Chemistry of Fatty acid

University Of Fallujah

College Of Medicine

Lecture : 6 +7

Stage : first

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Learning Objectives

1-Describe the functions of Fatty acid in the body. •

2-Describe the body's Fatty acid needs and how personal choices can • lead to health benefits or consequences

Medical Biochemistry

Chemistry of Fatty acid

Dr.Abdullah Ali

- **Fatty acids** are long-chain hydrocarbons with a carboxyl group (-COOH) at one end.
- They serve as the primary components of lipids (fats and oils) in the body.
- Fatty acids are crucial for energy production, cell membrane integrity, and the synthesis of hormones such as eicosanoid

Fatty acids can be classified into:

- **Saturated Fatty Acids (SFAs):**
  - No double bonds between carbon atoms.
  - **Sources:** Animal fats (butter, cheese, fatty meats), coconut oil, palm oil.
- **Unsaturated Fatty Acids (UFAs):**
  - One or more double bonds in the carbon chain.
  - **Types:**
    - **Monounsaturated Fatty Acids (MUFAs):** One double bond (e.g., olive oil, avocado).
    - **Polyunsaturated Fatty Acids (PUFAs):** Multiple double bonds (e.g., fish oil, flaxseeds).
- **Trans Fatty Acids (TFAs):**
  - Formed during industrial hydrogenation, increasing stability but reducing health benefits

Classification of Fatty Acids

Fatty acids can be classified into the following categories based on their chemical structure:

- **1. Saturated Fatty Acids (SFAs):**
- **Chemical structure:** No double bonds between carbon atoms; all carbon atoms are fully saturated with hydrogen.
- **Sources:** Found mainly in animal products such as butter, cheese, and fatty meats, as well as in some plant oils like coconut oil and palm oil.
- **Health Implications:**
  - Excessive intake of SFAs has been linked to an increased risk of cardiovascular diseases (CVD) by raising low-density lipoprotein (LDL) cholesterol.
- **2. Unsaturated Fatty Acids (UFAs):**
- **Monounsaturated Fatty Acids (MUFAs):**
  - **Chemical structure:** One double bond in the carbon chain.
  - **Sources:** Olive oil, avocado, nuts (e.g., almonds, cashews), and seeds.
  - **Health Benefits:** Associated with improved blood lipid profiles, reduction in CVD risk, and anti-inflammatory effects.

Classification of Fatty Acids

- **Polyunsaturated Fatty Acids (PUFAs):**
  - **Chemical structure:** Multiple double bonds in the carbon chain.
  - **Sources:** Found in fatty fish (salmon, mackerel), flaxseed, walnuts, and vegetable oils (corn, soybean, sunflower).
  - **Health Benefits:** Essential for normal cell function, reduce inflammation, and improve heart health. They include omega-3 and omega-6 fatty acids.
- **3. Trans Fatty Acids (TFAs):**
- **Chemical structure:** Formed through partial hydrogenation of unsaturated fats.
- **Sources:** Found in processed foods like baked goods, margarine, and snacks.
- **Health Implications:**
  - TFAs increase LDL cholesterol levels and decrease high-density lipoprotein (HDL) cholesterol, leading to an increased risk of heart disease and stroke.

Essential fatty acids are those that the body cannot synthesize and must be obtained through the diet.

- **Omega-3 Fatty Acids:**
  - **Types:** Alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA).
  - **Sources:** Fatty fish (salmon, mackerel), flaxseeds, walnuts.
- **Omega-6 Fatty Acids:**
  - **Types:** Linoleic acid (LA), gamma-linolenic acid (GLA), arachidonic acid (AA).
  - **Sources:** Vegetable oils (corn oil, soybean oil), nuts, seeds.

- **Omega-3 Deficiency:**
  - Leads to **cognitive decline** and increased risk of **neurodegenerative diseases** such as Alzheimer's.
  - Contributes to **cardiovascular diseases** by increasing triglycerides and promoting inflammation.
  - Linked to **depression**, **anxiety**, and other mood disorders.
- **Omega-6 Deficiency:**
  - Causes **skin disorders** like eczema and dry, flaky skin.
  - May result in **growth retardation** in infants and children.
  - Deficiency may contribute to **inflammatory conditions** like arthritis.

The Importance of Balance Between Omega-3 and Omega-6

- The **ideal ratio** of omega-6 to omega-3 should be approximately **4:1** or **1:1** for optimal health.
- A **high omega-6 to omega-3 ratio** (e.g., 20:1) is associated with an increased risk of **inflammatory diseases** and **cardiovascular diseases**.
- Balancing omega-3 and omega-6 intake is vital for reducing chronic inflammation and preventing related diseases.

- **Fatty acids** are integral to maintaining overall health, affecting everything from cell membranes to hormone regulation.
- Both **omega-3 and omega-6** fatty acids are essential, but **proper balance** is key for reducing inflammation and preventing chronic diseases.
- **Dietary recommendations** emphasize increasing omega-3 intake (via fatty fish and plant-based sources) while moderating omega-6-rich processed foods.

Essential Fatty Acids (EFAs)

- Essential fatty acids (EFAs) are fatty acids that cannot be synthesized by the body and must be obtained through the diet.
- They are critical for proper physiological function, particularly in the development and maintenance of the brain, retina, and immune system.
- **Types of Essential Fatty Acids:**
- **Omega-3 Fatty Acids:**
  - **Types:** Alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA).
  - **Sources:** ALA is primarily found in flaxseeds, chia seeds, walnuts, and certain vegetable oils (e.g., canola). EPA and DHA are primarily found in fatty fish such as salmon, mackerel, sardines, and anchovies.
  - **Health Benefits:**
    - Omega-3s are crucial for brain health, retinal function, and anti-inflammatory processes.
    - EPA and DHA have been shown to reduce the risk of cardiovascular diseases by decreasing blood triglycerides, improving endothelial function, and reducing blood pressure.
    - They also play a role in mental health, reducing symptoms of depression and anxiety, and in preventing cognitive decline.

- **Omega-6 Fatty Acids:**
  - **Types:** Linoleic acid (LA), gamma-linolenic acid (GLA), and arachidonic acid (AA).
  - **Sources:** Found in vegetable oils (corn oil, soybean oil, sunflower oil), nuts, and seeds.
  - **Health Benefits:**
    - Omega-6 fatty acids are involved in cell membrane structure, skin health, and inflammatory responses.
    - While necessary for health, excessive omega-6 intake, especially in relation to omega-3 intake, may promote inflammation and increase the risk of chronic diseases like cardiovascular disease and arthritis.

Diseases Linked to Deficiency of Essential Fatty Acids

- **Omega-3 Fatty Acids Deficiency:**
  - **Cognitive Decline:** Omega-3 fatty acids (particularly DHA) are vital for the structure and function of the brain. Deficiency is linked to age-related cognitive decline, Alzheimer's disease, and other neurodegenerative diseases.
  - **Cardiovascular Disease:** Omega-3s reduce the risk of cardiovascular disease by decreasing triglycerides, improving endothelial function, and preventing arrhythmias. A deficiency may lead to increased risk of heart attacks and strokes.
  - **Mental Health Issues:** Lack of omega-3s has been associated with mood disorders, including depression and anxiety.
  - **Inflammation:** Omega-3s are potent anti-inflammatory agents, and deficiency may lead to chronic inflammation, contributing to autoimmune diseases and other inflammatory conditions.

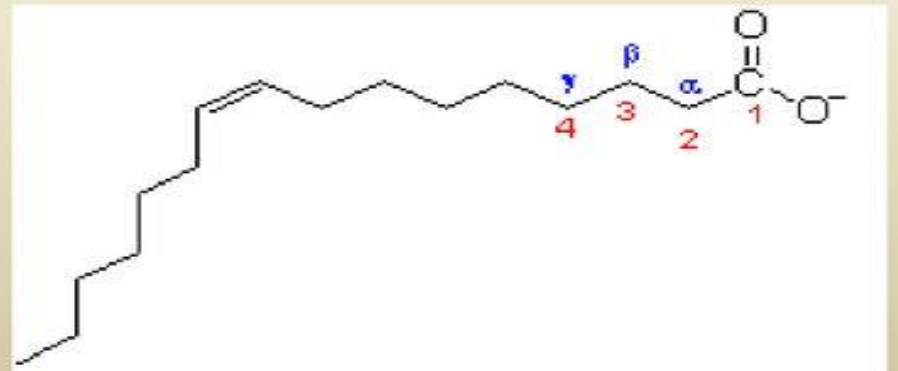
Diseases Linked to Deficiency of Essential Fatty Acids

- **Omega-6 Fatty Acids Deficiency:**
  - **Skin Disorders:** Omega-6 fatty acids, particularly linoleic acid (LA), are essential for maintaining skin health. A deficiency may result in dry, flaky skin, and conditions like eczema.
  - **Growth Retardation:** Essential fatty acids are important for proper growth, particularly in infants and children. Deficiency can lead to stunted growth and developmental issues.
  - **Increased Inflammation:** Although omega-6 fatty acids are pro-inflammatory by nature, an imbalance with omega-3 fatty acids (i.e., excess omega-6 intake) may exacerbate chronic inflammation and lead to conditions like rheumatoid arthritis.

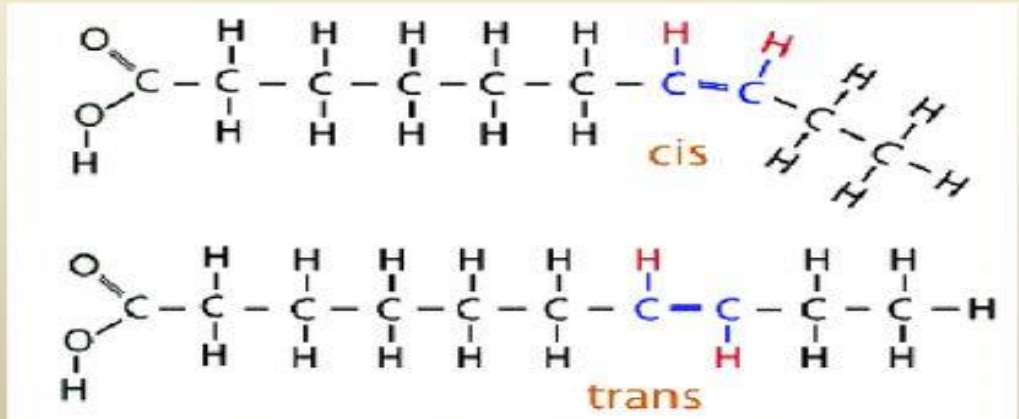
#	FA	Name
1	C2:0	Propanoic acid
2	C4:0	Butanoic acid
3	C6:0	Hexanoic acid
4	C8:0	Octanoic acid
5	C10:0	Decanoic acid
6	C10:1	Decaenoic acid
7	C12:0	Dodecanoic acid
8	C12:1	Dodecaenoic acid
9	C14:0	Tetradecanoic acid
10	C14:1	Tetradecaenoic acid
11	C15:0	Pentadecanoic acid
12	C16:0	Hexadecanoic acid
13	C16:1	Hesadecaenoic acid
14	C17:0	Heptadecanoic acid
15	C17:1	Heptadecaenoic acid
16	C18:0	Octadecanoic acid
17	C18:1	Octadecaenoic acid
18	C18:2	Octadecadienoic acid
19	C18:3	Octadecatrienoic acid
20	C20:0	Eicosanoic acid
21	C20:1	Eicosaenoic acid
22	C22:0	Docosanoic acid

Characters of naturally present fatty acids

- They are usually monocarboxylic acids, R-COOH.
- The number of carbon atoms is even (4-28).
- Hydrocarbon chain is not straight but zigzag.
- They are either saturated or unsaturated (up to 6 double bonds).
- Naturally present fatty acids are cis non-conjugated.
- The main functional group is COOH, sometimes fatty acids contain additional functional group other than COOH e.g. OH in hydroxy acids.



Zigzag chain of fatty acid and numbering



Cis and Trans Fatty Acids