Chapter 5

5.1 What are Fats?

- Fats are one type of lipid
- **Lipid** – diverse class of organic substances that are insoluble in water
  - Lipids (fats) do not dissolve in water

5.1.1 Triglycerides

- Most of the fat we eat is in the form of triglycerides
  - About 95% of the fats we consume
- Triglycerides are composed of
  - Three fatty acid molecules
    - **Fatty acids** – long chains of carbon atoms surrounded by hydrogen atoms
  - One glycerol molecule
    - **Glycerol** – a three-carbon alcohol that is the backbone of a triglyceride

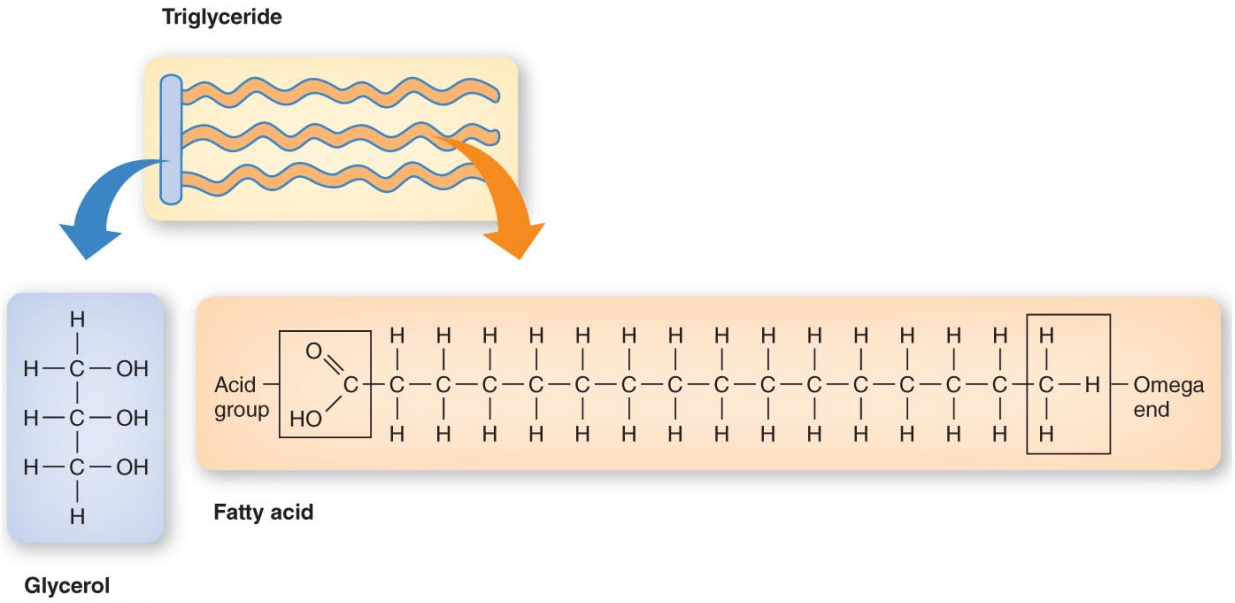


Figure 5.1: Triglyceride molecule

5.1.2 Phospholipids

- Composed of
  - Glycerol backbone
  - Two fatty acids
  - Phosphate
- Soluble in water
- Manufactured in our bodies so they are not required in our diet
- Important components of cell membranes

5.1.3 Sterols

Sterols – Lipids containing multiple rings of Carbon atoms

- Essential components of cell membranes and many hormones
- Manufactured in our bodies and therefore not an essential component of our body
- Cholesterool is the major sterol found in the body

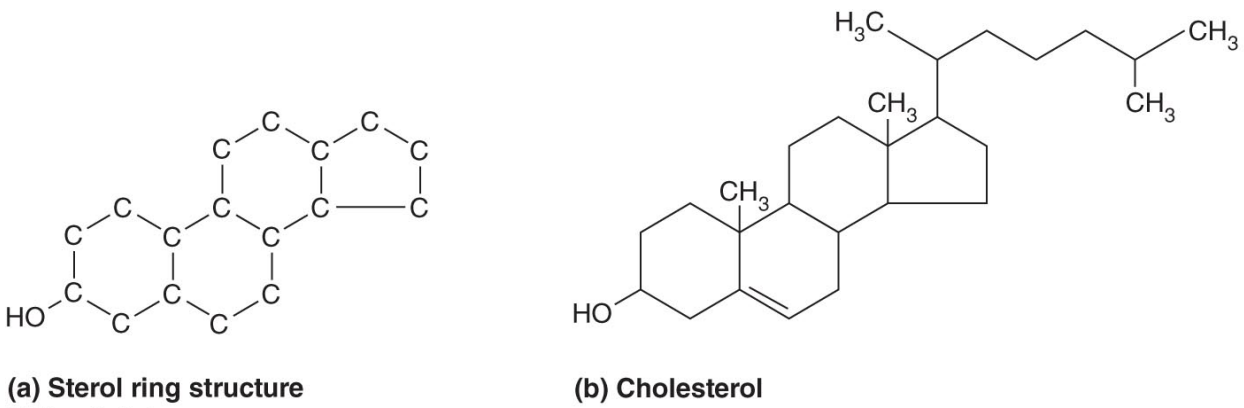
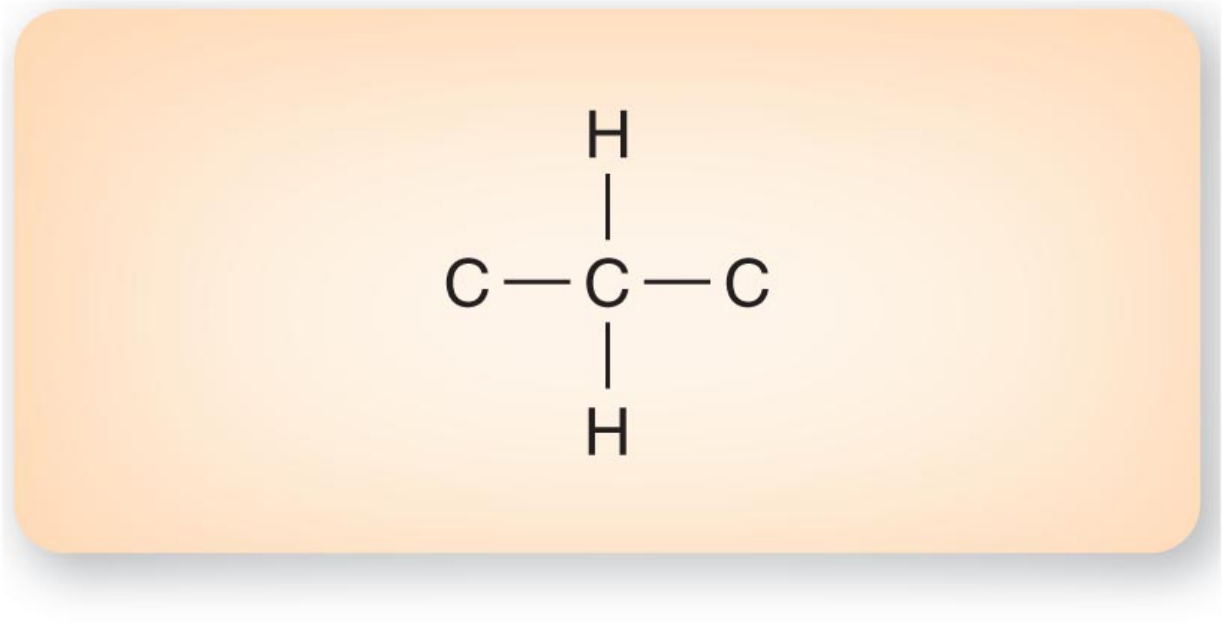


Figure 5.2: Sterol diagram

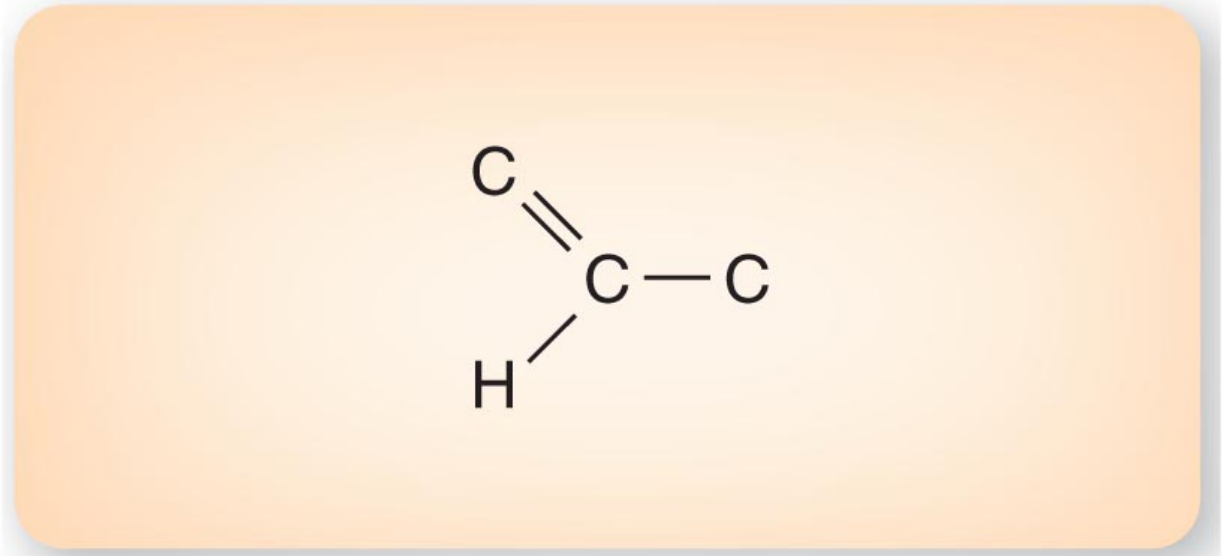
- Fatty acids can differ in
  - Length of their carbon chain
    - Short (< 6 Carbons)
    - Medium ($6 - -12$ Carbons)
    - Long (> 13 Carbons)
  - Level of saturation
    - Saturation refers to how many hydrogen atoms surround each carbon

  - Shape

- **Saturated fatty acids** – have strong hydrogen atoms surrounding every Carbon in the chain; they have no double bonds
- **Monosaturated fatty acids** – lack hydrogen atoms in one region; they have one double bond
- **Polysaturated fatty acids** – lack hydrogen atoms in multiple locationsl they have two or more double bonds
- Note: Each double bond causes the loss of two hydrogen atoms



(a) Saturated fatty acid



(b) Unsaturated fatty acid

Figure 5.3: Saturated and Unsaturated Fatty Acids

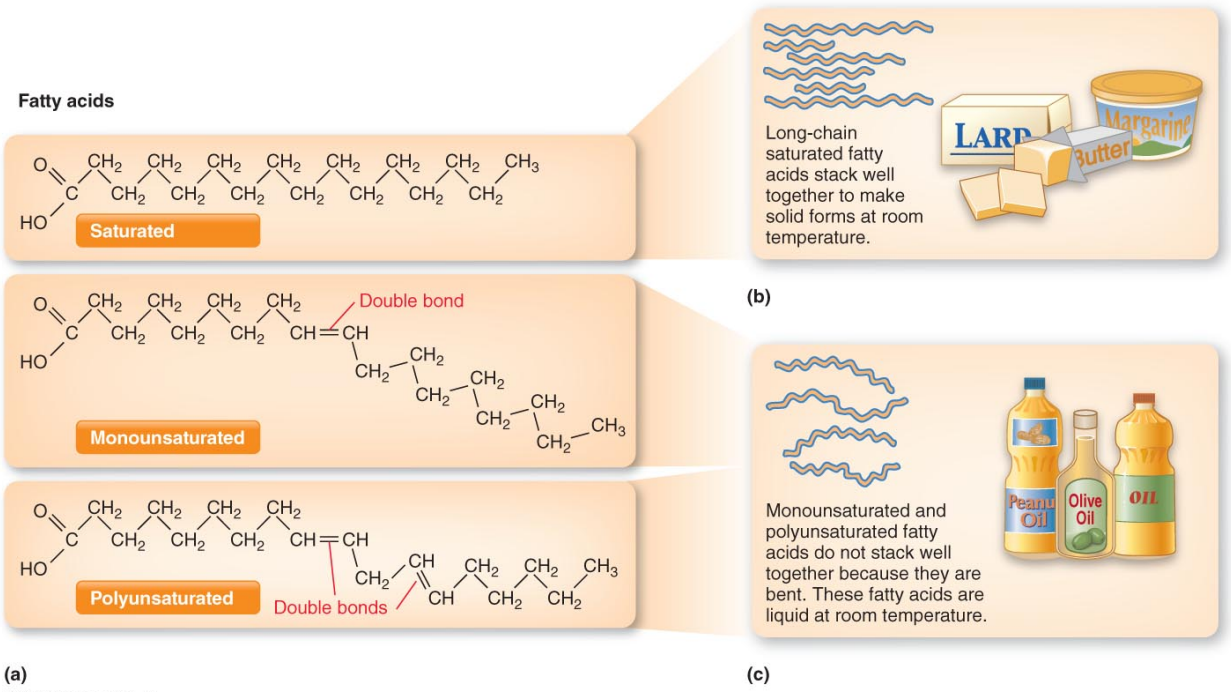


Figure 5.4: Levels of Saturation Among Fatty Acids

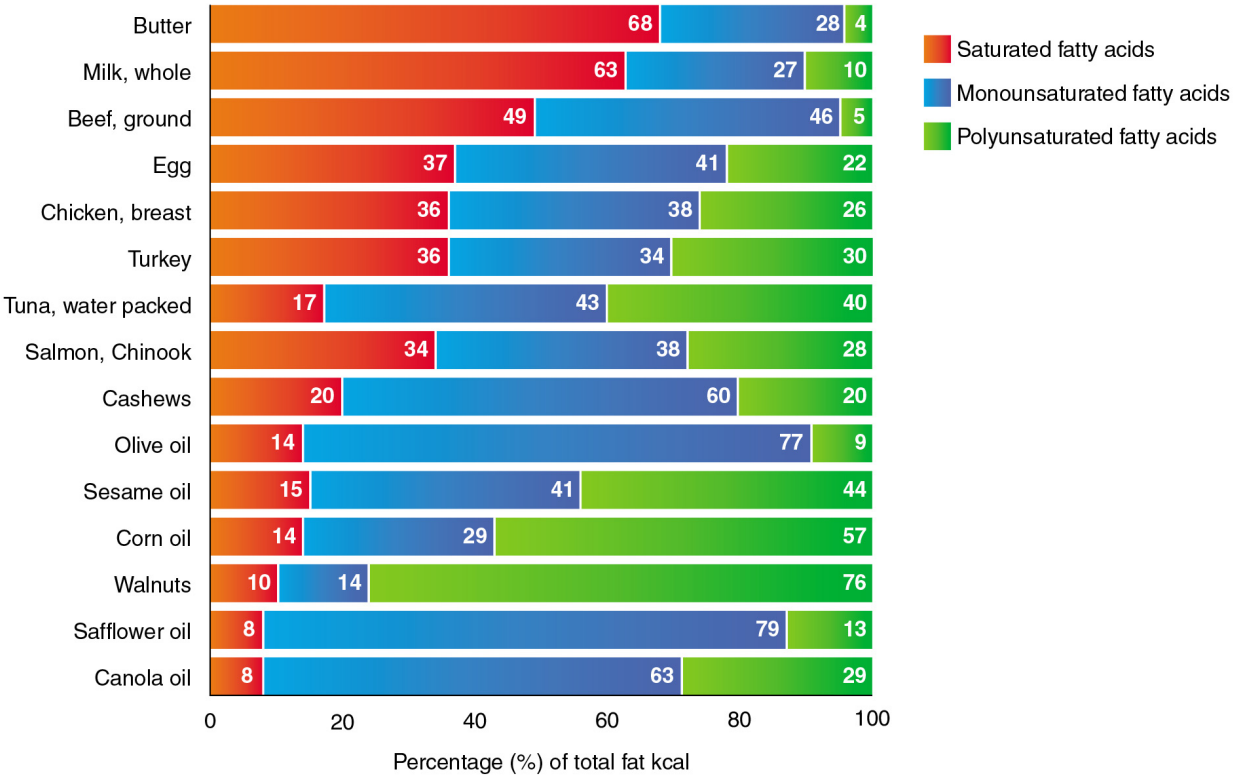


Figure 5.5: Major Sources of Dietary Fat

- The shape of a triglyceride is determined by the saturation of the carbon chains
- Saturated fatty acids can pack tightly together and are solid at room temperature
  - For example, coconut oil, animal fats, butter, and lard are high in saturated fatty acids
- Unsaturated fatty acids do not stack together well and are liquid at room temperature
  - Unsaturated fatty acids are the predominant type in plants
  - Two exceptions are coconut and palm kernel oil
- The hydrogen atoms at the unsaturated region can be arranged in different positions

  Cis same side of the carbon chain

  Trans opposite sides of the carbon chain

- **Hydrogenation** – the addition of hydrogen atoms to unsaturated fatty acids
  - Converts liquid fats (oils) into a semisolid (spreadable) or solid form
  - Used to create margarine from plant oil
  - Often creates *trans* fatty acids
  - Listed on food labels as partially hydrogenated oil

5.2 Essential Fatty Acids

Essential Fatty Acids – cannot be synthesized in the body and must be obtained in the diet

- Omega-6 and omega-3 fatty acids
- There are precursors to biological compounds called *eicosanoids*, which regulate cellular function
- Linoleic acid is found in vegetable and nut oils
- Alpha-linolenic acid (ALA) is derived from dark-green leafy vegetables, flaxseeds and flaxseed oil, soybeans and soybean oil, walnuts and walnut oil, and canola oil
- Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have important health benefits and are found in fish, shellfish, and fish oils

5.3 Why Do We Need Fats?

5.3.1 Energy

- Fat is very energy dense, providing 9 kcal/gram
- Much of the energy used during rest comes from fat
- Fat is used for energy during exercise, especially after glycogen is depleted
- Fat is also used for energy storage

5.3.2 Fat-soluble vitamins

- Vitamins A, D, E, and K are soluble in fat; fat is required for their transport
- Fat is essential to many body functions
  - Cell membrane structure
  - Nerve cell transmissions
  - Protection of internal organs
  - Insulation to retain body heat
- Fat provides flavor and texture to foods
- Fat contributes to making us feel satiated
  - Fats are more energy dense than carbohydrates or protein
  - Fats take longer to digest

5.4 How Does Our Body Process Fats?

- As fat enters the small intestine:
  - Bile is secreted from the gallbladder into the small intestine
    - Bile is produced by the liver and stored in the gallbladder
  - Bile disperses dat into smaller fat droplets
  - Pancreatic enzymes break triglycerides into two separate fatty acids and a monoglyceride
  - Fat enters the mucosal cell as a micelle (fatty acids, monoglycerides), phospholipids, and sterols)
- In the intestinal mucosal cell:
  - Fatty acids are reattached to the monoglyceride to re-form triglycerides

  - A small amount of protein is added to lipids, forming a chylomicron
  - **Chylomicron** – a lipoprotein produced by cells lining the small intestine
    * Composed of triglycerides surrounded by phospholipids and proteins
    * Soluble in water

- Chylomicrons are the transport vehicles that remove absorbed fats from the small intestine
  - Travel through the lymphatic system
  - Are transferred to the bloodstream
- Short- and medium-chain fatty acids are absorbed more quickly because they are not arranged into chylomicrons
- Once the chylomicron gets to a cell in the body, the triglycerides in the chylomicrons must be disassembled by lipoprotein lipase into two fatty acids and a monoglyceride before they can pass through the cell membrane
- After entering the cell, the two fatty acids and monoglyceride re-form a triglyceride
- The triglyceride can be
  - Used immediately for energy
  - Used to make lipid-containing compounds
  - Stored in liver and muscle cells

5.5 Recognize the Fat in Foods

Visible fats those we can see in foods or can easily see have been added to foods, such as dressing or chicken skin

Hidden fats those added to processed or prepared foods to improve texture or taste, which we may not be aware of, or that occur naturally

- Read the Nutrition Facts Panel on foods carefully
  - Lower-fat versions of foods may not always be lower in Calories

5.6 How Much Fat Should We Eat?

- The Acceptable Macronutrient Distribution Range (AMDR) for fat
  - 20–35% of Calories should be from fat
- Athletes and highly active people may need more energy from carbohydrates and can reduce their fat intake to 20–25% of total Calories

- The type of fat consumed is important
  - Intake of saturated and *trans* fatty acids should be minimized as much as possible
  - We typically set enough linoleic acid in our diets from salad dressings, vegetable oils, margarines, and mayonnaise
  - To ensure an adequate amount of omega-3 fatty acids, we need to consume more dark-green leafy vegetables, walnuts, flaxseeds, and fish or fish oils

5.7 Essential Fatty Acids

- Linoleic Acid (omega-6)
  - AI is 14–17 g per day for men and 11–12 g per day for women
- Alpha-linoleic acid (Omega-3)
  - AI is 1.6 g per day for men and 1.1 g per day for women

5.8 Limit Saturated and *Trans* Fats

- Reduce your intake of saturated fats
  - Be conscious of the saturated fat content of meats, baked goods and snack goods, and foods including vegetables that are fried, breaded, or drenched in sauce
- Avoids *trans* fatty acids
- Limit your intake of dietary cholesterol, which will also help limit your intake of saturated fats

5.9 Select Beneficial Fats

- Consume and cook with leafy green vegetables, avocados, soybeans, soybean oil, and flaxseed oil
- Add walnuts, almonds, flaxseeds, and chia seeds to your diet, and try almond milk in your cereal
- Consider including fish in your diet at least twice a week or consider taking a fish oil supplement
  - Fish can contain mercury, PCBs, and other environmental contaminants, so be selective

5.10 Fat Replacers

- Snack foods are frequent targets for fat replacers, substances that can reduce the fat content
- Fat replacers such as olestra have not proved very popular or effective because of potential gastrointestinal side effects
- Our growing obesity problems indicate that fat replacers do not help Americans lose weight

5.11 Role of Fats in Chronic Disease

- The chronic disease most closely associated with diets high in saturated fat is cardiovascular disease
- The role of dietary fat in the development of cancer has been extensively researched, but the relationship between some cancer types and dietary fats is controversial (e.g., breast cancer)
- The strongest association between dietary fat and cancer is for prostate cancer

5.12 In Depth: Cardiovascular Disease (CVD)

- Dysfunction of the heart or blood vessels
- The most common forms:
  - Coronary heart disease, or coronary artery disease
  - Stroke
  - Hypertension, or high blood pressure
  - Peripheral vascular disease
- **Atherosclerosis** – a disease in which artery walls build up lipid deposits and scar tissue, impairing blood flow
  - The stiffness that results is commonly called "hardening of the arteries"
  - The result is that the heart must work harder to push blood through the vessels
- **Hypertension** – a major chronic disease in the United States
  - It functions as a warning sign for a person's risk for developing heart disease or stroke
  - For many people, hypertension is hereditary; for others, it can be induced through poor nutrition and exercise habits or a combination of poor habits and heredity

- Modifiable risk factors for cardiovascular disease include
  - Being overweight
  - Physical inactivity
  - Smoking
  - Type 2 diabetes mellitus
  - Inflammation in the body
  - Abnormal blood lipids
- The intake of certain types of fats can protect against heart disease
- Diets high in omega-3 fatty acids (along with moderate exercise) can reduce inflammation and increase HDL ("good") cholesterol levels
- Low-density lipoproteins (LDLs) are often called "bad" cholesterol because of their role in transporting cholesterol throughout the body
- Diets high in saturated fats
  - Decrease the removal of LDLs from the blood
  - Contribute to the formation of plaques that can block arteries
  - Increase triglyceride levels (chylomicrons and very-low-density lipoproteins, or VLDLs)
- Recommendations to improve blood lipid levels
  - Keep total fat intake level to within 20–35% of your daily energy intake
  - Decrease your dietary saturated fat to less than 7% of total energy intake
  - Increase your consumption of dietary omega-3 fatty acids from foods (e.g., green vegetables, fish)
  - Consume 400 μg/day of folate
  - Increase dietary intakes of whole grains, fruits and vegetables
  - Maintain blood glucose within normal ranges
  - Eat meals throughout the day rather than eating most of your Calories in the evening before bed
  - Limit alcohol consumption
  - Don't smoke
  - Maintain an active lifestyle
  - Maintain a healthful body weight
- Recommendations to reduce blood pressure
  - Limit dietary sodium
  - Follow the DASH diet "Dietary Approaches to Stop Hypertension"
  - If need, use doctor-prescribed medications