chapter 3- lipids and membranes  
  
lipids are water-insoluble that are either hydropinghobic (nonpolar) or amphipathic (polar and nonpolar regions).  
  
there are many types of lipids:  
1) fatty acids  
• the simplest with structural formula of r-cooh where r = hydrocarbon chain.  
• they differ from each other by the length of the tail, degree of unsaturation, and position of double bonds.  
• pka of -cooh is 4.5-5.0 > ionized at physiological ph.  
• if there is no double bond, the fatty acid is saturated.  
• if there is at least one double bond, the fatty acid is unsaturated.  
• monounsaturated fatty acids contain 1 double bond polyunsaturated fatty acids have >2 double bonds.  
• iupac nomenclature =?n represents where double bond occurs as you count from the carboxyl end (see table 9.1).  
e.g. -enoate one double bond  
-dienoate 2 “  
-trienoate 3 “  
-tetraenoate 4 “  
• can also use a colon separating 2 numbers, where the first number represents the number of carbon atoms and the second number indicates the location of the double bonds.  
e.g. linoleate 18:2?9,12 or cis,cis -?9,12octadecadienoate  
• physical properties differ between saturated and unsaturated fatty acids.  
saturated = solid at rt often animal source e.g. lard  
unsaturated = liquid at rt plant source e.g. vegetable oil  
• the length of the hydrocarbon tails influences the melting point.  
• as the length of tails increases, melting points increases due to number of van der waals interactions.  
• also affecting the melting point is the degree of unsaturation.  
• as the degree of unsaturation increases, fatty acids become more fluid > melting point decreases ( kinks in tails decrease number of van der waals interactions).  
  
• fatty acids are also an important sources of energy.  
9 kcal/g vs. 4 kcal/g for carbohydrates and proteins.  
  
2) triacylglycerols  
  
• also called triglycerides.  
• made of 3 fatty acyl residues esterified to glycerol.  
• very hydropinghobic, neutral in charge -> can be stored in anhydrous form.  
• long chain, saturated triacylglycerols are solid at rt (fats).  
• shorter chain, unsaturated triacylglycerols are liquid at rt (oils).  
  
• lipids in our diet are usually ingested as triacylglycerols and broken down by lipases to release fatty acids from their glycerol backbones  
• also occurs in the presence of detergents called bile salts.  
? form micelles around fatty acids that allow them to be absorbed by intestinal epithelial cells.  
? transported through the body as lipoproteins.  
  
3) glycerophospholipids  
  
• main components of cell membranes.  
• are amphipathic and form bilayers.  
• all use glycerol 3-phosphate as backbone.  
• simplest is phosphatidate = 2 fatty acyl groups esterified to glycerol 3- phosphate.  
• often, phosphate is esterified to another alcohol to form...  
? phosphatidylethanolamine  
? phosphatidylserine  
? phosphatidylcholine  
  
• enzymes called phospholipases break down biological membranes.  
? a-1 = hydrolysis of ester bond at c-1.  
? a-2 = hydrolysis of ester bond at c-2 found in pancreatic juice.  
? c = hydrolysis of p-o bond between glycerol and phosphate to create phosphatidate.  
? d = same  
  
4) sphingolipids  
  
• second most important membrane constituent.  
• very abundant in mammalian cns.  
• backbone is sphingosine (unbranched 18 carbon alcohol with 1 trans c=c between c-4 and c-5), nh3+ group at c-2, hydroxyl groups at c-1 and c-3.  
• ceramides are intermediates of sphingolipid synthesis.  
• there are three families of sphingolipids:  
1) sphingomyelin - phosphocholine attached to c-1 hydroxyl group of ceramide present in the myelin sheaths around some peripheral nerves.  
2) 2)cerebrosides - glycosphingolipid has 1 monosaccharide (galactose) attached by ?-glycosidic linkage to c-1 of ceramide most common is galactocerebroside, which is abundant in nervous tissue.  
3) gangliosides - glycosphingolipid containing n-acetylneuraminic acid present on all cell surfaces.  
• hydrocarbon tails embedded in membrane with oligosaccharides facing extracellularly.  
• probably used as cell surface markers, e.g. abo blood group antigens.  
• inherited defects in ganglioside metabolism > diseases, such as tay-sachs disease.  
  
5) steroids  
• called isoprenoids because their structure is similar to isoprene.  
• have 4 fused rings: 3 6-membered rings (a,b,c) and 1 5-membered ring (d).  
• cholesterol is an important component of cell membranes of animals, but rare in plants and absent in procaryotes.  
• also have mammalian steroid hormones (estrogen, androgens) and bile salts.  
• differ in length of side chain at c-17, number and location of methyl groups, double bonds, etc.  
• cholesterol’s role in membranes is to broaden the phase transition of cell membranes -> increases membrane fluidity because cholesterol disrupts packing of fatty acyl chains.  
  
6) other lipids not found in membranes  
• waxes - nonpolar esters of long chain fatty acids and alcohols  
very water insoluble  
high melting point > solid at outdoor/rt.  
roles: protective coatings of leaves, fruits, fur, feathers, exoskeletons.  
  
• eicosanoids - 20 carbon polyunsaturated fatty acids  
e.g. prostaglandins - affect smooth muscle > cause constriction bronchial constriction of asthmatics uterine contraction during labor  
  
• limonene - smell of lemons  
  
• bactoprenol - involved in cell wall synthesis  
  
• juvenile hormone i - larval development of insects  
  
  
  
biological membranes  
  
• central transport of ions and molecules into and out of the cell.  
• generate proton gradients for atp production by oxidative phosphorylation.  
• receptors bind extracellular signals and transduce the signal to cell interior.  
• structure:  
• glycerophospholipids and glycosphingolipids form bilayers.  
• noncovalent interactions hold lipids together.  
• 5-6 nm thick and made of 2 leaflets to form a lipid bilayer driven by hydropinghobic effects.  
• about 40% lipid and 50% proteins by mass, with about 10% carbohydrates.  
  
• protein and lipid composition varies among membranes but all have same basic structure > singer and nicholson fluid mosaic model in 1972.  
  
membrane fluidity:  
  
• lipids can undergo lateral diffusion can move about 2 ?m/sec.  
• can undergo transverse diffusion (one leaflet to another) but very rare.  
• membrane has an asymmetrical lipid distribution that is maintained by flippases or translocases that are atp-driven.  
• in 1970, frye and edidin demonstrated that proteins are also capable of diffusion by using heterocaryons, but occurs at a rate that is 100-500 times slower than lipids.  
• most membrane protein diffusion is limited by aggregation or attachment to cytoskeleton.  
• can examine distribution of membrane proteins by freeze-fracture electron microscopy.  
• membrane fluidity is dependent upon the flexibility of fatty acyl chains.  
• fully extended saturated fatty acyl chains show maximum van der waals interactions.  
• when heated, the chains become disordered > less interactions > membrane “shrinks” in size due to less extension of tails > due to rotation around c-c bond.  
• for lipids with unsaturated acyl chains, kink disrupts ordered packing and increases membrane fluidity > decreases phase transition temperature (becomes more fluid at lower temperature).  
• some organisms can alter their membrane fluidity by adjusting the ratio of unsaturated to saturated fatty acids.  
e.g. bacteria grown at low temperature increase the proportion of unsaturated fatty acyl groups.  
  
e.g. warm-blooded animals have less variability in that ratio because of the lack of temperature fluctuations.  
  
exception: reindeer leg has increased number of fatty acyl groups as get closer to hoof > membrane can remain more fluid at lower temperatures.  
  
• cholesterol also affects membrane fluidity.  
• accounts for 20-25% of lipid mass of membrane.  
• broadens the phase-transition temperature.  
• intercalation of cholesterol between membrane lipids restricts mobility of fatty acyl chains -> fluidity decreases.  
• helps maintain constant membrane fluidity despite changes in temperature and degree of fatty acid saturation.