VITAMINS

• **Learning Objectives**

1. Know the classifications and properties of the vitamins group.
2. Understand the structure of each vitamin.
3. Understand the role of each vitamin in metabolism
4. Know the symptoms of vitamin deficiency.
5. Acknowledge the new nutritional pyramid & the importance of healthy eating.
Vitamin classification

Lipid-soluble vitamins (A, D, E and K)
• hydrophobic compounds, absorbed efficiently with lipids,
• transport in the blood in lipoproteins or attached to specific binding proteins,
• more likely to accumulate in the body,
• more likely to lead to hypervitaminosis

Water-soluble vitamins - 8 B vitamins and vitamin C
• Function: mainly as enzyme cofactors,
• Hydrophilic compounds dissolve easily in water,
• Not readily stored, excreted from the body,
• Their consistent daily intake is important
• Many types of water-soluble vitamins are synthesized by bacteria.
Water soluble vitamins

- Vitamin B$_1$ (thiamine)
- Vitamin B$_2$ (riboflavin)
- Vitamin B$_3$ or Vitamin P or Vitamin PP (niacin)
- Vitamin B$_5$ (panthotenic acid)
- Vitamin B$_6$ (pyridoxine and pyridoxamine)
- Vitamin B$_7$ or Vitamin H (biotin)
- Vitamin B$_9$ or Vitamin M and Vitamin B-c (folic acid)
- Vitamin B$_{12}$ (cobalamin)
Vitamin B₁ (thiamine)

- Thiamin has a central role in energy-yielding metabolism.
- Composed of a substituted pyridine and thiazole ring.
- Active form is thiamine diphosphate (thiamin pyrophosphate, TPP), a coenzyme for three multi-enzyme complex →
- This complex catalyses oxidative decarboxylation of α-ketoacids →
  - pyruvate dehydrogenase in carbohydrate metabolism,
  - α-ketoglutarate dehydrogenase → citric acid cycle,
  - Branched-chain keto-acid dehydrogenase.
  - TPP is coenzyme for transketolase – pentose phosphate pathway.
Vitamin B<sub>1</sub> - deficiency

1. Mild deficiency – leads to gastrointestinal complaints, weakness
2. Moderate deficiency - peripheral neuropathy, mental abnormalities, ataxia
3. Full-blown deficiency - *beri-beri* – characterized with severe muscle weakness, muscle wasting and delirium, paresis of the eye muscles, memory loss.
   - Degeneration of the cardiovascular system.
   - Beri-beri causes long-term consumption of foods rich in carbohydrates but poor in thiamine - husked rice, white flour and refined sugar.
Source of vitamin B<sub>1</sub>

- paddy grains, cereals
- meat
- yeast
- honey
- nuts
Vitamin B$_2$ (riboflavin)

- Yellow to orange-yellow natural dye slightly soluble in water.
- Has a central role in energy-yielding metabolism.
- Provides the reactive moieties of the coenzymes \textit{flavin mononucleotide (FMN)} and \textit{flavin adenine dinucleotide (FAD)}.
- Flavin coenzymes are electron carries in oxidoreduction reaction.
Vitamin B2 - riboflavin

Riboflavin is a precursor for FAD and FMN.

FAD - flavin adenine dinucleotide.

FAD is a cofactor for pyruvate dehydrogenase complex (PDC), and succinate dehydrogenase in TCA cycle.

FMN - Flavin mononucleotide

FMN is an electron carrier in the electron transport chain.
Vitamin B$_2$

FMN $\rightarrow$ ATP-dependent phosphorylation of riboflavin
FAD $\rightarrow$ further reaction with ATP in which its AMP moiety is transferred to FMN.
FMN a FAD function

FMN and FAD act as prosthetic groups of many oxidoreduction enzymes, flavoprotein:

- **oxydase of α-amino acids** – degradation of amino acids
- **Xanthin oxidase** – degradation of purines
- **aldehyde dehydrogenase**
- mitochondrial **glycerol-3-phosphate dehydrogenase** – transport of reducing unit (H⁺) from mitochondria to cytosol
- **Succinate dehydrogenase** – citric acid cycle
- **succinyl CoA-dehydrogenase** – β-oxidation of FA
- **NADH-dehydrogenase** – part of respiratory chain in mitochondria
- coenzymes in hydrogen transfer – formation of reducing forms - FMNH₂ a FADH₂
Vitamin $B_2$ absorption

- Riboflavin is absorbed in the proximal intestine.
- Riboflavin is stored mainly in the liver, kidney and heart in the form of FAD (70-90%) or FMN.

Causes of vitamin $B_2$ deficiency

- Lack of dietary vitamin B.
- A result of conditions that affect absorption in the intestine.
- The body not being able to use the vitamin.
- An increase in the excretion of the vitamin from the body.
Vitamin B\textsubscript{2} — symptoms of deficiency

• Cracked and red lips.
• Inflammation of the lining of mouth and tongue.
• Dry and scaling skin—keratitis, dermatitis and iron-deficiency anemia
Sources of vitamin B₂

- foods of animal origin (liver, pork and beef, milk, dairy products, fish eggs)
- cocoa,
- nuts,
- yeast,
- of smaller quantities in cereals.
Vitamin B₃ - niacin

- Active form – nikotinic acid and nikotinamid.
- NAD & NADP → key components of the metabolic pathways of carbohydrates, lipids, amino acids.
- Nicotinic acid prevents the release of fatty acids from adipose tissue, decreases lipoproteins VLDL, IDL & LDL.
- High dose of niacin dilates blood vessels.
Vitamin B₃ - niacin

• Absorption:
  – At low concentration by active transport.
  – At high concentration by passive diffusion.

• Transportation:
  – Both nicotinic acid (NA) and nicotinamide (NAm) bind to plasma proteins for transportation.

• Biosynthesis:
  – The liver can synthesize *Niacin* from the essential amino acid *tryptophan*, but the synthesis is extremely slow and requires vitamin B₆ (60 mg of Tryptophan = 1 mg of niacin). Bacteria in the gut may also perform the conversion but are inefficient.
Vitamin B3 - nicotinic acid (a precursor for NAD). Also known as niacin.

NAD$^+$ is needed for glycolysis, NADH gets oxidized in electron transport chain, etc.
Vitamin B₃ - deficiency

- **Pellagra**: A serious deficiency of niacin.
- The main results of pellagra can easily be remembered as "the four D's": diarrhea, dermatitis, dementia, and death.
- Pellagra is very rare now, except in alcoholics, strict vegetarians, and people in areas of the world with very poor nutrition.

- Milder deficiencies of niacin can cause dermatitis around the mouth and rashes, fatigue, irritability, poor appetite, indigestion, diarrhea, headache.
Sources of vitamin B₃

- foods of animal origin
- yeast
- sunflower seeds, beans, peas
- green leafy vegetable
- broccoli, carrots
Vitamin B₅ — panthotenic acid

- Part of acetyl-CoA — consists of pantoic acid and β-alaninem.
Vitamin B₅ – panthotenic acid

- Co-enzyme A assists the following reactions:
  - formation of sterols (cholesterol and 7-dehydrocholesterol).
  - formation of fatty acids.
  - formation of keto acids such as pyruvic acid.

Other reactions are acylation, acetylation, signal transduction deamination.
Vitamin B₅ - deficiency

Rare to occur.

- When occur it leads to paresthesias.
- Disorders of the synthesis of acetylcholine – neurological symptoms (paresthesia).

Sources of vitamin B₅

- meat, foods of animal origin,
- yeast,
- wholemeal bread,
- broccoli, avocado
- royal gelly
Vitamin B₆

- Precursor of active coenzyme pyridoxal phosphate – PPL.
Vitamin B₆

- Vitamin B₆ is needed for more than 100 enzymes involved in protein metabolism.
- It is also essential for red blood cell metabolism and hemoglobin formation.
- The nervous and immune systems need vitamin B₆ to function efficiently.
- It is also needed for the conversion of tryptophan to niacin (vitamin B₃).
- Vitamin B₆ also helps maintain blood glucose within a normal range. When caloric intake is low, vitamin B₆ helps to convert stored carbohydrate or other nutrients to glucose to maintain normal blood sugar levels.
Transamination reaction
Vitamin B₆ deficiency

Signs of vitamin B₆ deficiency include:

• Skin: dermatitis (skin inflammation), stomatitis (inflammation of the mucous lining of any of the structures in the mouth), glossitis (inflammation or infection of the tongue).

• Neurological abnormalities: Depression, confusion, and convulsions.

• Vitamin B₆ deficiency also can cause anemia.
Vitamin B₆ – natural sources

- cereals,
- beans,
- meat,
- liver,
- fish,
- yeast,
- nuts and some fruits as banana
- potatoes.
- It is also produced by bacterial flora in the colon.
Vitamin B₇ - biotin

- Prosthetic group of *pyruvate carboxylase, acetyl-CoA carboxylase* and other *ATP-dependent carboxylases*. 
Biotin – natural source

- liver
- meat
- kidney
- yeast
- egg yolk
- mushrooms
- milk and diary products.
Vitamin B₉ – folic acid

- Consist of pteroic acid - pteridine + paraaminobenzoic acid (PABA) + glutamic acid
Vitamin B$_9$ – folic acid

- Active metabolite of folic acid is tetrahydrofolate (THF).
- THF is coenzyme of transferases carrying one carbon units.
- This reaction participate in nucleotide and nucleic acid synthesis.
- N$^5$,N$^{10}$-THF carries one carbon units (methylen or methenyl).
- Important for rapidly dividing cells (very important in early pregnancy).
Folic acid deficiency

Deficiency results in elevated levels of homocysteine. Deficiency in pregnant women can lead to birth defects.

Sources of vitamin $B_9$

- sources of animal origin
- milk and milk products
- yeast
- greens
Vitamin B$_{12}$ - cobalamin

- Chemically most complex vitamin
- Complex of organic compounds atom within the molecule is Co, similar to the heme.
- In man there are two metabolically active forms: methylcobalamin and adenosylcobalamin.
- Cobalamin is needed in making adenosylcobalamin, a cofactor for “methyl malonyl mutase”, which breaks down odd-chain fatty acids.
- B12 is also used in regenerating folate
Vitamin B$_{12}$ - cobalamin

• Cobalamin catalyses two reactions
  – Cytoplasmic *methylation of homocystein to methionin.*
  – Mitochondrial *methylmalonyl-CoA mutase* (methylmalonyl-CoA → sukcynyl-CoA) needs *deoxy adenosylkobalamin.*

• Essential for the maturation of erythrocytes.
• Protects against pernicious anemia.
• Essential for cell growth and reproduction.
• Essential for the formation of myelin and nucleoproteins
Vitamin B$_{12}$ – cobalamin

- Vitamin B$_{12}$ in food is bound to the protein.
- Hydrochloric acid in the stomach releases free vitamin B$_{12}$.
- Once released vitamin B$_{12}$ combines with a substance called intrinsic factor (IF). This complex can then be absorbed by the intestinal tract.

Sources of vitamin B$_{12}$

- fish and shellfish,
- meat (especially liver),
- poultry,
- eggs,
- milk, and
- milk products
- while lacto-ovo vegetarians usually get enough consuming diary products, vegan will lack B$_{12}$
Vitamin C

• Vitamin C is a water-soluble vitamin.
• Almost all animals and plants synthesize their own vitamin C, not man.
• Vitamin C was first isolated in 1928 and in 1932 it was proved to be the agent which prevents scurvy.
• Vitamin C is a weak acid, called ascorbic acid or its salts “ascorbates”.
• It is the L-enantiomer of ascorbic acid.
• The D-enantiomer shows no biological activity.
The role of vitamin C

- Cofactor in the synthesis of norepinephrine from dopamine.

- Involved in a variety of metabolic processes (oxidation-reduction reactions and cellular respiration, carbohydrate metabolism, synthesis of lipids and proteins).

- Antioxidant and free radical scavenger → maintain proper immune system.
The role of vitamin C

• T-lymphocyte activity, phagocyte function, leukocyte mobility, and possibly antibody and interferon production seem to be increased by vitamin C.

• Involved in the synthesis of collagen, the major component of ligaments, tendons, cartilages and skin.

• Involved in tyrosine metabolism.
Deficiency of vitamin C

- Fatigue, personality changes, decline in psychomotor performance and motivation.

- Vitamin C deficiency over 3-5 months results in symptomatic scurvy.

- Scurvy leads to the formation of liver spots on the skin, spongy gums, and bleeding from all mucous membranes.

- In advanced scurvy there are open, suppurating wounds and loss of teeth. Severe scurvy may progress to neuritis, jaundice, fever, dyspnea, and death.
Vitamin C as antioxidant
Vitamin C as antioxidant

\[ \text{ascorbate (Vitamin C)} \rightarrow R^* \rightarrow \text{dehydroascorbate (oxidized Vitamin C)} \]

\[ \text{dehydroascorbate reductase} \]

\[ \text{GSSG (oxidized glutathione)} \rightarrow \text{GSH (reduced glutathione)} \]
Vitamin C as pro-oxidant

• Ascorbic acid reduces transition metals - Cu$^{2+}$, to Cu$^+$, and Fe$^{3+}$ to Fe$^{2+}$ during conversion from ascorbate to dehydroascorbate. This reaction can generate superoxide and other ROS:

• Fenton’s reaction:
  • (1) $\text{Fe}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{3+} + \text{OH} \cdot + \text{OH}^-$
  • (2) $\text{Fe}^{3+} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{2+} + \text{OOH} \cdot + \text{H}^+$

$2 \text{Fe}^{2+} + 2 \text{H}_2\text{O}_2 \rightarrow 2 \text{Fe}^{3+} + 2 \text{OH} \cdot + 2 \text{OH}^-$

$2 \text{Fe}^{3+} + \text{ascorbate} \rightarrow 2 \text{Fe}^{2+} + \text{dehydroascorbate}$
The FOOD Pyramid

Eating Right Every Day
Eating Right . . . Every Day!

• Good nutrition is important to good health. This will give your body energy and help you grow.

• Make “smart” choices from every food group.

• Eating foods from the Food Guide Pyramid and being physically active will help you grow healthy and strong!

• **Eat a variety of foods.** A **balanced diet** is one that includes all the food groups.

• We are going to explore the food guide pyramid to learn about the food groups.
The Food Guide Pyramid

Grains 6 oz.
Vegetables 2 1/2 cups
Fruits 2 cups
Oils Eat Less
Milk 3 cups
Meat & Beans 5 1/2 oz.
The New Food Pyramid

- **Restrict Red meat & butter**
- **Restrict Food of high sugar content**
- **Multi-Vitamins (Every day)**
- **Eggs, fish, poultry, and plant proteins**
- **Nuts and seeds**
- **Plant oils**
- **Fruits**
- **Whole grains**
- **Legumes**
- **Vegetables**

- **Dairy, soymilk, or calcium supplement**
- **Water, 5-8 glasses**

**Daily exercise and weight control**
Fruits

• Any fruit or 100% fruit juice counts as part of the fruit group. Fruits may be fresh, canned, frozen, or dried, and may be whole, cut-up, or pureed.

• Apples, bananas, strawberries, grapes, lemons, oranges, cantaloupe, watermelon, peaches, and raisins are some examples of foods in the fruit group.

• Eat 2 cups every day.
Vegetables

- Any vegetable or 100% vegetable juice counts as a member of the vegetable group.
- Vegetables may be raw or cooked; fresh, frozen, canned, or dried/dehydrated; and may be whole, cut-up, or mashed.
- Broccoli, carrots, corn, peas, green beans, tomatoes, squash, celery, cucumbers, lettuce, potatoes, cabbage are some examples of foods in the vegetable group.
- Eat 2 ½ cups every day.
Meats, Beans, and Nuts

- All foods made from meat, poultry, fish, dry beans or peas, eggs, nuts, and seeds are considered part of this group. Dry beans and peas are part of this group as well as the vegetable group.

- Most meat and poultry choices should be lean or low-fat. Fish, nuts, and seeds contain healthy oils, so choose these foods frequently instead of meat or poultry.

- Beef, lamb, pork, chicken, turkey, fish, tuna, crawfish, crabs, shrimp, eggs, beans, nuts, and sunflower seeds are some examples of foods in the meat group.

- Eat 5 ½ oz. every day.
Milk, Yogurt, and Cheese

• Milk and many foods made from milk are considered part of this food group.
• Most milk group choices should be fat-free or low-fat.
• Milk, yogurt, cheese, ice cream, and pudding are some examples of foods in the milk group.

• Need 3 cups every day.
Grain Group

- Any food made from wheat, rice, oats, cornmeal, barley or another cereal grain is a grain product.
- Bread, pasta, oatmeal, breakfast cereals, tortillas, popcorn, crackers, pretzels, noodles, and grits are some examples of foods in the grain group.
- Eat 6 oz. every day.
Fats, Oils, and Sweets

• Oils are fats.
• Cooking oil, butter, mayonnaise, chips, dips, and salad dressings are some examples of foods in the fat and oil group.
• Oily foods and fats should be eaten in very small amounts.
• Sweets have lots of sugar and have no vitamins or nutrients. Sweets, candy and soft drinks are also things you should eat less of.
Snacks

- When you get hungry between meals, choose a healthy snack.
- Any fruit or 100% fruit juice, water, or dried fruit, like raisins, would be healthy choices.
- Remember . . . fewer sweets, candy, and soft drinks.
Eat Well and Stay Healthy!

• Don’t forget daily physical activity is important, too.
• At the end of the week, check to see if you made healthy choices.
• What changes should you make to eat more healthy?
• You can make changes little by little, take one step at a time!