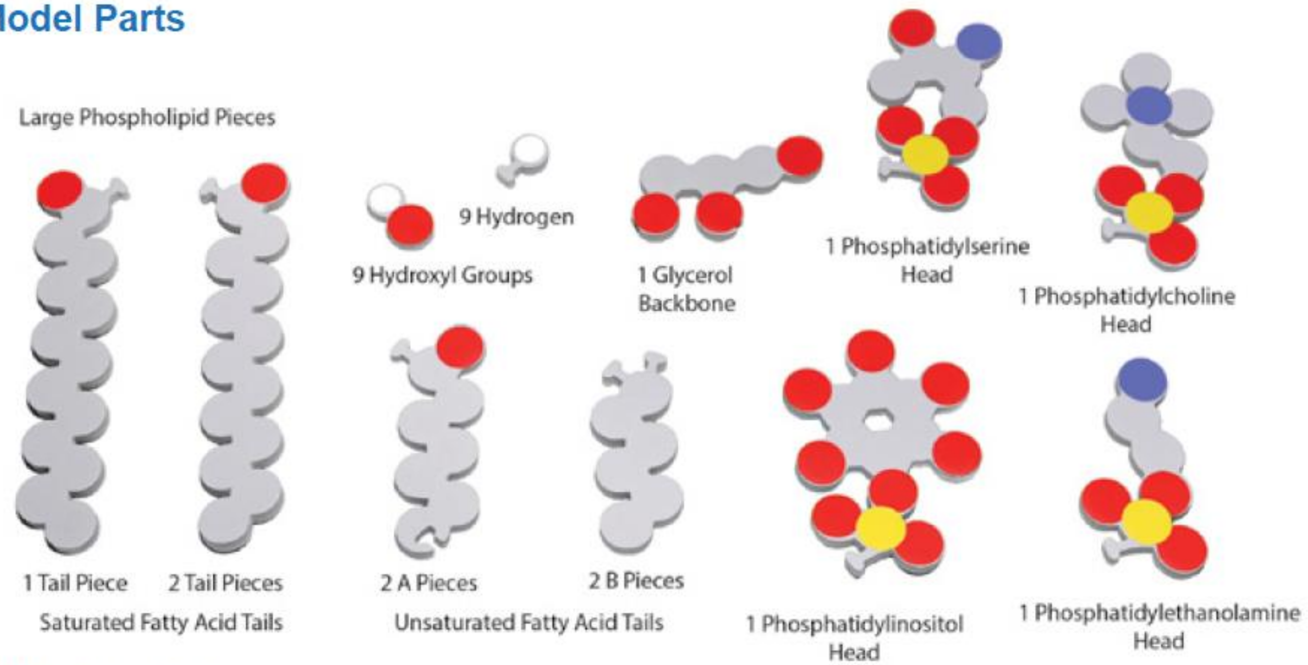
Membrane Kit
Activity 1

Model Parts



CPK Color Scheme

Oxygen (red) | Nitrogen (blue) | Phosphorus (yellow) | Hydrogen (white) | Carbon (grey)

Introduction to Lipids

Biomolecules are molecules unique to living systems and include **carbohydrates**, **proteins**, **nucleic acids** and **lipids**. Lipids are a diverse group of organic compounds primarily composed of carbon, hydrogen, and oxygen. Fatty acids, triglycerides, phospholipids, fat-soluble vitamins and steroids are a few examples of molecules classified as **lipids**.

The main biological functions of the many varied types of lipids include:

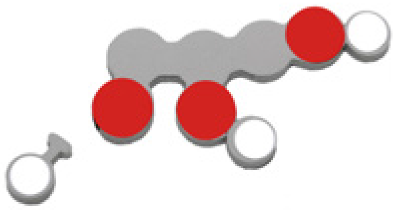
- energy storage
- protection
- insulation
- regulation of physiological processes

Some lipids serve as the structural components of cell membranes.

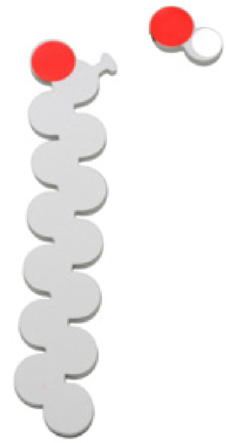
In this activity you will model a dehydration synthesis reaction in the formation of a triglyceride and determine the resulting products. **Triglycerides** are neutral fats. Some triglycerides are considered **fats** and others **oils**. When a triglyceride is a **solid** at room temperature it is a **fat**. When a triglyceride is a **liquid** at room temperature it is an **oil**. The two building blocks that compose triglycerides are fatty acids and glycerol. **Fatty acids** are **linear chains of carbon and hydrogen atoms** with an **organic acid group** (-COOH) at one end.

1. Begin with glycerol and three of the straight-chain fatty acids as the reactants in this simulation. A fatty acid is said to be saturated if the carbons comprising the tail are all singly bonded to each other. Before starting, make sure your glycerol has 3 H atoms and the fatty acids all have OH atoms attached.

2. Remove one of the hydrogen (H) atoms from the glycerol.

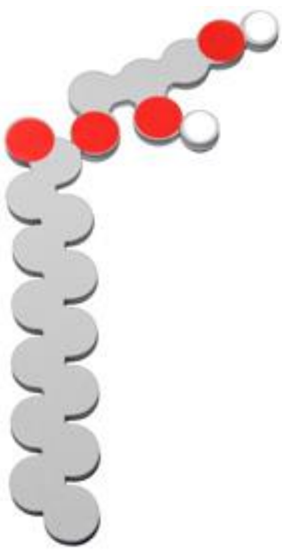


3. Remove the hydroxyl (OH) from one of the fatty acids.

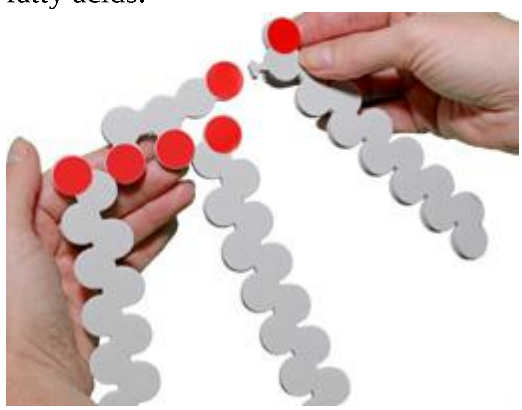


4. Combine the H and the OH.

5. Join the fatty acid to the glycerol.



6. Repeat this process with the two remaining fatty acids.

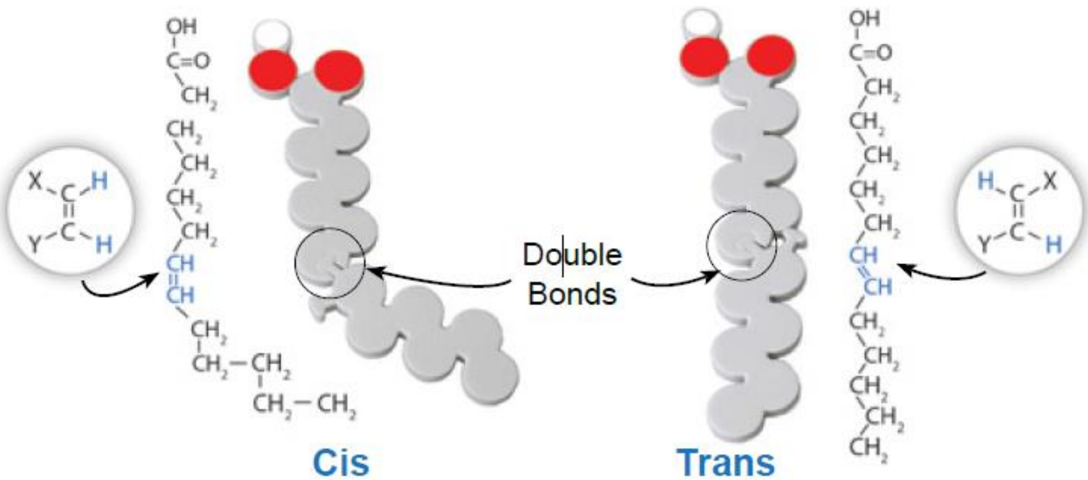


NOW ANSWER QUESTIONS #1-3 ON YOUR ANSWER SHEET

7. Substitute the third fatty acid tail with the two-part fatty acid tail. The post and hole connection in the two-part tail symbolizes a **double bond** between the carbons. When one or more double bonds is present between the carbons in the tail of the fatty acid, the molecule is **unsaturated**.

The double bond in an unsaturated fatty acid may form one of two possible configurations: ***trans*** or ***cis***. You may model the *trans* configuration by attaching the second piece of the tail to the first to produce a straighter chain. The *cis* configuration may be modeled by producing a kinked configuration. Most naturally-occurring unsaturated fats are in the *cis* configuration.

If the hydrogens associated with the double bonded carbons are on the same side, the fatty acid is called *cis*. If the hydrogens associated with the double-bonded carbons are on opposite sides, the fatty acid is called *trans*. (See illustrations below.)

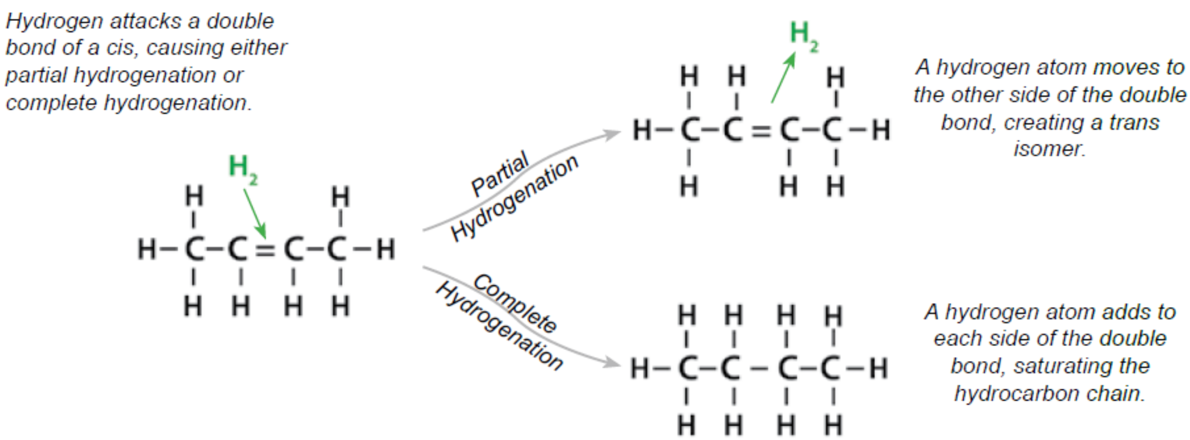


NOW ANSWER QUESTIONS #4-6 ON YOUR ANSWER SHEET

Hydrogenation occurs when hydrogen atoms are added to an unsaturated fatty acid tail, causing double bonds between atoms to become single bonds.

Full hydrogenation occurs when all double bonds convert to single bonds resulting in a saturated fatty acid.

Partial hydrogenation occurs when some of the double bonds are replaced with single ones. Trans fat may be created in partial hydrogenation.



Introduction to Plasma Membranes

The **plasma membrane** is the structural boundary that separates the cell from its surroundings and controls what substances move into and out of the cell it surrounds. As only some substances are allowed to cross the membrane, the plasma membrane demonstrates the property of **selective permeability**. The plasma membrane is also called a cell membrane.

In particular, the plasma membrane of mammalian red blood cells (erythrocytes) has been the focus of cell membrane study because these cells do not contain nuclei or internal membranes. They represent a source from which a pure plasma membrane may be easily isolated for analysis. In 1925, Dutch scientist Evert Gorter and his research assistant F. Grendel extracted lipids from the membranes of a known number of red blood cells which corresponded to a known surface area of plasma membrane. The surface area occupied by a monolayer of the extracted lipid and the air/water interface was then determined. The results of their experiment showed that the surface area of the lipid monolayer was twice that occupied by the erythrocyte plasma membrane, leading to the conclusion that the plasma membrane consists of **lipid bilayers**.

Plasma membranes primarily consist of phospholipids. Note the hydrophobic and hydrophilic regions of the lipid.

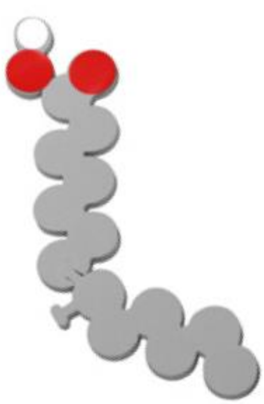
The most abundant lipids in most membranes are phospholipids. The ability of phospholipids to spontaneously form membranes is inherent to their **amphipathic** (containing both hydrophilic and hydrophobic regions) nature. The "head" of a phospholipid is composed of the negatively-charged phosphate groups and may contain other polar groups. The tail of a phospholipid usually consists of long fatty acid hydrocarbon chains.

Focus on Phospholipids

The building blocks of a phospholipid include two fatty acid tails, the glycerol backbone and a phosphate head. In this next activity you will model a dehydration synthesis reaction in the formation of a phospholipid.

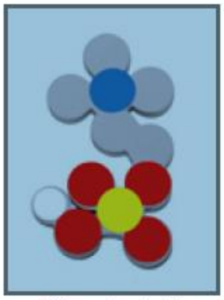
1. Begin with one of the straight-chain fatty acids (saturated), the kinked-chain fatty acid (unsaturated), glycerol and one of the phospholipid heads as the reactants in this simulation.

Straight-Chain Saturated Fatty Acid (Trans Configuration)



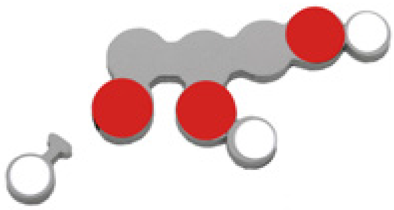
Kinked-Chain Unsaturated Fatty Acid (Cis Configuration)

Glycerol

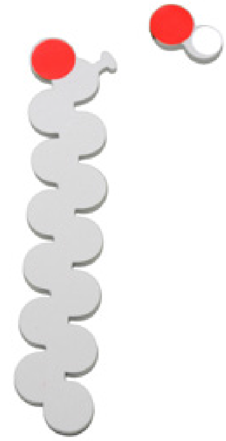


Phosphate Head (Phosphotidlycholine)

2. Remove one of the hydrogen (H) atoms from the glycerol.

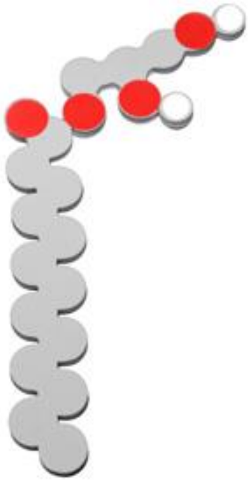


3. Remove the hydroxyl (OH) from one of the fatty acids.

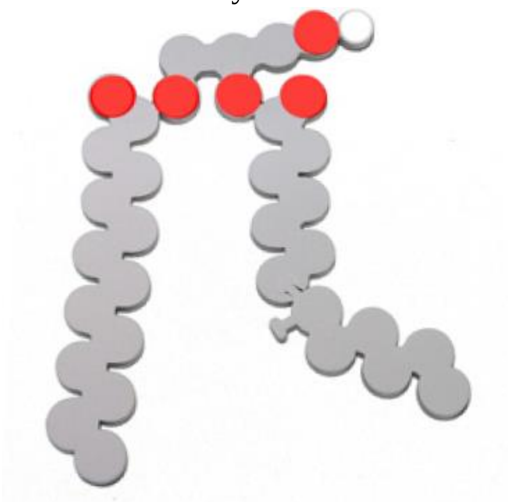


4. Combine the H and the OH.

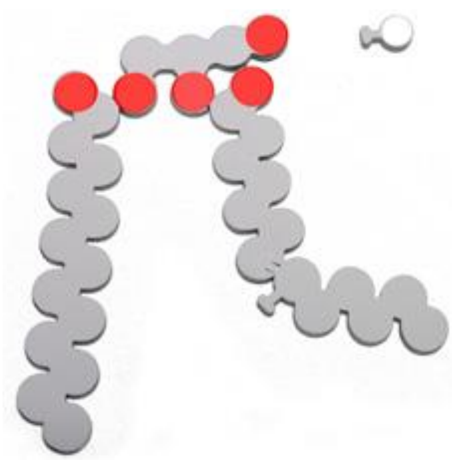
5. Join the fatty acid to the glycerol.



6. Repeat this process with the unsaturated fatty acid.

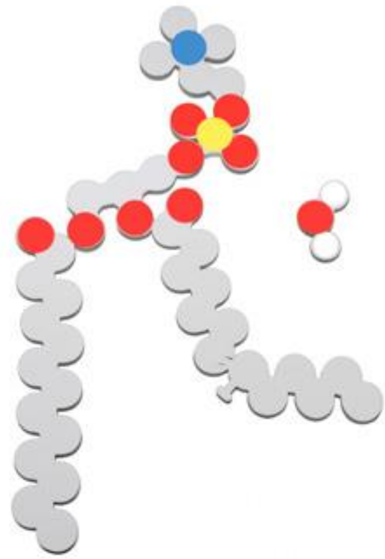


7. Remove the hydroxyl group from the phospholipid head and the final hydrogen (H) atom from the glycerol.



8. Combine the H and the OH.

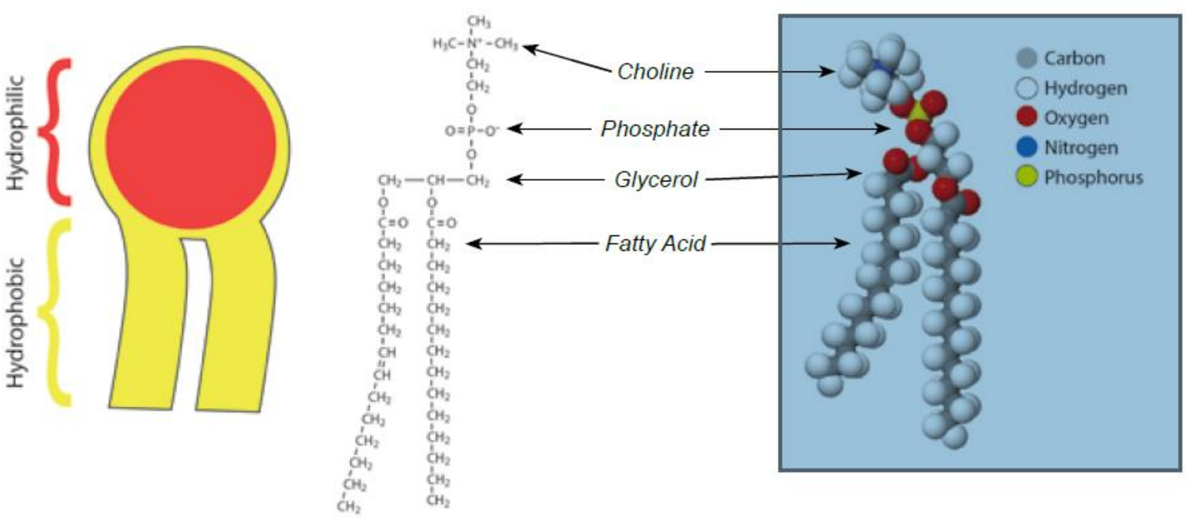
9. Bind the phospholipid head to the glycerol backbone.



NOW ANSWER QUESTIONS #7-9 ON YOUR ANSWER SHEET

There are four major phospholipids that comprise the plasma membrane. Phosphatidylcholine and sphingomyelin make up the outer leaflet layer of the membrane while phosphatidylethanolamine and phosphatidylserine make up the inner leaflet layer of the plasma membrane. Although phosphatidylinositol is a minor membrane component, it plays a major role in cell signaling.

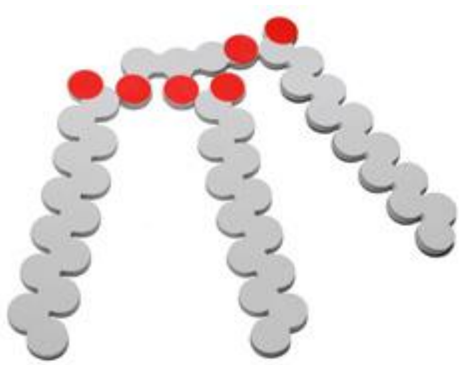
The general structure of a phospholipid is most often represented by the phosphatidylcholine structure:



NOW ANSWER QUESTIONS #10-12 ON YOUR ANSWER SHEET

AP Biology
Membrane Activity #1 Answer Sheet

Name ____________________
Period ___ Date ____________



1. How many water molecules were formed in this reaction? __________

2. What are the final products of this dehydration synthesis reaction?

3. Predict whether you think this resulting triglyceride would most likely be a fat or an oil? ***Explain*** your reasoning.

****

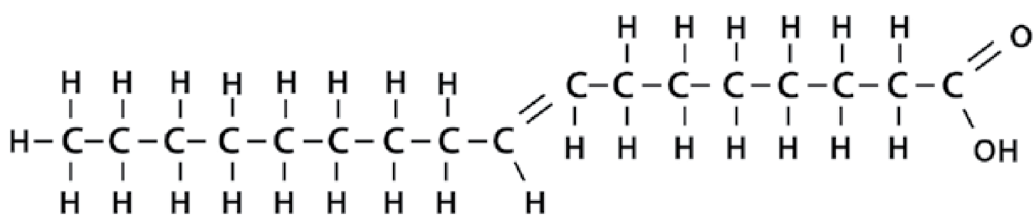
4. Which configuration produces the bigger kink in the structure of the hydrocarbon chain of the triglyceride?

   ____

5. ***Explain*** how the *cis* or *trans* configurations might contribute to the triglyceride being an oil or a fat.

   ____

   ____



6. Is the fatty acid in the diagram above in the *cis* or *trans* configuration? ***Explain***.

   ____

   ____

****

7. What type of reaction was used in the formation of your phospholipid?

   ____

8. Define dehydration synthesis.

   ____

   ____

9. You modeled two dehydration synthesis reactions, one to form a ***triglyceride*** and one to form a ***phospholipid***. Compare and contrast these two reactions in terms of:
   - The parts you combined to form the product
   - The number of water molecules synthesized
   - The hydrophilic/hydrophobic nature of the products formed

****

10. Sketch the specific structural formula of the phospholipid model you synthesized in the space provided below. Label the hydrophilic and hydrophobic regions of your structure.

11. Sketch a simple model in the space below, and label the hydrophilic and hydrophobic portions of this simple model.

12. Examine the 4 different molecules found at the head of the phospholipids: ***phosphatidylserine***, ***phosphatidylinositol***, ***phosphatidylcholine***, and ***phosphatidylethanolamine***. How are they similar? How are they different? How might this be reflected in their function as part of the plasma membrane?