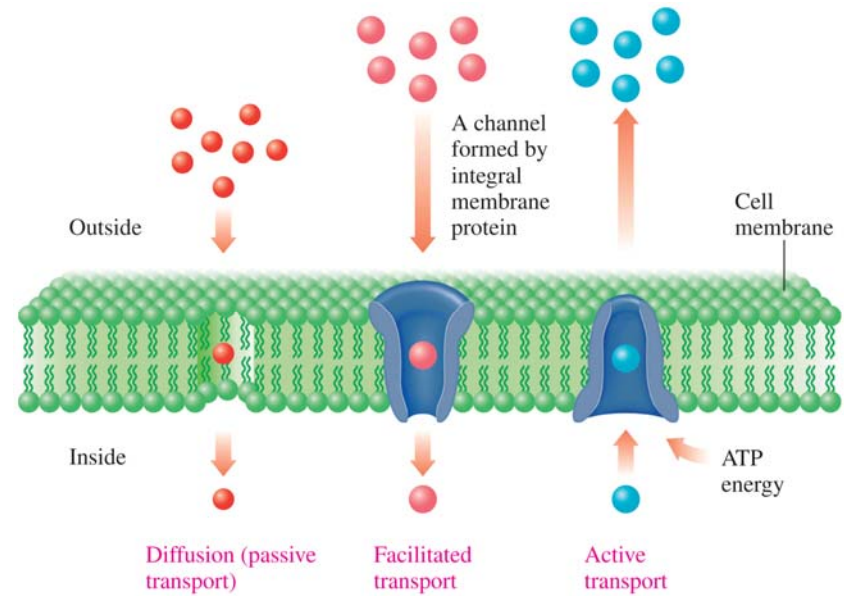
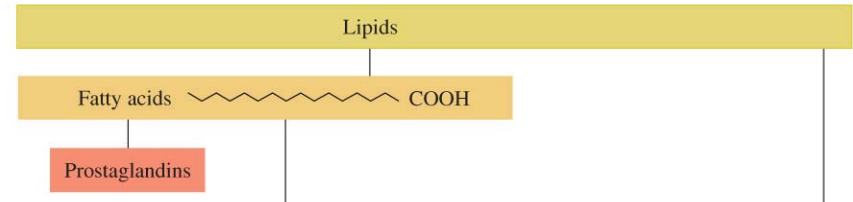


Chapter 17 Lipids

Lipids are structurally the most diverse class of compounds found in living systems with the most diverse functions



Lipids are biomolecules that contain fatty acids or a steroid nucleus;
they are soluble in organic solvents but not in water;
they named for the Greek word *lipos*, which means “fat”;
and are extracted from cells using organic solvents



The lipids that contain fatty acids
are:

waxes

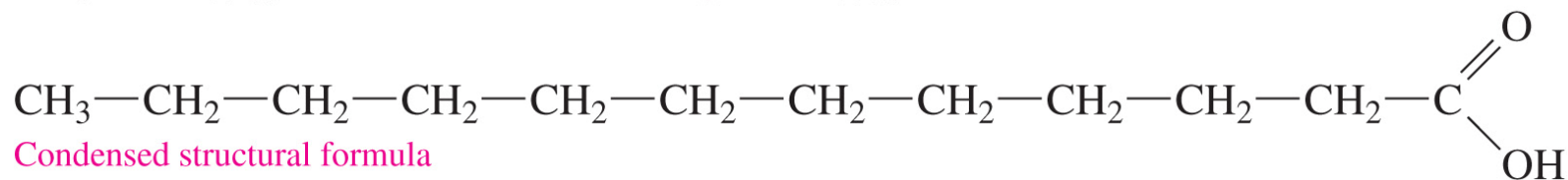
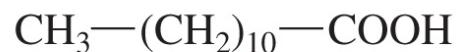
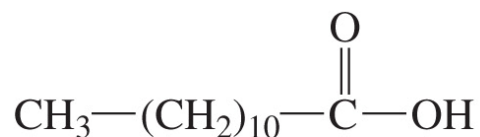
fats and oils (triacylglycerols)

glycerophospholipids

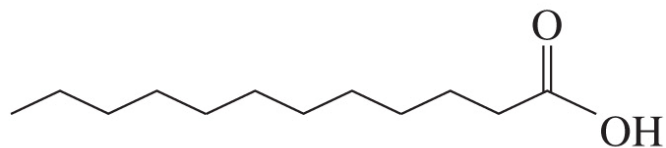
prostaglandins

Fatty acids are long-chain carboxylic acids
typically contain 12 to 18 carbon atoms
are insoluble in water
can be saturated or unsaturated

Typical ways of representing saturated fatty acids

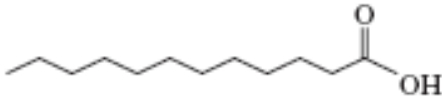
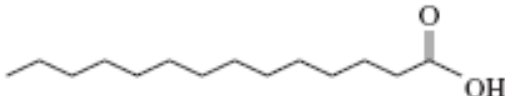
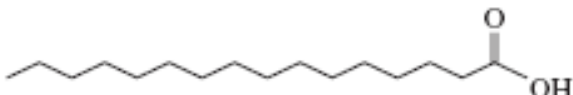
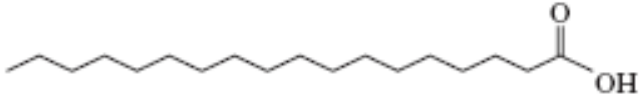


Condensed structural formula



Line-bond structural formula

TABLE 17.1 Structures and Melting Points of Common Fatty Acids

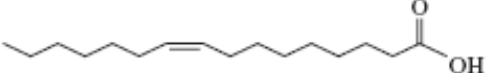
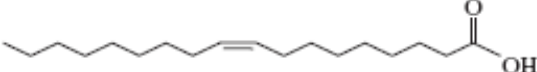
Name	Carbon Atoms	Source	Melting Point (°C)	Structures
Saturated Fatty Acids				
Lauric acid	12	Coconut	43	$\text{CH}_3-(\text{CH}_2)_{10}-\text{COOH}$ 
Myristic acid	14	Nutmeg	54	$\text{CH}_3-(\text{CH}_2)_{12}-\text{COOH}$ 
Palmitic acid	16	Palm	62	$\text{CH}_3-(\text{CH}_2)_{14}-\text{COOH}$ 
Stearic acid	18	Animal fat	69	$\text{CH}_3-(\text{CH}_2)_{16}-\text{COOH}$ 

Triglycerides made from saturated fatty acids are very stable solids

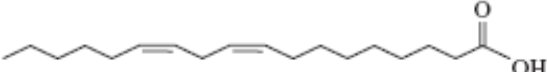
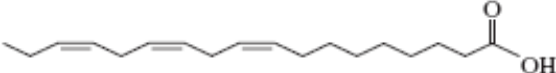
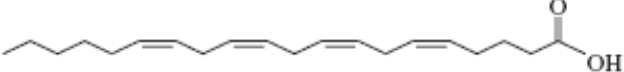


Monounsaturated Fatty Acids

mp ° C

Palmitoleic acid	16	Butter	0	$\text{CH}_3 - (\text{CH}_2)_5 - \text{CH} = \text{CH} - (\text{CH}_2)_7 - \text{COOH}$
				
Oleic acid	18	Olives, corn	13	$\text{CH}_3 - (\text{CH}_2)_7 - \text{CH} = \text{CH} - (\text{CH}_2)_7 - \text{COOH}$
				

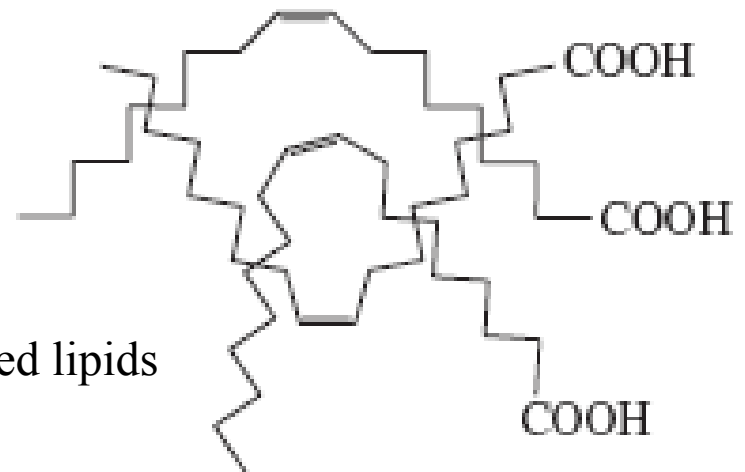
Polyunsaturated Fatty Acids

Linoleic acid	18	Soybeans, sunflowers	-9	$\text{CH}_3 - (\text{CH}_2)_4 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH} = \text{CH} - (\text{CH}_2)_7 - \text{COOH}$
				
Linolenic acid	18	Corn	-17	$\text{CH}_3 - (\text{CH}_2 - \text{CH} = \text{CH})_3 - (\text{CH}_2)_7 - \text{COOH}$
				
Arachidonic acid	20	Meat, eggs, fish	-50	$\text{CH}_3 - (\text{CH}_2)_3 - (\text{CH}_2 - \text{CH} = \text{CH})_4 - (\text{CH}_2)_3 - \text{COOH}$
				

Unsaturated fatty acids

have “kinks” in the fatty acid chains
do not pack closely
have fewer attractions between chains
have lower melting points
are liquids at room temperature

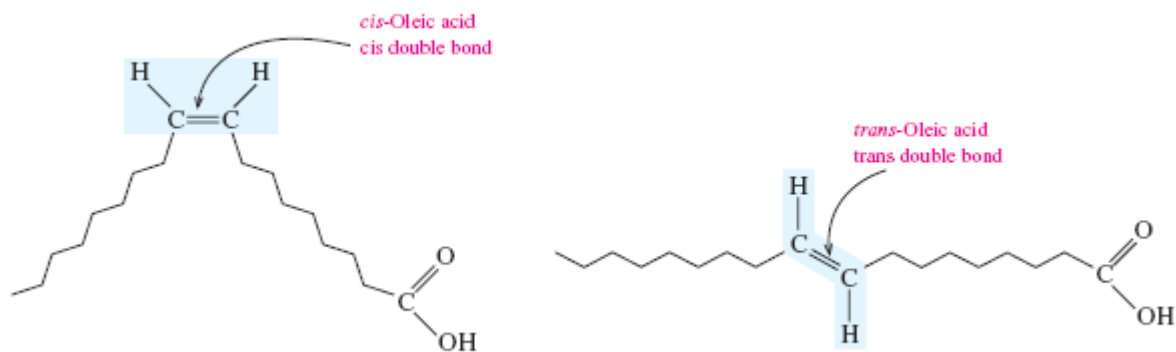
ω- unsaturated lipids



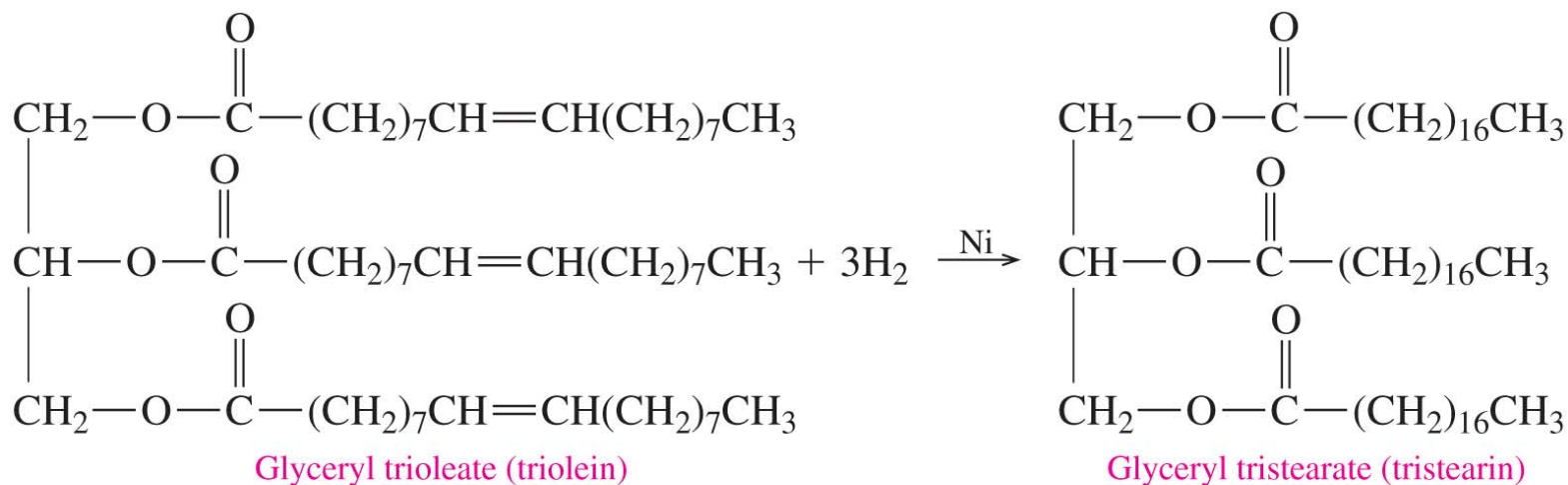
Triglycerides made from unsaturated fatty acids tend to be oils. They are much less stable in air and degrade much faster.



Unsaturated triglycerides tend to be isolated from plants whereas saturated triglycerides tend to be found in animal fats. Hydrogenation of unsaturated triglycerides produces saturated triglycerides. Partially hydrogenating unsaturated triglycerides produces some partially unsaturated triglycerides with trans double bonds as illustrated in the fatty acids below.



Remember that triglycerides are triesters of fatty acids with glycerol (1,2,3-trihydroxypropane).



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The **hydrogenation** of oils converts double bonds to single bonds
 adds hydrogen (H₂) to the carbon atoms of double bonds;
 increases the melting point;
 increases the lifetime of the triglyceride;
 produces solids such as margarine and shortening



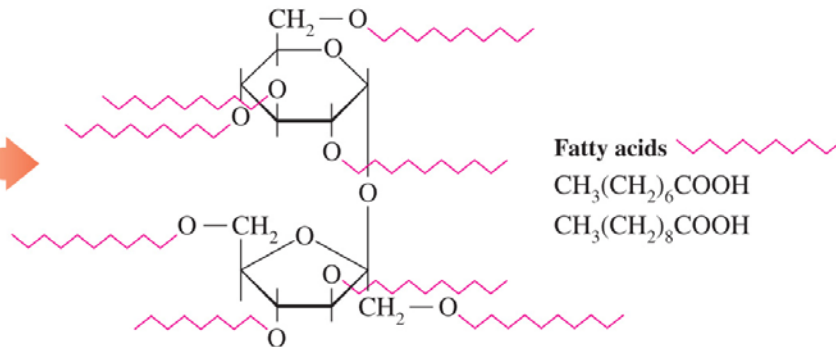
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Olestra is

used in foods as an artificial fat

sucrose linked by ester bonds to several long-chain fatty chains

not broken down in the intestinal tract and passes through the intestines

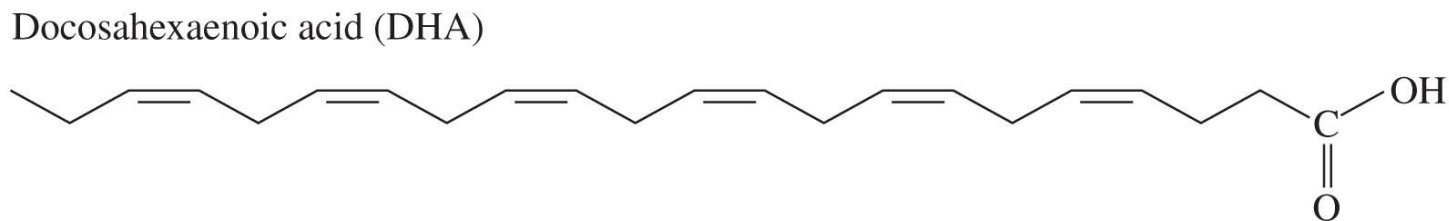
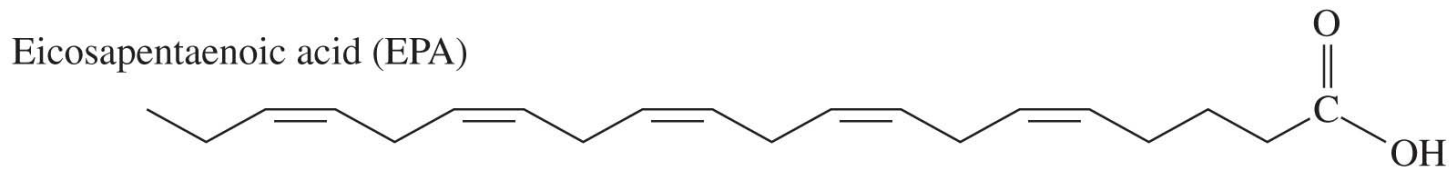
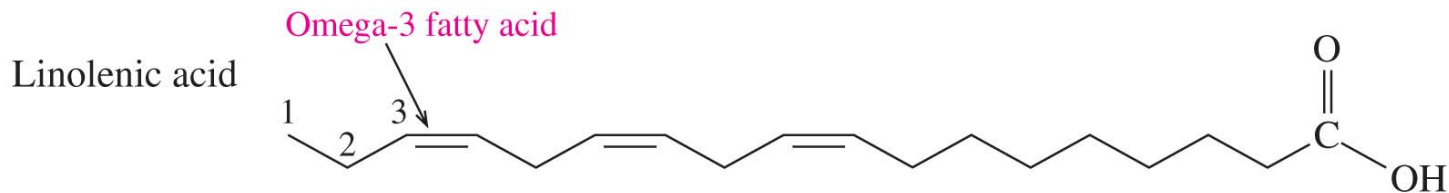
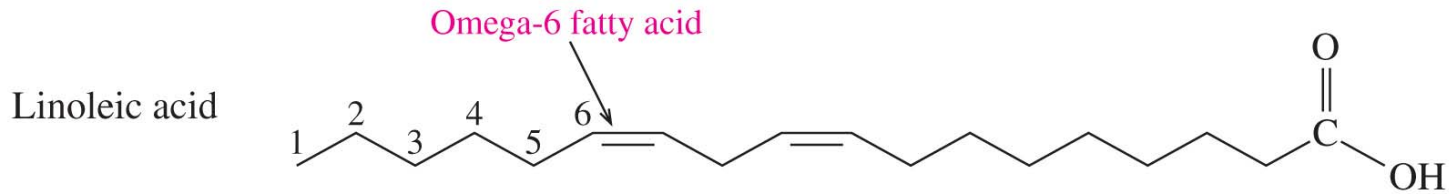


Olestra

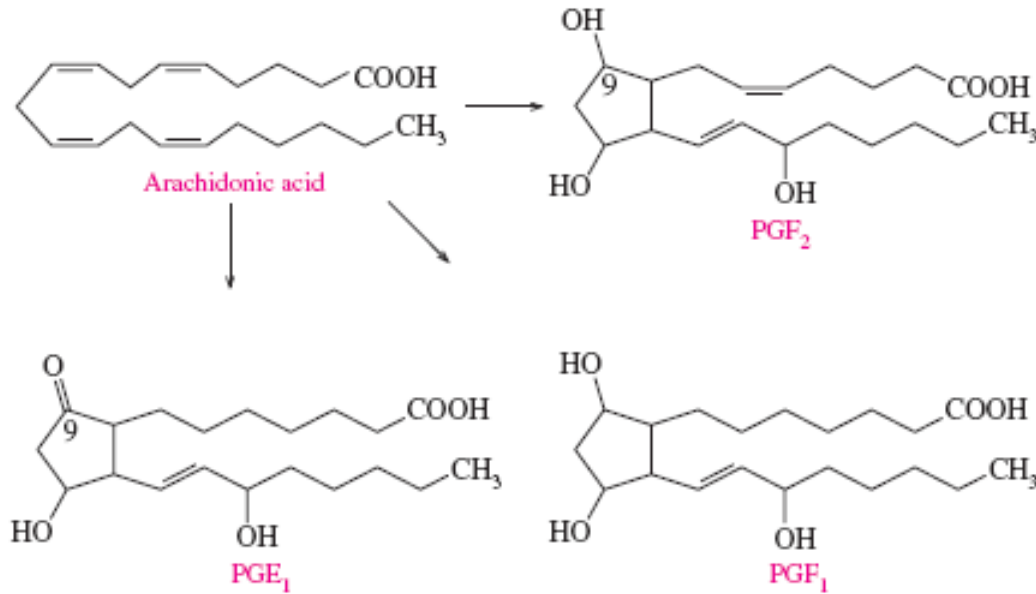
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Some Omega-6 and Omega-3 Fatty Acids

Omega is the last letter of the Greek alphabet. These are called omega three because you are suppose to count from the other end of the molecule, contrary to the IUPAC convention. Remember these acids are present as triglycerides in fish oil and other sources

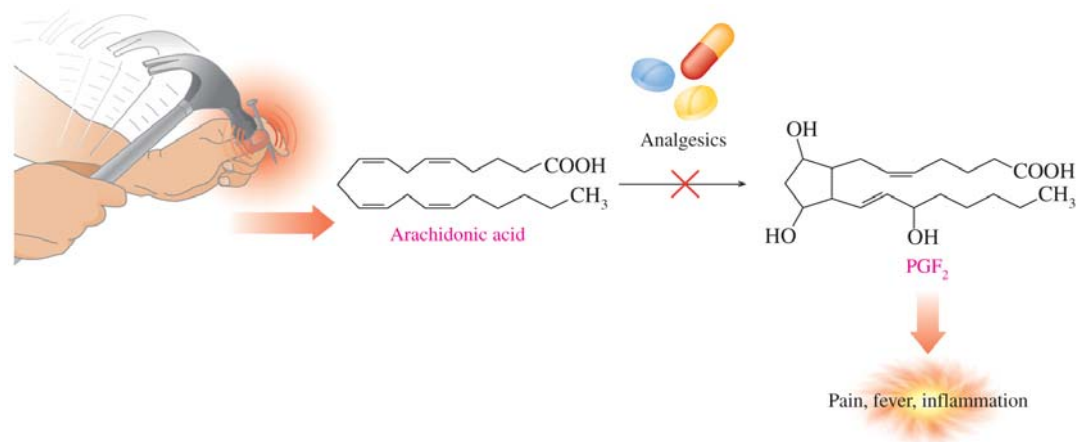


Prostaglandins are hormone like substances that control various cell functions they tend to have 20 carbon atoms in their fatty acid chains are produced from unsaturated fatty acids; many have an OH on **carbons 11 and 15** and a trans double bond at **carbon 13**



Some prostaglandins increase blood pressure, others lower it;

Some stimulate smooth muscle contraction and relaxation during the birth process. The treatment of pain often involves inhibiting enzymes that produce prostaglandins.



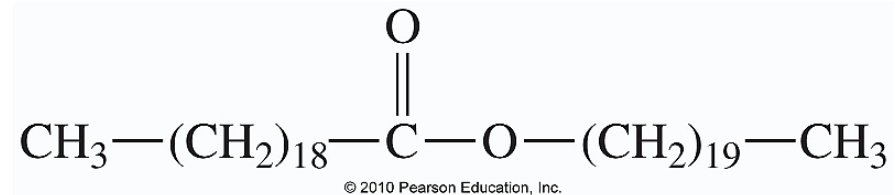
Waxes

The waxes are simplest class of lipids; they are used as protective coatings by plants and animals; they are simple esters of long chain fatty acids and alcohols

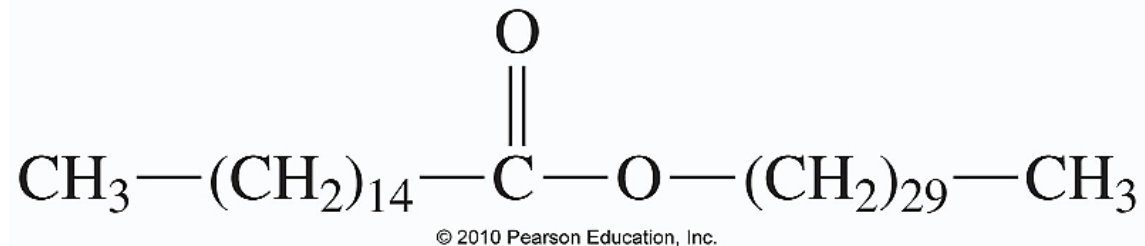


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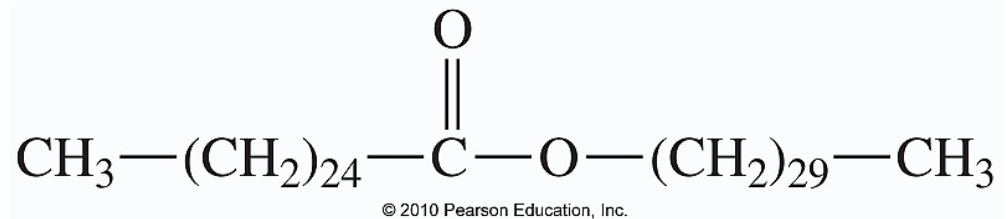
Jojoba wax in candles consists of an acid (C₂₀) and a 22-carbon saturated alcohol



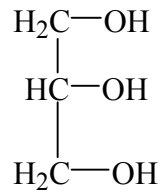
Beeswax



Carnauba wax

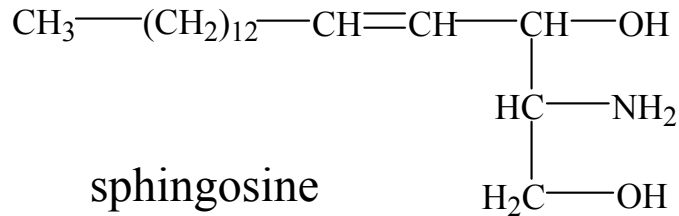
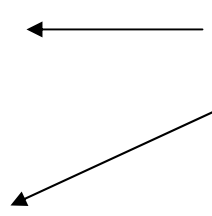


A number of lipids found in the body are classified according to the groups they yield when they are broken down in their component parts



glycerol

backbones of a variety of lipids found in various organs

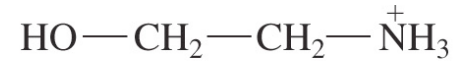
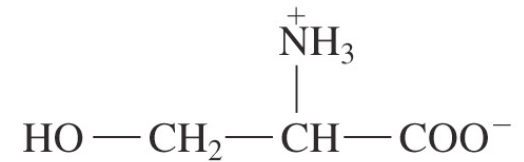
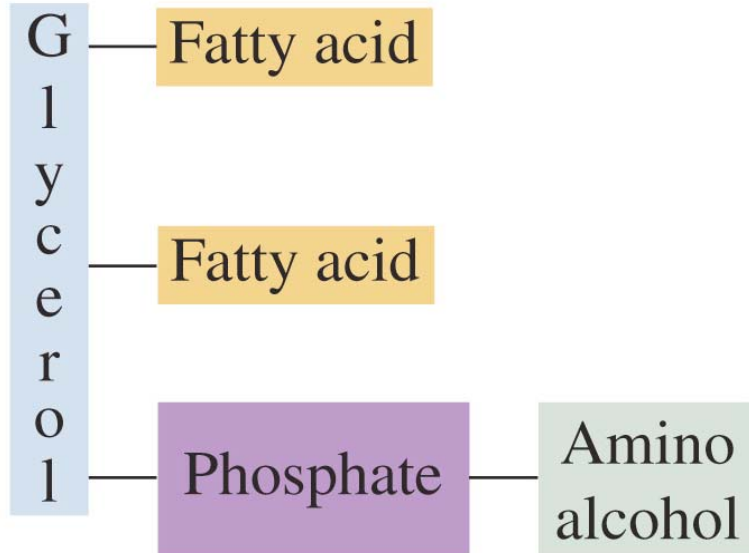


sphingosine

Glycerol and sphingosine are the two common backbones to which a variety of other groups are attached. These include fatty acids, phosphate, aminoalcohols, aminoacids or sugars. Attachment occurs at either nitrogen or oxygen

Phospholipids

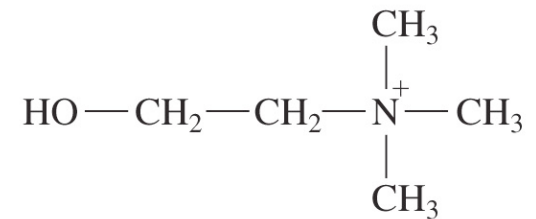
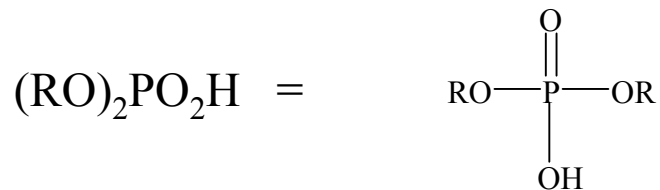
Glycerophospholipids are the most abundant lipids in cell membranes composed of glycerol, two fatty acids, phosphate, and one of three amino alcohols



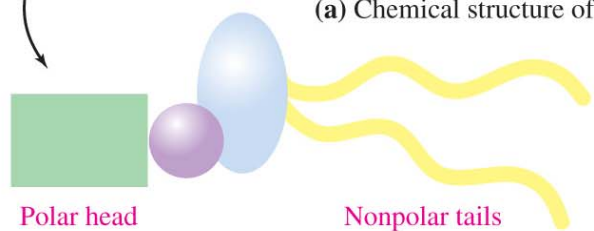
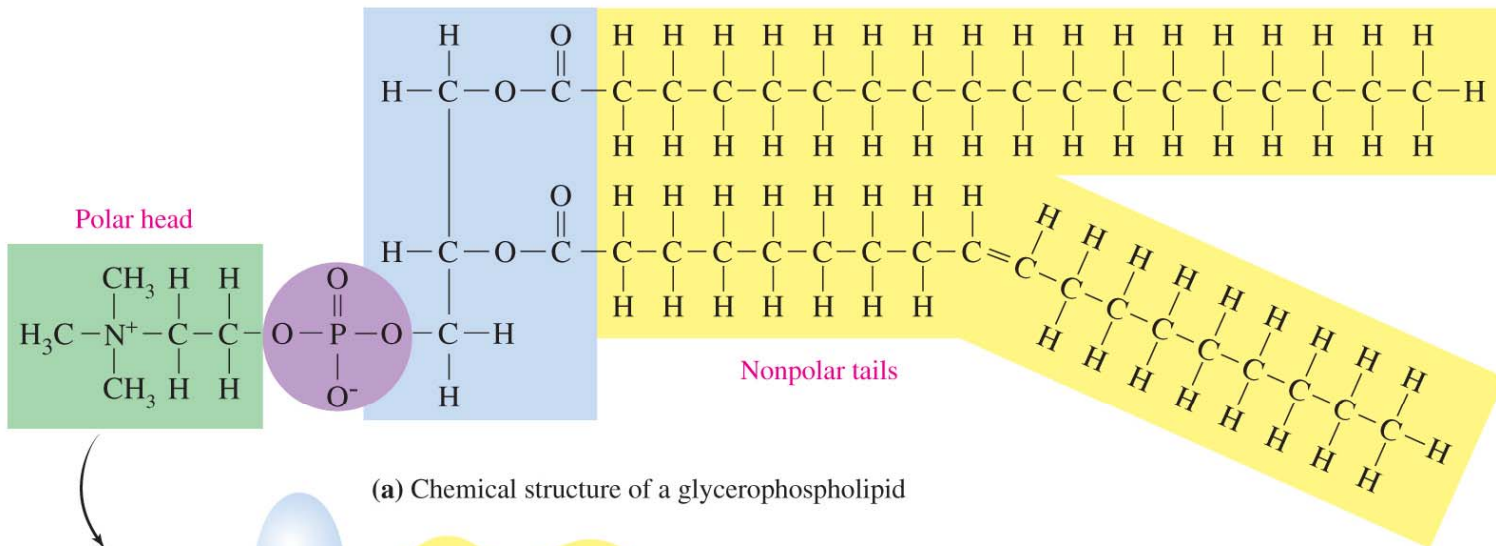
Serine

Ethanolamine

Glycerophospholipid

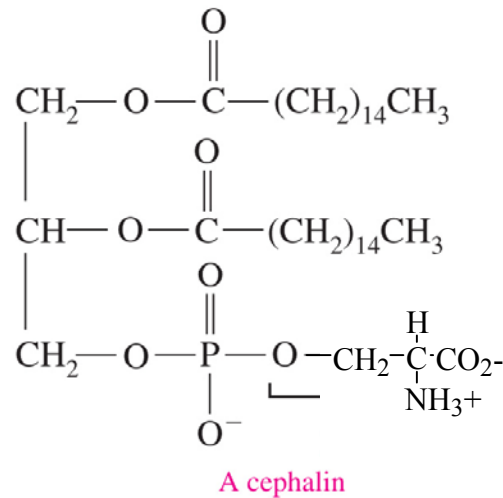
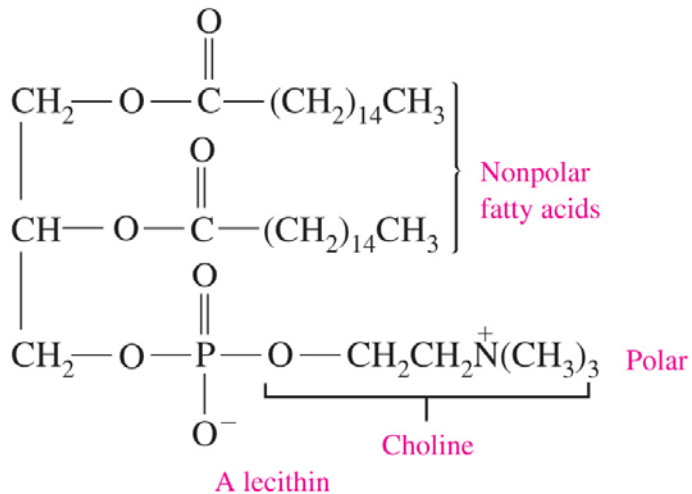


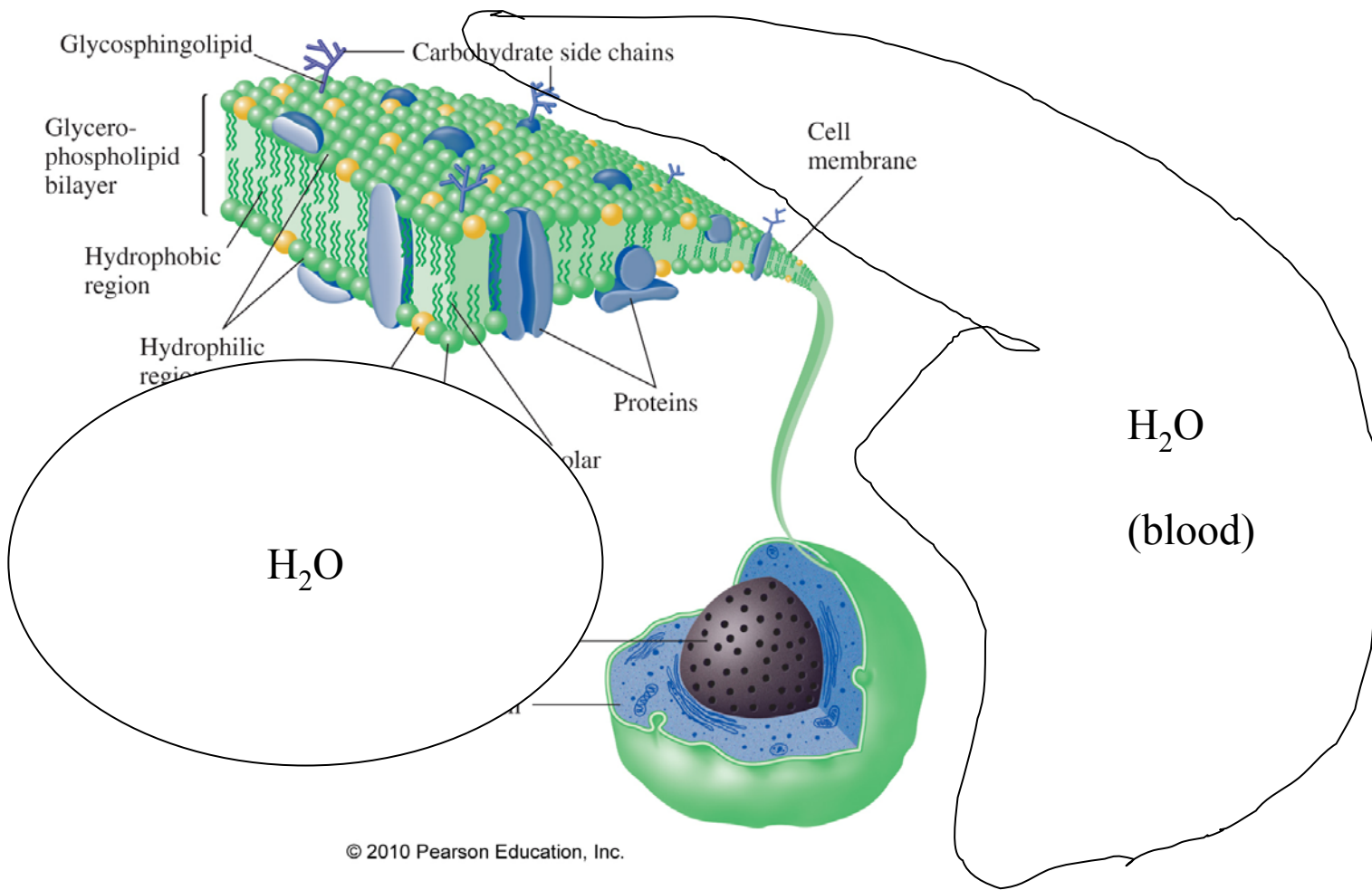
Choline



(b) Simplified way to draw a glycerophospholipid

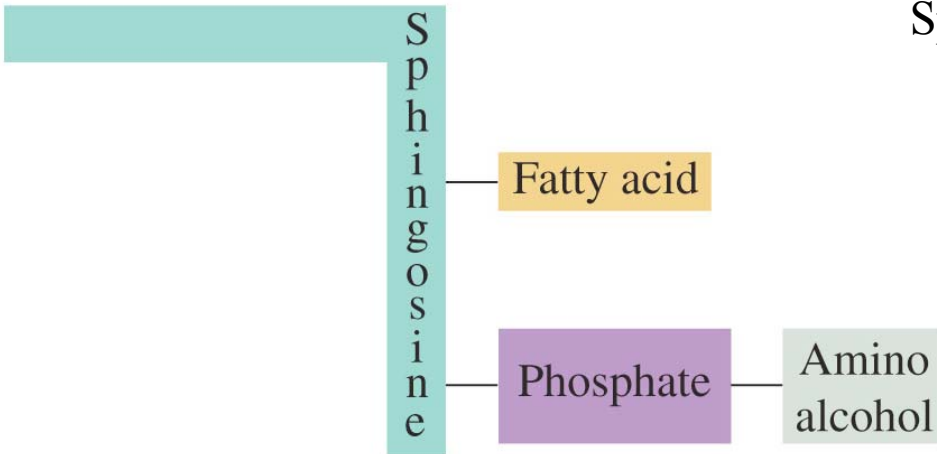
Lecithin and **cephalin** are glycerophospholipids that are abundant in brain and nerve tissues; are found in egg yolk, wheat germ, and yeast contain choline (in lecithins) or either ethanolamine or serine (in cephalins)



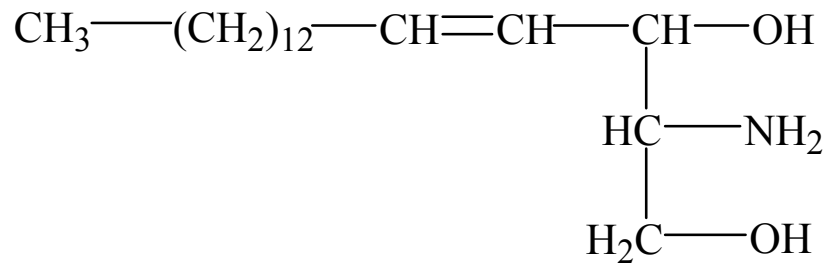


Cell membranes separate cellular contents from the external environment, both environments are essentially aqueous the membrane consists of a lipid bilayer made of two rows of phospholipids having an inner portion made of the nonpolar tails of phospholipids with the polar heads at the outer and inner surfaces

Sphingolipids



Sphingolipid

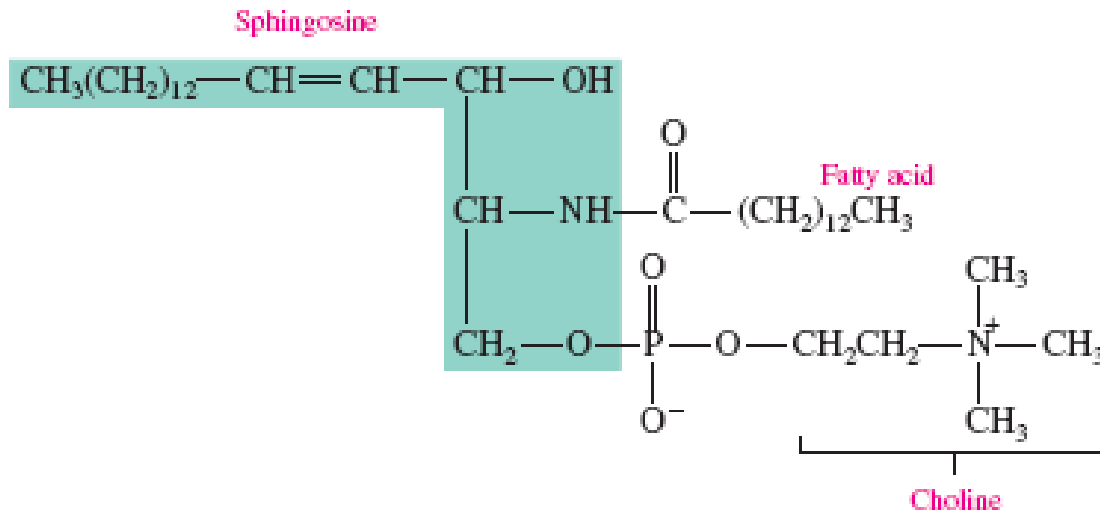


Sphingosine

Sphingomyelin

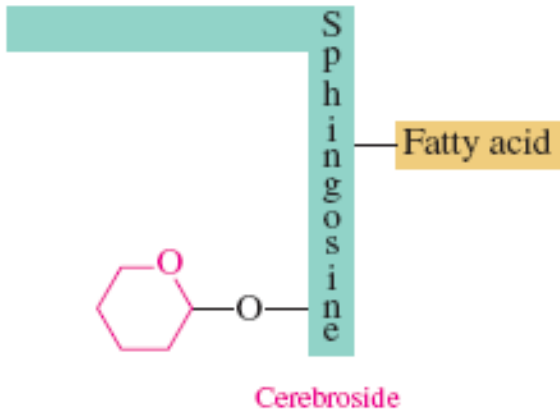
is a sphingolipid found in nerve cells

bonds the —OH of a ceramide to a phosphate ester of choline

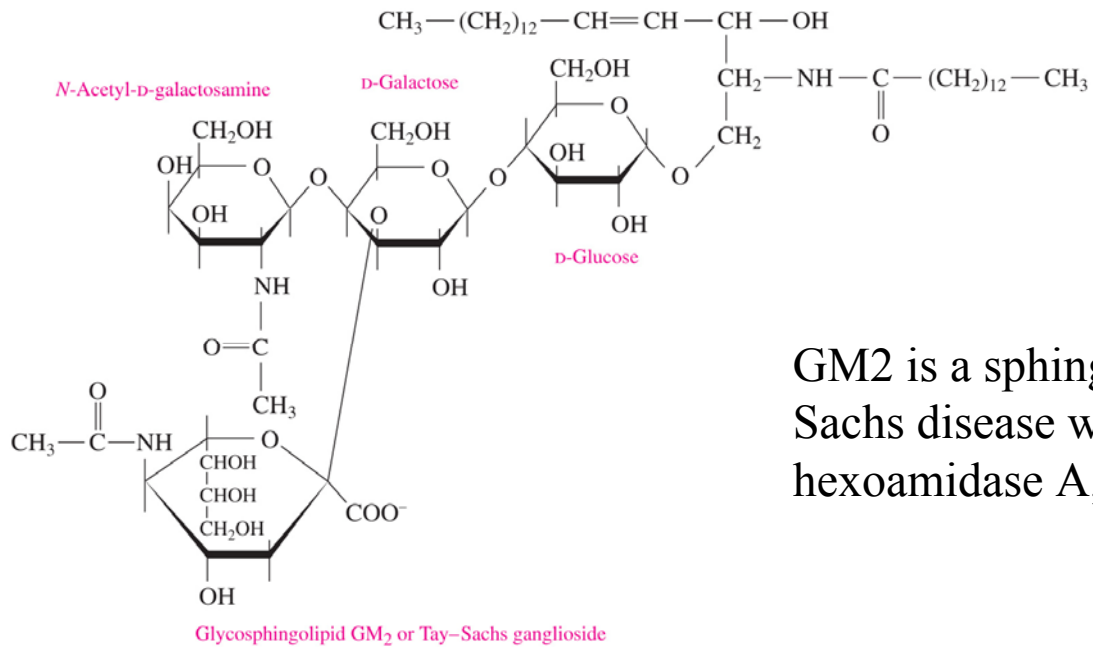


Sphingomyelin (a sphingolipid)

Glycosphingolipids are sphingolipids that contain monosaccharides attached to the —OH group of sphingosine



Certain sphingolipids contain chains of two to seven monosaccharides (sugars) and are important in neurons;
 are found on cell membrane surfaces
 act as receptors for hormones, viruses, and drugs
 are a cause of disease and death if they accumulate; the disease is often genetic in nature



GM2 is a sphingolipid that accumulates in Tay-Sachs disease when a specific enzyme, hexoamidase A, is defective

Many lipid diseases are caused by a deficiency of an enzyme resulting in the accumulation of glycolipids

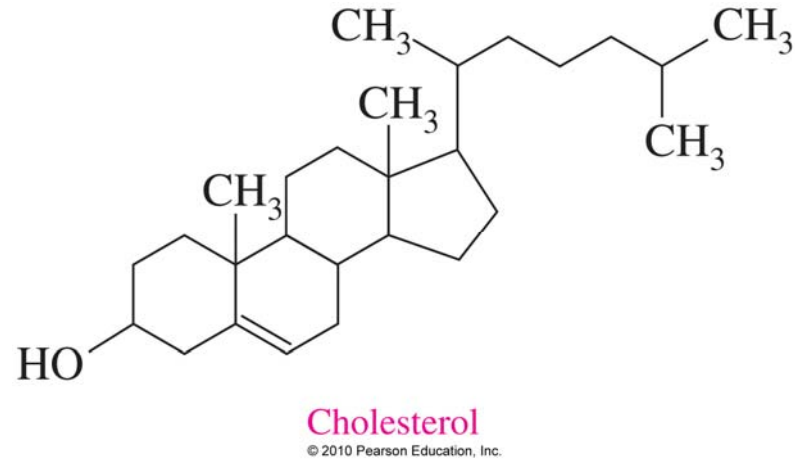
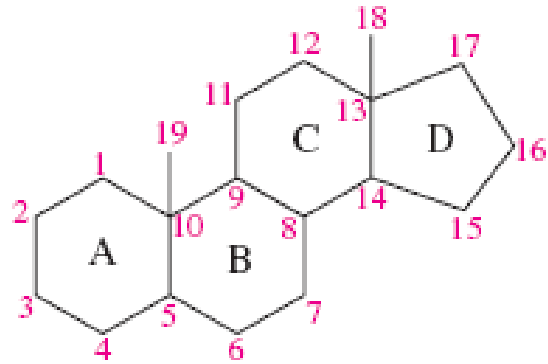
TABLE 17.3 Lipid Diseases

Name of Disease	Lipid Stored	Type	Enzyme Absent
Fabry's	Gal-gal-glucosylceramide	Ganglioside	α -Galactosidase
Gaucher's	Glucosylceramide	Cerebroside	β -Glucosidase
Niemann–Pick	Sphingomyelin	Sphingolipid	Sphingomyelinase
Tay–Sachs	GM ₂ ganglioside	Ganglioside	Hexosaminidase A

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The name of the enzyme is often associated with the name of the group it acts upon followed by the suffix -ase

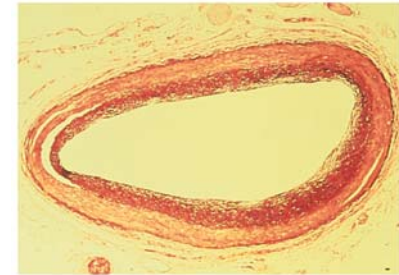
Steroids



The steroid nucleus

Cholesterol in the body is obtained from meats, milk, and eggs; most is synthesized in the liver if needed; it is needed for cell membranes, brain and nerve tissue, and the synthesis of steroidal hormones, most cholesterol is found esterified with a fatty acid at the -OH

It can also help clogs arteries when high levels form plaque



(a)



(b)

Cholesterol is synthesized in the liver
 and also obtained from foods;
 it is used to make a variety of other steroids
 used to regulate body functions;
 it is used to make the bile acids used to
 emulsify fats stored in the gallbladder
 it considered elevated if plasma cholesterol
 exceeds 200 mg/dL
 high levels of cholesterol crystallize in the
 gallbladder as gallstones

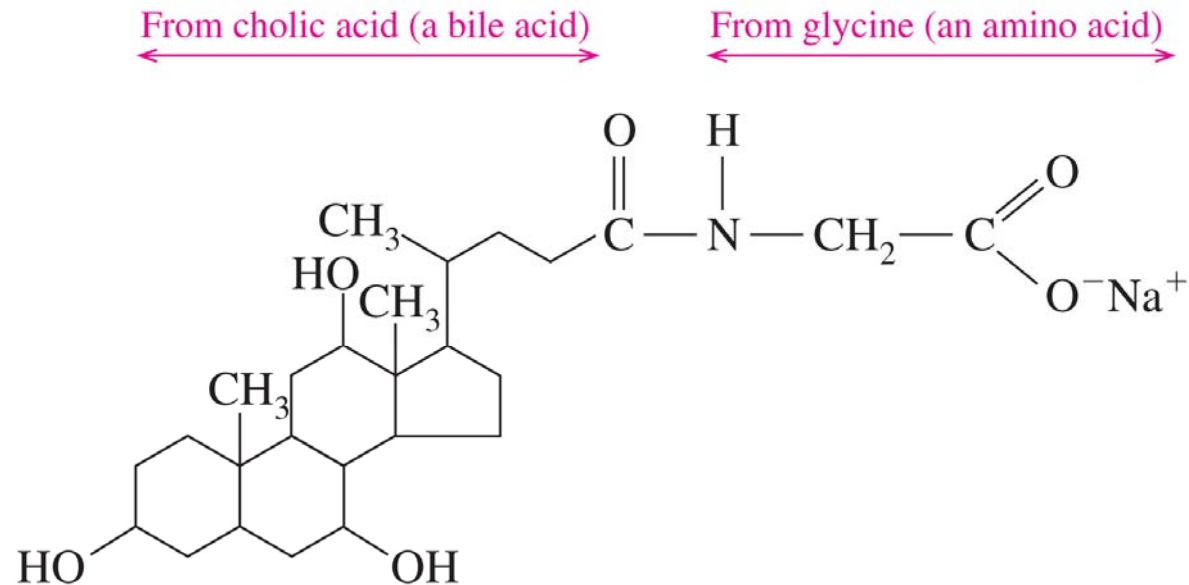


TABLE 17.4 Cholesterol Content of Some Foods

Food	Serving Size	Cholesterol (mg)
Liver (beef)	3 oz	370
Large egg	1	200
Lobster	3 oz	175
Fried chicken	3½ oz	130
Hamburger	3 oz	85
Chicken (no skin)	3 oz	75
Fish (salmon)	3 oz	40
Butter	1 tablespoon	30
Whole milk	1 cup	35
Skim milk	1 cup	5
Margarine	1 tablespoon	0

Bile salts

are synthesized in the liver from cholesterol;
are stored in the gallbladder;
are secreted into the small intestine;
have a polar and a nonpolar region;
mix with fats to break them part;
emulsify fat particles to provide large surface
area

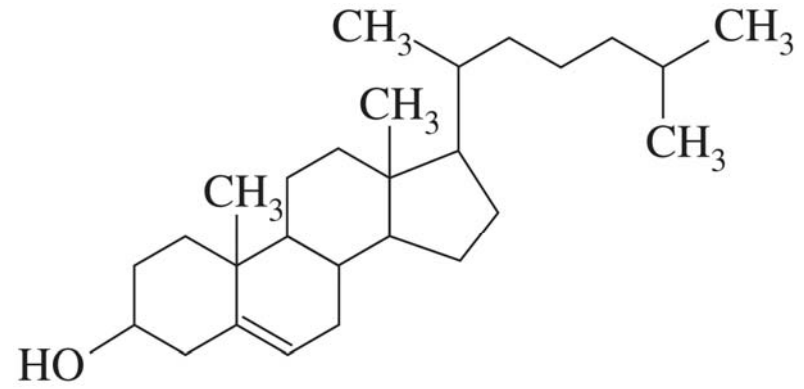


Sodium glycocholate (a bile salt)

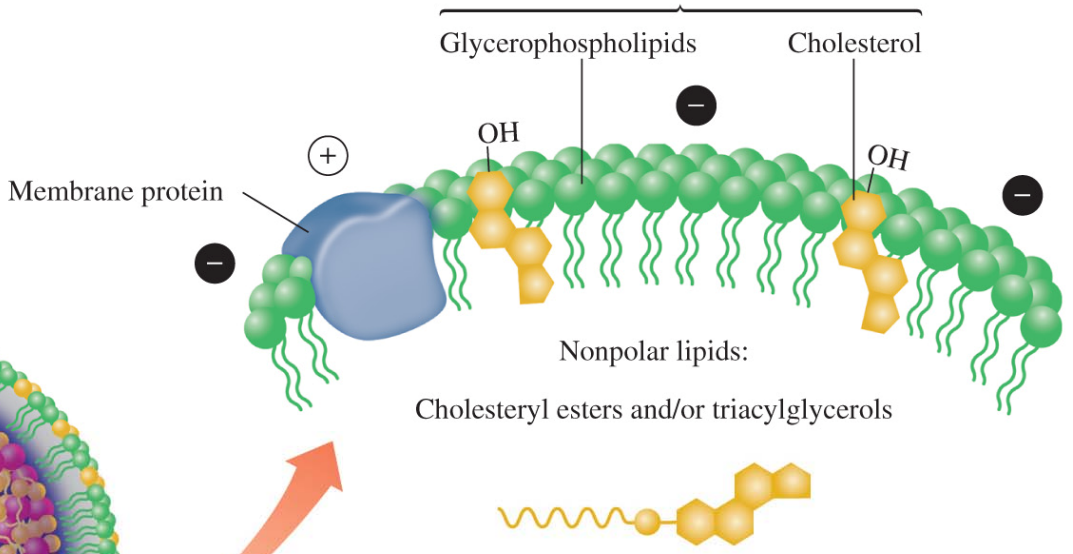
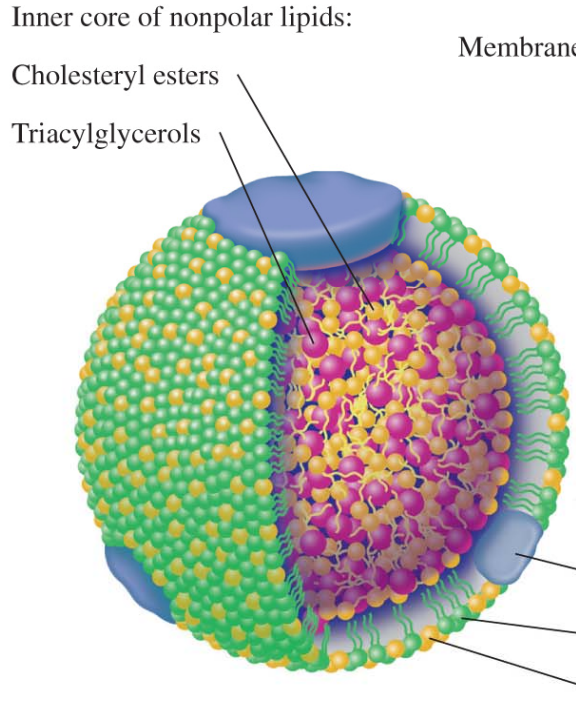
“Good and bad cholesterol”

Lipoproteins

combine lipids with proteins and phospholipids are soluble in water because the surface consists of polar lipids



Cholesterol
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Lipoproteins differ in density, composition, and function; they include low-density lipoprotein (LDLs) and high-density lipoprotein (HDLs); HDLs transport not needed cholesterol to the liver where it is converted to bile salts and excreted; high levels of saturated fats stimulate the production of cholesterol by the body; high levels of LDLs can deposit unneeded cholesterol in the arteries

TABLE 17.5 Composition and Properties of Plasma Lipoproteins

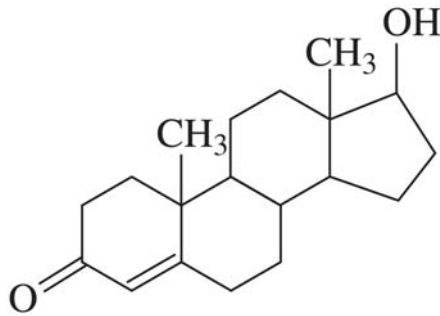
	Chylomicron	VLDL	LDL	HDL
Density (g/mL)	0.940	0.950–1.006	1.006–1.063	1.063–1.210
Composition (% by mass)				
Type of Lipid				
Triacylglycerol	86	55	6	4
Phospholipids	7	18	22	24
Cholesterol	2	7	8	2
Cholesteryl esters	3	12	42	15
Protein	2	8	22	55

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Triacylglycerol = fat

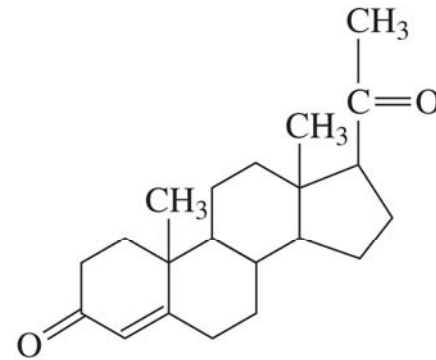
Steroidal Hormones are chemical messengers in cells and are produced from cholesterol include sex hormones such as androgens (testosterone) in males and estrogens (estradiol) in females

Examples



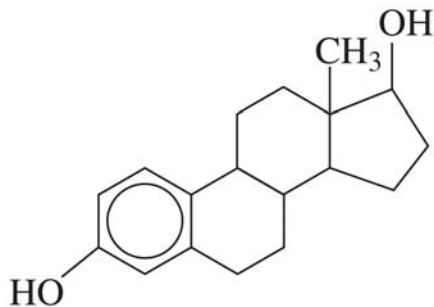
Testosterone (androgen)
(produced in testes)

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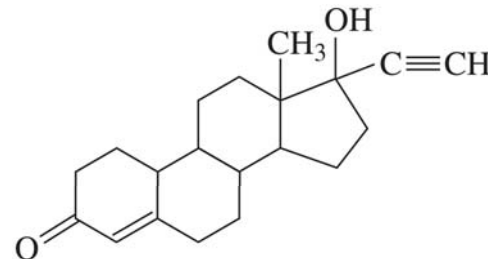
Progesterone
(produced in ovaries)

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Estradiol (estrogen)
(produced in ovaries)

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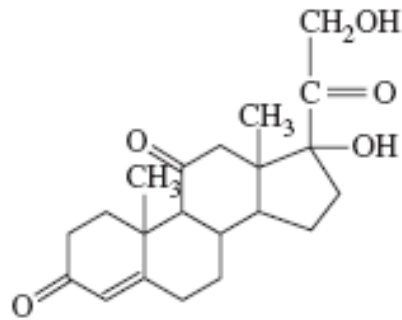


Norethindrone
(synthetic progestin)

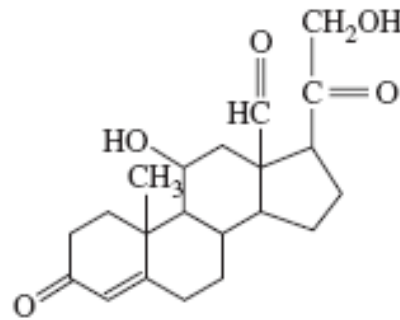
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Adrenal corticosteroids are steroidal hormones that are produced by the adrenal glands located on the top of each kidney; they include *aldosterone*, which regulates electrolytes and water balance by the kidneys; *cortisone*, a glucocorticoid, which increases blood glucose level and stimulates the synthesis of glycogen in the liver

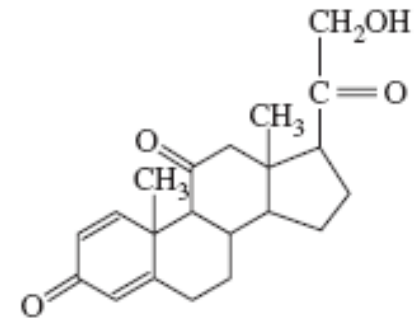
Corticosteroids



Cortisone
(produced in adrenal gland)



Aldosterone (mineralocorticoid)
(produced in adrenal gland)



Prednisone
(synthetic corticoid)

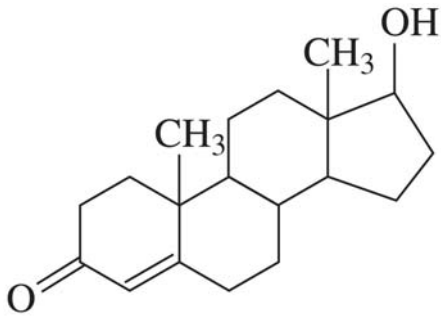
Biological Effects

Increases the blood glucose and glycogen levels from fatty acids and amino acids

Increases the reabsorption of Na^+ in kidneys; retention of water

Reduces inflammation; treatment of asthma and rheumatoid arthritis

High levels of testosterone increase muscle mass; many hormones taken orally are destroyed by the digestive process



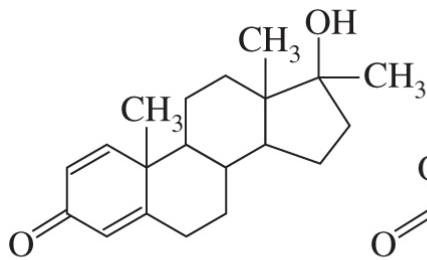
Testosterone (androgen)
(produced in testes)

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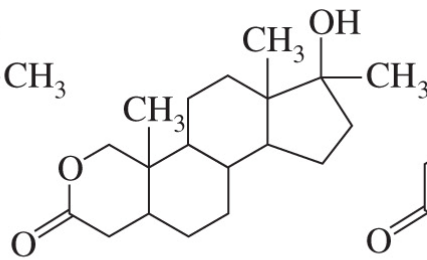
Anabolic steroids are derivatives of testosterone often used illegally to increase muscle mass have side effects that include fluid retention, hair growth, sleep disturbance, and liver damage; they can be taken orally



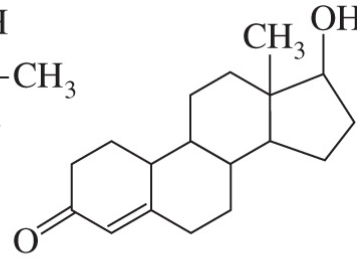
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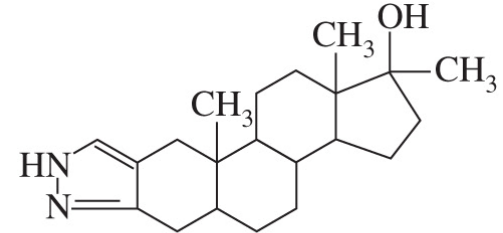
Methandienone



Oxandrolone



Nandrolone



Stanozolol

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