

LIPIDS

In this concept, we will discuss one class of biological polymers called lipids or fats. You might be familiar with this class of biopolymers, which are found in butters and oils.

We will discuss saturated and unsaturated fats, and what those terms mean for the molecule's structure as well as its properties at room temperature.



1. Which of the following is a source of lipids?

- Sugar, fruits, and bread
- Water
- Steaks
- **Butter and oils**

STRUCTURES AND PROPERTIES OF LIPIDS

The category of biomolecules known as **lipids** contain fats and oils as well as fatty acids. The monomer of a lipid is a **fatty acid**. The fatty acids are the simplest lipids and are found as components in more complex lipids. A fatty acid contains a long carbon chain attached to a carboxylic acid group at one end. Fatty acids that contain only single bonds between carbon atoms are **saturated fatty acids**.

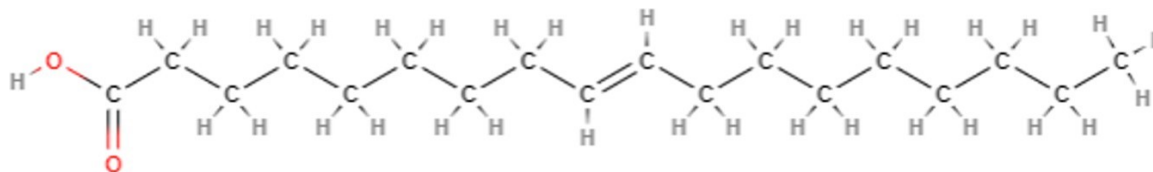
Recall from the organic chemistry lesson that saturated carbon chains contain all single bonds and are called alkanes. One example of a saturated fat is **butanoic acid**, a component of butter. This contains a four-carbon chain with a carboxylic acid functional group on the end carbon: $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.

If there is one double bond between carbon atoms in a fatty acid, then it is a monounsaturated fatty acid; if there are more than one double bonds between carbon atoms, then the fatty acid is polyunsaturated.

You will notice in the structures of oleic acid, $\text{CH}_3(\text{CH}_2)_7\text{CHCH}(\text{CH}_2)_7\text{COOH}$, and linoleic acid, $\text{CH}_3(\text{CH}_2)_4\text{CHCHCH}_2\text{CHCH}(\text{CH}_2)_7\text{COOH}$, **the double bonds cause the molecules to curve and take up more area than a saturated fat**. This decrease in the molecule's density causes unsaturated fats to be liquid at room temperature (oils), compared to the densely packed and solid saturated fats that contain single bonds.

- Mnemonic: "Solid, single bonds, and saturated." This refers to the structure (all single bonds) and relative density (solid) of the saturated fats.
- Mnemonic: "Unsaturated oils" The oils include unsaturated alkenes, either monounsaturated or polyunsaturated.

One type of unsaturated fat is called trans fats, referring to the position of the carbons around the double bond that creates a linear structure rather than a curved structure. Trans fats are often created through the process of hydrogenation and include the hydrogenated oils found in margarine, such as trans-oleic acid. Because of their arrangement, they are similar in structure to saturated fats and thus are solids at room temperature.



SATURATED OR UNSATURATED

Lipids	
UNSATURATED	SATURATED
$\text{CH}_3\text{CHCHCH}_2\text{CHCHCH}_2\text{COOH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
$\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHCHCHCHCH}_2\text{CH}_2\text{COOH}$

Answer the following questions about lipids

2. Triglycerides are:

- Always unsaturated
- **Made of fatty acid monomers**
- Used for catalysis in the body
- Soluble in

water Select all that apply.

3. Saturated fatty acids contain _____ functional groups

- **Alkanes**
- Amine
- **Carboxylic acid**
- Halogen
- Alkenes

From the condensed structural formula, determine if the structure represents a saturated fatty acid, monounsaturated fatty acid, or a polyunsaturated fatty acid.

	SATURATED FATTY ACID	MONOUNSATURATED FATTY ACID	POLYUNSATURATED FATTY ACID
$\text{CH}_3\text{CH}_2\text{CHCHCH}_2\text{COOH}$			X
$\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{COOH}$			X
$\text{CH}_3\text{CHCHCH}_2\text{CHCHCH}_2\text{COOH}$			
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$		X	

4. Contains carboxylic acid = **Both Saturated and Unsaturated**

Contains a single double carbon-to-carbon bond = **Unsaturated**

Contains multiple double carbon-to-carbon bonds =

Unsaturated Solid at room temperature = **Saturated**

Contains no carbon-to-carbon double bonds = **Saturated**

Liquid at room temp = **Unsaturated**

Does not mix with water = **Both Saturated and Unsaturated**

Both saturated and unsaturated do not mix with water.

Saturated contains no double carbon-to-carbon bonds and is solid at room temperature.

Unsaturated contains a single double carbon-to-carbon bond (monounsaturated) or multiple double carbon-to-carbon bonds (polyunsaturated) and are mostly liquid at room temperature.

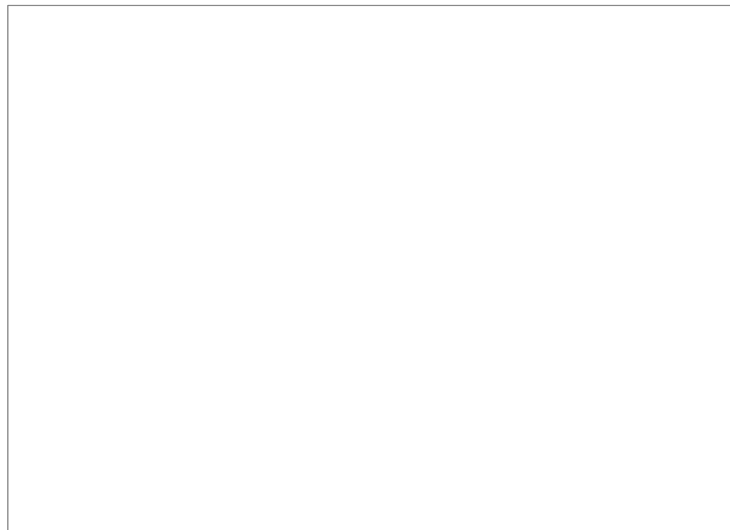
TRIGLYCERIDES, GLYCEROPHOSPHOLIPIDS, AND STERIOD

Fats and oils consist of fatty acids that have been bound to glycerol through an **ester bond**.

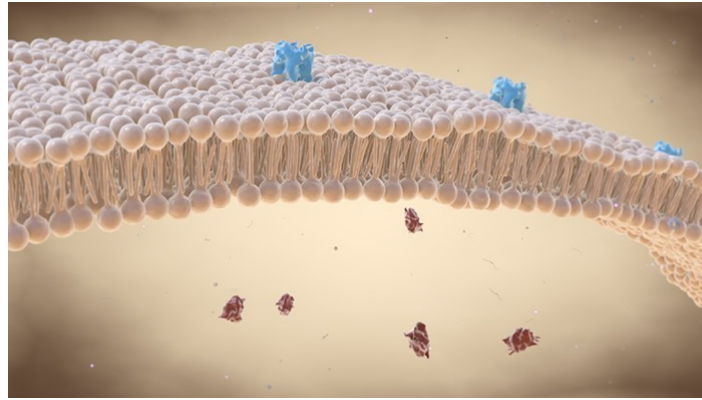
Lipids, or fats and oils, are also found in abundance in our kitchens. While the **carboxylic acid group is soluble in water, the long carbon chain makes the fatty acid insoluble in water**. You can observe this by pouring equal amounts of water and vegetable or olive oil into a small, clear container. **Two layers will appear: one is the polar (hydrophilic) water, one is the nonpolar (hydrophobic) oil**. Because of the differences in hydrophobicity, **polar and nonpolar molecules will not mix**. This idea is commonly referred to as "Like Dissolves Like," **meaning polar (hydrophilic) molecules will only mix with other polar (hydrophilic) molecules; nonpolar (hydrophobic) molecules will only mix with other nonpolar molecules**.

Triacylglycerols, or triglycerides, are triesters of glycerol (a trihydroxy alcohol) and fatty acids. Basically, **the glycerol molecule has three tails of fatty acids. These molecules are formed by esterification, the condensation of the carboxylic acid on the fatty acid and the alcohol groups on the glycerol**.

Triacylglycerols also undergo hydrogenation, hydrolysis, and saponification (soap-making) reactions.



Glycerophospholipids are similar to triacylglycerols, except that **one hydroxyl group of glycerol has been replaced by the ester of phosphoric acid and an amino alcohol and bonded through a phosphodiester bond**. One consequence of their structure is that **glycerophospholipids have both polar and nonpolar regions**. These macromolecules are the most abundant lipid in cell membranes.



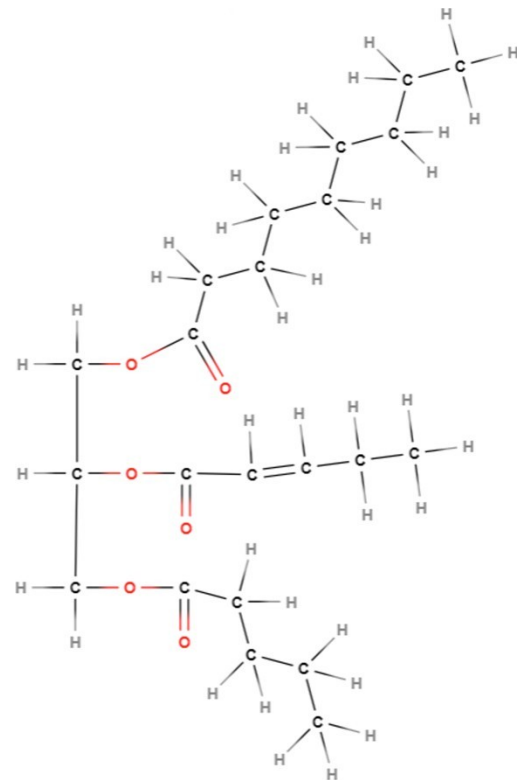
Cell Membrane lipid bilayer with receptors

Steroids are compounds that consist of **three cyclohexane rings and one cyclopentane ring that are fused together**. This structure is referred to as the steroid nucleus. **A very common steroid is cholesterol, which is a component of cellular membranes, myelin sheath tissue, and brain and nerve tissue. Cholesterol is also used to synthesize Vitamin D and steroid hormones.**

FATTY ACIDS ATTACHING TO GLYCEROL

Using the molecule below, answer the following questions

- This molecule is best described as
 - A polyunsaturated fatty acid
 - An unsaturated fatty acid
 - A triglyceride**
 - A fatty acid
- How many fatty acids were used to create this triacylglycerol molecule?
 - One
 - Two
 - Three**
 - Four
- The fatty acids used to create this triacylglycerol are
 - All unsaturated
 - All saturated
 - All connected through an ester linkage**
 - All identical
- Match the lipid to the function
 - Glycerophospholipids** comprises the majority of cell membranes because it contains a polar head and a nonpolar tail
 - Triacylglycerol** used in soap making



- **Cholesterol** structure included three six-member rings fused with a five-member rings, and in cell membranes provides stability and is a precursor for vitamin D
9. Select all that apply. Which of the following are typically solids at room temperature?
- **Trans lipids**
 - **Saturated lipids**
 - Unsaturated lipids
 - Monosaturated lipids
 - Polysaturated lipids
10. Which class of lipids is found in cell membranes?
- Sterols
 - Triacylglycerol
 - Glycerophospholipid
 - Steroids and triacylglycerol
 - **Steroids and glycerophospholipids**
11. What type of linkage is found in triacylglycerol's?
- Amide
 - Ether
 - Peptide
 - **Ester**
 - Glycoside
12. Triacylglycerols contain_____.
- 3 molecules of glycerol and 1 steroid
 - **1 molecule of glycerol and 3 molecules of fatty acid**
 - 1 molecule of glycerol and 3 steroids
 - 3 molecules of glycerol and 1 molecule of fatty acid
13. Which of the following is true for both saturated and unsaturated fatty acids?
- Both are considered alkenes
 - Both are solid at room temperature
 - Both contain ester linkages
 - Both are soluble in water
 - **Both contain carboxylic acid groups**

PROTEINS

In this concept we discuss the third class of macromolecules: the proteins. Proteins are essential for multiple functions within cells: catalysis, structure, transport, energy, and many others.

We will discuss the role of the amide (peptide) linkage, four levels of protein structures, and properties of the proteins.

14. Rank the levels of protein structure from top (least complex/ structured) to bottom (most complex/ structured)
- Primary – sequence of amino acids
 - Secondary – alpha helices, beta strands, and loops
 - Tertiary – the three-dimensional structure
 - Quaternary – interaction of multiple tertiary structures
15. Examples of proteins include

- **Meat and muscle**

- Sugars and candy
- Butter and oil
- All of these

STRUCTURE OF AMINO ACIDS

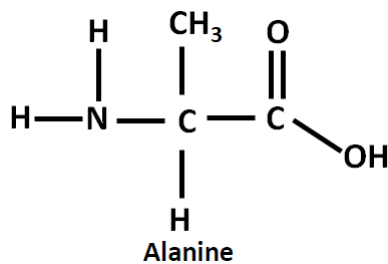
As with our other biomolecules, to understand proteins, we first need to understand their parts.

Proteins are polymers of **amino acids**.

Amino acids have two functional groups: an **amino group (-NH₂)** and a **carboxylic acid group (-COOH)**. This is where their name comes from: **amino acid**. For all amino acids found in proteins, the amino group, the carboxylic acid group, and a hydrogen atom are bonded to the central carbon atom (called the alpha carbon). The **R** is the placeholder for the **sidechain**.

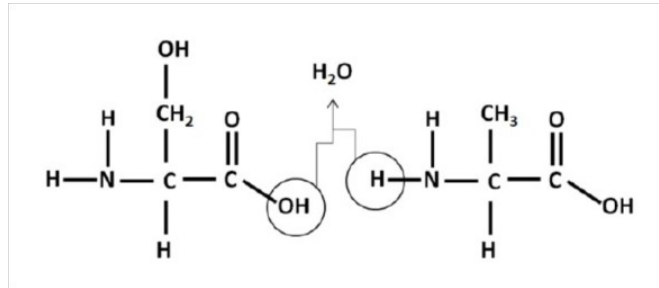
Different amino acids have different side chains, but they all have the amine group, alpha carbon, and carboxylic acid groups. While there are many amino acids, only 20 different amino acids are found in humans. On the general structure of an amino acid below, click on the following parts: amino group, carboxylic acid group, and alpha hydrogen.

General structure of an amino acid can be written as **NH₂CHRCOOH**. The **backbone** is the portion that repeats in every amino acid: the amine, the alpha carbon, and the carboxylic acid. To show a specific amino acid, the R is replaced by the sidechain. One of the twenty amino acids is shown below.



As we can see, we have replaced "R" with a -CH₃. This -CH₃ is one of many possible side chains. The name of this particular amino acid is Alanine and it is one of the 20 amino acids found in our bodies.

Two amino acids will join when the -OH from the carboxylic acid of the first molecule condenses with the amine group of the next amino acid, releasing a molecule of water as a by-product.



AMINO ACID SIDE CHAINS

16. The backbone of an amino acid refers to all of the following except
- The alpha carbon
 - The amine
 - The carboxylic acid
 - **The sidechain**
17. Select all that apply. What functional groups are found in amino acids?
- **Carboxylic acid**
 - Ester
 - **Amine**
 - Alkene
 - Hydroxyl
18. Alpha carbons are always bound to
- the amine.
 - a hydrogen.
 - the carboxylic acid.
 - the sidechain.
 - **All of these.**

FORMATION OF PEPTIDE BONDS

Two amino acids will join when the -OH from the carboxylic acid of the first molecule condenses with the amine group of the next amino acid, releasing a molecule of water as a by-product.