loss.
C: inadequate dietary protein cause decrease in protein intake and synthesis with normal nitrogen excretion (nitrogen loss is more than intake).
D: increase protein intake, decrease in synthesis and and increase in excretion (this happen when the body is supplied by proteins NOT required by the body so, the body will excrete the unwanted proteins.
- the nitrogen excreted in the form of urea+ NH4 (ammonium).

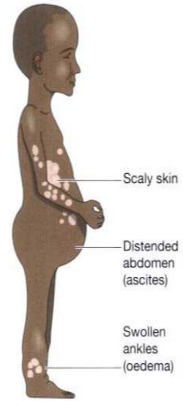
1. recommended dietary allowance
2.during illness you will be deficient in protein but during recovery you will need more proteins shifting the nitrogen balance from negative to positive nitrogen balance

Protein–Energy Malnutrition

- Malnutrition: A condition or disease caused by not eating enough food or not eating a balanced diet.
- Malnutrition is due to inadequate intake of proteins or energy.
- two conditions:

	Marasmus	Kwashiorkor
Cause	Inadequate energy intake with adequate protein intake.	Inadequate proteins intake with adequate energy intake.
Age and food intake	• 1– 3 years • Mother's milk is supplemented with food (cereals) deficient in calories	• After Weaning[1] (at about 1 year) • Diet mainly contain CHOs
Symptoms	• Arrested growth • Extreme muscle wasting • Weakness • Weight loss • No edema or changes in plasma proteins	• edema[2] • Distended abdomen • Diarrhea • Dermatitis / thin hair • enlarged fatty liver • Low plasma albumin

B Marasmus



A Kwashiorkor

1.When breast feeding stop.
2.Due to protein deficiency.

Carbohydrates

- Types in diet:

1. Simple CHO : sucrose, fructose, lactose, corn syrup.
2. Complex CHOs: whole grains, pasta, wheat, starch.

Their major role in diet is energy production

RDA: 130 g/day for adults and children

Protein–Sparing Effect

- Dietary protein requirements and CHOs[1] diet are related to each other

- CHOs have protein sparing effect:
  - They inhibit gluconeogenesis from amino acids.
  - That way amino acids are used for repair and maintenance of tissue protein.

CHOs intake above RDA:

- cause weight gain or obesity due to increase fat storage in adipose tissue

CHOs intake below RDA:

- More protein will be metabolized
- More gluconeogenesis

1.CHOs prevent you from losing muscle mass HOW? When there is CHOs deficiency the body will use amino acids derived from the muscles for gluconeogenesis causing loss of the muscle mass.

Dietary Fibers

- The Component of food that can't be broken down by human digestive enzymes. Gives no energy (no calories)
- RDA (g/day): : 38, : 25

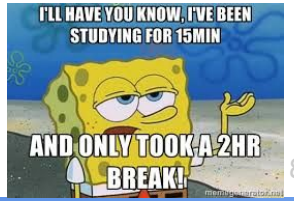
Benefits

- Lower serum LDL levels[2]
- Reduce constipation
- Slows gastric emptying (long term glucose control in patient with diabetes mellitus)[1]
- Reduce exposure of gut to carcinogens.
- promote feeling of fullness

1.The fibers binds with glucose and slow down glucose absorption and help to improve blood sugar level
2.How? Bile acid are made of cholesterol, fiber bind with bile acid thus they are not reabsorbed to the liver and excreted with fiber.

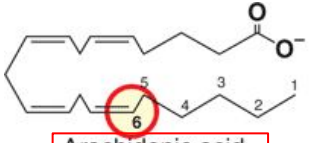
Fats in Diet

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

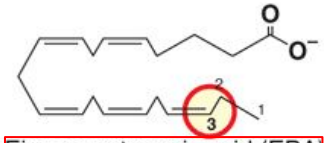


Essential Fatty Acids

- 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 eicosanoid synthesis which appear to have cardioprotective effects:
  - ↓ Blood Clotting
  - ↓ Blood pressure



Arachidonic acid
(20:4, n-6)
found in seed oils



Eicosapentaenoic acid (EPA)
(20:5, n-3)
found in fish oils

Omega 3:
- the double bond starts at C number 3 from terminal (C16).
- 20:5, n-3 :it has 20 C, 5 double bonds so it's more unsaturated than omega 6.
- Found in fish oil.

Omega 6:
- Double bond start at C number 6 from terminal (C13).
- 20:4, n-6: has 20 C, 4 double bond so, it's less unsaturated than omega 3.
- Found in seed oil

Omega-6 Fatty Acid

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

Sources

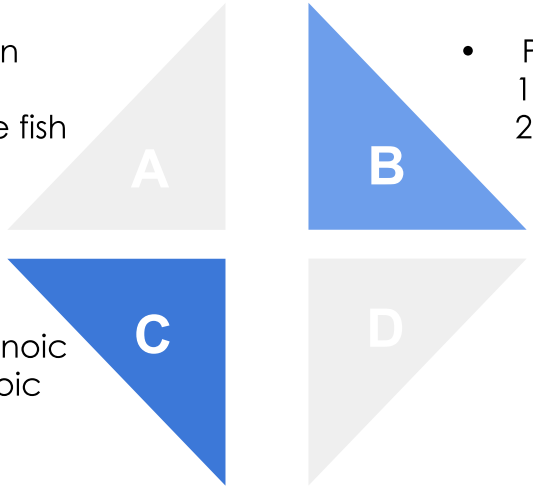
Effect

- ↓ Plasma cholesterol
- ↓ LDL
- ↓ HDL[1]

1.Undesirable effect

Omega-3 Fatty Acid

- Mainly found in cold water ocean fish such as: albacore, mackerel, salmon, sardines, tuna and white fish



- Play an important role as:
  1- structural membrane lipids
  2- Modulator of omega-6 fatty acid metabolism

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

- Effect:

1. Suppress cardiac arrhythmia
2. Little effect on LDL and HDL levels
3. ↓ serum triglycerides
4. ↓ tendency to thrombosis
5. ↓ risk of cardiovascular mortality
6. ↓ blood pressure

Recommendation for Omega-3 Fatty Acid Intake

American heart association guidelines

1 Patients without coronary heart disease (CHD):

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

2 Patient with CHD

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

3 Patient who need to lower triglycerides (fats)

- 2-4 grams of EPA+DHA per day

Trans Fatty Acids

- Unsaturated fatty acids, behaving more like saturated fatty acids in the body:
  - ↑ serum LDL (but not HDL)
  - risk of CVD CardioVascular Disease
- Not found in plants (animals only)
- Formed during hydrogenation of liquid vegetable oil
- 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	Water-soluble Vitamins
A,D,E and K	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

May have a role in fertility and anti-aging effect

Antioxidant[1]: prevents oxidation of cell components by molecular oxygen and free radicals

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)

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

1.Becoming stable free radical

Vitamin B_1

Functions of Vitamin B_1 (Thiamin)

- Coenzyme for transketolase and oxidative decarboxylation reactions
- Active form: Thiamin pyrophosphate (TPP)
- 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

Vitamin C

Functions of Vitamin C

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

Sources and RDA (mg/day)

Citrus Fruits, tomatoes, melon, peppers

Men: 90, Women: 75, Children: 15-25

Deficiency → Scurvy:

Gums become painful, swollen and spongy

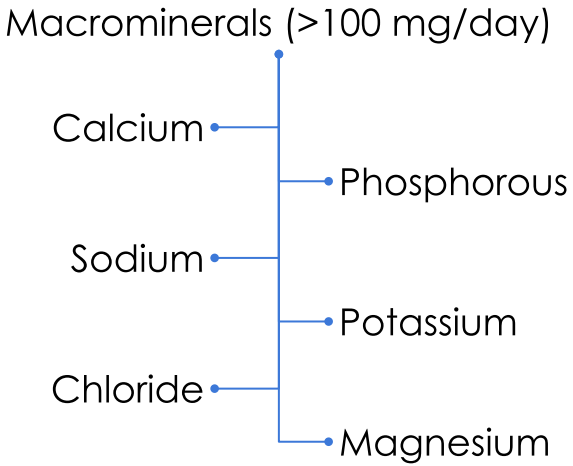
Abnormal collagen production

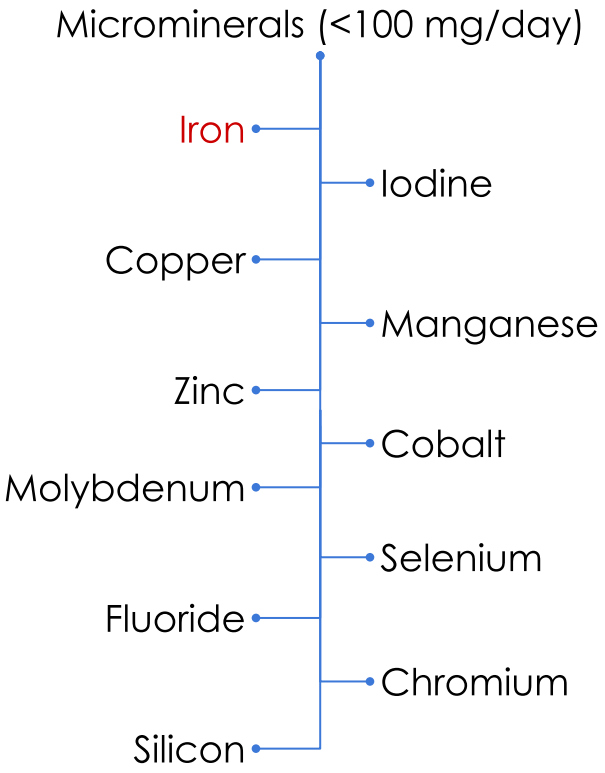
The pulp is separated and the teeth are lost

Scurvy

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





Iron

Functions of iron

- Part of hemoglobin, myoglobin, cytochromes electron transport chain
- Oxygen transport and metabolism
- 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 the most common)

- Growing children, pregnant, lactating and menstruating women need more iron

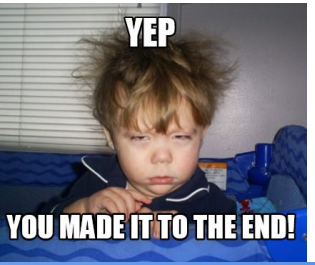
Hemosiderosis (iron overload disorder)

- 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 Messages

- **Macro and micronutrients are essential for energy and maintaining good health.**

- **Various diseases are associated either with malnutrition or excessive intake of these nutrients.**



Summary

amino acids

- Essential (body can't synthesis)
- Non-Essential (body can synthesis)

Normal Nitrogen Balance	• In a healthy person, the nitrogen intake is equal to to nitrogen loss
Negative Nitrogen Balance	• When nitrogen loss is more than intake
Positive Nitrogen Balance	• Nitrogen intake is more than loss

Marasmus	
Cause	Inadequate intake of energy with adequate protein intake

Kwashiorkor	
Cause	Inadequate intake of proteins with adequate energy intake

Dietary fibers:

Benefits

- Lower serum LDL levels
- Reduce constipation
- Slows gastric emptying (long term glucose control in patient with diabetes mellitus)
- Reduce exposure of gut to carcinogens.
- promote feeling of fullness

Two essential fatty acids:

a-Linolenic acid (ω-3 fatty acid)

Linoleic acid (ω-6 fatty acid)

Summary

Omega-6 fatty acid

Sources:
- Nuts.
- Avocado.
- Olives.
- Soybeans.
- Oils (sesame, cottonseed, corn oil).

Effect :
Plasma cholesterol.
- LDL.
- HDL[1]

Omega-3-fatty acid

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

- Effect :
1. Suppress cardiac arrhythmia.
2. Little effect on LDL and HDL levels.
3. ↓ serum triglycerides.
4. ↓ tendency to thrombosis.
5. ↓ risk of cardiovascular mortality.
6. ↓ blood pressure

Iron

Functions
1. Oxygen transport and metabolism
2. Part of hemoglobin, myoglobin, cytochromes
3. Body stores iron as ferritin, hemosiderin and transferrin
4. Adult women have much lower iron storage than men

Iron Deficiency → Hemosiderosis
↓
Iron deficiency anemia

Vitamins - Classified Based on solubility

Fat -soluble Vitamins

A,D,E and K

Water-soluble Vitamins

Ascorbic acid (vitamin C), Thiamin (vitamin B1), (vitamin B2), (vitamin B3), (vitamin B6), (vitamin B12)

Vitamin B1 (Thiamin)

Disorders of vitamin B1 (Thiamin) Deficiency:

Beriberi: A type of chronic peripheral neuritis due to severe thiamin deficiency causes weakness, neuropathy, disorderly thinking, paralysis

Wernicke-Korsakoff syndrome: Common in alcoholics due to defective intestinal absorption of thiamin or dietary insufficiency

Vitamin C

Deficiency causes scurvy : Abnormal collagen production
- Gums become painful, swollen and spongy
- The pulp is separated and the teeth are lost

Vitamin E

Deficiency: (mostly observed in premature infants)
1- Defective lipid absorption
2- Anemia due to oxidative damage to RBCs
3- Neurological problems
4- Male infertility

Quiz

MCQs :

Q1: Inadequate protein intake with adequate energy intake describe which of the following condition:

A) Marasmus **B)** Korsakoff **C)** Kwashiorkor **D)** Scurvy

Q2: Which of the following cause decrease of LDL level?

A) Proteins **B)** Dietary fibers **C)** Omega 3 **D)** B,C

Q3: Which of the following is a fat soluble vitamin?

A) Vitamin C **B)** Vitamin B **C)** Vitamin E **D)** Folate

Q4: Wernicke-Korsakoff syndrome is due to deficiency in which of the following enzymes?

A) Vitamin B12 **B)** Vitamin C **C)** Vitamin A **D)** Vitamin B1

Q5: Regarding micronutrients which of the following is correct?

A) Provide energy **B)** Needed large amounts

C) Don't provide energy **D)** A,B

Q6: Vitamin E Deficiency will lead to?

A) Defective lipid absorption **B)** Beriberi

C) Scurvy **D)** Wernicke-Korsakoff syndrome

Q7: Body store iron as?

A) Ferritin **B)** Transferrin **C)** Hemosiderin **D)** All of them

SAQs :

Q1: Mention two Effects and Sources of omega 3 fatty acid.

Q2: Explain how carbohydrates deficiency can affect proteins.

Q3: What is the cause of Kwashiorkor and mention three symptoms of this condition?

Q4: Enumerate two functions of Vitamin C and mention the disorder caused when it's deficient?

★ **MCQs Answer key:**

1) C 2) B 3) C 4) D 5) C 6) A 7) D

★ **SAQs Answer key:**

1. Sources:1- Plants. 2-Fish oil containing DHA and EPA.
   Effects: 1- Suppress cardiac arrhythmia. 2-lower BP.
2. CHOs have protein sparing effect and their dificnct cause increase protein metabolization and gluconeogenesis using proteins.
3. Inadequate protein intake with adequate energy intake.
   1-Edema. 2-Diarrhea. 3-Dermatitis.
4. 1- increase iron absorption 2- promote wound healing
   - scurvy

Team members

Girls Team:

- Ajeed Al-Rashoud
- Alwateen Albalawi
- Amira AlDakhilallah
- Arwa Al Emam
- Deema Almaziad
- Ghaliah Alnufaei
- Haifa Alwaily
- Leena Alnassar
- Lama Aldakhil
- Lamiss Alzahrani
- Nouf Alhumaidhi
- Noura Alturki
- Sarah Alkhalife
- Shahd Alsalamah
- Taif Alotaibi

Boys Team:

- Abdulrahman Bedaiwi
- Alkassem Binobaid
- Khayyal Alderaan
- Mashal Abaalkhail
- Naif Alsolais
- Omar Alyabis
- Omar Saeed
- **Omar Odeh**
- Rayyan Almousa
- **Yazen Bajeaifer**

Team Leaders

Lina Alosaimi

Mohannad Alqarni

★ (من سلك طريقًا يلتمس فيه علمًا، سهّل الله به طريقًا إلى الجنة)

438 BIOCHEMISTRY TEAM

We hear you