Notes 10/17

Tuesday, October 16, 2007
7:41 PM

Notes 1017 - 2

Audio recording started: 10:08 AM Wednesday, October 17, 2007

Lipids: Classification

Oct. 17, 2007

Problem Set #5

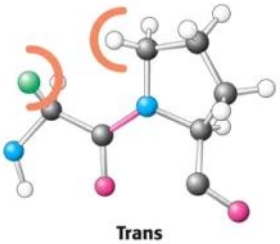
- Voet and Voet, 3rd edition
- Chapter 2 Problems 1, 3, 5, 8, 10, 12, 14,
- Chapter 4 Problems 1, 2, 3, 4, 5, 8, 10,
- Chapter 8 Problems 1, 4, 5, 6, 7, 12, 13, 18 (You don't need to use numbers to answer #18. Just compare them to each other.), 22
- Chapter 9 Problems 3, 4, 6, 7, 12, 13
- Chapter 10 Prolbems 1, 8,

Today's Overview

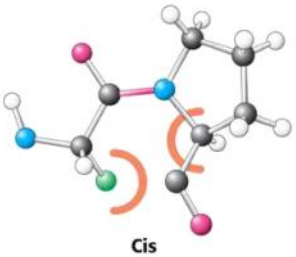
- Quick discussion of conformation vs. configuration
- Finish our focused discussion of carbohydrates
  - Lactose (mistaken identity)
  - Peptidoglycan
- Fats

Proline's **configuration** about peptide bond (slide from Oct. 8, 2007)

Proline has a fixed phi angle. We describe its R-group's arrangement in space as either the trans or cis configuration/conformation. For the other amino acids the arrangement in space is described as either the trans or cis conformation.



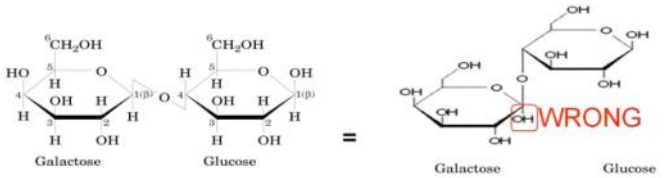
Trans Proline

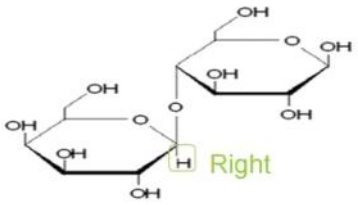


Cis Proline

Cis trans is technically a confirmation not a configuration, but is sometimes losly called configuration

Lactose (slide 5 from 10/16/07)





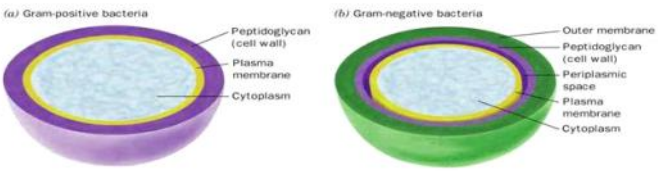
Changd 10/15 notes

Peptidoglycan (a.k.a. murein) is a polysaccharide that serves a structural role in bacterial cell walls

- Covalently linked polysaccharide and polypeptide chains form the peptidoglycan framework
- Medically significant because the cell wall is responsible for bacterial virulence
- Cell walls alone can induce disease symptoms in humans
- The thickness of the cell wall that encloses the plasma membrane distinguishes bacteria as either gram-positive or gram-negative

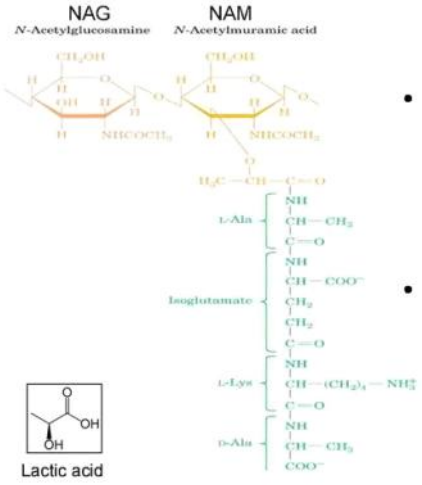
Schematic diagram comparing the cell envelopes of (*a*) gram-positive bacteria and (*b*) gram-negative bacteria.

+ −



- Gram-positive wall is about 250 angstroms thicker thick
- Gram-negative wall is about 30 angstroms thiner thick

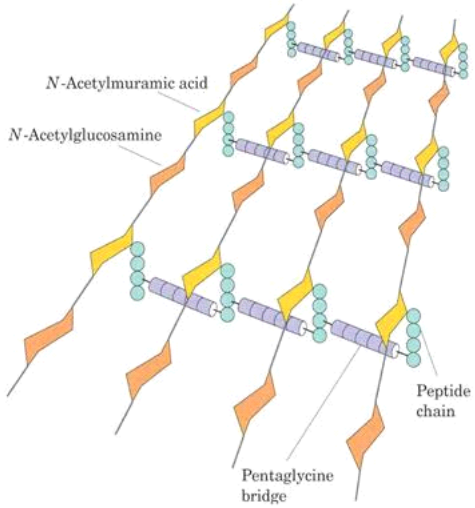
Chemical structure of the repeating unit of peptidoglycan



- The polysaccharide portion is an alternating NAG and NAM linked beta(1-->4)
- NAM has a tetrapeptide linked by an amide bond to its lactic acid moiety

Don't need to know to draw entire thing on exam but should be able to identify components and it

Structure of the gram positive *Staphylococcus aureus* bacterial cell wall peptidoglycan



- Peptidoglycan chains form parallel layers that are cross-linked by a pentaglycine bridge
- The pentaglycine bridge extends from the terminal carboxyl group of one tetrapeptide to the epsilon-amino group of the K in the neighboring tetrapeptide

Lipids

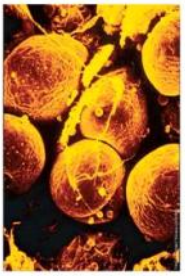
- Triacylglycerols
- Glycerophopholipids
- Sphingolipids
- Cholesterol

Lipids make up a very heterogenous class of highly reduced biological compounds that consist of fats, oils, and waxes

- Biological functions
  - Energy storage
  - Membrane components
  - Protective coatings
  - Precursors to bile acids, hormones, vitamins, intercellular mediators
  - Insulation
  - Pulmonary surfactants
- Classification
  - Biological roles
  - Structural composition
- Some properties
  - Soluble in organic solvents (chloroform, methanol)
  - Very little (if any) solubility in water

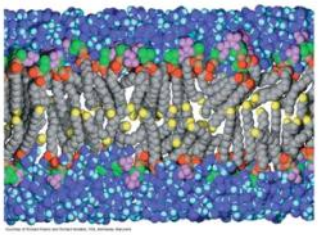
Lipids play various biological roles

- Triacylglycerols are energy storage lipids
  - (a.k.a. triglycerides)



Electron micrograph of adipocytes

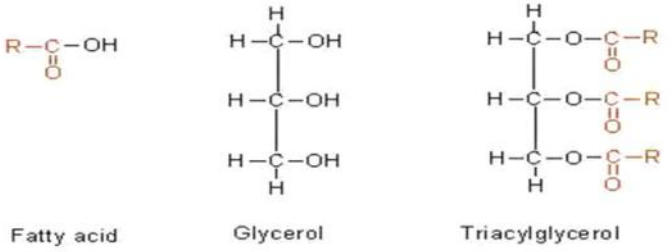
- Phosopholipids, glycolipids, and cholesterol are membrane lipids



Example of a lipid bilayer

Triclycerol and trigycerides are same thing

Triacylglycerols are involved in energy storage in animals



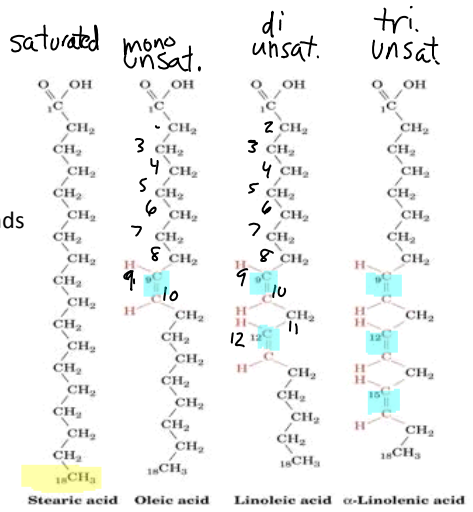
Fatty acid Glycerol Triacylglycerol

- Nonpolar, water-insoluble, fatty acid triesters of glycerol
- Most abundant class of lipids

What is a fatty acid?

Fatty acids are carboxylic acids with long chain hydrocarbon side groups

f.a = fatty acid



Saturated=
No double bonds

- Rarely occur in the free form in nature
- Predominant residues are C_{16} and C_{18} species palmitic, oleic, linoleic, and steric acids
- Uncommon to find f.a. that are <14 and >20 carbon atoms long
- Most f.a. have an even number of carbons
- Saturated and unsaturated
- Found in triacylglycerols, waxes

Found in glycerophophopholipids, sphingolipids, cholesterol too

Saturated fatty acids

#C in chain

Symbol[a]	Common Name	Systematic Name	Structure	mp (°C)
Saturated fatty acids				
12:0	Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	44.2
14:0	Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	52
16:0	Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	63.1
18:0	Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	69.6
20:0	Arachidic acid	Eicosanoic acid	$CH_3(CH_2)_{18}COOH$	75.4
22:0	Behenic acid	Docosanoic acid	$CH_3(CH_2)_{20}COOH$	81
24:0	Lignoceric acid	Tetracosanoic acid	$CH_3(CH_2)_{22}COOH$	84.2

increasing

- Free to move about each C-C bond
- Assumes wide arrange of conformations
- Fully extended form is most energetically favorable
- Melting point increases with size

Do not have to memorize melting points

Know the fatty acids in the blue boxes, # of carbons, common name, system name, structure (basically everything in box)

All of these have 18C but differ by # of double bonds

Unsaturated Fatty Acids

Systematic name... need to give structure given it but don't need to know inverse.

Symbol[a]	Common Name	Systematic Name	Structure	mp (°C)
Unsaturated fatty acids (all double bonds are cis)				
16:1*n*−7	Palmitoleic acid	9-Hexadecenoic acid	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	−0.5
18:1*n*−9	Oleic acid	9-Octadecenoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	13.4
18:2*n*−6	Linoleic acid	9,12-Octadecadienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$	−9
18:3*n*−3	α-Linolenic acid	9,12,15-Octadecatrienoic acid	$CH_3CH_2(CH{=}CHCH_2)_3(CH_2)_6COOH$	−17
18:3*n*−6	γ-Linolenic acid	6,9,12-Octadecatrienoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_3(CH_2)_3COOH$	
20:4*n*−4	Arachidonic acid	5,8,11,14-Eicosatetraenoic acid	$CH_3(CH_2)_4(CH{=}CHCH_2)_4(CH_2)_2COOH$	−49.5
20:5*n*−3	EPA	5,8,11,14,17-Eicosapentaenoic acid	$CH_3CH_2(CH{=}CHCH_2)_5(CH_2)_2COOH$	−54
22:6*n*−3	DHA	4,7,10,13,16,19-Docosahexenoic acid	$CH_3CH_2(CH{=}CHCH)_6CH_2COOH$	
24:1*n*−9	Nervonic acid	15-Tetracosenoic acid	$CH_3(CH_2)_7CH{=}CH(CH_2)_{13}COOH$	39

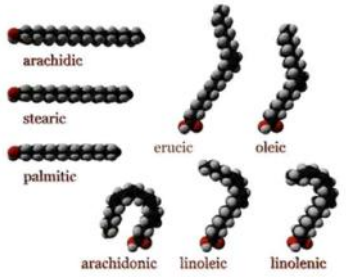
[a]Number of carbon atoms : number of double bonds. For unsaturated fatty acids, *n* is the number of carbon atoms, *n* − *x* is the double-bonded carbon atom, and *x* is the number of that carbon atom counting from the methyl terminal (ω) end of the chain.

Source: Dawson, R.M.C., Elliott, D.C., Elliott, W.H., and Jones, K.M., *Data for Biochemical Research* (3rd ed.), Chapter 8, Clarendon Press (1986).

- Double bonds are indicated in symbol and tend to occur at every third carbon toward the methyl terminus
- 18:1n-9 means that it is an 18 carbon fatty acid, there is one double bond, the double bond occurs after carbon #9
- 18:3n-3 means that is is an 18 carbon fatty acids, there are three double bonds, and the double bonds are located after carbons #15, 12, and 9

Need to know to decipher symbol

Unsaturated fatty acids



- Double-bond almost always cis configuration
- Rigid 30° bend restricts packing
- Reduced van der Waals interactions
- m.p. increases with increasing unsaturation
- Lard is solid, vegetable oil is liquid at R.T.

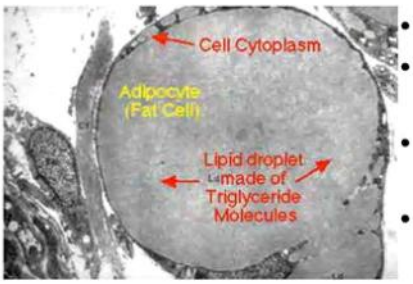
? Do not study sentence possibly wrong

more kinks → more unsaturation

Example of a solid fat at room temperature

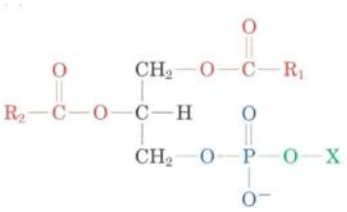
Now we can discuss triacylglycerols some more

Triacylglerols are efficient for energy storage



- Less oxidized than proteins and carbohydrates (more reduced)
- Stored in anhydrous form
- Provides 6X energy than glycogen
- Made and stored in adipocytes of animals
- Typical human can use stored fat to survive starvations for 2-3 months
- Glycogen only lasts a day

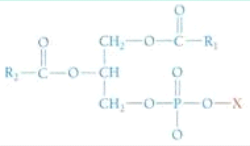
Glycerophospholipids

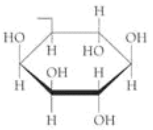
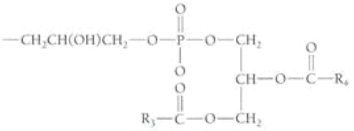


Glycerophospholipid

- A.k.a phophoglycerides (5)
- Major component of biological membranes
- Consist of a glycerol, two fatty acids (R_1 and R_2), and polar phosphoryl-X head group (usually alcohols)
- R_1 is usually a saturated C_{16} or C_{18} f.a. and R_2 is usually an unsaturated C_{16} to C_{20} f.a.

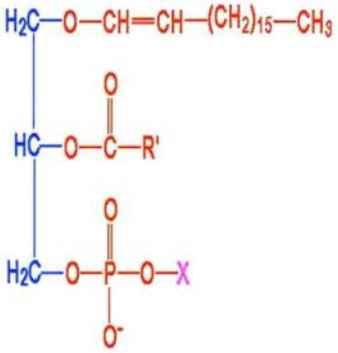
Common Classes of Glycerophospholipids



Name of X—OH	Formula of—X	Name of Phospholipid
Water	—H	Phosphatidic acid
Ethanolamine	$-CH_2CH_2NH_3^+$	Phosphatidylethanolamine
Choline	$-CH_2CH_2N(CH_3)_3^+$	Phosphatidylcholine (lecithin)
Serine	$-CH_2CH(NH_3)COO^-$	Phosphatidylserine
myo-Inositol		Phosphatidylinositol
Glycerol	$-CH_2CH(OH)CH_2OH$	Phosphatidylglycerol
Phosphatidylglycerol		Diphosphatidylglycerol (cardiolipin)

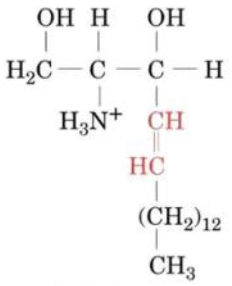
Need to recognize structure and components of highlighted ones. Do not need to draw from scratch.

Plasmalogens are a type of glycerophopholipid



- Vinyl ether on C1 rather than an ester
- Head groups (X) are commonly ethanolamine, choline

Sphingolipids are also major membrane components



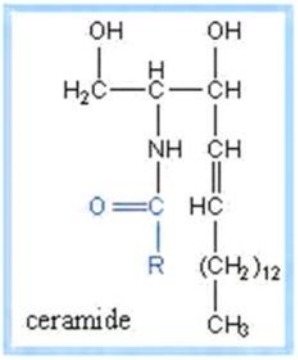
Sphingosine

- Sphingolipids are derived from sphingosine

Know this structure

Not a fatty acid

The N-acyl fatty acid derivative of sphingosine is ceramide



- Ceramides are the parent compounds of the more common sphingolipids
  - Sphingomyelins
  - Cerebrosides
  - Gangliosides

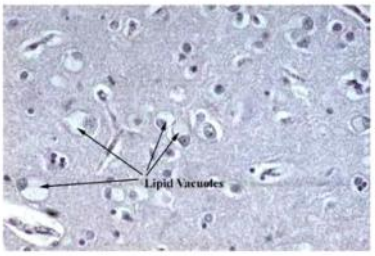
Common sphingolipids

- Sphingomyelin
  - Ceramides + phosphocholine or phophoethanolamine head group
  - Most common sphingolipid
  - Major component of myelin sheaths of nerve cells
- Cerebrosides
  - Ceramides + monosaccharide residue head group
  - Found in neuronal cell membranes of the brain and in the membranes of other tissues
- Gangliosides
  - Ceramide + oligosaccharides
  - Primarily components of cell-surface membranes and significant portion of brain lipids (6%)

In mylen sheets of nerve cells

Should be able to distinguish between these when given structure

Gangliosides are medically significant

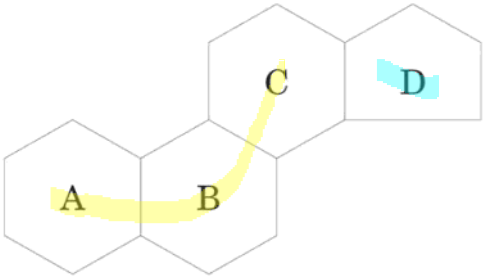


Neurons affected by Tay-Sachs

- Complex carbohydrate head groups act as specific receptors for certain pituitary hormones
- Receptors for bacterial protein toxins like cholera toxin
- Thought to play an important role in cell growth and differentiation
- May be involved in carcinogenesis
- Tay-Sachs disease is a hereditary sphingolipid (ganglioside) storage disease marked by fatal neurological deterioration

- Lipids we have discussed so far:
  - Triacylglerols
  - Glycerophospholipids
  - Sphingolipids
- Now let's discuss cholesterol

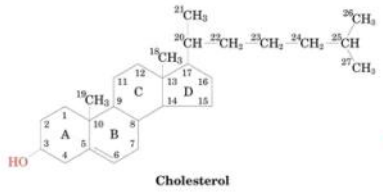
Steroids are derivatives of a rigid four fused ring structure



Cyclopentanoperhydrophenanthrene

Should know this long name

Cholesterol is the most abundant steroid in animals



- Major component of animal plasma membranes
- Occurs in membranes of subcellular organells to a lesser extent
- Flexible hydrophobic tail
- Polar head
- Weakly amphipathic
- Rigid
- Abundant in blood plasma lipoproteins

Will not have to draw but should be able to identify

Cholesterol serves many functions

- Precurso to bile acids, which aid in lipid digestion
- Precursors to steroid hormones
- Major component of plasma membranes
- Minor component of subcellular organelles