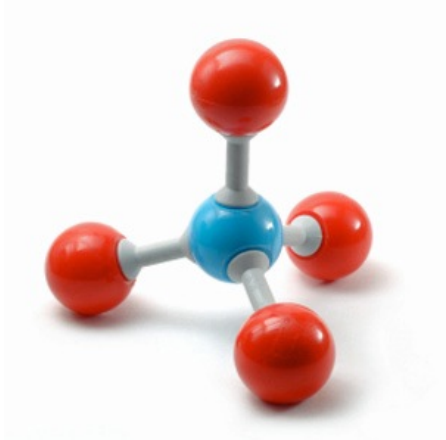
Ch15

# Cell Membranes

Making islands from molecules.

How lipids create cell membranes.

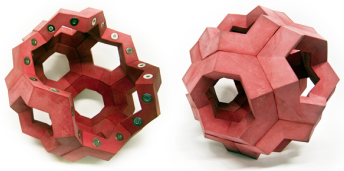


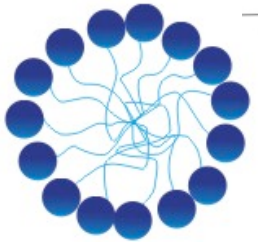
version 1.0

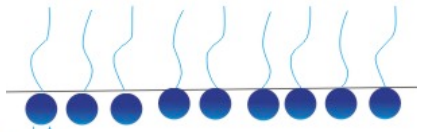
Ch15

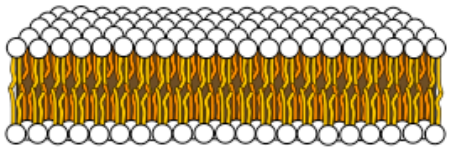
# Cell Membranes

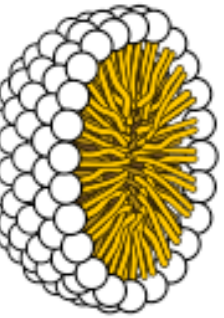
- Self Assembly
  - Amphiphilicity
    - Living in two worlds
  - Phospholipids
    - Glycerophospholipids
      - Lecithin
      - Cephalin
      - Forming Bilayers
    - Sphingomyelin
  - Steroids
    - Steroid Ring System
    - Cholesterol
      - Digestion
      - Lipoproteins
      - Hormones



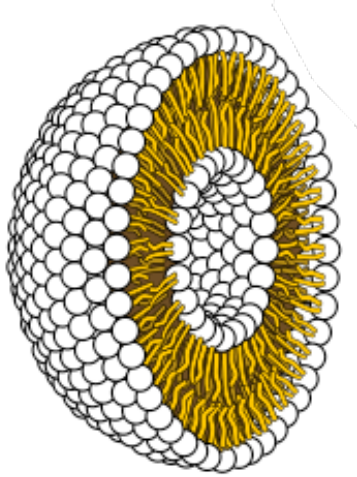


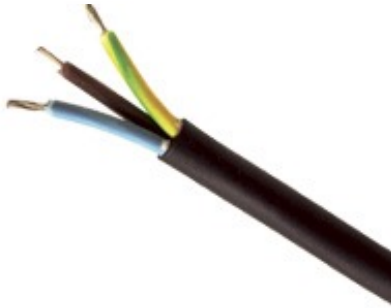


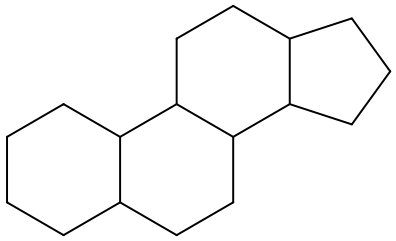


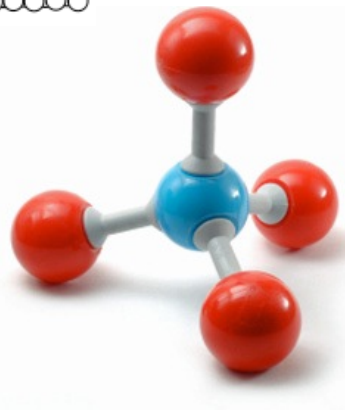


- Cell Membranes
  - Forming Membranes
  - Membrane Structure
  - Transport Across Membranes
    - Diffusion
    - Facilitated & Active Transport

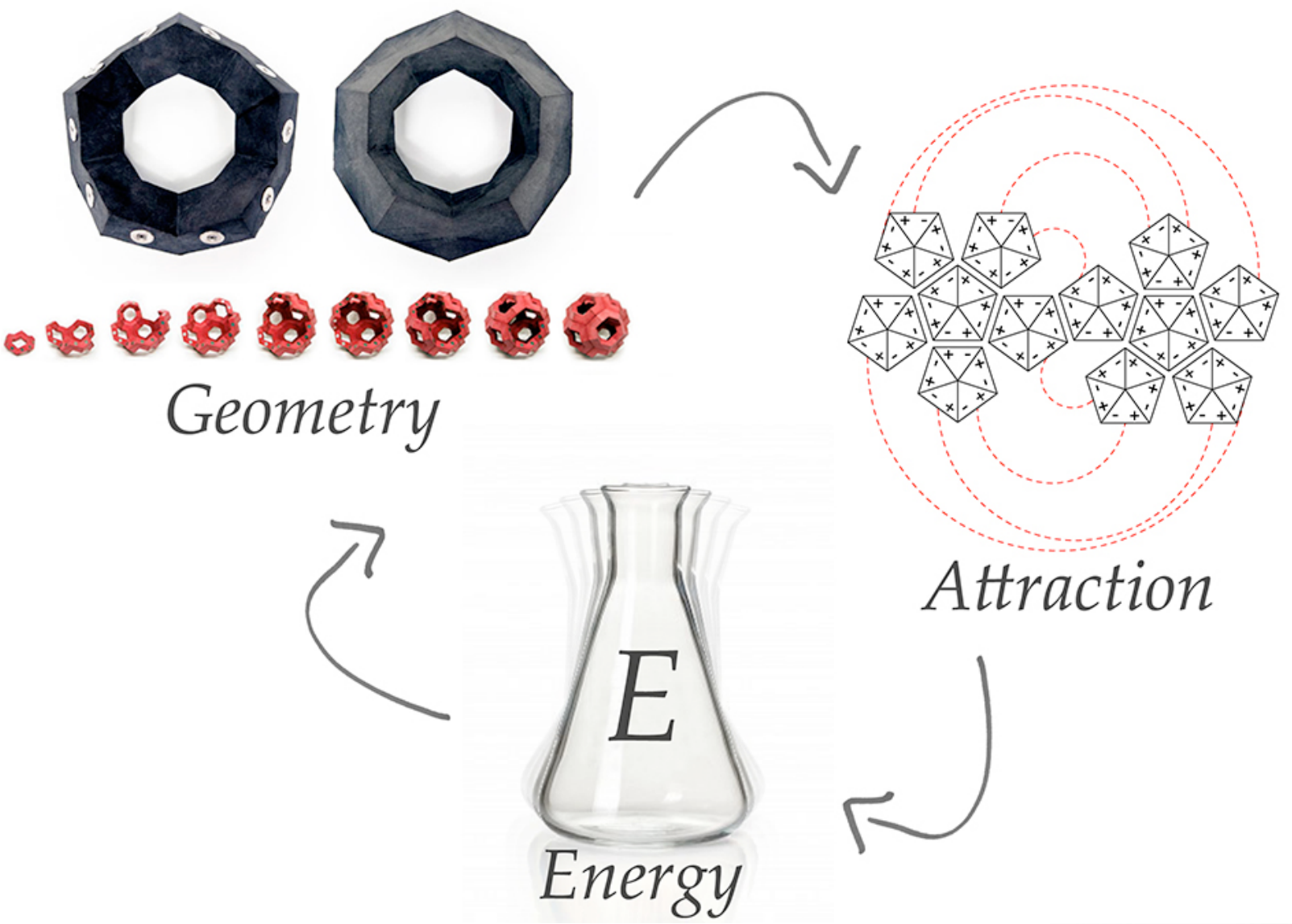






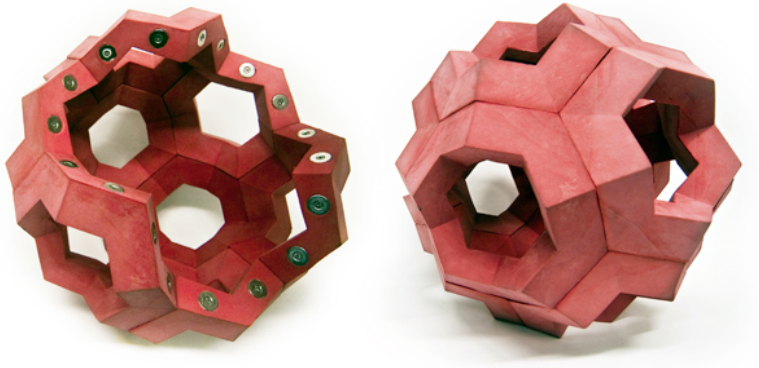


# Self Assembly



# Self Assembly Examples

- Self Assembling Geometry
  - http://chem.ws/selfassemble
- Aerial Assembly
  - http://chem.ws/aerial
- Self Assembling Chair
  - http://chem.ws/chair

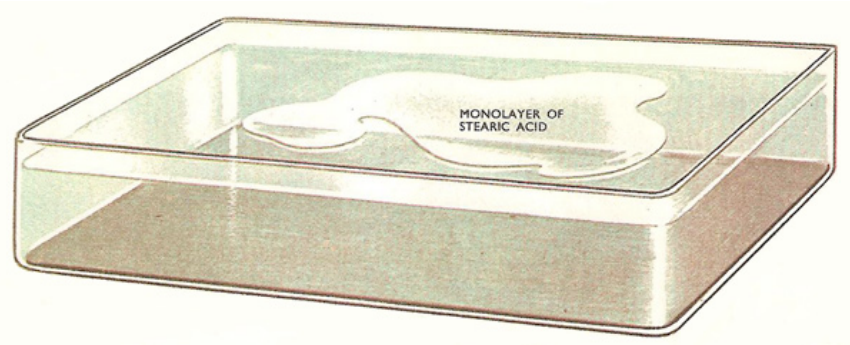



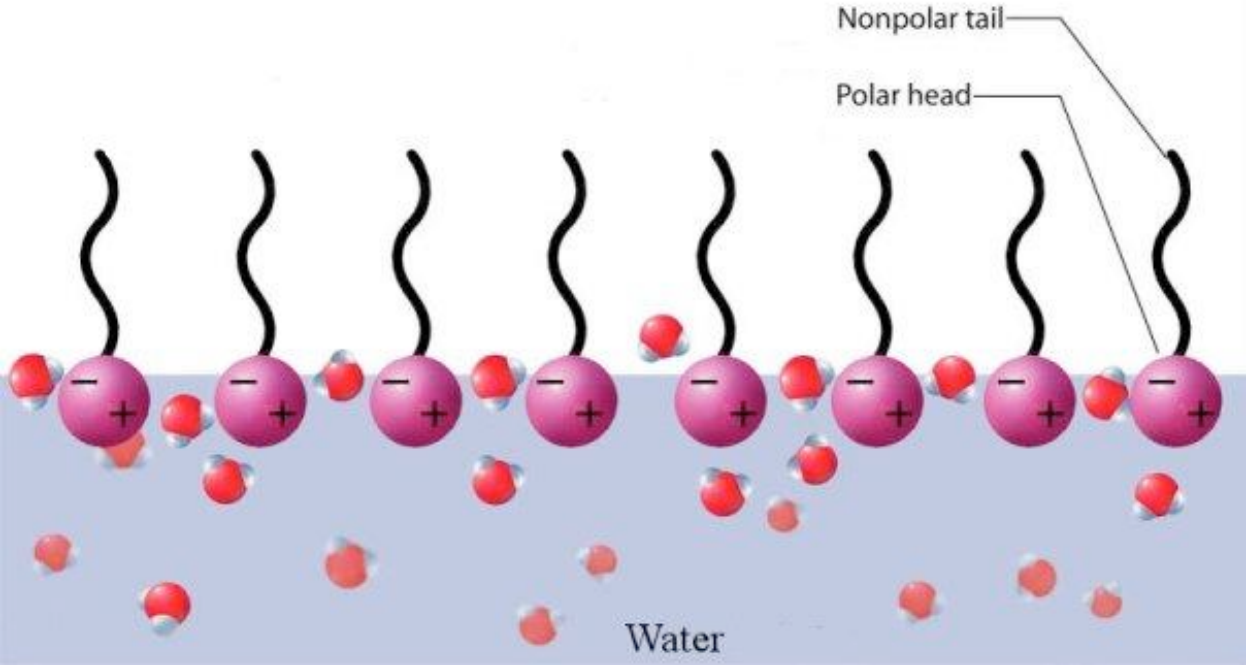
# Amphiphile

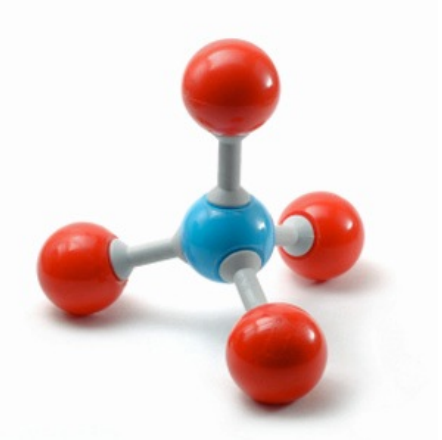
- Hydrophilicity is the property of a substance to mix with water or other polar substances.
- Lipophilicity is the property of a substance to mix with alkanes or other non-polar substances.
  - Triglycerides are lipophilic. They'll mix with non-polar substances but run away from polar ones.
  - Triglycerides are our containers for the carbon chains we need to build molecules in our bodies. Bodies that contain a lot of water.
    - Lipophilic substances tend to be hydrophobic, they run away from water.
- Biologies solution is to modify those triglycerides to give them the necessary property to live in both worlds.
- Amphiphilicity is a property of substances to have both hydrophilic (water-loving, polar) and lipophilic (fat-loving, non-polar) properties.
    - In the same molecule.
    - It's uncommon.
- Phospholipids are molecules that contain lipids (fatty acids) but have this dual nature.
- Amphilphilicity allows molecules to self assemble into complex and useful structures.

# Amphiphile Behavior

- Amphiphiles form monolayers on the surface of water.
- With one end being attracted to water and the other repelled they form very ordered structures.



# Amphiphile Behavior

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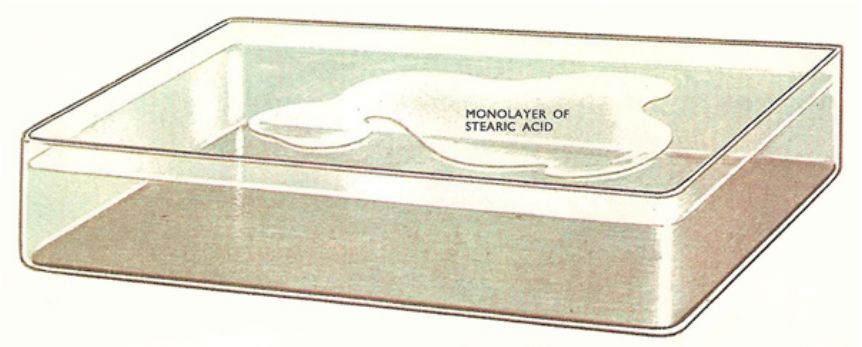
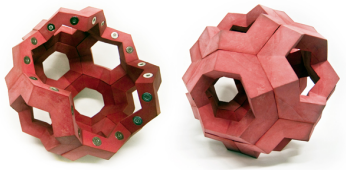
- It's possible to produce a layer of stearic acid on water surface that is one molecule thick.




Ch15

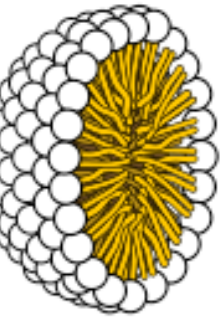
# Cell Membranes

- Self Assembly
  - Amphiphilicity
    - Living in two worlds



- Phospholipids
  - Glycerophospholipids
    - Lecithin
    - Cephalin
    - Forming Bilayers
  - Sphingomyelin

- Steroids
  - Steroid Ring System
  - Cholesterol
    - Digestion
    - Lipoproteins
    - Hormones



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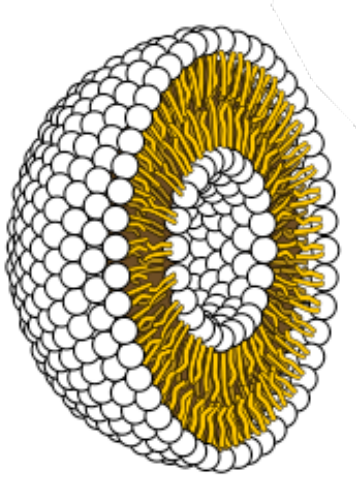
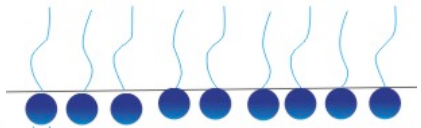
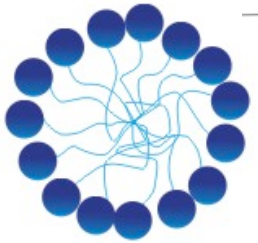
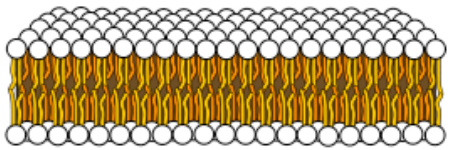
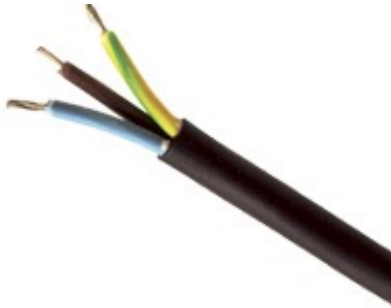
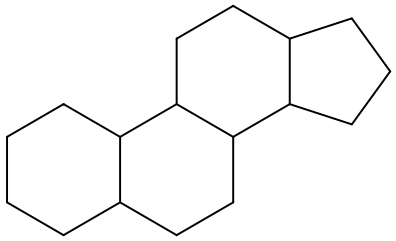


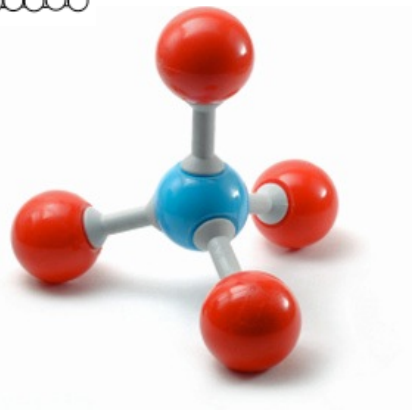






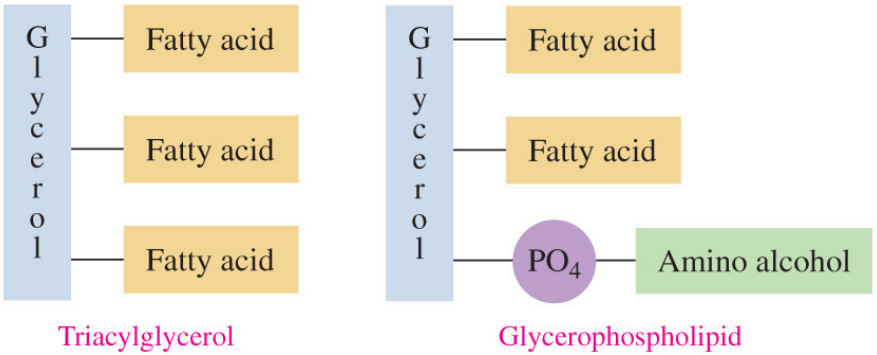


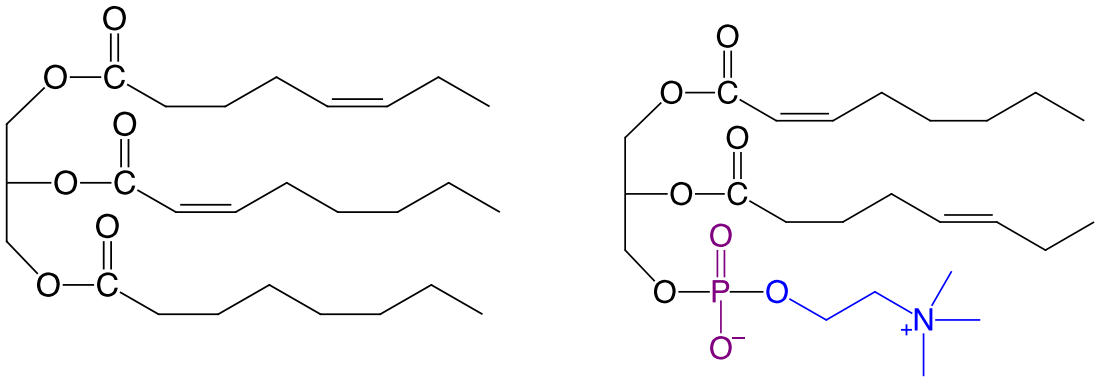


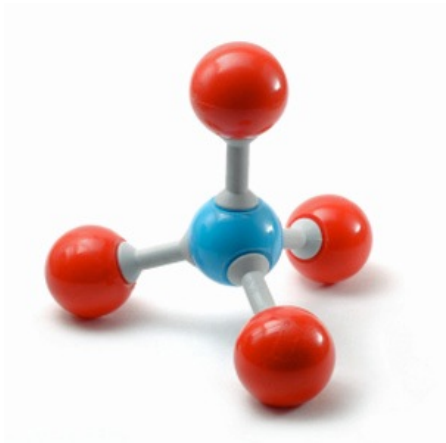


# Phospholipids

- The phospholipids are a family of lipids similar in structure to triacylglycerols.
- They include glycerophospholipids and sphingomyelin.
- They incorporate an amino alcohol and a phosphate group.

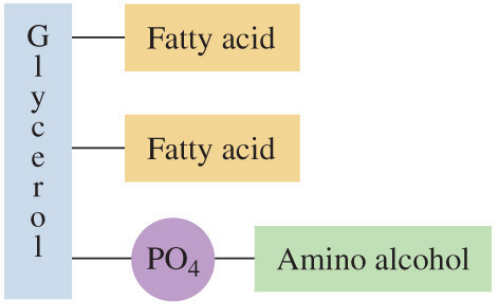


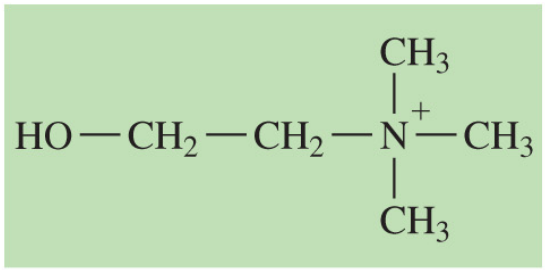


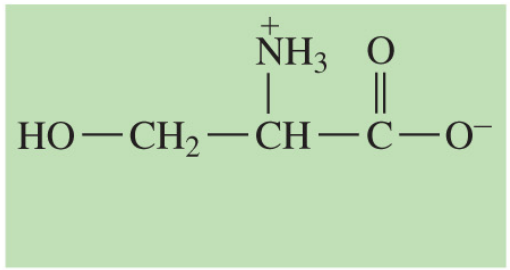
# Glycerophospholipids

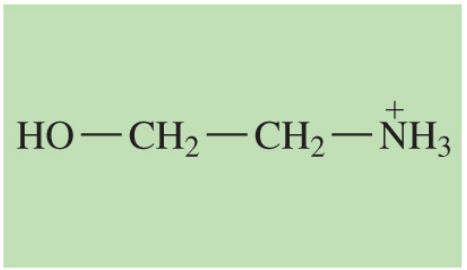
- Amino alcohols found in glycerophospolipids
  - are choline, erine, and ethanolamine
  - are ionized at physiological pH of 7.4
- These amino alcohols are attached with a phosphate group.

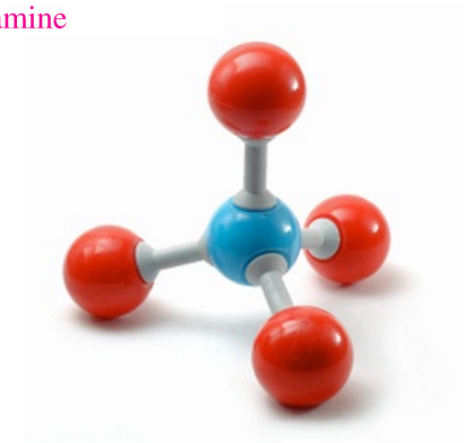


Glycerophospholipid


Choline

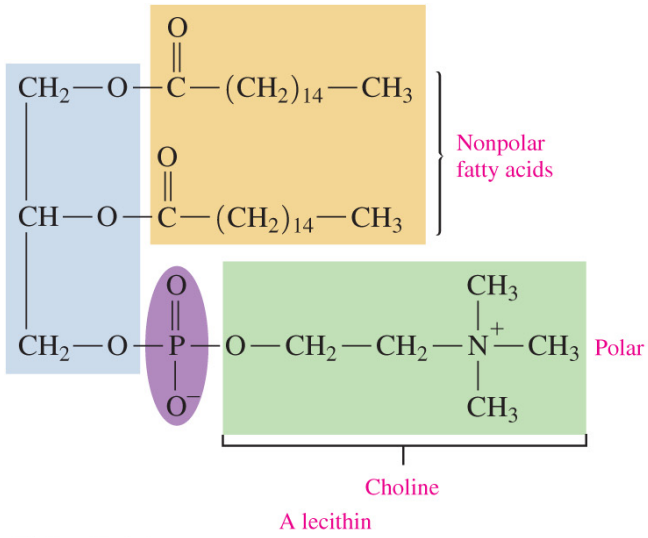

Serine

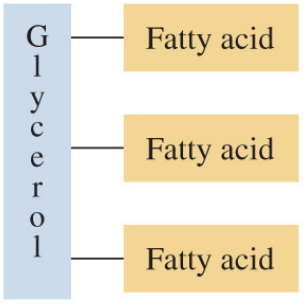

Ethanolamine



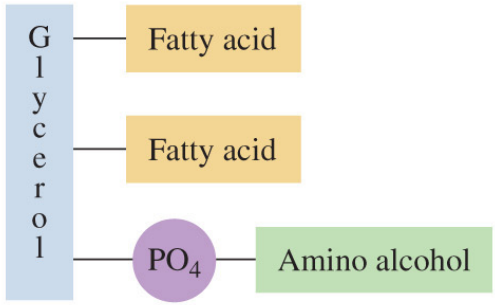
# Lecithin

- Lecithin a type of glycerophospholipid
  - It's used in brain and nerve tissue.
  - It's like a triglycerol, but one of the ester bonds is replaced with phosphoester bond.
  - Phophate links an amino acohol (choline) in one of the ester "sockets"
    - The other two sockets are free to carry or utilize various fatty acids.

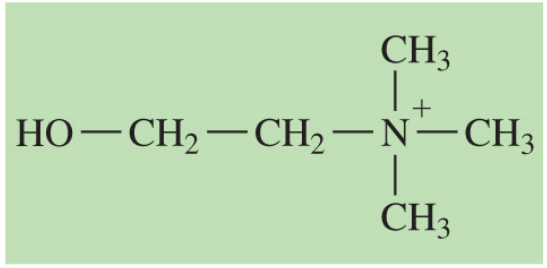


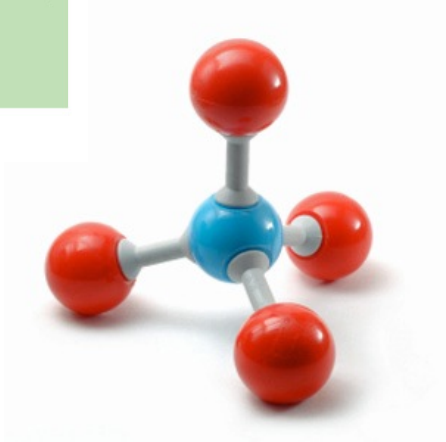



Triacylglycerol



Glycerophospholipid


Choline



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  - It's also used in brain and nerve tissue.
  - It's like a triglycerol, but one of the ester bonds is replaced with phosphoester bond.
  - Phophate links an amino acohol (ethanolamine) in one of the ester "sockets"
  - In brain tissue it sometimes uses serine instead.
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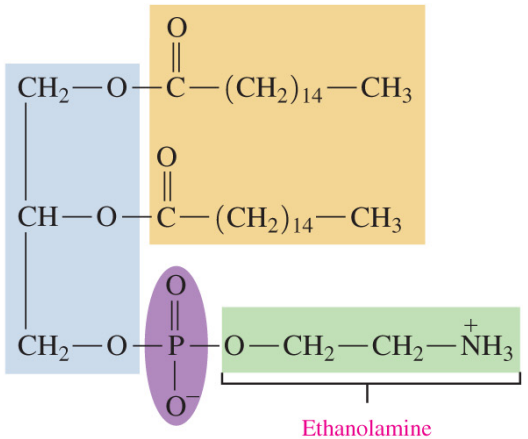
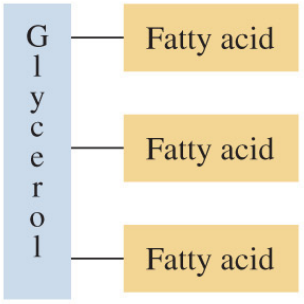
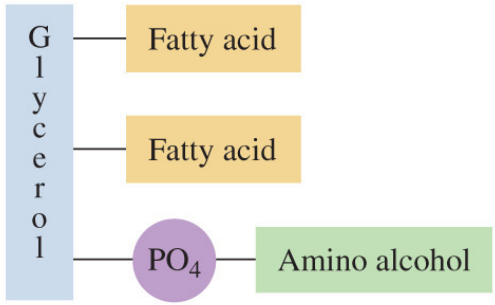


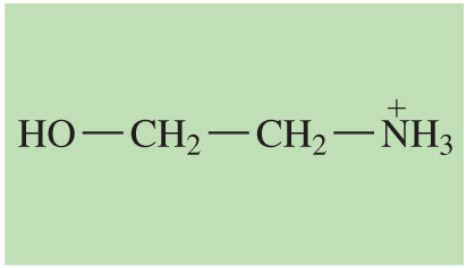

A cephalin

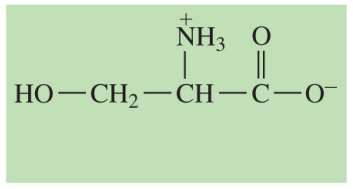


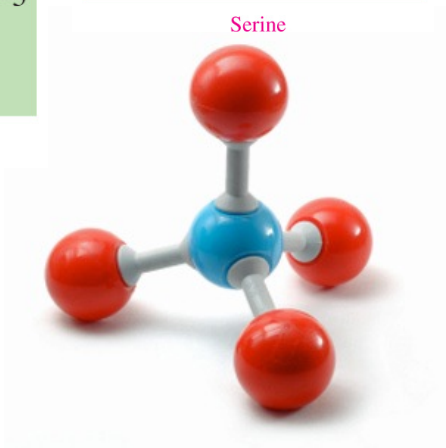

Triacylglycerol




Glycerophospholipid

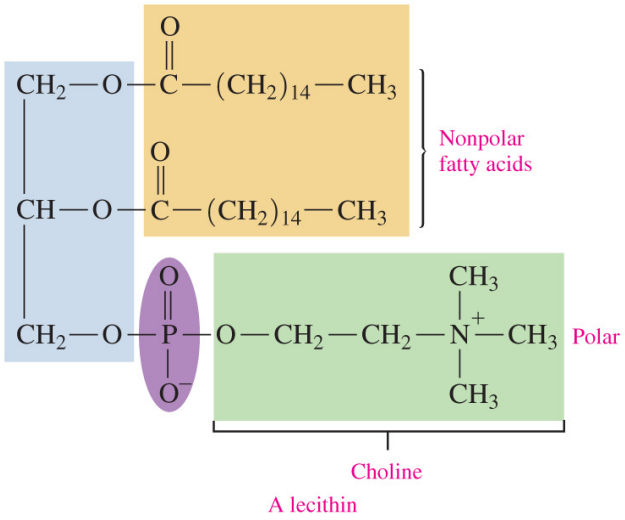


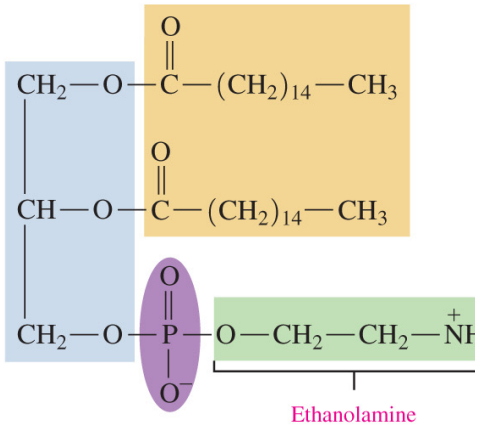



# Glycerophospholipids

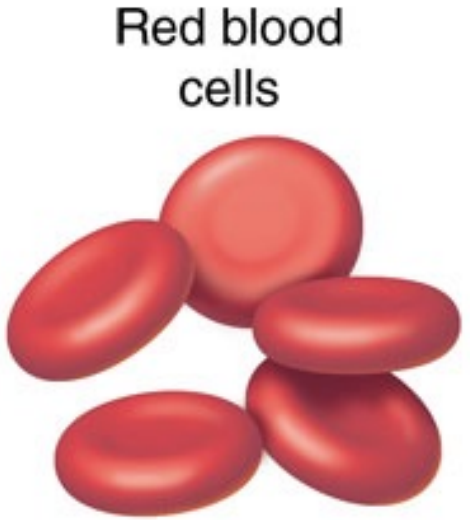
- Both lecithin and cephalin…
  - Are found in egg yolk, wheat germ, and yeast.
  - Are used to build structures, including the cell walls of red blood cel
  - Are used to build an insulating envelope that surrounds the core of a nerve fiber.
    - Called the medullary sheath of myelin sheath.
  - These glycerophospholipids facilitate the transmission of nerve impulses and long the fiber.

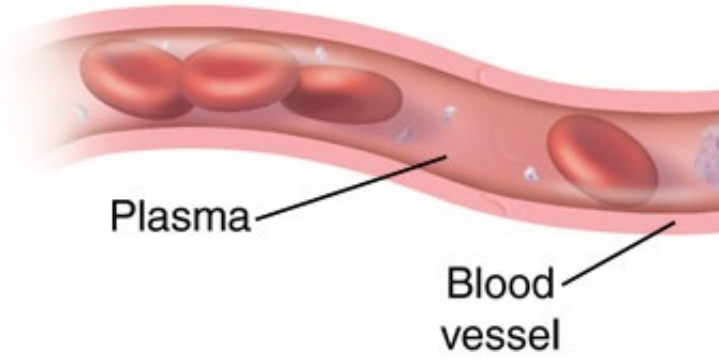


A lecithin



A cephalin



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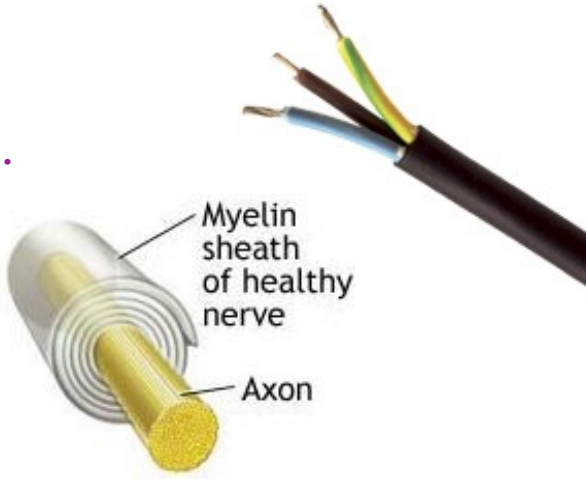
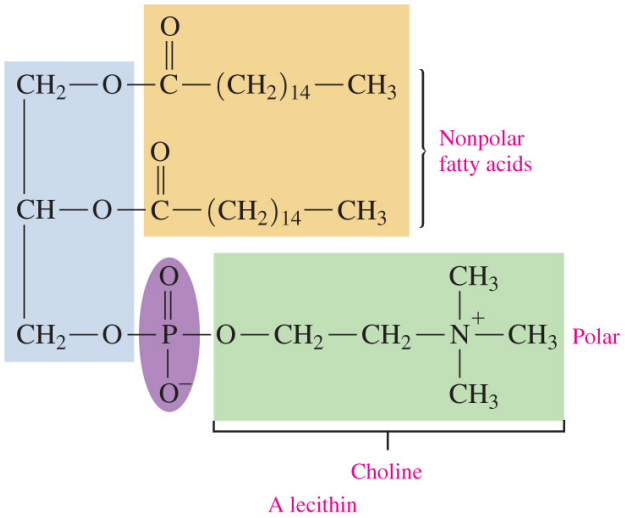
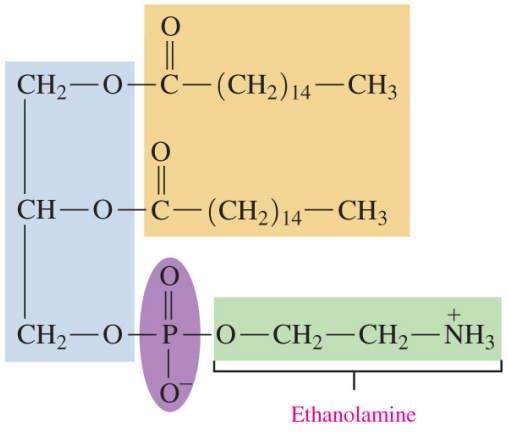
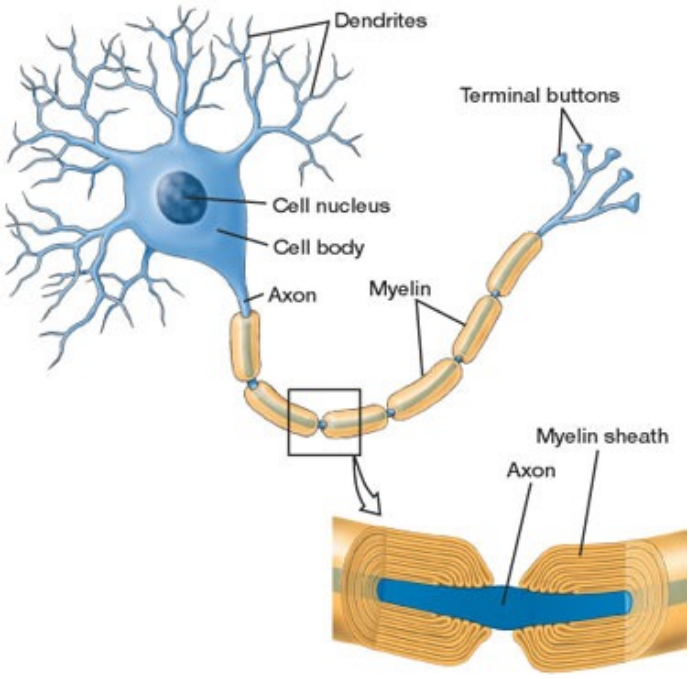


A lecithin

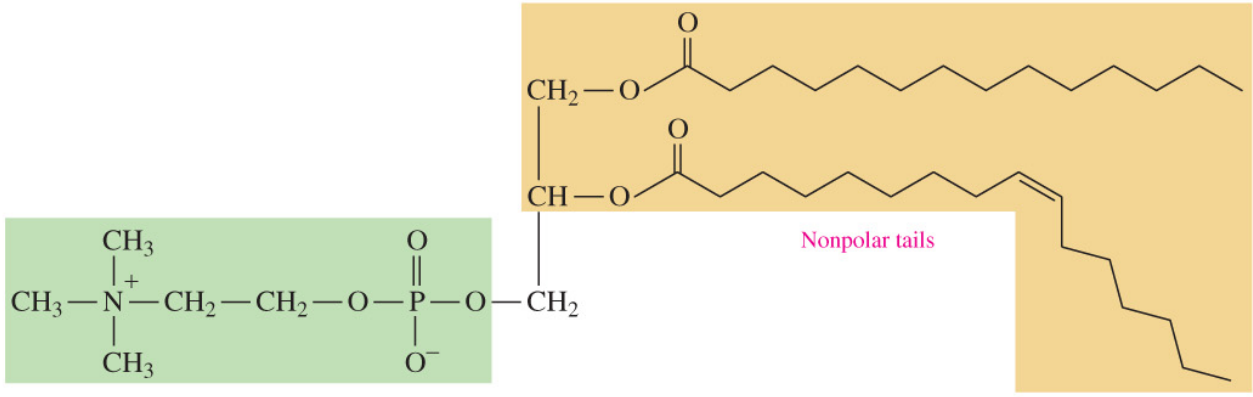


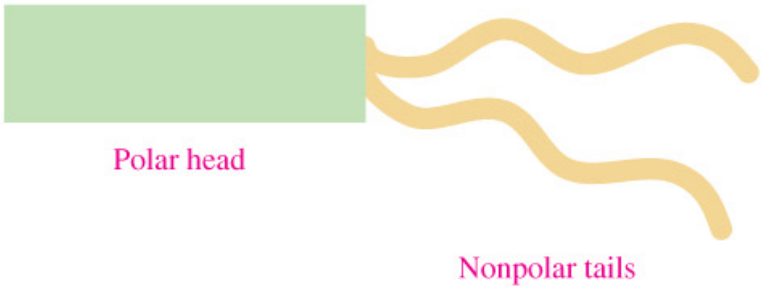
A cephalin

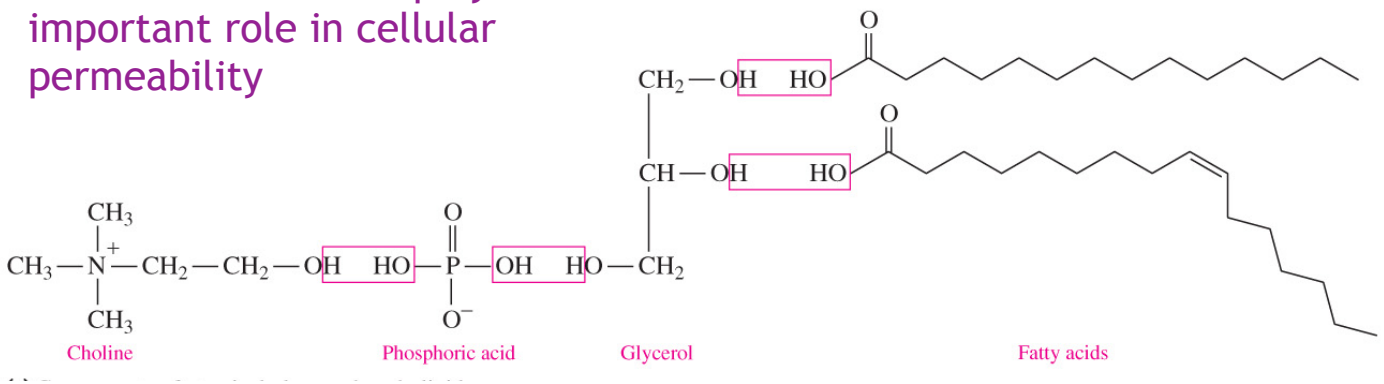


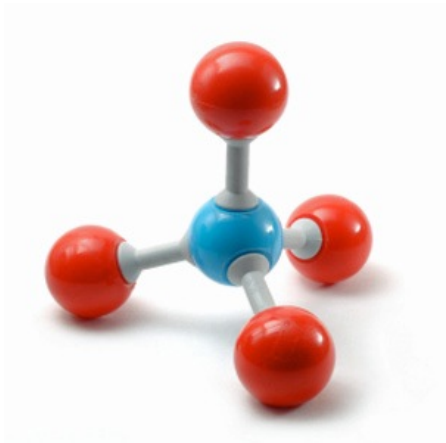
# Glycerophospholipids

- Glycerophospholipids
  - have both polar and nonpolar regions that allow them to interact with polar and nonpolar substances
    - have a polar head containing the ionized amino alcohol and phosphate portion, which is strongly attracted to water
    - have a nonpolar hydrocarbon tail portion soluble only in nonpolar substances such as lipids
  - are the most abundant lipids in cell membranes and play an important role in cellular permeability



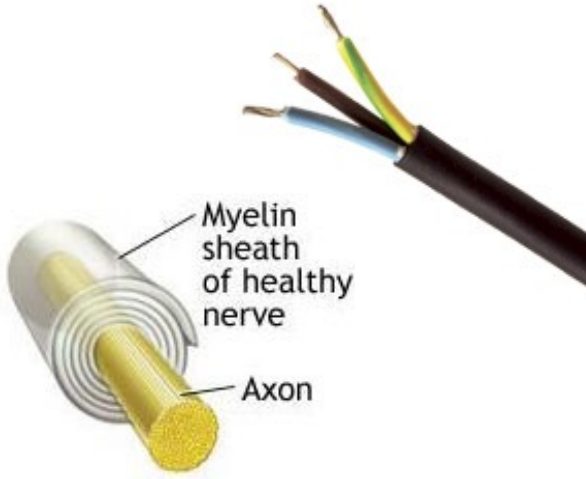



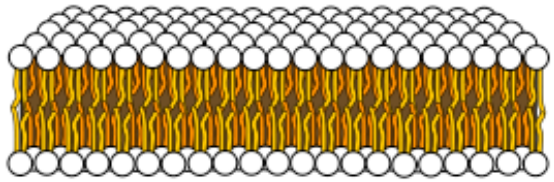



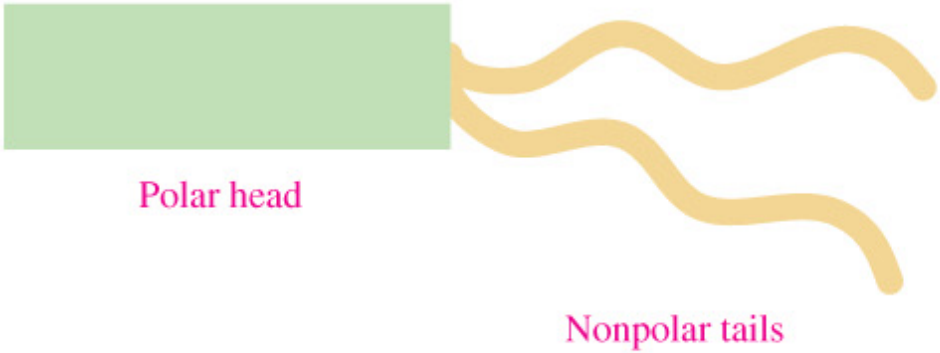



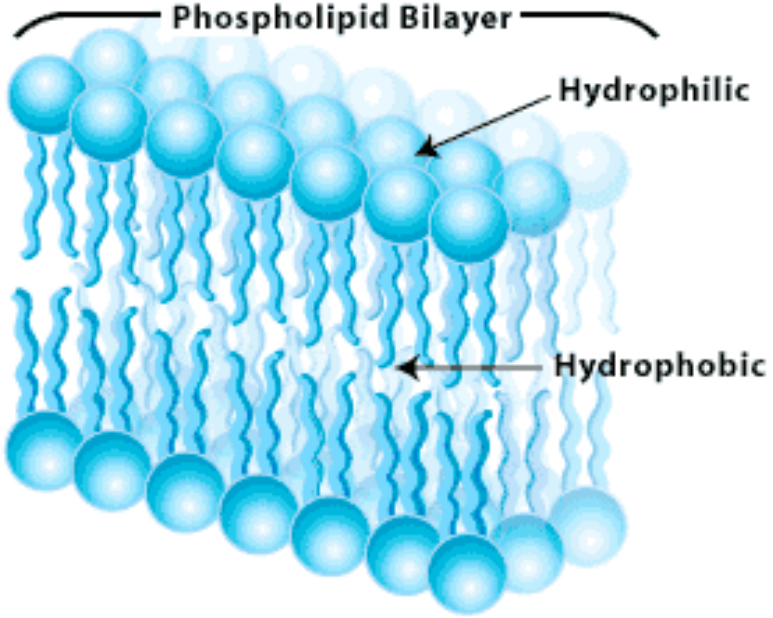
# Glycerophospholipids

- Glycerophospholipids order themselves to form a bilayer.
- This bilayer forms into sheets, including the myelin sheath and cell walls.
- Ways the body segments off areas at the cellular level, provides insulation, protection or directs the flow of processes.



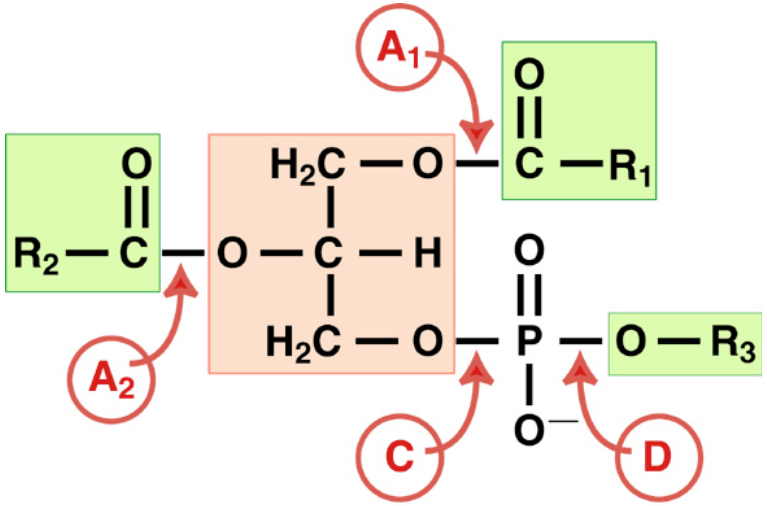



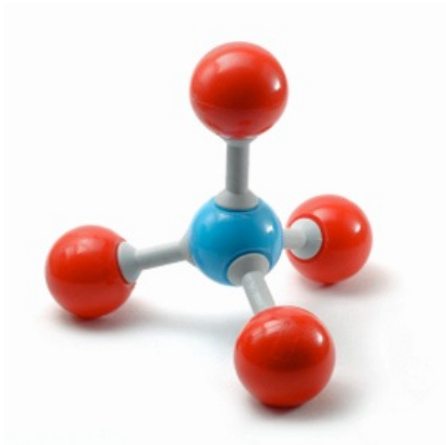


# Snake Venom

- Snake venom contains phospholipases.
- Phospholipases are enzymes that release fatty acids from the second carbon group of glycerol.
- The particular phospholipases in snake venom specifically recognizes the sn-2 acyl bond of phospholipids and catalytically hydrolyzes the bond releasing arachidonic acid and lysophospholipids.
- It breaks down glycerophospholipids and therefore all the structures built from them.
  - Including blood cells, brain matter, nerve insulation…



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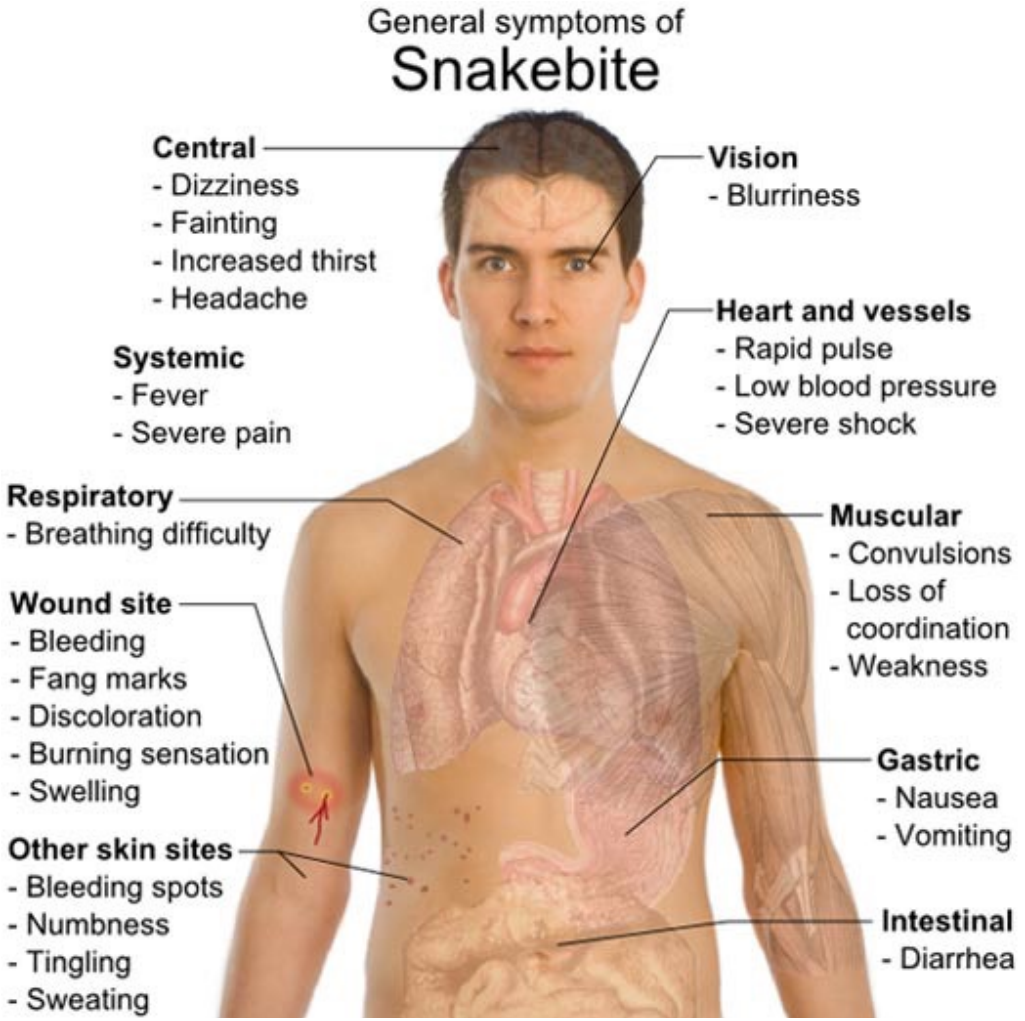
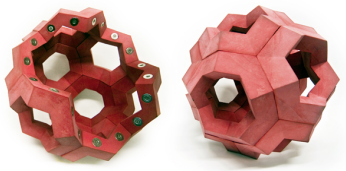
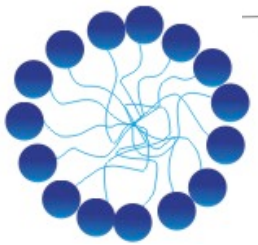


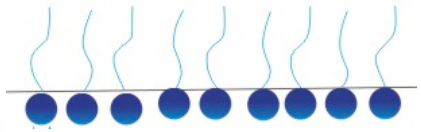
Ch15

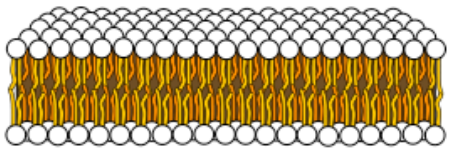
# Cell Membranes

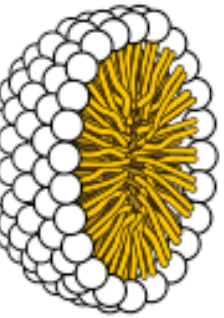
- Self Assembly
  - Amphiphilicity
    - Living in two worlds
- Phospholipids
  - Glycerophospholipids
    - Lecithin
    - Cephalin
    - Forming Bilayers
  - Sphingomyelin
- Steroids
  - Steroid Ring System
  - Cholesterol
    - Digestion
    - Lipoproteins
    - Hormones

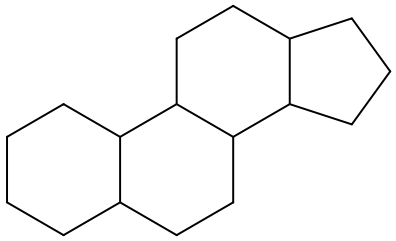




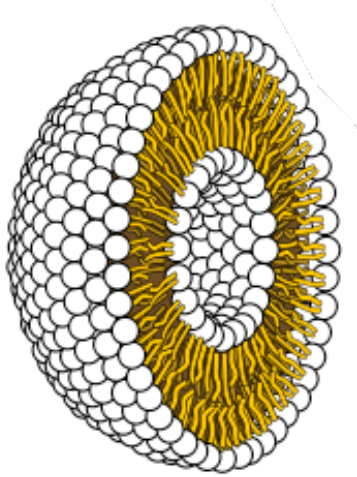


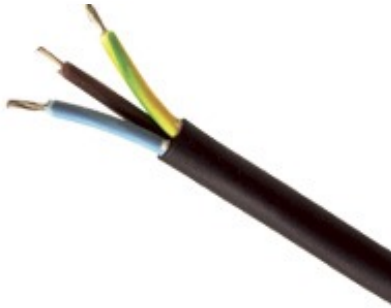


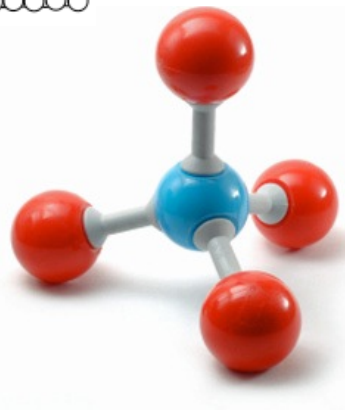




- Cell Membranes
  - Forming Membranes
  - Membrane Structure
  - Transport Across Membranes
    - Diffusion
    - Facilitated & Active Transport

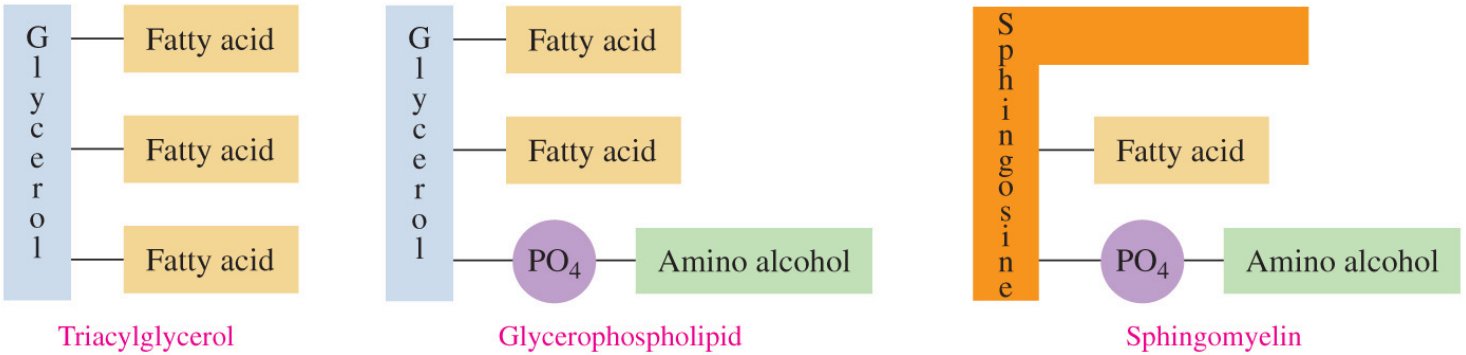


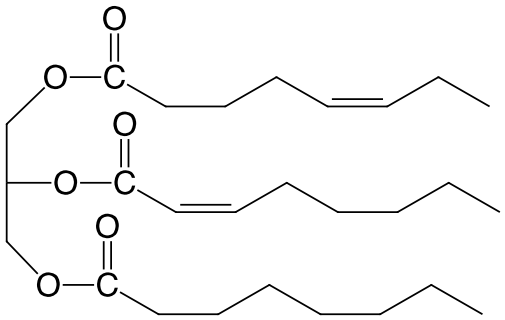


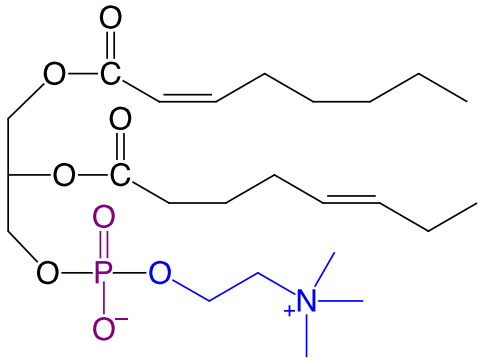


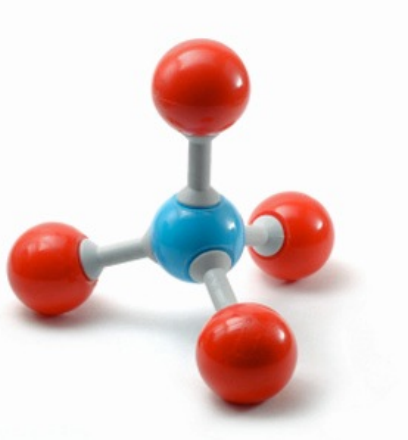
# Phospholipids

- The phospholipids are a family of lipids similar in structure to triacylglycerols.
- They include glycerophospholipids and sphingomyelin.
- They incorporate an amino alcohol and a phosphate group.



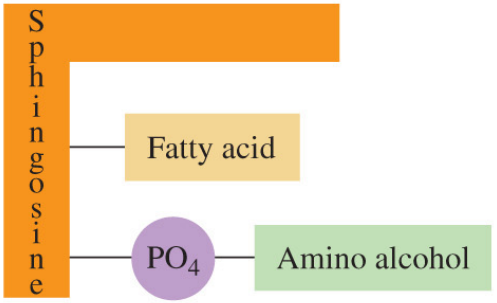



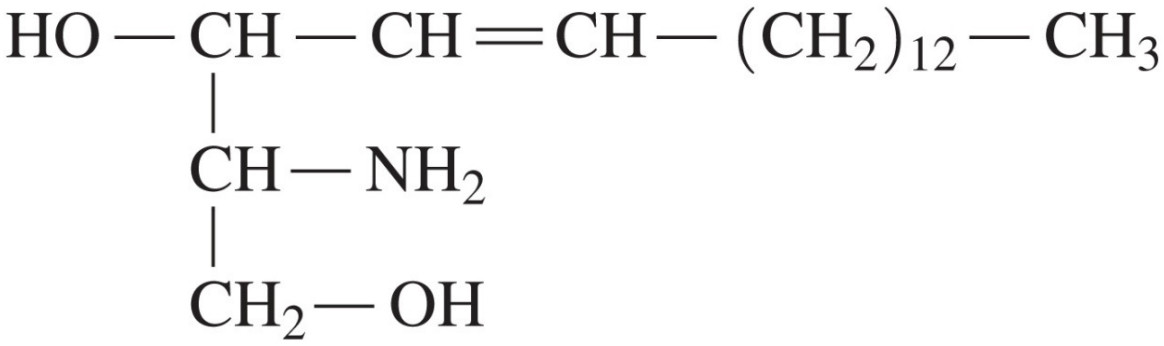




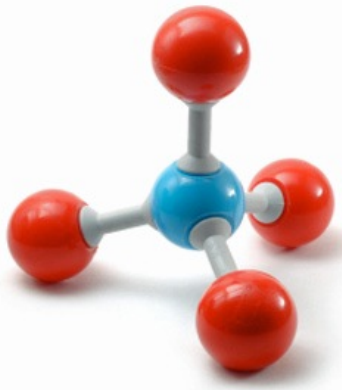
# Sphingomyelin

- In a sphingomyelin,
  - the amine group of sphingosine forms an amide bond to a fatty acid
  - the hydroxyl group forms an ester bond with phosphate, which forms another phosphoester bond to choline or ethanolamine
- Sphingomyelins are abundant in the white matter of the myelin sheath.
- The make up about 20% of blood plasma membrane lipids.




Sphingosine



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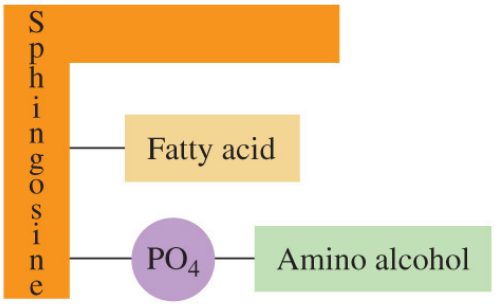
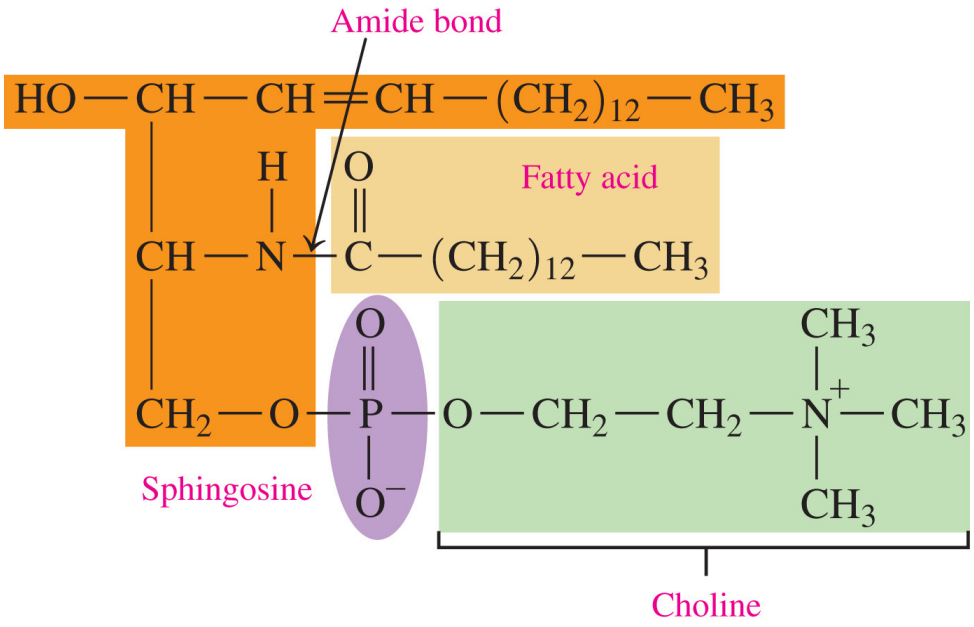
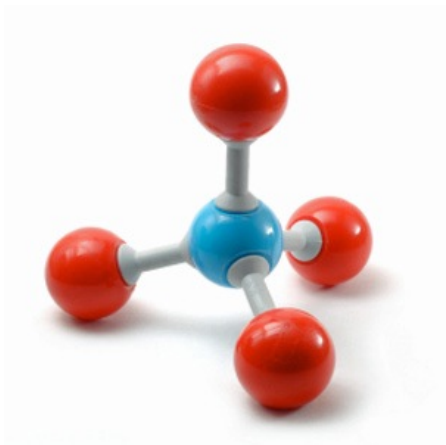
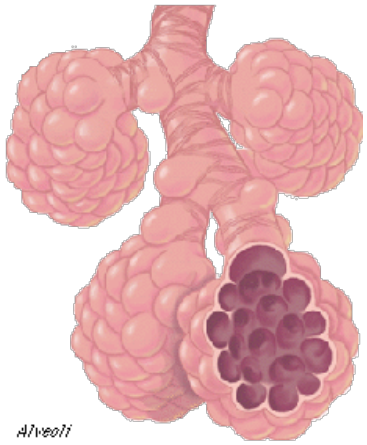


# Respiratory Distress (RDS)

- Respiratory distress syndrome (RDS) is a breathing disorder that affects newborns. RDS rarely occurs in full-term infants.
- Lungs have air sacks, alveoli, where $O_2$ is taken into the body and $CO_2$ is released.
- These organic structures need to pull away from each other to allow air in.
- Your body promotes this by releasing a mixture phospholipids rich in sphingomyelin into the alveoli.
- The sphingomyelin coats the inside of the alveoli, the lipidophlic part binds to the inside of the lung reducing surface tension and causing the sacks to separate.
- Without enough sphingomyelin, aveoli collapse and the infant has to work harder to breath.

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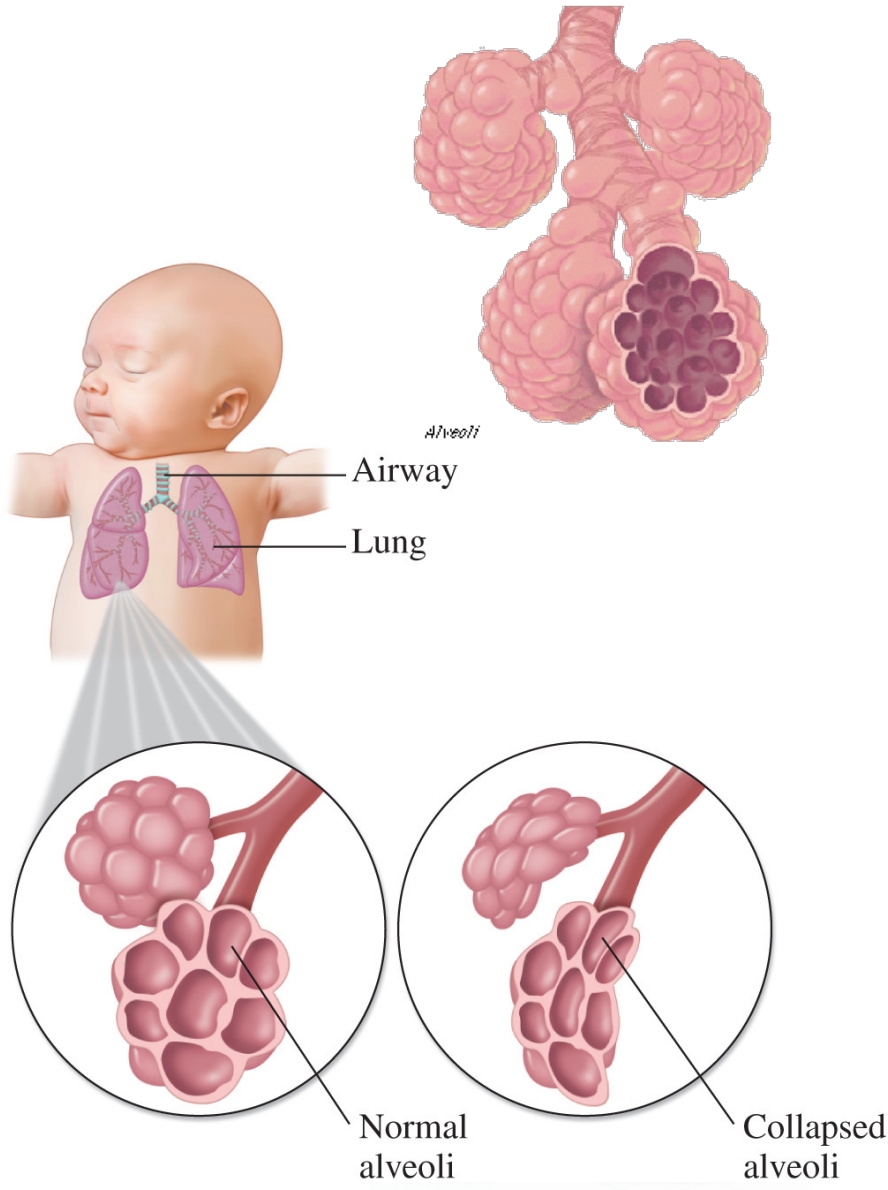

Ch15

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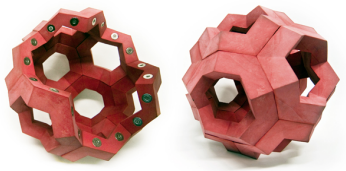

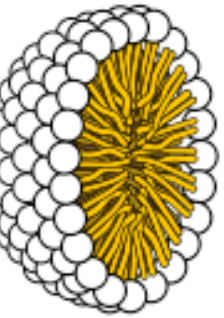

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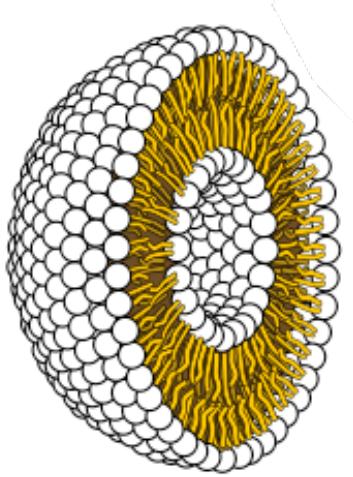
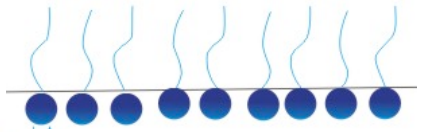
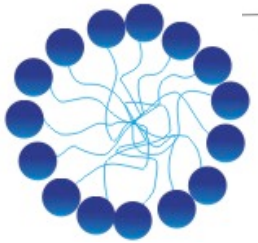
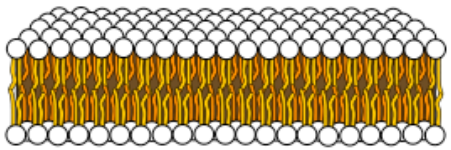
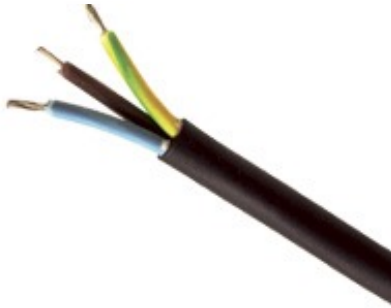
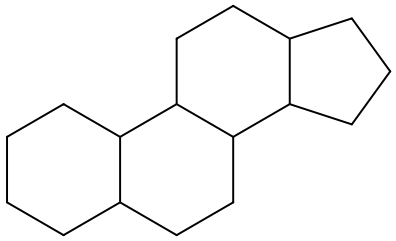


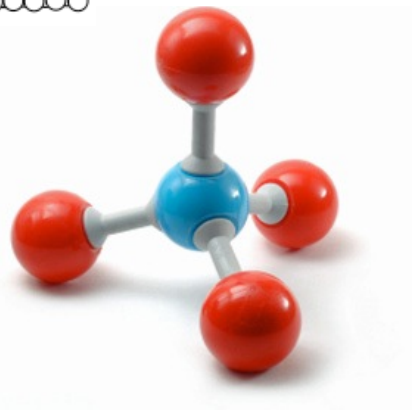






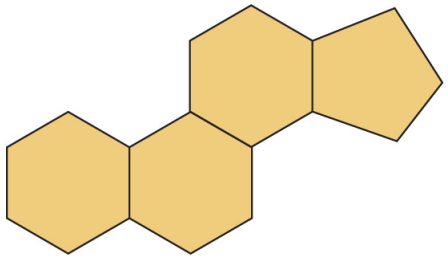


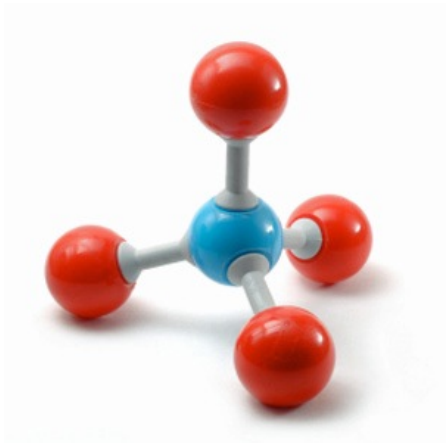




# Steroids

- Steroids are a family of compounds distinguished by a unique ring system.
- All steroids have a ring system of…
  - three cyclohexane rings
  - one cylopentane ring, fused together
- These rings are called the steroid nucleus.





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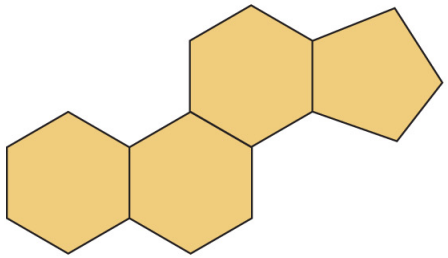
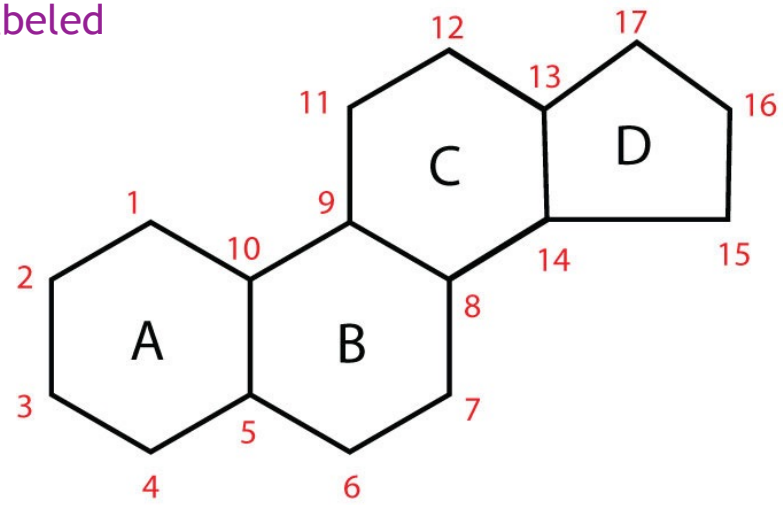
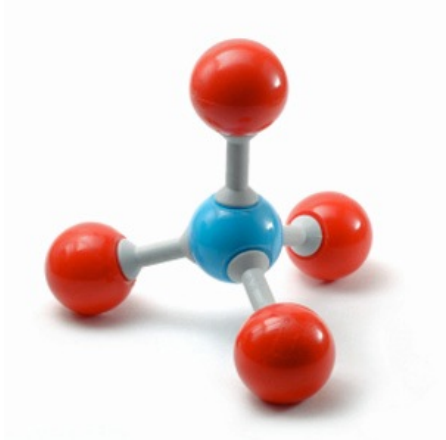
- These rings are called the steroid nucleus.
- Steroid
  - rings are designated as A, B, C, and D
  - carbon atoms are numbered beginning in ring A
  - two methyl groups that may be attached to carbon-10 and 13 are labeled carbons 18 and 19

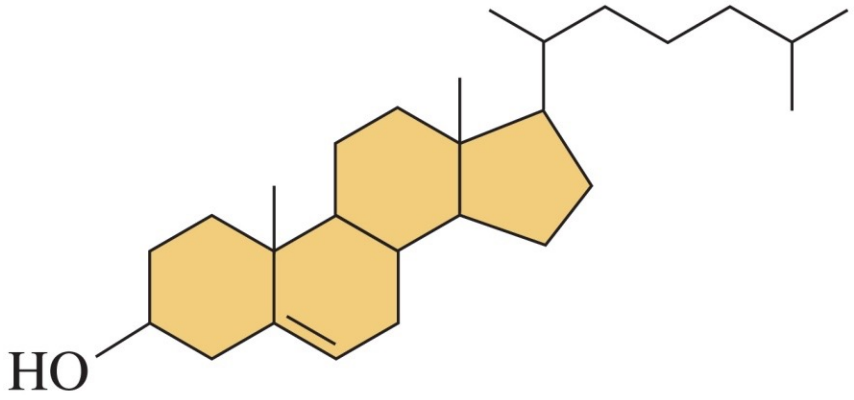




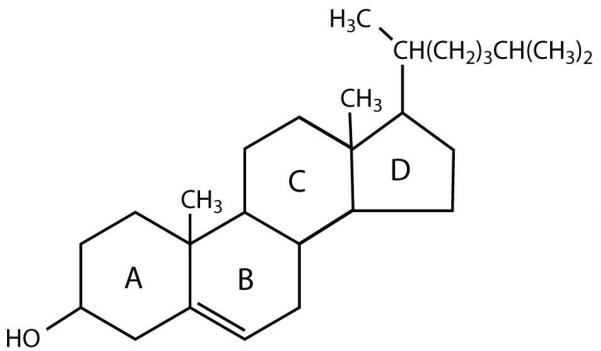



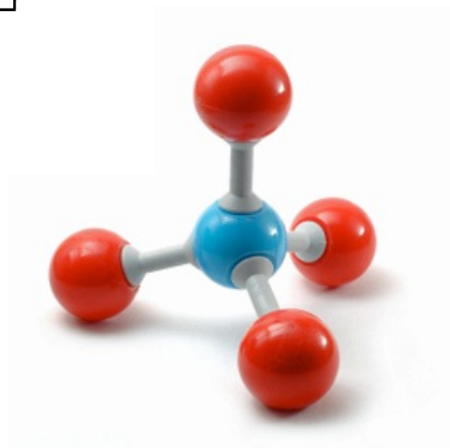
# Cholesterol

- Cholesterol, from the Ancient Greek chole- (bile) and stereos (solid) followed by the chemical suffix -ol for an alcohol.
- Cholesterol
  - is the most important and abundant steroid in the body
  - has an hydroxyl group (— OH) on (carbon 3)
  - has a double bond between carbons 5 and 6
  - has methyl groups at carbons 10 and 13
  - has an alkyl chain at carbon 17
- Cholesterol is a sterol (an alcohol made from a modified steroid).
- It is made by all animal cells and is an essential structural component of all animal (not plant or bacterial) cell membranes
- It provide both membrane structural integrity and fluidity.



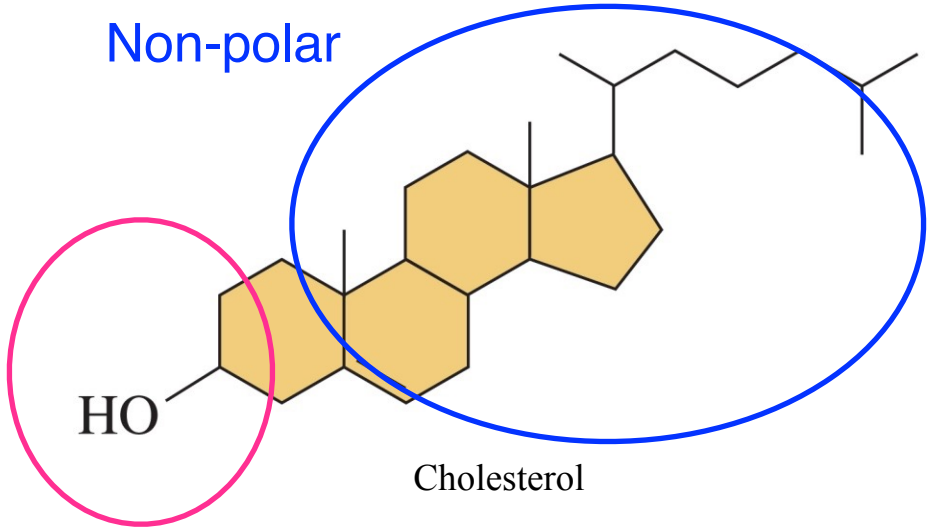

Cholesterol

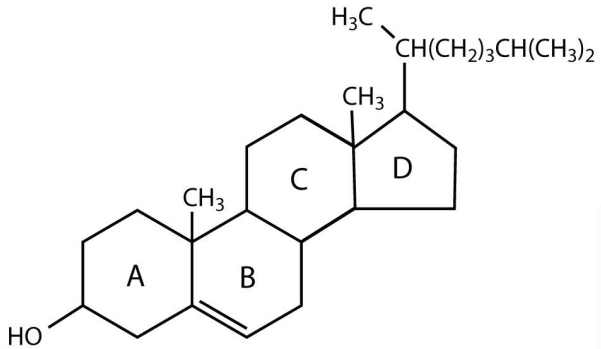


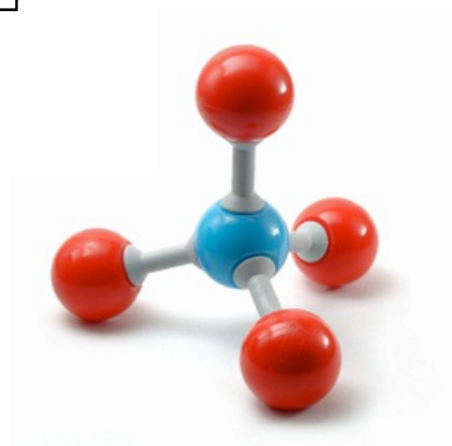



# Cholesterol

- Cholesterol, from the Greek chole- (bile) and stereos (solid) followed by the chemical suffix -ol for an alcohol.
- Cholesterol is amphiphilic.
  - It has a polar hydrophilic end.
  - It has a non-polar lipophilic end.

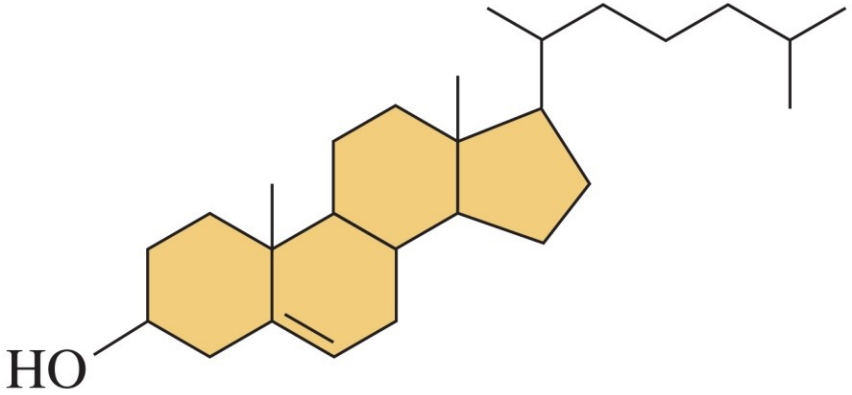


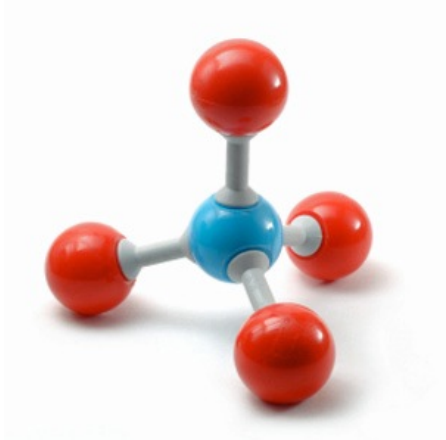



# Cholesterol

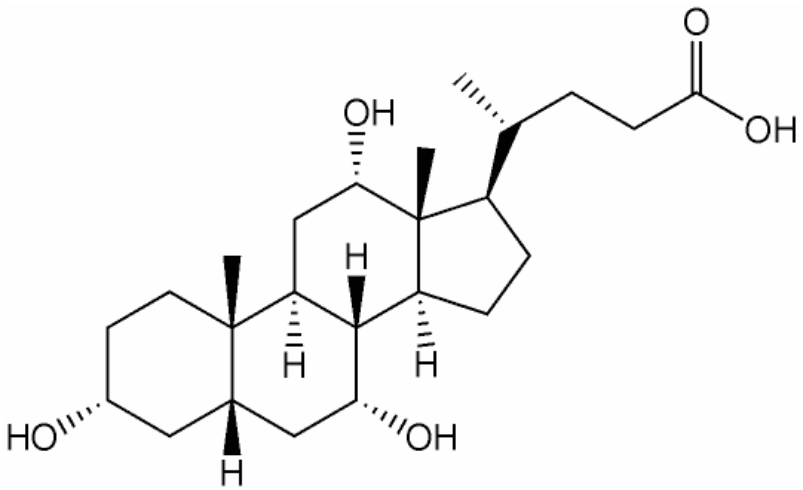
- How we use cholesterol.
  - Digestion
    - Bile Salts & Micelles
  - Fatty Acid Esters
  - Lipoproteins
    - LDL
    - HDL
  - Steroid Hormones

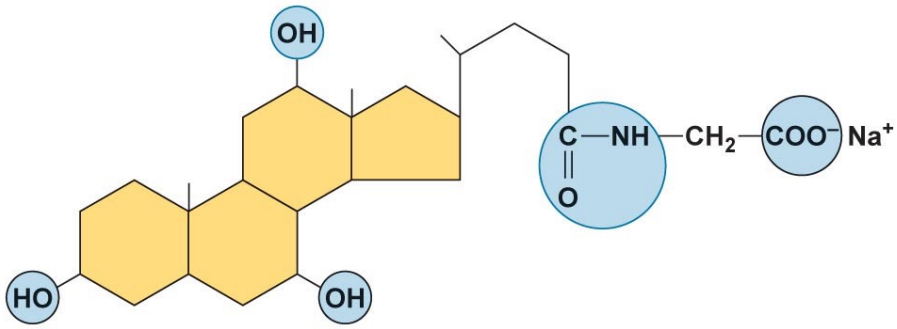


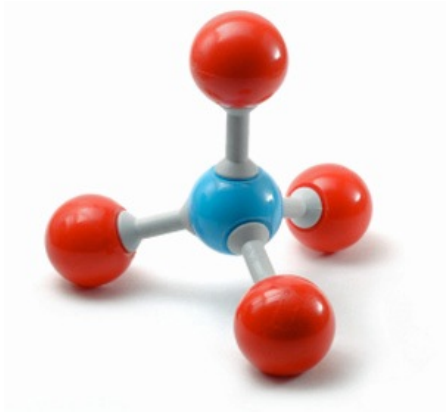



# Cholesterol in Digestion

- One of the principle uses of cholesterol in the body is the production of bile acids.
- Cholic acid is the primary bile acid produced.
- Synthesis of bile acids is a major route of cholesterol metabolism in most species other than humans.
- The body produces about 800 mg of cholesterol per day and about half of that is used for bile acid synthesis producing 400–600 mg daily.
- Human adults secrete between 12-18 g of bile acids into the intestine each day, mostly after meals.
- Cholic acid is amphiphilic, it has polar and non-polar regions.



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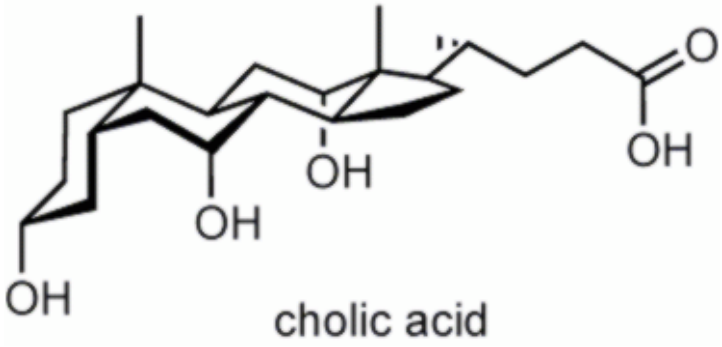
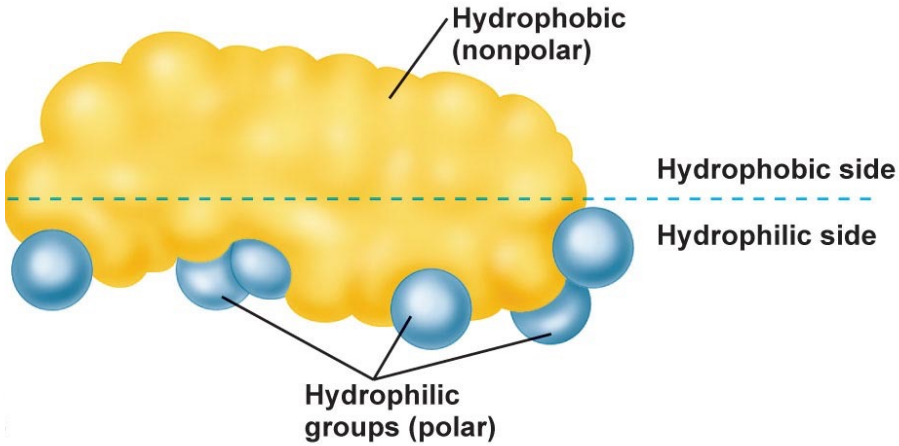
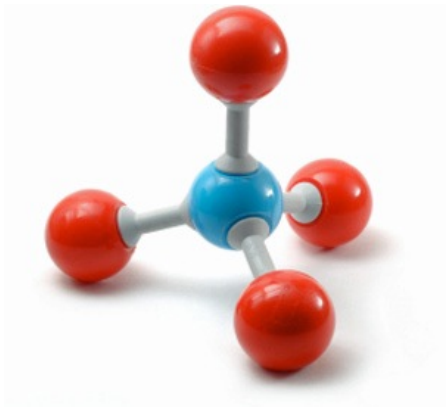
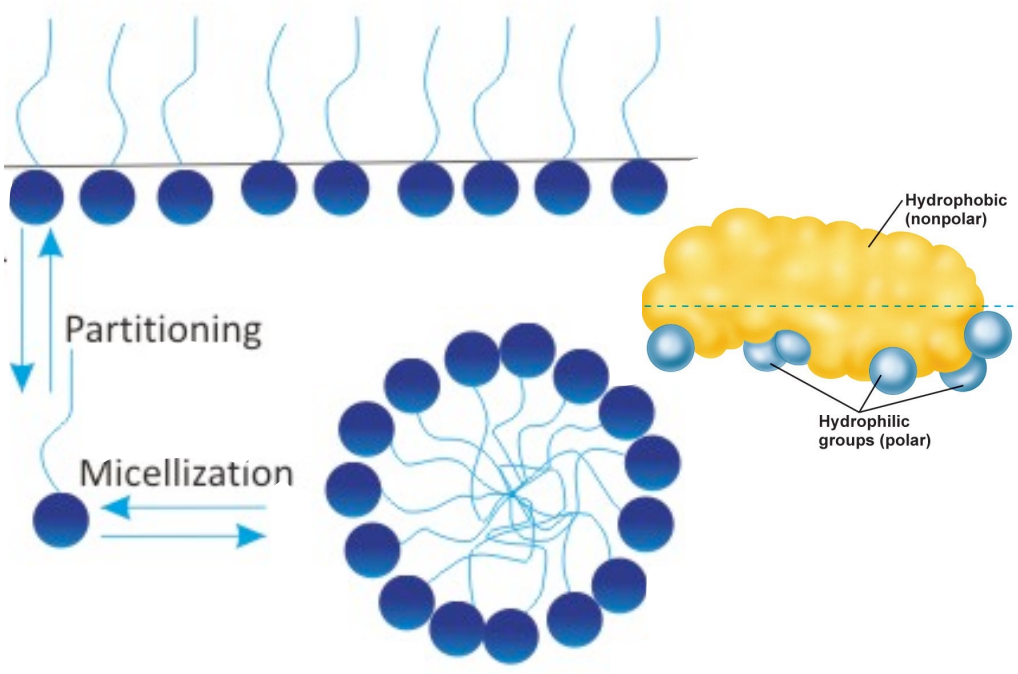


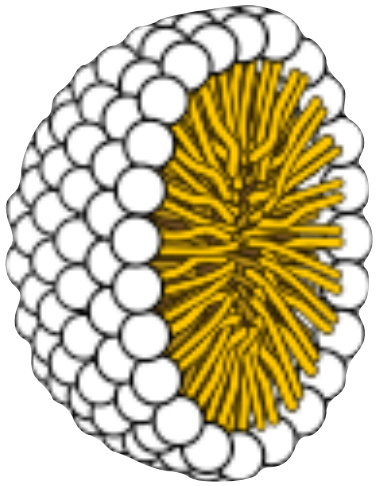



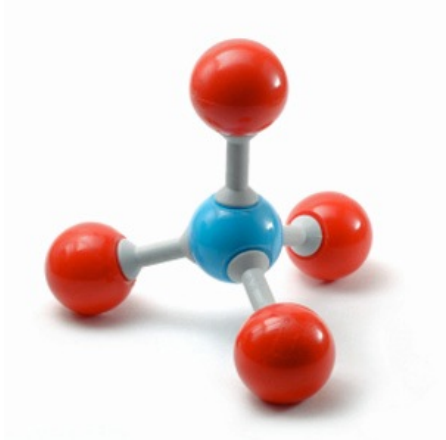



# Cholesterol in Digestion

- Cholic acid assembles into a monolayer on the lipid water interface.
- As the concentration builds up, cholic acid cholesterol molecules break off and form micelles.
  - Micelles are usually made of less than 10 molecules.
    - But can form with up to 100 molecules, depending on cholic acid and fat concentrations.
  - Micellization pulls other lipids from the lipid layer into micelle as it forms.
  - This process of breaking apart and solubilizing fats is emulsification.
  - Emulsification aids digestion.
  - The emulsion droplets (micelles) are where digestion occurs.
  - Emulsification greatly increases the surface area and accessibility of the fats to the digestive process.





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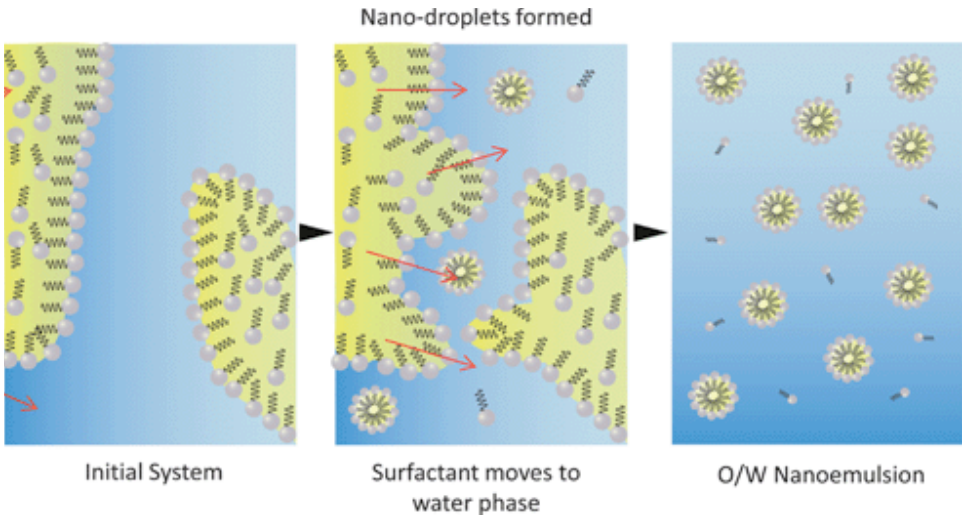
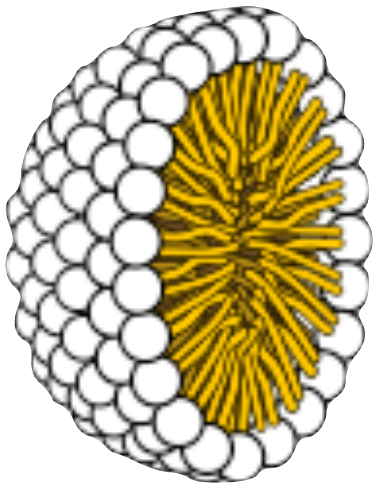
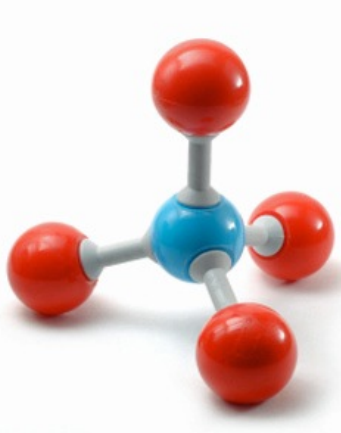


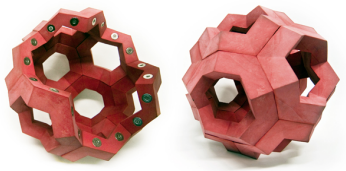



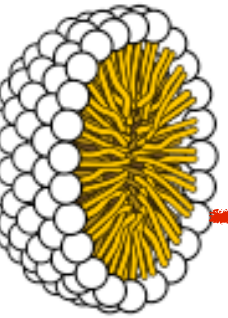


Ch15

# Cell Membranes

- Self Assembly
  - Amphiphilicity
    - Living in two worlds
- Phospholipids
  - Glycerophospholipids
    - Lecithin
    - Cephalin
    - Forming Bilayers
  - Sphingomyelin
- Steroids
  - Steroid Ring System
  - Cholesterol
    - Digestion
    - Lipoproteins
    - Hormones





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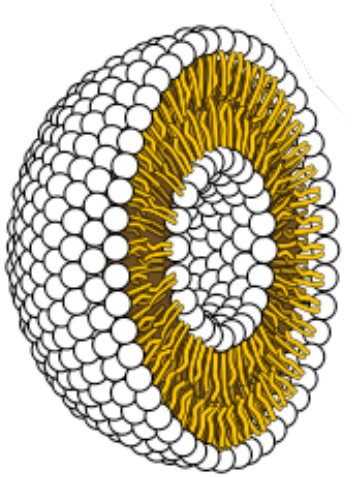
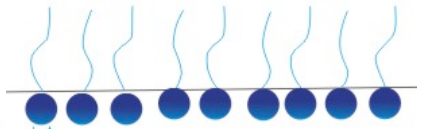
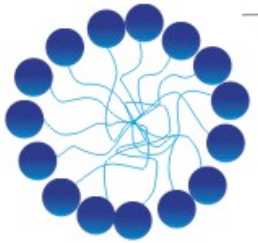
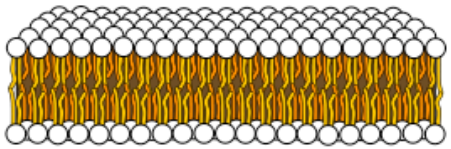
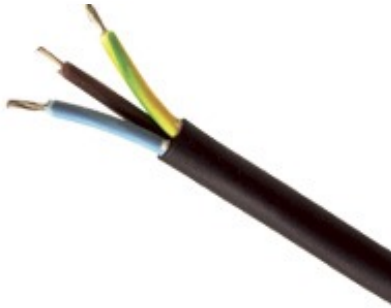
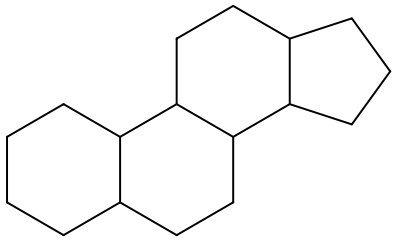


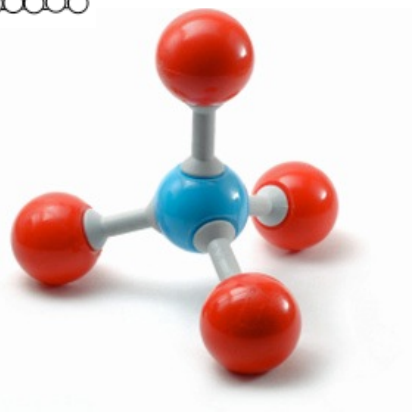






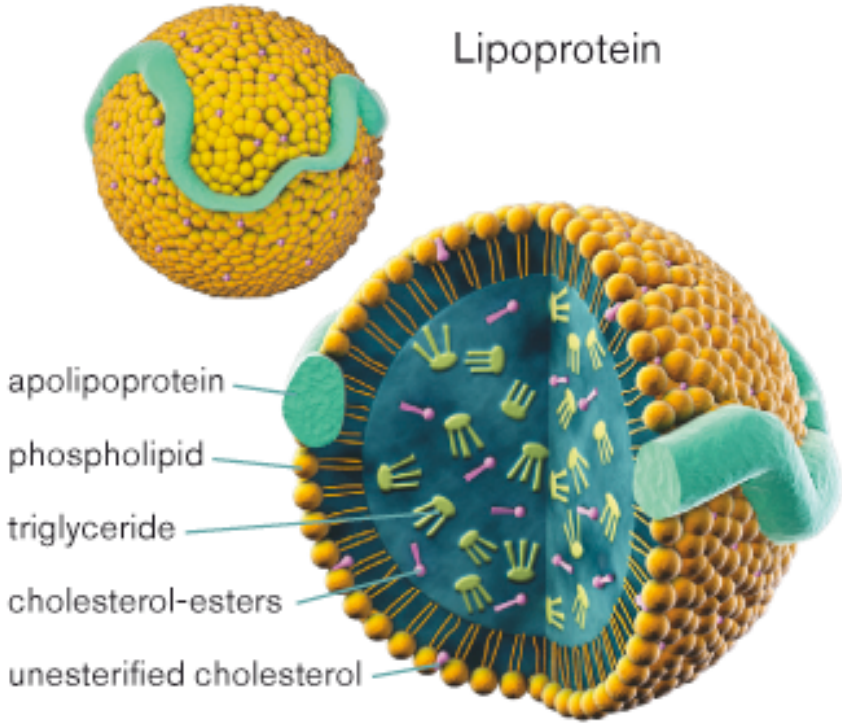


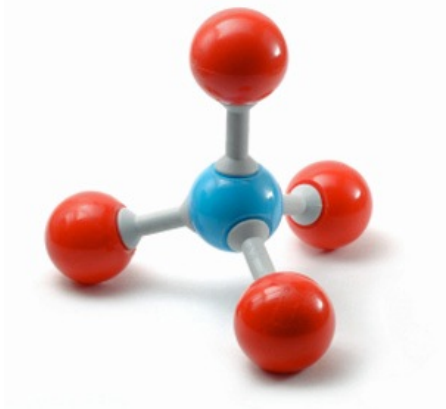




# Lipoproteins

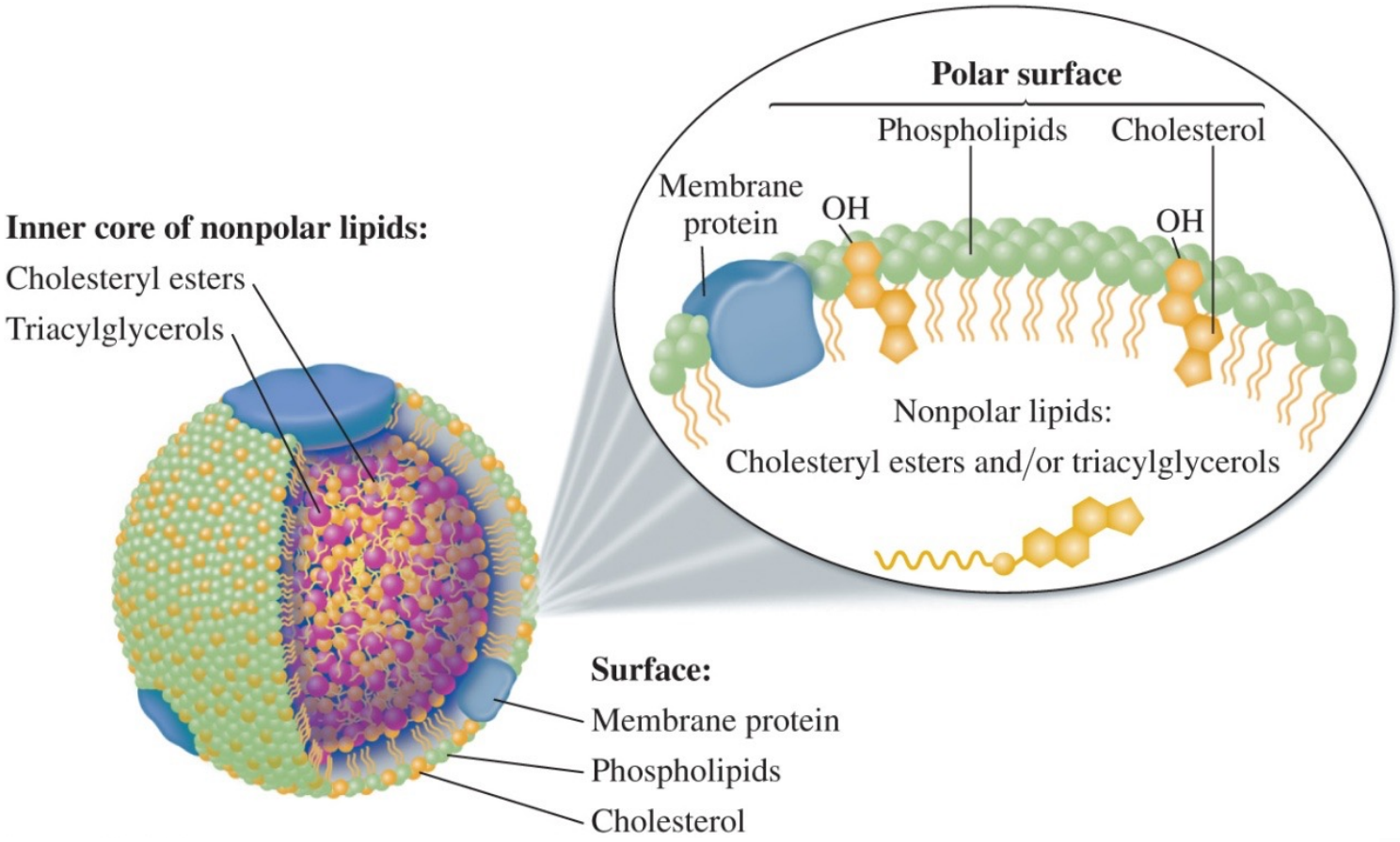
- Cholesterol and other amphiphilic lipids can form larger assemblies.
- Lipoproteins are assemblies used to transport fats in the body.
- They’re made of of protein and thousands of cholesterol, triglycerides, and phospholipids.
- Lipoproteins have a single layer of phospholipid molecules on their outside, surrounding a central core.
- There are difference sizes of lipoproteins, but even the smallest can hold thousands of molecules.

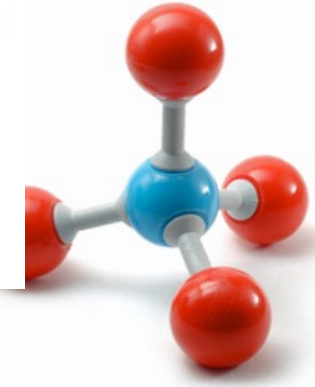


# Lipoproteins

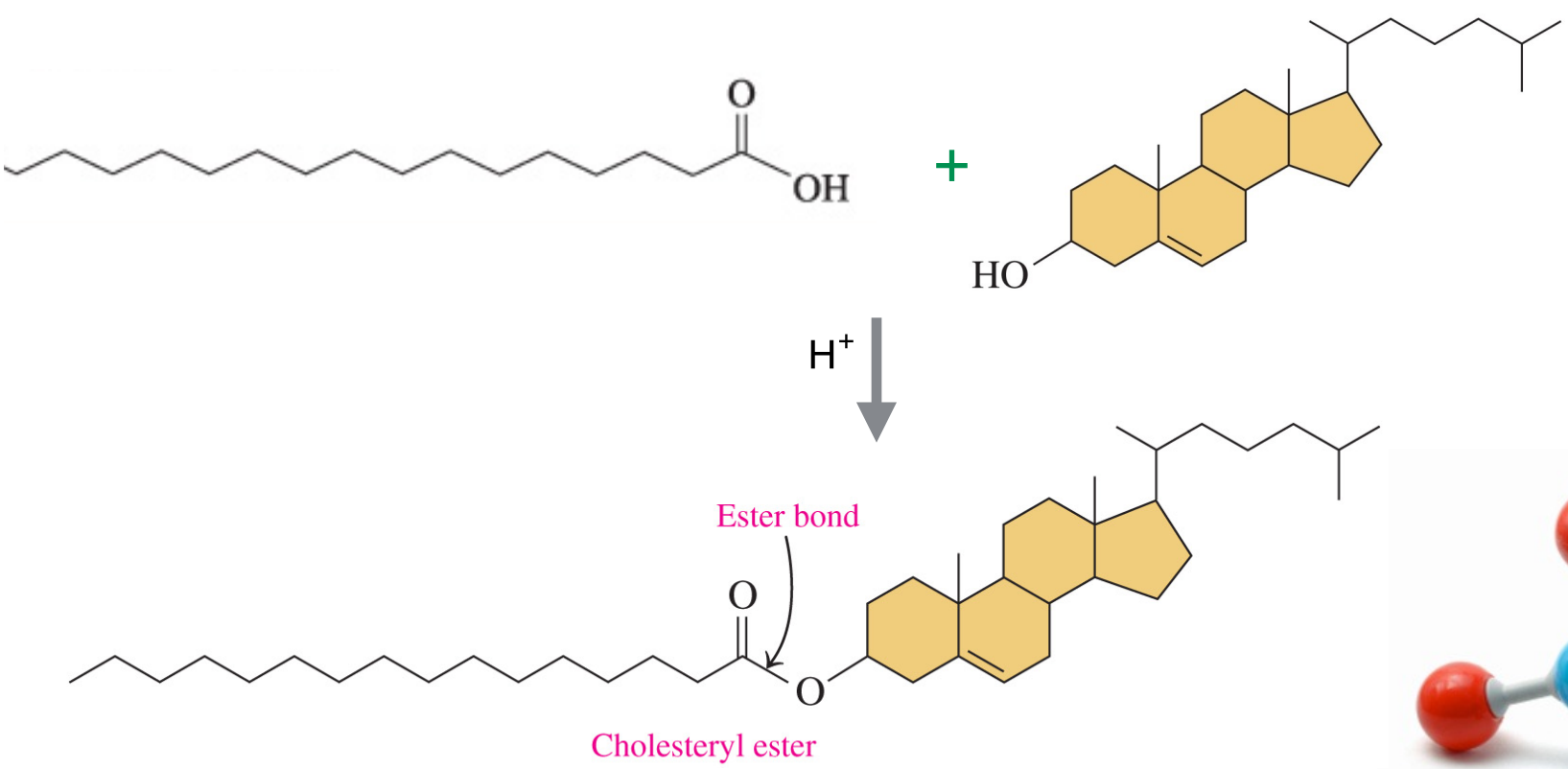
- Cholesterol in the surface of lipoproteins gives it a greater structure and rigidity.
- Cholesterol is also transported inside the lipoprotein, in the form of cholesterol esters.



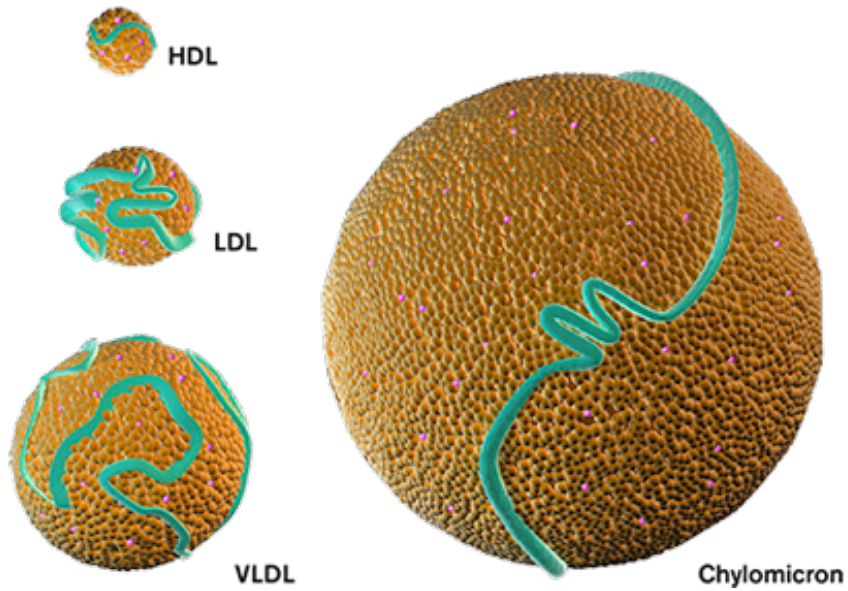
# Fatty Acid-Cholesterol Esters

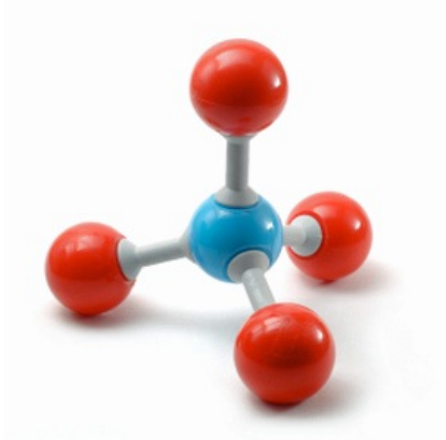
- Cholesterol can form esters with fatty acids.
- This allows both to be transported inside the non-polar centers of lipoproteins.



# Lipoprotein Types

- Different types of lipoproteins have different functions.
  - Chylomicrons carry triglycerides (fat) from the intestines to the liver, muscles, and adipose tissue. (how we move stuff you eat)
  - Very-low-density lipoproteins (VLDL) carry (newly synthesised) triglycerides from the liver to adipose tissue. (how we move stuff you make)
- These lipoproteins are converted to LDL and HDL
  - Low-density lipoproteins (LDL) carry 3,000 to 6,000 fat molecules (phospholipids, cholesterol, triglycerides) to cells all over the body.
    - LDL particles are sometimes referred to as "bad" lipoprotein because they can leave behind plaque (deposited cholesterol) in your arteries.
  - High-density lipoproteins (HDL) collect fat molecules (phospholipids, cholesterol, triglycerides, etc.) from the body's cells/tissues, and take it back to the liver.
    - HDLs are sometimes referred to as "good" cholesterol because they scavenge plaque from your arteries.



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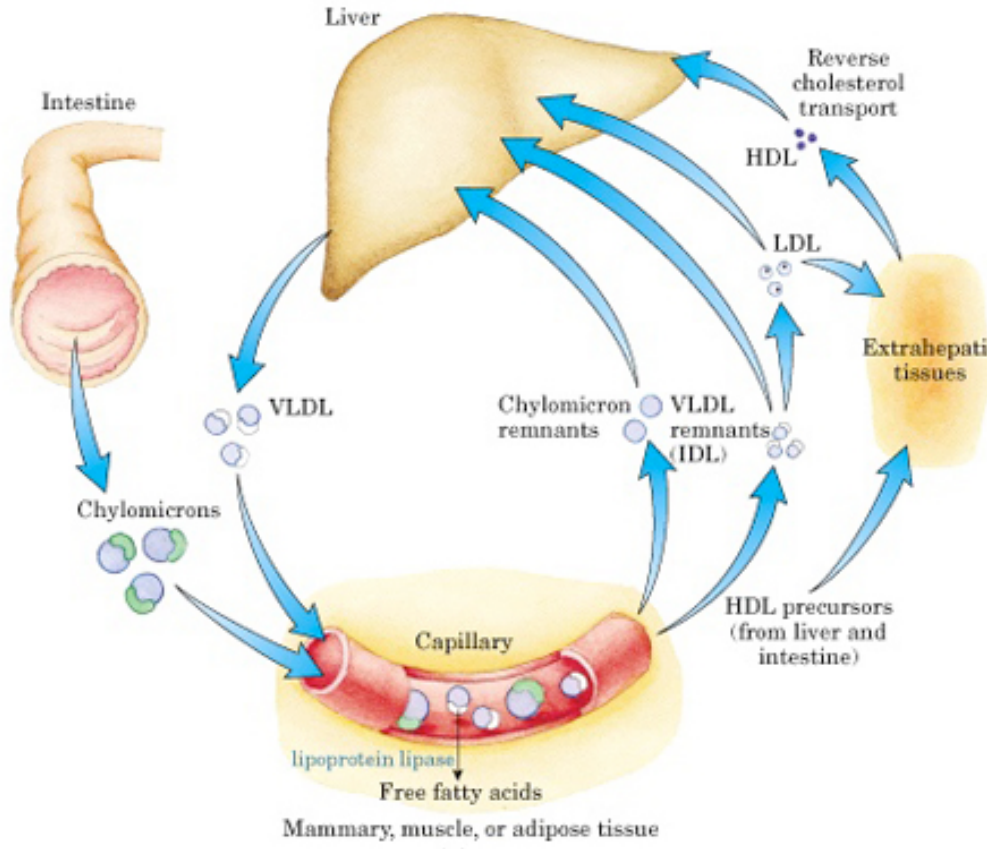
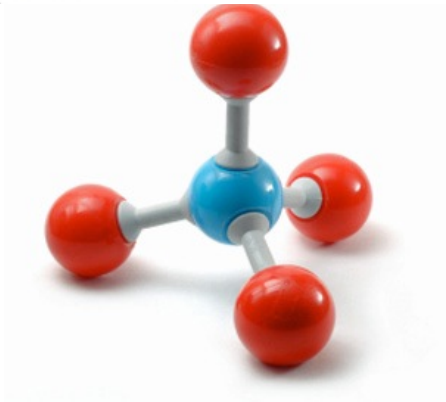
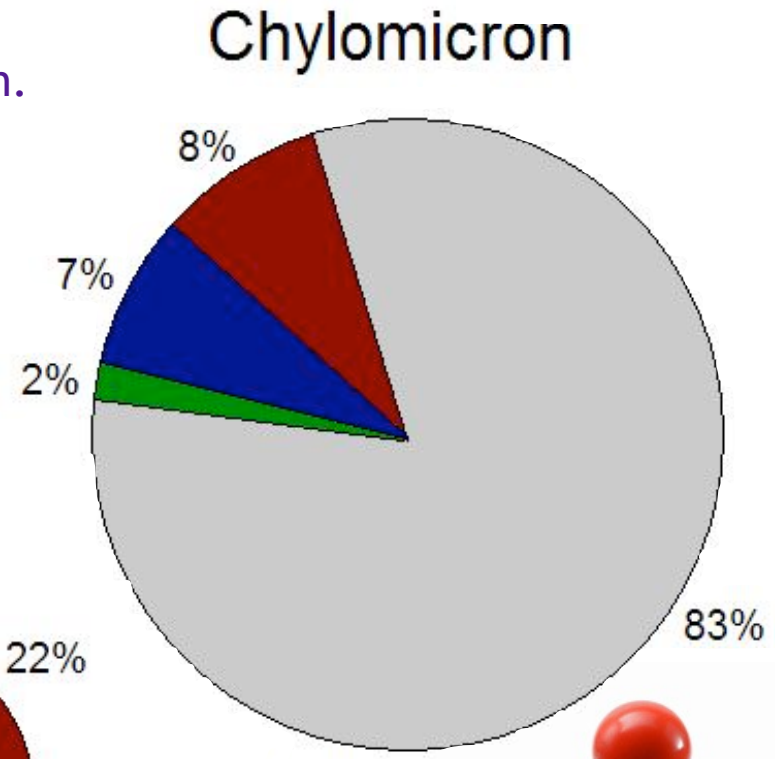
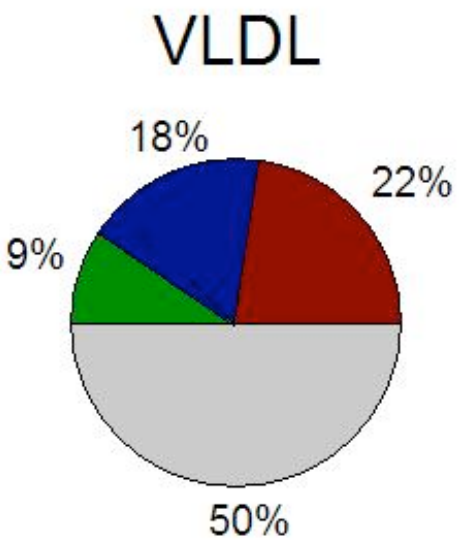


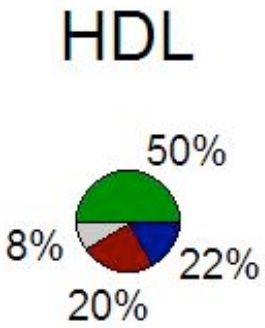



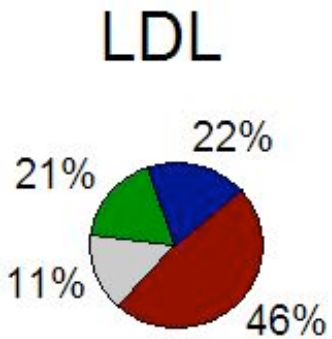
# Lipoprotein Composition

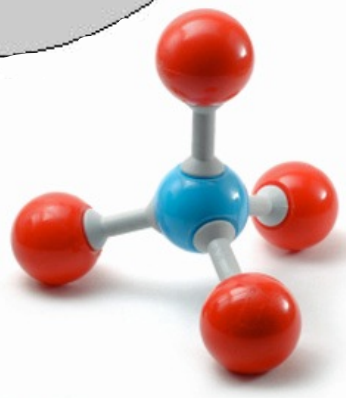

- Lipoprotein types have different composition.
- Chylomicron and VLDL are mostly triglycerides.
- LDL is mostly cholesterol.
- HDL is mostly protein.



Ch15

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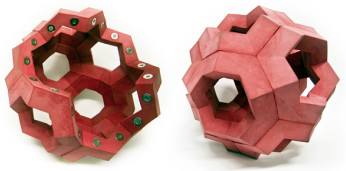

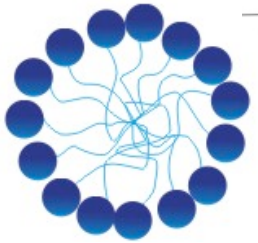

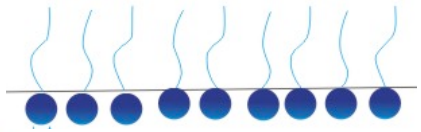

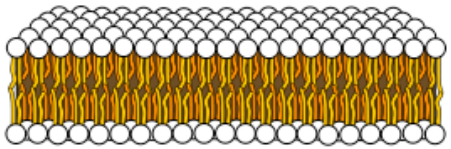

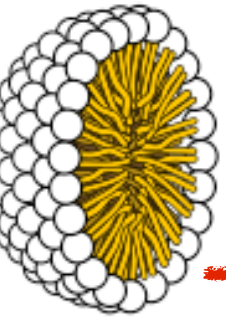

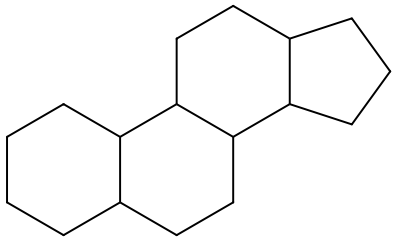

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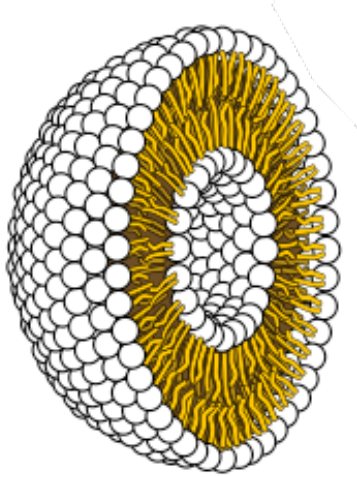
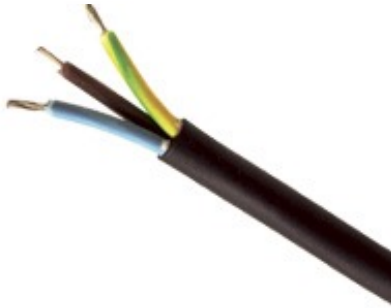
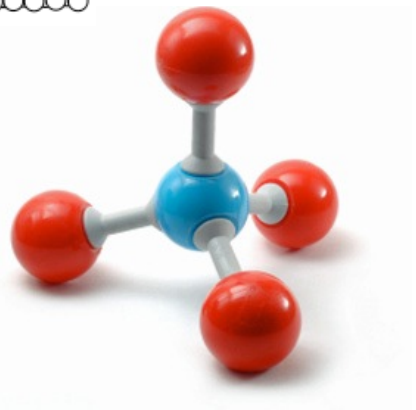
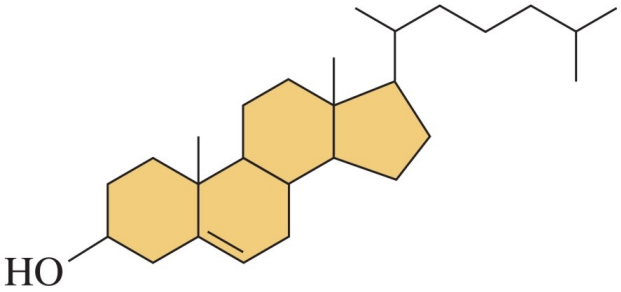


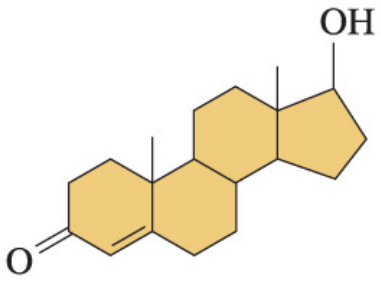




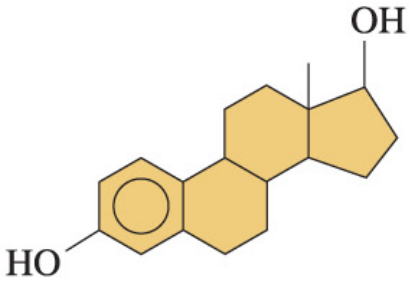
# Steroidal Hormones

- Cholesterol is also used to build steroidal hormones.
- Steroid hormones are
  - chemical messengers that serve as a communication system for the body
  - produced from cholesterol
  - male sex hormones, testosterone and androsterone
  - female sex hormones, estrogens and progesterone
  - adrenal corticosteroids from adrenal glands
    - mineralocorticoids (electrolyte balance)
    - glucocorticoids (regulate glucose level)

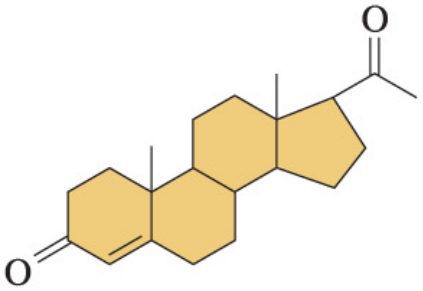


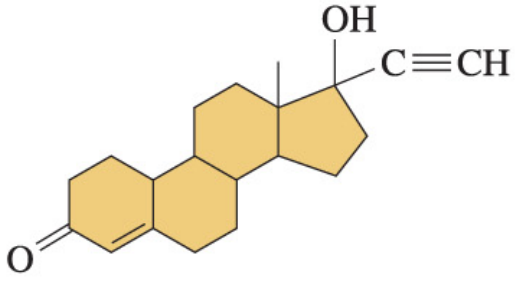

Testosterone (androgen)
(produced in testes)




Estradiol (estrogen)
(produced in ovaries)



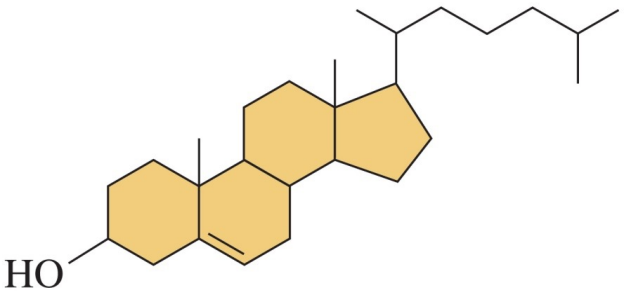

Progesterone
(produced in ovaries)

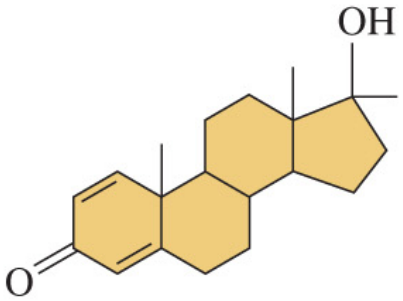



Norethindrone
(synthetic progestin)

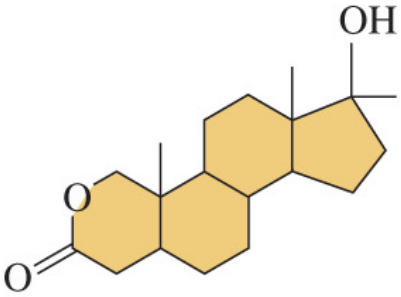
# Steroidal Hormones

- Anabolic steroids
  - are derivatives of testosterone (a naturally occurring steroid)
  - are used illegally to increase muscle mass
  - have side effects including fluid retention, hair growth, sleep disturbance, and liver damage

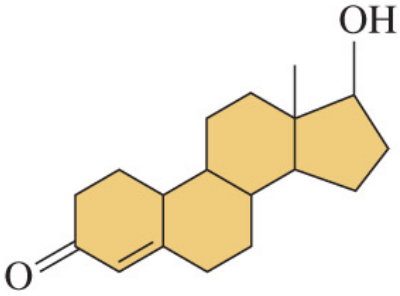


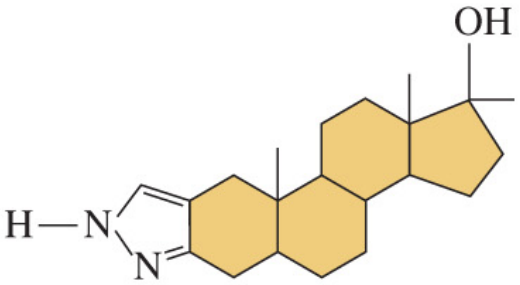

Methandienone



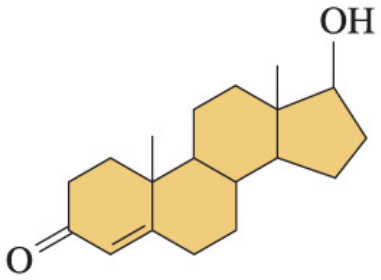

Oxandrolone




Nandrolone



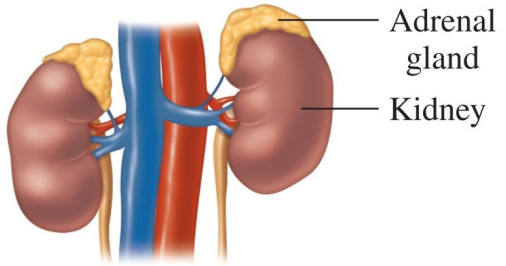

Stanozolol

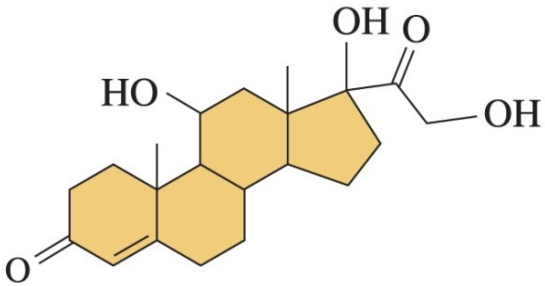



Testosterone (androgen)
(produced in testes)

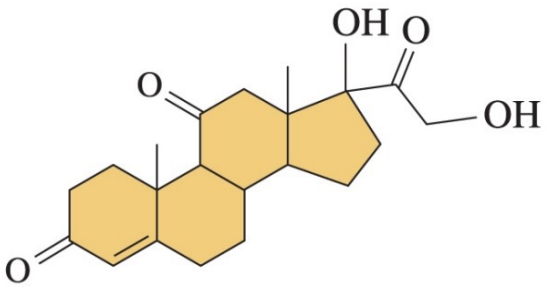
# Steroidal Hormones

- Adrenal cortical steroids or corticosteroids are hormones synthesized by the adrenal cortex.
- There are two types of corticosteroids:
  - glucocorticoids and mineralocorticoids.
- Glucocorticoids e.g. cortisol and cortisone, are essential for the utilization of carbohydrate, fat and protein by the body and for normal response to stress.
- Naturally occurring and synthetic glucocorticoids have very powerful anti-inflammatory effects and are used to treat conditions that involve inflammation.

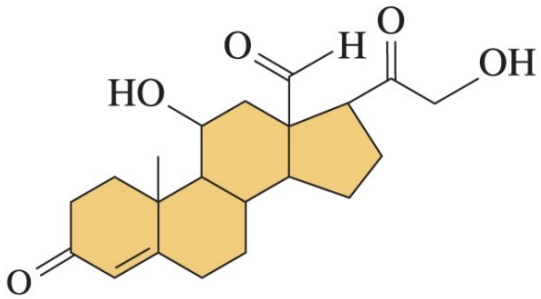


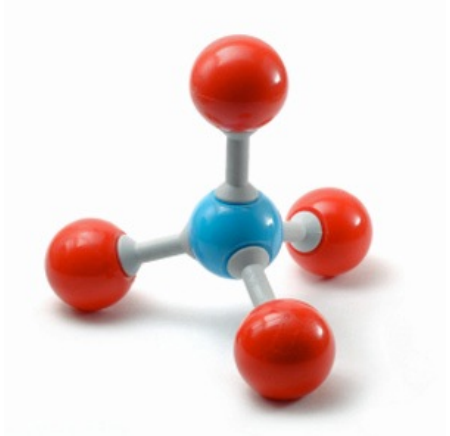

Cortisol
(produced in adrenal cortex)




Cortisone
(produced in adrenal gland)




Aldosterone (mineralocorticoid)
(produced in adrenal gland)

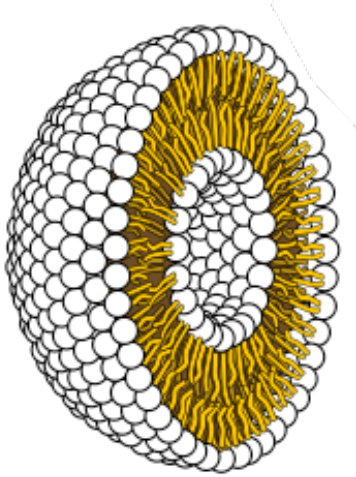


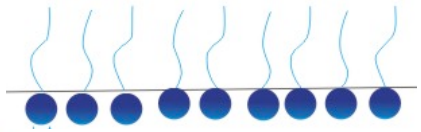
Ch15

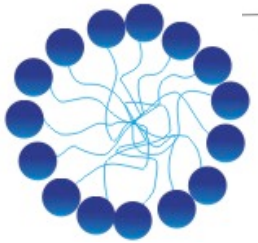
# Cell Membranes

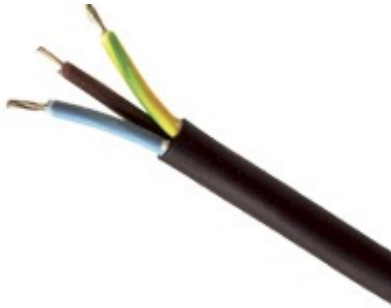
- Self Assembly
  - Amphiphilicity
    - Living in two worlds
- Phospholipids
  - Glycerophospholipids
    - Lecithin
    - Cephalin
    - Forming Bilayers
  - Sphingomyelin
- Steroids
  - Steroid Ring System
  - Cholesterol
    - Digestion
    - Lipoproteins
    - Hormones

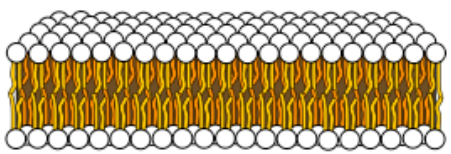
- Cell Membranes
  - Forming Membranes
  - Membrane Structure
  - Transport Across Membranes
    - Diffusion
    - Facilitated & Active Transport

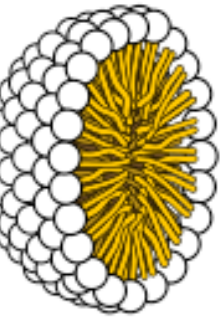


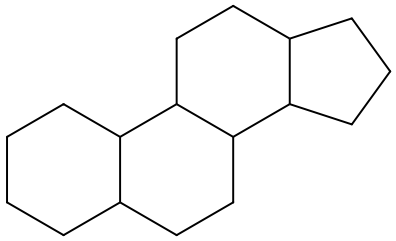


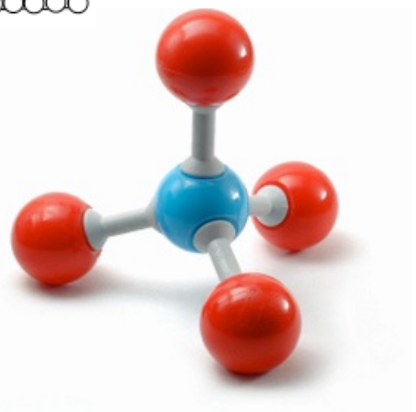






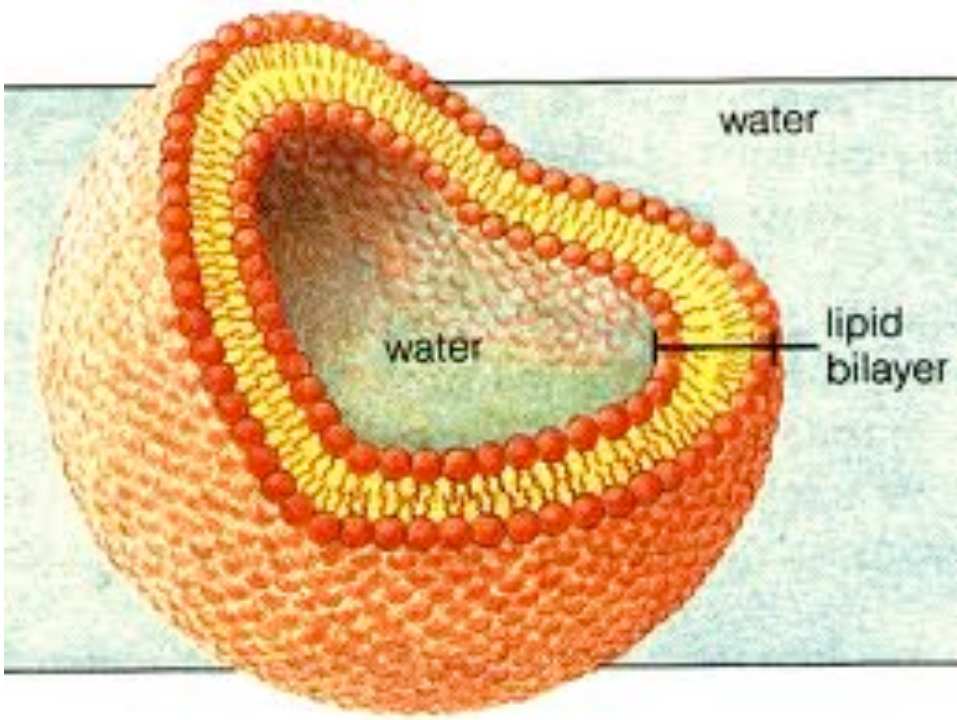


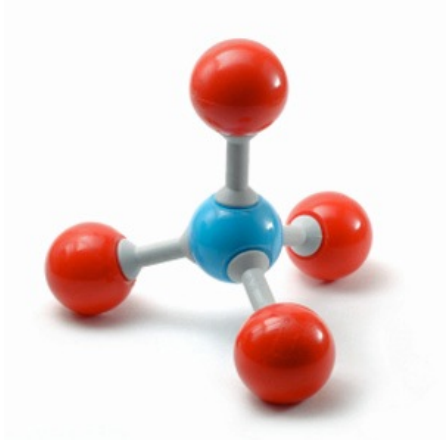




# Cell Membranes

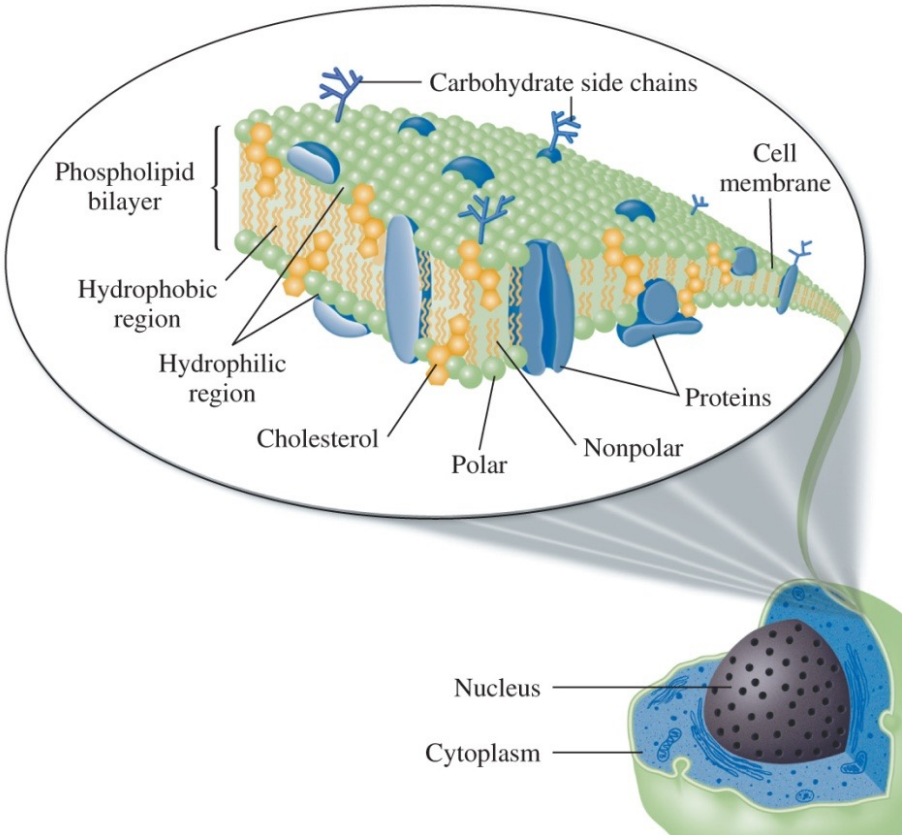
- Phospholipids and cholesterol also form into still larger assemblies.
- Cell membranes are a barrier that separates the inside of a cell from the outside.
- They're formed from a lipid bilayer that completely encloses the inside of the cell.
- These membranes are selectively permeable, some substances can cross the barrier, others are contained or kept out.
- The basic function of the cell membrane is to protect the cell from its surroundings.
- It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others.
- Animal cells, plant cells, prokaryotic cells, and fungal cells have cell membranes.



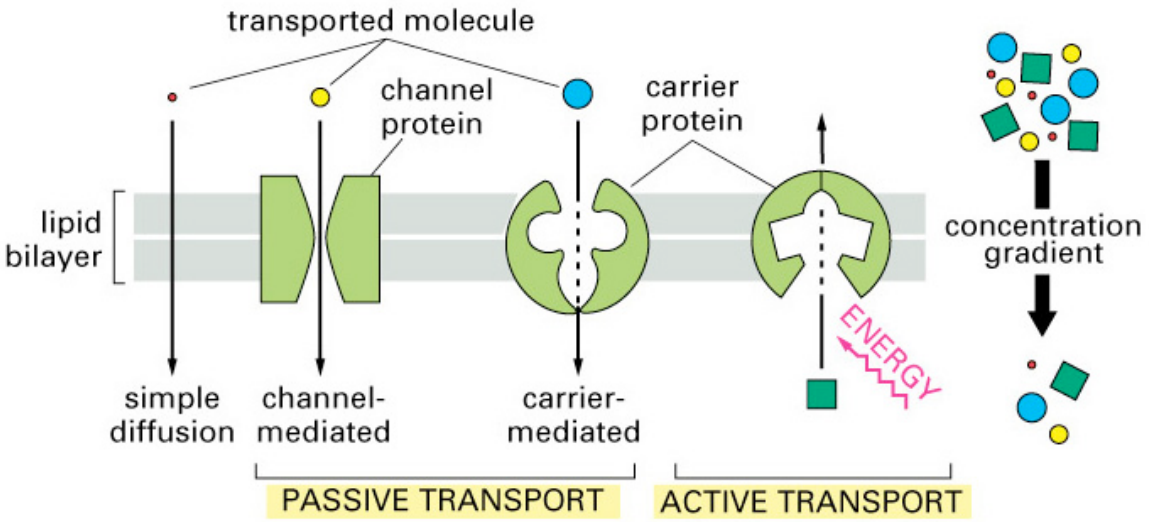
# Structure of Cell Membranes

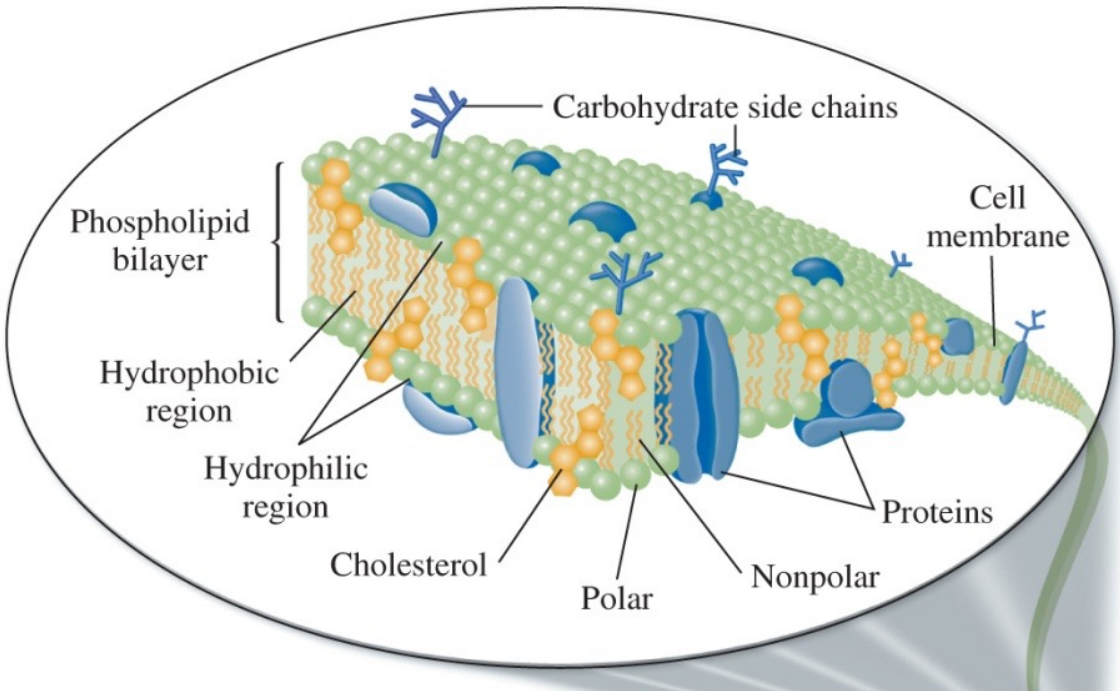
- The cell membrane is primarily composed of a mix of proteins and lipids.
- Depending on the membrane's location and role in the body, lipids can make up anywhere from 20 to 80 percent of the membrane, with the remainder being proteins.
- Cell membranes
  - have unsaturated fatty acids that make cell membranes fluid-like rather than rigid
  - have proteins and carbohydrates on the surface that communicate with hormones and neurotransmitters
    - provide intelligence and identification of the cell
  - is semipermeable meaning it
  - substances can be transported across a cell membrane by
    - diffusion (passive) transport
    - facilitated transport
    - active transport



# Transport Through Membranes

- The transport of substances through cell membranes involves
  - diffusion, which moves particles from a higher to a lower concentration
  - facilitated transport, which uses protein channels to increase the rate of diffusion
  - active transport, which moves ions against a concentration gradient
    - Active transport is work, and takes energy to accomplish.



Ch15

# Cell Membranes

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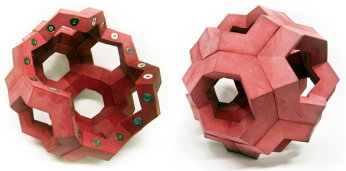

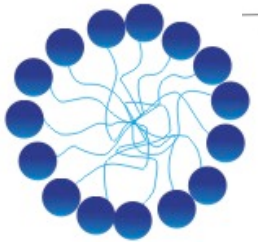

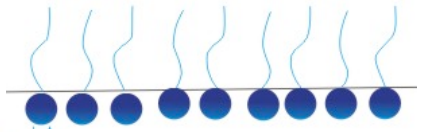

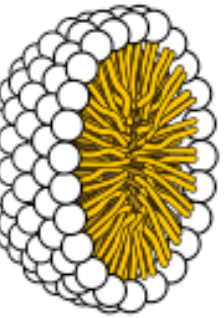

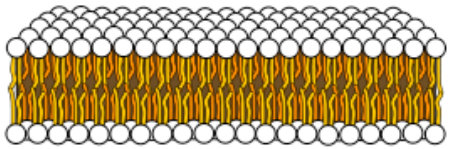

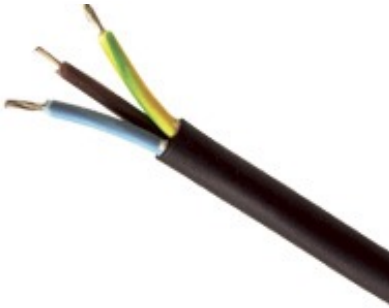

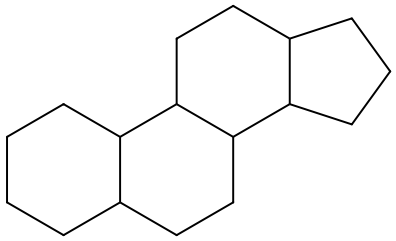

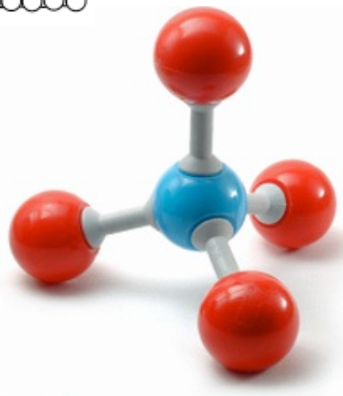

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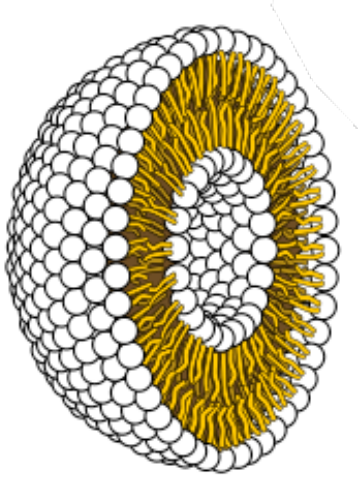

# Questions?