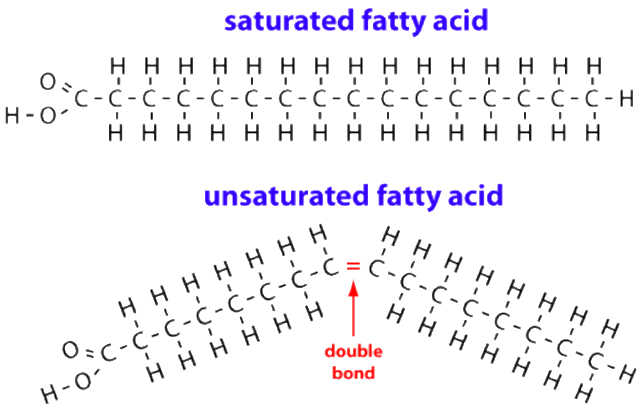
WEEK 6

UNIT 2-3 : LIPIDS	**Where? How long?**	***Explanations /Questions***
Introduction Lipids, commonly referred to as fats, are organic compounds from both animals and plants, they are water insoluble but soluble in most of nonpolar organic solvents. Lipids share in common the same property of having hydrophobic regions and are made from a small number of molecules in their backbone. These include mainly fatty acids, glycerol and sphingosine. There are different classes of lipids; here we will talk about three classes: triglycerides, phospholipids and sterols. ***Expectation*** In this lesson, we will learn more about the chemical structure and biological function of various lipids. ***Course outline*** Fatty acids triglycerides, phospholipids sterols	10 minutes	Where is this from? Explain here what it is they are going to be learning and ***why*** they need to know about Lipids Also what the expectations are in terms of time commitment, tutor support and so on.
Learning outcomes At the end of this unit, you should be able to: • Define and classify lipids • Differentiate between saturated and unsaturated fatty Acids • Define the basic structure of a steroid		

ACTIVITY AHEAD OF LESSON :LIPIDS			
Purpose:	Lipids are an important source of energy .You will learn how the hydrocarbon tails in triglycerides contain energy available for life, and how phospholipids with cholesterol molecules are structures of the cell membrane.	30 minutes	For the video activate the subtitle in English.
Over to you:	Watch this video and read this course about structure of lipids ***Be certain to note anything that you don't understand***		
Activity:	Answer following questions: Define lipids Draw the primary structure of triglycerides, phospholipids and sterols and provide an example for each class of lipids. What are the main functions of lipids in Cell. Bring your answers to the class.		

TYPES OF LIPIDS		Notes to tutor
- **Fatty acids** Fatty acids are linear hydrocarbon compound of varying lengths. They are the building blocks for triglycerides and phospholipids and have two regions: **a long nonpolar, hydrophobic hydrocarbon chain** and **a polar, hydrophilic carboxyl (–COOH) head**. These two chemically distinct (polar and nonpolar) regions make fatty acids amphiphilic. They may be saturated or unsaturated; saturated fatty acids are solid for example palmitic acid, while unsaturated ones are liquids for example linolenic acid.	20 minutes	
 **Figure 2.10: Saturated fatty acids versus unsaturated fatty acid (have a double bound) .** By Liantai Lin [Illustration], uploaded on January 28, 2018. Accessed on the February 20, 2019. https://www.flickr.com/photos/fossil_lin/28161978809		Fatty acids found in biological organisms are in cis conformation.

IN CLASS ACTIVITY: SATURATED VS UNSATURATED FATTY ACIDS.	10 minutes for search 15 for feedback	Use group of 4 students
Purpose: Compare and contrast Saturate and unsaturated fatty acids **Over to you:** Using a laptop look on the website the difference of saturate and unsaturated fatty acids, then look for various shape of unsaturated fatty acids). Give an example for each type of lipids . **Activity:** Using a PPT of 2 slides the group representative will present to the class their search		To stimulate students to ask questions.

• **Quick review of fatty acids** Structure : Carbon and hydrogen chain, carboxylic acid, methyl group Fatty acids are the basic structural units of triglycerides and phospholipids Differ in chain length, degree of saturation, shape ▪ Saturated fatty acids: no carbon to carbon double bonds ▪ Monounsaturated fatty acids: one C=C double bond ▪ Polyunsaturated fatty acids: two or more C=C double bonds Types of essential fatty acids ▪ Linoleic ▪ Alpha-linolenic acid Food manufactures hydrogenate or add antioxidants to unsaturated fatty acids to reduce susceptibility to rancidity	30 minutes	Notes to tutor Discusses with students and check if they understand all important information about fatty acids.
Fatty acids an health What is an essential fatty acids? What is rancidity What are the effects of rancidity of heath ? What is prostaglandin?		Orient the discussion around the question on the right column.

Triglycerides

Triglycerides or Triacylglycerols also called fats and oils are lipids containing three fatty acid molecules attached to one molecule of glycerol by ester bonds.

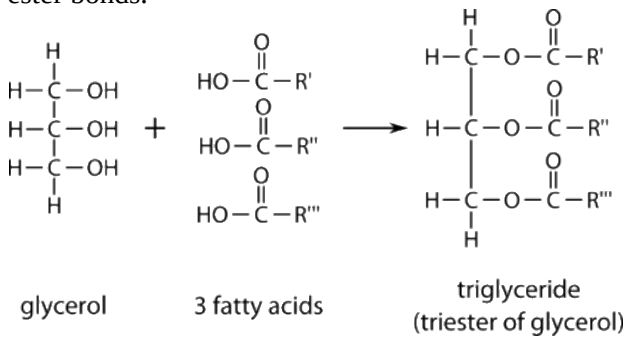


Figure 2.11: Triglycerides components. By Allison Soult. November 2, 2018. Accessed on the February 20, 2019. https://chem.libretexts.org/Courses/University_of_Kentucky/UK%3A_CHE_103_Chemistry_for_Allied_Health_(Soult)/Chapters/Chapter_14%3A_Biological_Molecules/14.2%3A_Lipids_and_Triglycerides

Each fatty acid in the triglyceride molecule can potentially be different in structure, thus producing many possible structural forms of triglycerides. Most triglycerides from plant sources, such as corn, sunflower seeds, and safflower seeds, are rich in polyunsaturated fatty acids and are oils, whereas triglycerides from animal sources contain mostly saturated fatty acids and are usually solid at room temperature. In the cell, triglycerides are found as tiny droplets in cytosol and they function as storage lipids in animals and in plants.

A triglyceride is called a fat if it is a solid at 25°C; it is called an oil if it is a liquid at that temperature.
P*ure* fats and oils are colorless, odorless, and tasteless and can participate in a variety of chemical reactions.
Example : Saponification is the hydrolysis of esters in fats and oils in the presence of a base is used to produce soap.

20 minutes

Note to tutor

Discuss about the saponification.

IN CLASS ACTIVITY: FATS AND OILS.		10 minutes for search 15 for feedback	Use group of 4 students
Purpose:	Differentiate fats and oils		
Over to you:	Using a laptop look on the website the difference of fats and oils		To stimulate students to ask questions.
Activity:	After compare fats and oils use a table , then answer the questions below: 1. Explain how fats function as energy-storage molecules. 2. List the functions of fat in the body. 3. Why does fat keep the body from being hungry? Provide feedback in class for discussion.		

- **PHOSPHOLIPIDS**

Phospholipids which are the main component of biological membranes are similar in structure to triglycerides except that they only have two esterified fatty acids. The third position on the glycerol backbone instead, contains a phosphate head group, to which a varied number of chemical groups can be attached.

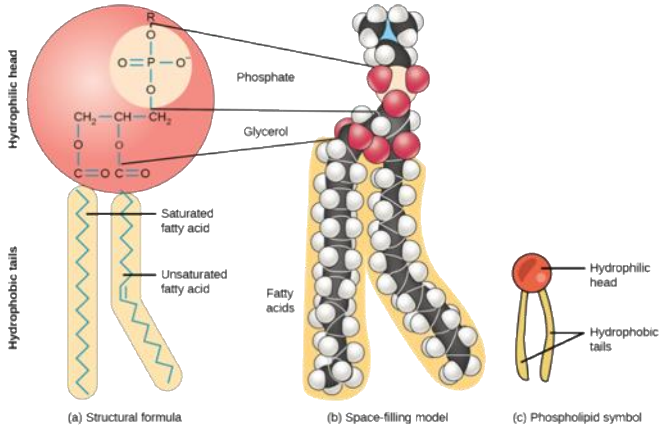


Figure 2.12: Phospholipids have polar hydrophilic head and non-polar hydrophobic tails. By OpenStax Biology 2nd Edition, Biology 2e. OpenStax CNX. Feb 13, 2019, accessed February 24, 2019. https://cnx.org/contents/jVCgr5SL@15.3:lQpWuQGI@10/3-3-Lipids

A phospholipid is an amphipathic molecule, meaning it has a hydrophobic and a hydrophilic part. The fatty acid chains are hydrophobic and cannot interact with water; whereas, the phosphate-containing group is hydrophilic and interacts with water. Because they are amphipathic, phospholipids are effective as ***emulsifying agents***, compounds that make or stabilize emulsions

There are two classes of phospholipids:
- Glycerophospholipid (contains glycerol as alcohol)
- Sphingophospholipids (contain sphingosine as alcohol)

20 minutes

- **Glycerophospholipid**

1,2-diacylglycerol (the fatty acids) with a phosphate group at position 3

Essential components of cell membranes and other cellular structures

You can have additional compounds esterified to the phosphate group

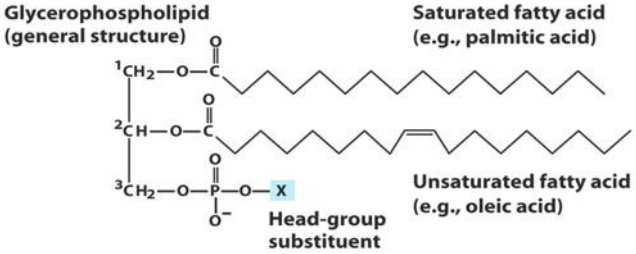


Figure 2.13: General structure of Glycerophospholipid: *Lafer, Eileen. "Membrane Lipids I and II: Glycerophospholipids and Sphingolipids." Lecture. San Antonio, Texas. December 6, 2011, Accessed on February 24,2019.* http://biochem.uthscsa.edu/~lafer/VIRGIL/MembraneLipids/MembraneLipidsNotes2011FIN.pdf

10 minutes

The parent molecule is phosphatidic acid.
The presence of an additional group attached to the phosphate allows for many different phosphoglycerides.
Each derivative is named for the head-group alcohol (X) with the pre-fix "phosphatidyl-"

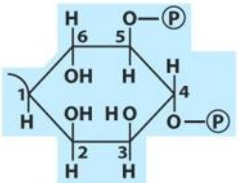
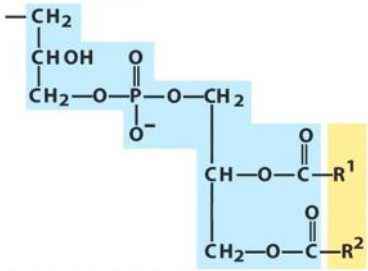
Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	$-H$	−1
Phosphatidylethanolamine	Ethanolamine	$-CH_2-CH_2-\overset{+}{N}H_3$	0
Phosphatidylcholine	Choline	$-CH_2-CH_2-\overset{+}{N}(CH_3)_3$	0
Phosphatidylserine	Serine	$-CH_2-CH(COO^-)-\overset{+}{N}H_3$	−1
Phosphatidylglycerol	Glycerol	$-CH_2-CH(OH)-CH_2-OH$	−1
Phosphatidylinositol 4,5-bisphosphate	*myo*-Inositol 4,5-bisphosphate		−4
Cardiolipin	Phosphatidyl-glycerol		−2

Figure 2.14: Common head groups found in glycerophospholipids and their basic characteristics. Source: Lafer, Eileen. "Membrane Lipids I and II: Glycerophospholipids and Sphingolipids." Lecture. San Antonio, Texas. December 6, 2011.Accessed on February 24,2019. *http://biochem.uthscsa.edu/~lafer/VIRGIL/MembraneLipids/MembraneLipidsNotes2011FIN.pdf*

10 minutes

Phosphatidylcholine or lecithin

- **Sphingophospholipids**

Shingolipids are typically found in brain tissues (eg. brain lipids).
Based upon sphingosine (or dihydrosphingosine), an amino alcohol.
Sphingosine is rare in plants and animals while sphingolipids are common
Simplest sphingolipids are ceramides
Sphingosine + N-linked fatty acid = ceramide

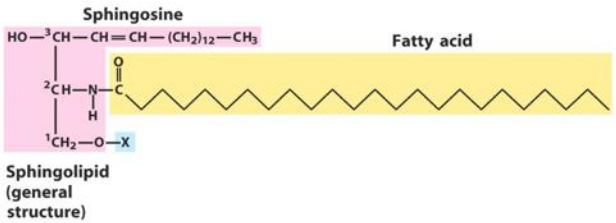


Figure 2.15: Sphingolipid general structure. Source: Lafer, Eileen. "Membrane Lipids I and II: Glycerophospholipids and Sphingolipids." Lecture. San Antonio, Texas. December 6, 2011.Accessed on February 24,2019. *http://biochem.uthscsa.edu/~lafer/VIRGIL/MembraneLipids/MembraneLipidsNotes2011FIN.pdf*

The 3- carbon backbone is analogous to the 3-carbons of glycerol.
At C3 there is the long chain amino alcohol sphingosine.
At C2 there is a fatty acid which is usually saturated or mono- unsaturated, and can be either 16,18, 22, or 24 carbons long.
Ceramide is the parent compound.
Other polar head groups can be attached at position X
Glycosphingolipids are a sub-group of sphingolipids that contain saccharide headgroups.

20 minutes

Some common sphingolipids headgroups

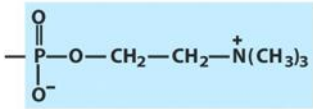
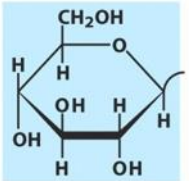
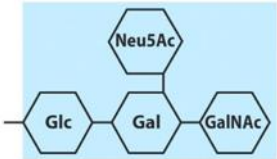
Name of sphingolipid	Name of X	Formula of X
Ceramide	—	— H
Sphingomyelin	Phosphocholine	
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

Figure 2.15: Sphingolipid structure and common head groups. Source: Lafer, Eileen. "Membrane Lipids I and II: Glycerophospholipids and Sphingolipids." Lecture. San Antonio, Texas. December 6, 2011.Accessed on February 24,2019. *http://biochem.uthscsa.edu/~lafer/VIRGIL/MembraneLipids/MembraneLipidsNotes2011FIN.pdf*

10 minutes

Glycolipids

Glycolipids contain a sub-group of sphingolipids and a mono- or oligosaccharide bound to the *C3*group Glycosphingolipids are a sub-group of sphingolipids that contain saccharide headgroups.

The human blood groups (O, A, B) are determined in part by the **oligosaccharide head groups** of these **glycosphingolipids.**

Glc:D-glucose
Gal:D-galactose
GalNAc:N-acetyl-D- galactosamine
Fuc:fucose

Glycosphingolipids are especially relevant to neuronal membranes, where D-glucose is added to the hydroxyl group of ceramide to create GlcCer.

If the headgroup has any (one to four) silica acid(s) attached to it, the new molecule is referred to as a **ganglioside .**

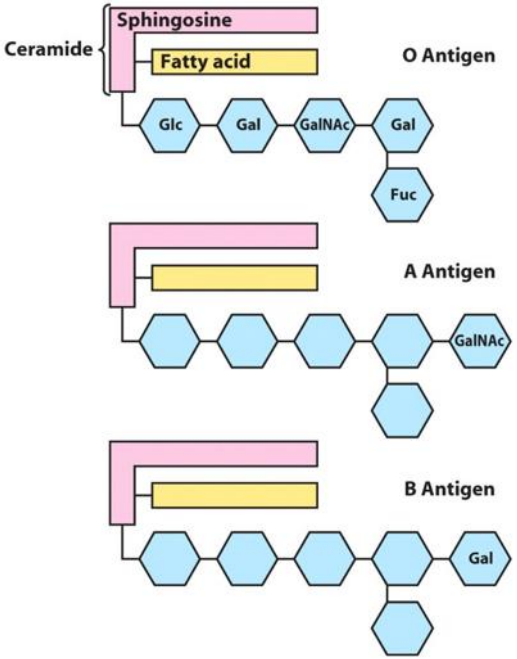


Figure 2.16: Blood group types in humans are determined by the glycolipid headgroup. Source: Lafer, Eileen. "Membrane Lipids I and II: Glycerophospholipids and Sphingolipids." Lecture. San Antonio, Texas. December 6, 2011.Accessed on February 24,2019. *http://biochem.uthscsa.edu/~lafer/VIRGIL/MembraneLipids/MembraneLipidsNotes2011FIN.pdf*.

10 minutes

Gangliosides are degraded by a set of lysosomal enzymes These enzymes catalyze the stepwise removal of sugar units, finally Yielding a ceramide. A genetic defect in any one of these hydrolytic enzymes leads to the Accumulation of gangliosides in the cell, with severe medical consequences. Example : defect in Sphingomyelinase leads to accumulation of Sphingomyelin in the brain, spleen, and liver causing a disease called : Niemann-pick disease.	10 minutes	

IN CLASS ACTIVITY: PHOSPHOLIPIDS		10 minutes	
Purpose:	To Apply knowledge of the structure of phospholipids to the formation of membranes		
Over to you:	After the class lecturer and pre-class reading activities answer the questions bellow:		
Activity:	Explain how the structure and properties of phospholipids help to maintain the structure of cell membranes. Why would a molecule need to be soluble in water, but also not soluble in water?		

STEROIDS

Lipids mainly made of four fused rings known as steroid nucleus and named as **cyclopentano-perhydro-phenanthrene**. Rings are numbered through ABCD and carbon backbone is numbered from 1 to 17.

All steroids have the steroids nucleus in their structure. The difference comes from chemical modifications on rings. These modifications may be the replacement of hydrogen atoms with other chemical groups such as hydrocarbon chains or functional groups such as hydroxyl and carboxyl or aldehyde groups. Modification can be created by introducing carbon-carbon double bonds into one or more of the cyclohexane rings.

The most known steroid in animals is **cholesterol**. It is found in cell membranes where it contributes to the proper functioning of the membranes.

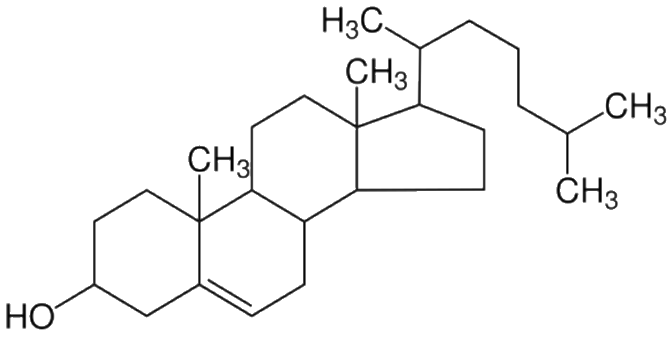


Figure 2.17: Cholesterol Structure. By Wesalius . May 17, 2017. Accessed on February 24, 2019. https://commons.wikimedia.org/wiki/File:Cholesterol_(chemical_structure).svg#/media/File:Cholesterol_(chemical_structure).svg.

10 minutes

Anticipated time required for Unit 2.3 activities :

Theory : 2h all activities + 2h self-learning