Chapter 24 – Lipids_Summary

Overview  Chapter 24 presents an overview of the biochemistry of lipids, including fatty acids and esters of fatty acids. Structure and function of cell membranes and membrane transport are introduced. Don’t miss out reading on the applications for fats and lipids. They are all categorized as FYI (i.e not in tests) but fun, and make some light reading!

Chapter Objectives
• To understand chemical structures and properties of fatty acids, waxes, and fatty acid esters
• To be able to describe hydrogenation and hydrolysis of triacylglycerols
• To be able to identify membrane lipids and describe their structures
• To be able to distinguish between passive and active transport and describe simple and facilitated diffusion.
  Basic features of Fluid Mosaic Model structure of cell membrane as talked in lecture.
• To understand the general structure of eicosanoids and how they function in physiology

Lecture Outline
24.1 Structure and Classification of Lipids
• Most lipids contain fatty acid residues; many of these are fatty acid esters.
  -Waxes are esters of long chain carboxylic acids and long chain fatty alcohols.
  -Triacylglycerols (triglycerides) are esters of glycerol and fatty acids.
  -Phospholipids and sphingomyelins are esters containing phosphate groups.
  -Glycolipids contain carbohydrate portions in addition to lipid esters.
• Steroids and eicosanoids are lipids that are not esters.

24.2 Fatty Acids and Their Esters
• Fatty acids are long chain carboxylic acids, generally of 12 carbons or more.
  -Fatty acids are usually named with trivial or common nomenclature rather than IUC.
  -A number of polyunsaturated fatty acids are essential in human diets.
  -Plant lipids contain more polyunsaturated fatty acids than animal lipids do, but dietary plant lipids aren’t always healthier for us than diets containing lipids from animal sources.

• Waxes are esters of long chain fatty acids and long chain alcohols.
  -Esters are found in nature as protective coatings on fruits, berries, leaves, and feathers.

• Triacylglycerols, esters of glycerol and fatty acids, are classified as fats or oils.
  -Triacylglycerols that are solids at room temperature are called fats. Most triacylglycerols from animals are fats.
  -Triacylglycerols that are liquids at room temperature are called oils.

Adapted from Fundamentals of GOB Chemistry; McMurry et. al, 5th ed; Prentice Hall 2007
Application (FYI)
Lipids in the Diet
• Some lipids in our diet, such as animal fats, butter, and margarine, are apparent in our foods, but others are not readily identified as lipids.
• Lipids in animal tissue tend to be more highly saturated and to contain cholesterol.
• Lipids from plant tissue are usually less saturated and contain no cholesterol.
• On average, experts in nutrition recommend diets containing low percentages of calories from saturated lipids.

24.3 Properties of Fats and Oils
• Double bonds of most unsaturated fatty acids in natural triglycerides are in the \(-\text{cis}\) configuration.
  -The \(\text{cis}\)- bonds cause hydrocarbon chains to bend, interfering with interchain bonding and resulting in decreased melting points. Consequently, unsaturated lipids tend to have lower melting points than saturated lipids.
  -Increased chain length of fatty acids results in increased melting points of lipids.
• Triacylglycerols are stored in adipocytes of fatty tissue (in general terms ‘fat cells’)
• Fatty acid residues sometimes oxidize, forming shorter-chain acids that have unpleasant tastes or odors. (Have you smelled a long forgotten jar of Crisco?)

FYI: Antioxidants are often added to foods to prevent oxidation. Look at the back of your potato chips bag and see how many antioxidants as food preservatives you can detect !!
24.5 Cell Membrane Lipids: Phospholipids and Glycolipids

- Cell membranes form a hydrophobic barrier between the aqueous cytoplasm and the aqueous environment outside.
- Cell membranes are usually considered to be a bilayer made up of lipid molecules such as phospholipids, sphingolipids, and glycolipids.
- Phospholipids typically are similar to triacylglycerols but the third fatty acid residue replaced by phosphoric acid.
  - The phosphoric acid may link the diacylglycerol with choline to form lecithin.
  - Sphingolipids are phospholipid derivatives of the amino alcohol sphingosine.
  - Glycolipids are similar to sphingomyelins but have a carbohydrate portion in place of phosphate.

FYI: Many glycolipids such as cerebrosides and gangliosides are present in brain tissue and neurons. Some fatal genetic disorders result from deficiencies in metabolism of sphingolipids.

24.6 Cell Membrane Lipids: Cholesterol

- Cholesterol, the most abundant animal steroid, is a polycyclic compound that is a major component of cell membranes.
- Elevated levels of cholesterol seem to be related to increased risk of heart disease.
- Cholesterol molecules are relatively rigid and contribute to the structure of membranes.

Application (FYI)
   Butter and its Substitutes

- Many persons avoid butter in diets because of its contribution to blood cholesterol levels.
- Margarine made from partially hydrogenated vegetable oils contains no cholesterol and is less saturated than butter, but some of the double bonds remaining are in the trans- configuration. (I think starting 2008 the trans fats have to be removed)
  - Harder, stick margarines appear to contain more of the trans- double bonds and may contribute more to heart disease.
  - Nutrition authorities now recommend use of softer, spreadable margarine.
  - Many commercial products are prepared with hydrogenated oils to extend shelf life. Many snack foods are cooked in saturated fats for this reason.

24.7 Structure of Cell Membranes

- Cell membranes are made up primarily of phospholipids and cholesterol.
- The hydrophilic ends of lipid components orient toward the aqueous environment and the hydrophobic portions orient toward each other, forming a lipid bilayer.
- The membrane is said to be a fluid mosaic, with portions that can move around in it.
- Some proteins (peripheral) are partially embedded in the membrane.
- Other proteins (integral) extend through the membrane.
- Fluid mosaic membranes can reseal themselves if punctured.
- The composition of the membrane determines its rigidity.
  - Higher levels of cholesterol contribute to higher rigidity of the membrane.

Adapted from Fundamentals of GOB Chemistry; McMurry et. al, 5th ed; Prentice Hall 2007
-Higher levels of unsaturated fatty acid chains contribute to lower rigidity at low temperatures.
• Nonpolar substances can pass through the membrane readily. Polar substances must be transported across by special mechanisms.
• Phospholipids spontaneously form hollow spheres called liposomes.

**Application**

*Liposomes for Health and Beauty*
• Liposomes are tiny spherical vesicles consisting of an aqueous center surrounded by lipid.
• Liposomes may be used to deliver drugs to target tissues as well as delivering beauty products to cell membranes.

24.8 Transport across Cell Membranes
• In passive transport, substances (which are usually nonpolar) diffuse across membranes, passing from regions of high concentration to regions of low concentration.
• Simple diffusion allows some substances to diffuse along the concentration gradient.
  -Simple diffusion passes very small molecules, some nonpolar steroid molecules and some hydrophilic molecules of a size allowed by pores in integral proteins.
  -Some integral proteins are capable of opening and closing channels.
• Facilitated diffusion requires no energy input. It takes place when a substance binds to proteins in the membrane which change shape so that the substance is moved to the other side of the membrane and released.
  -Among other substances, glucose passes into many cells by facilitated diffusion. In active transport, substances can pass against a concentration gradient.
  -Active transport requires a supply of energy (often ATP) to overcome the concentration gradient.
• The relatively high ratio of K⁺/Na⁺ between the inside and outside of the cell membrane is maintained by an active transport mechanism that uses hydrolysis of ATP to ADP as a source of energy to move three Na⁺ ions out and pass three K⁺ ions in.

24.9 Eicosanoids: Prostaglandins and Leukotrienes
• Eicosanoids, formed from 20-carbon fatty acids, act as chemical messengers near their point of synthesis; eicosanoids are sometimes referred to as local hormones.
• Prostaglandins (containing a five-membered ring) and leukotrienes (which have no ring, but have three adjacent double bonds) are examples of eicosanoids.

*Additional Info: FYI*
• Eicosanoids have many biological effects and potential therapeutic applications.
  -Prostaglandins mediate the pain response.
  -Aspirin transfers an acetyl group to the enzyme which synthesizes prostaglandins. This is thought to be the mechanism by which aspirin relieves pain.
  -Leukotrienes may be involved in allergic reactions, inflammation, and the asthmatic response.

**HW Assignment (EOC)**


Adapted from Fundamentals of GOB Chemistry; McMurry et. al, 5th ed;Prentice Hall 2007