ADVANCED CELL BIOLOGY//MOLECULAR BIOLOGY OF CELLS
Sept. 3, 2009 **01-146:470 + 16-148:514**

Course coordinator: Prof. David Denhardt (Nelson A301, denhardt@biology.rutgers.edu)
First period (8:40-10:00 AM) Monday and Thursday, Fall semester - SEC 118.
TEXT: MOLECULAR CELL BIOLOGY by Lodish et al. 6ed, WH Freeman & Co,
Course Website URL: http://lifesci.rutgers.edu/~denhardt/course/AdvCellBiol.2009.htm
(for Dr. Ron Hart's lectures it is: http://spine.rutgers.edu/cellbio/default.htm.)

Please note that for all lectures except Dr. Hart's the PowerPoint slides can be accessed by clicking on the highlighted title; homework questions are accessed similarly.

Before each lecture, students should submit to Dr. Denhardt (usually) or the lecturer brief answers to questions on the subject of the lecture.

We attempt to make audiotapes of each lecture.
Dr. Hart will explain how this works next Thursday.

Please sign in on the circulating note pads.
If you want to use an email other than eden, be sure to carefully spell it out.
If you do not receive an email from me by next Monday, send me an email.
Today: Course overview; review of cell structure and function (Chapters 1, 2)

(no nuclear membrane)

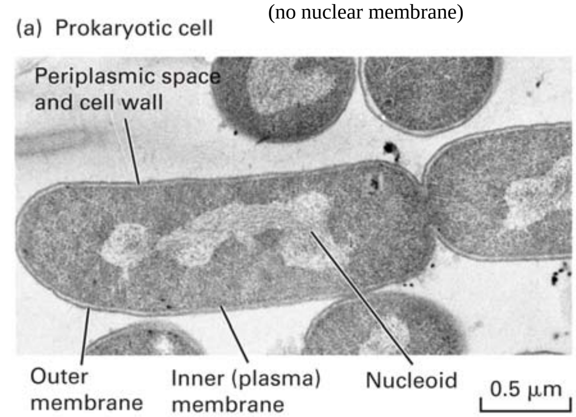
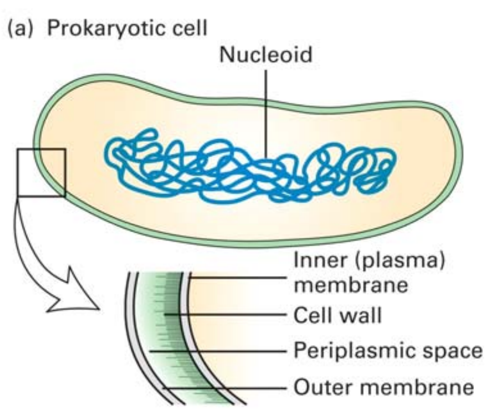
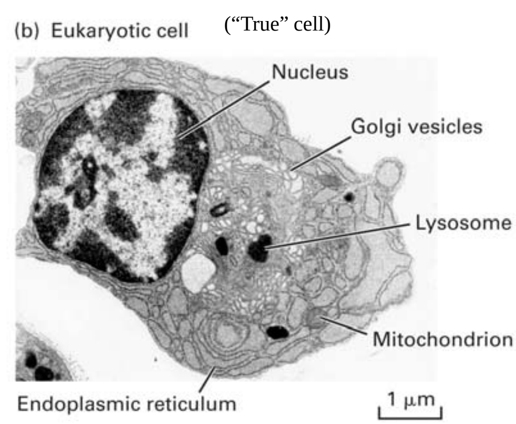


Fig. 1-2

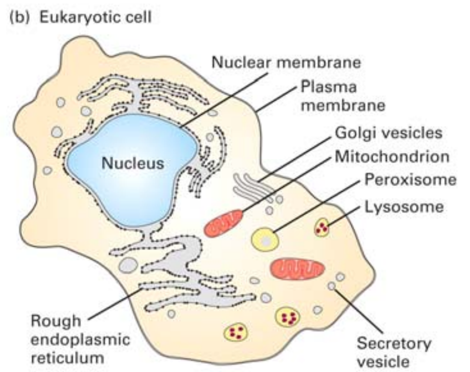


Double membrane characteristic of only some prokaryotes

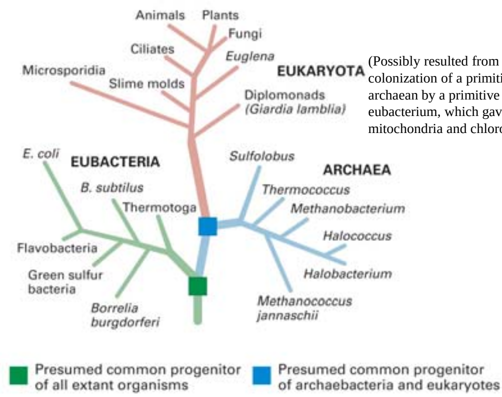
("True" cell)



(Note the double membrane (two lipid bilayers) around the nucleus; only a single lipid bilayer makes up the plasma membrane.)



Likely a single origin of living systems on earth.



(Possibly resulted from the colonization of a primitive archaean by a primitive eubacterium, which gave rise to mitochondria and chloroplasts.)

Fig. 1-3

Size relationships among proteins, nucleic acids and lipids.
Differences may consist of permutations and combinations of subunits.

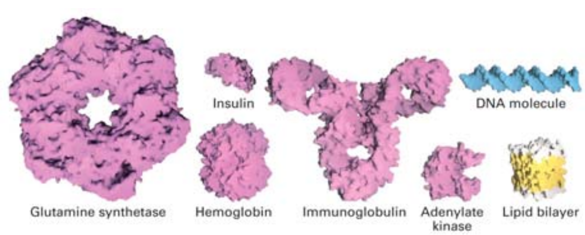


Fig. 1-9. Three-dimensional shapes are the consequences of macromolecular folding determined by the constituent monomeric subunits.

Double-helical structure of DNA and an illustration of the semi-conservative mechanism of replication.

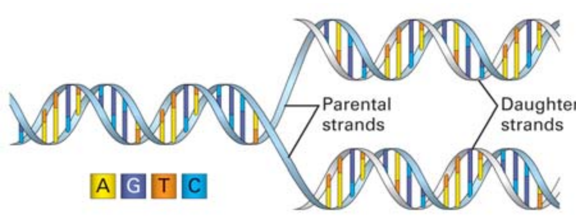


Fig. 1-10. THE GENETIC MATERIAL

Simplified view of the decoding of the genetic information in a typical eukaryote.

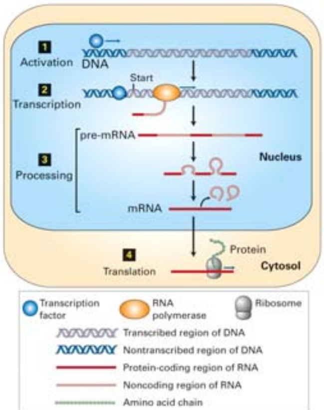


Fig. 1-11

The formation of a lipid bilayer surrounding the cell was a critical development in the evolution of living systems. Incompatibility of hydrophobic and hydrophilic molecules.

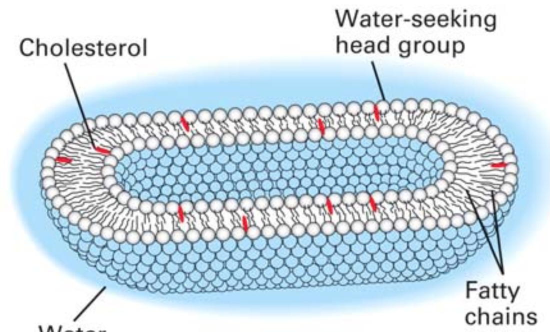


Fig. 1-13

ATP is the most common molecule used by cells to capture and transfer metabolic energy.

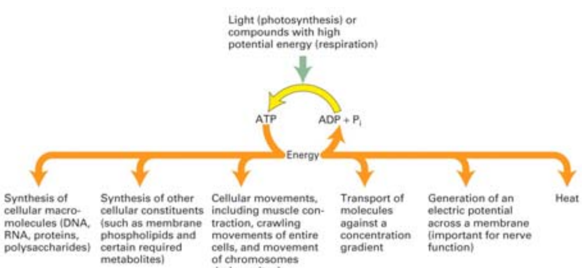


Fig. 1-14

The three types of cytoskeletal filaments found in eukaryotic cells.

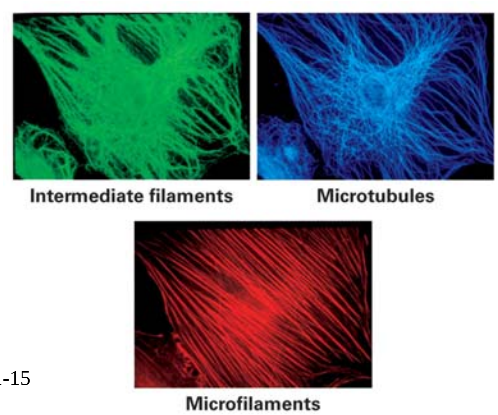


Fig. 1-15

A generic view of two mechanisms to activate cell signaling.

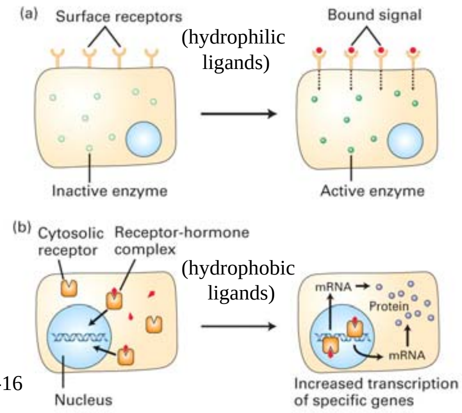


Fig. 1-16

The eukaryotic cell cycle.

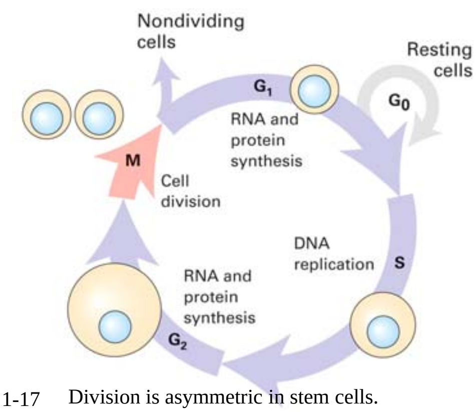


Fig. 1-17 Division is asymmetric in stem cells.

Apoptosis, or programmed cell death.
Cell breaks up into numerous innocuous fragments (blebs).

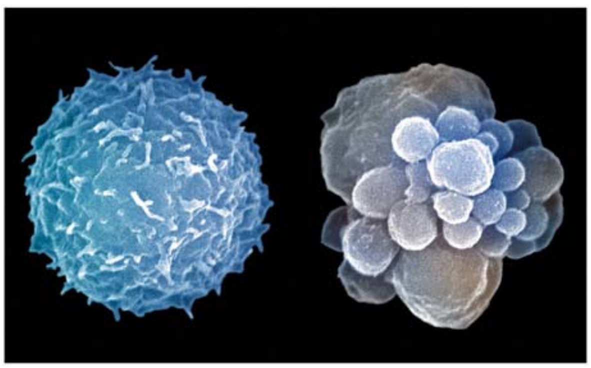


Fig. 1-19 Normal white cell (left). An apoptotic cell (right).

Size relationships among biological objects.

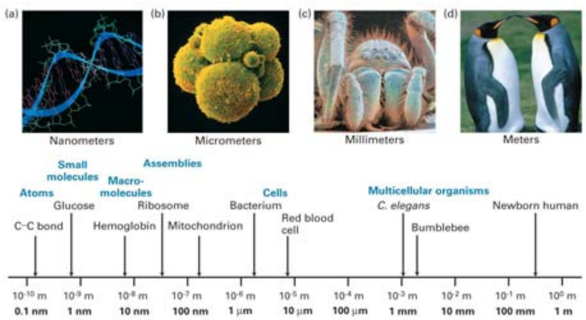


Fig. 1-20

CHAPTER 2: CHEMICAL FOUNDATIONS

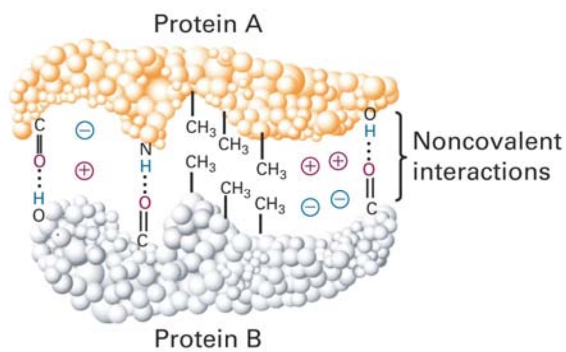


Fig. 2-1a: Multiple weak interactions constitute a strong glue.

Chemical reactions are often readily reversible.
Equilibrium depends on the rate constants,
which are determined by the thermodynamics of the reaction.

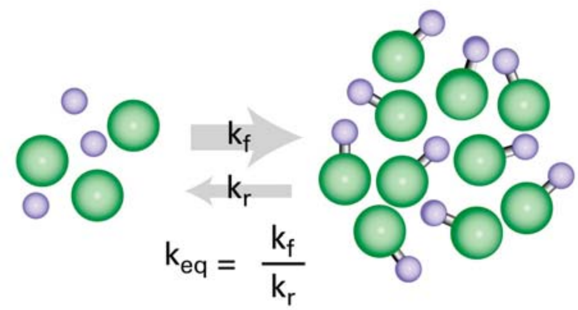


Fig. 2-1c. Catalysts (enzymes) facilitate the attainment of equilibrium, but do not affect the ratio of the reactants at equilibrium.

The source of energy for many biochemical reactions - ATP.

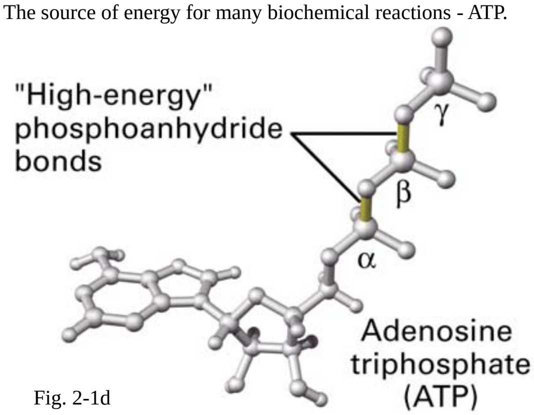


Fig. 2-1d

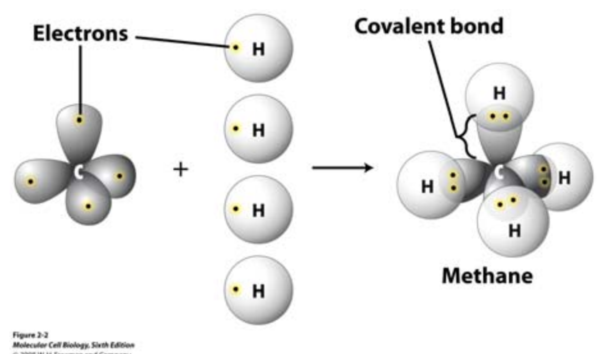
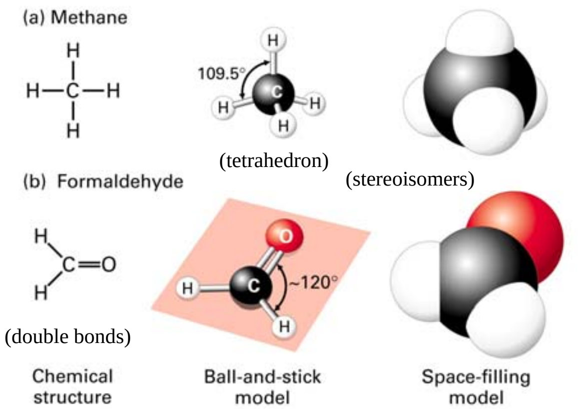


Fig. 2-2: Covalent bonds form by the sharing of electrons, which form pairs with opposite spins.

Fig. 2-3: The geometry of carbon-based chemical bonds.



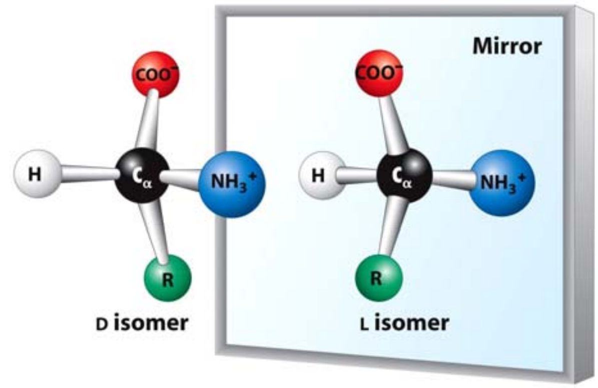
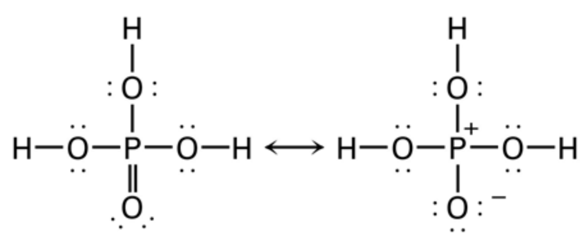


Fig. 2-4: Stereoisomers (chirality):
Mirror images – depends on an asymmetric atom.

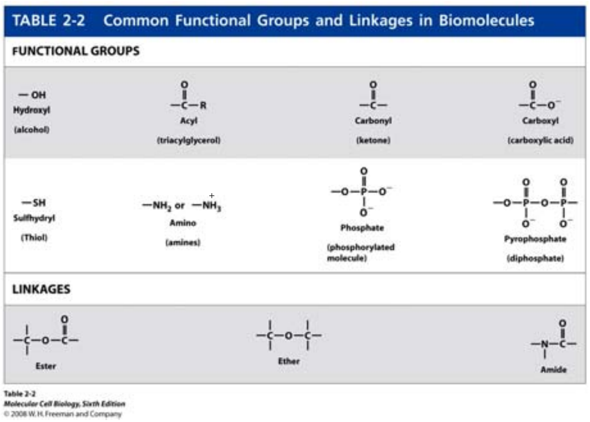
TABLE 2-1 Bonding Properties of Atoms Most Abundant in Biomolecules

Atom and Outer Electrons	Usual Number of Covalent Bonds	Bond Geometry
H·	1	—H
·Ö·	2	O
·S̈·	2, 4, or 6	S
·N̈·	3 or 4	N
·P̈·	5	P
·Ċ·	4 (3 or 2 also)	C

Resonance structure of phosphoric acid



Dipole structures (asymmetric electron distribution) are important in noncovalent interactions.



The dipole nature of a water molecule.

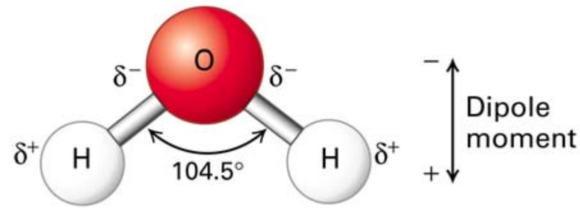


Fig. 2-5

Relative bond energies

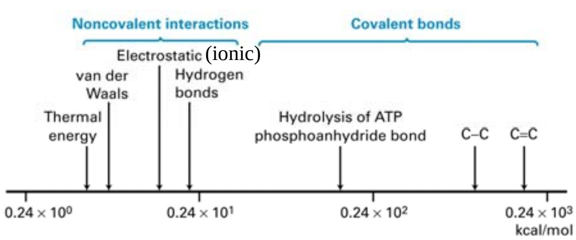
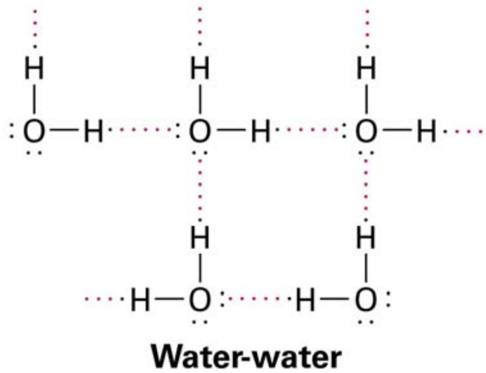


Fig. 2-6 Bond strength increases left to right.

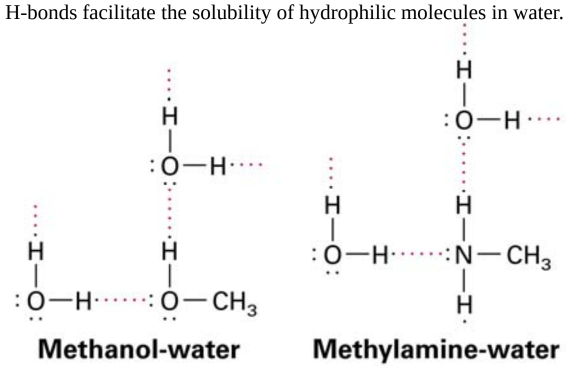
Nature of the hydrogen bond:
the sharing of a proton between two electronegative atoms.

$$D^{\delta-}—H^{\delta+} + :A^{\delta-} \rightleftharpoons \underbrace{D^{\delta-}—H^{\delta+} \cdots\cdots :A^{\delta-}}$$

Hydrogen bond



H-bonds facilitate the solubility of hydrophilic molecules in water.



Two oxygen molecules (permanent dipoles) in van der Waals contact.

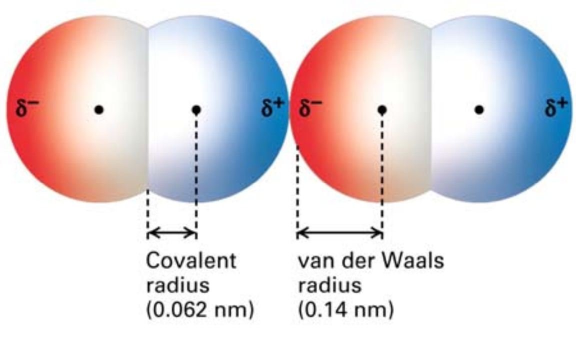


Fig. 2-10. Transient dipoles in the electron clouds of all atoms give rise to weak attractive forces called van der Waals interactions.

Fig. 2-11: The hydrophobic effect: the consequence of a reduction in entropy, the result of avoiding a less stable state.

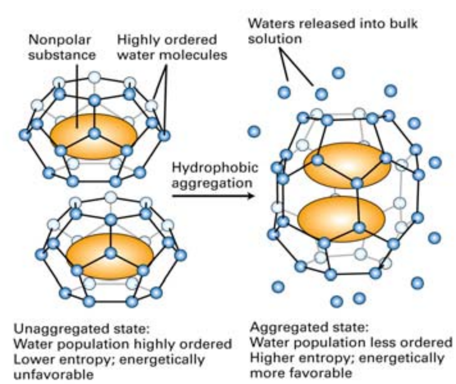


Fig. 2-12: The power of molecular complementarity.
Multiple weak interactions give rise to strong binding.

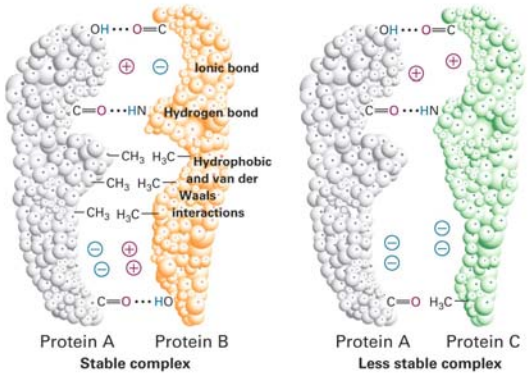
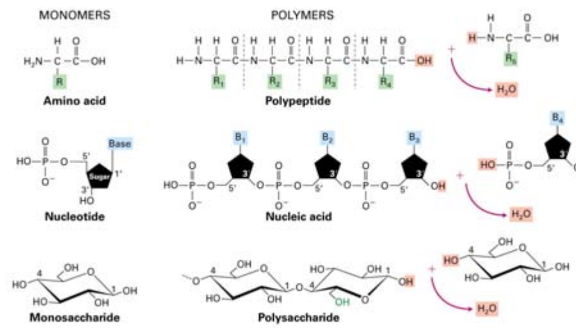
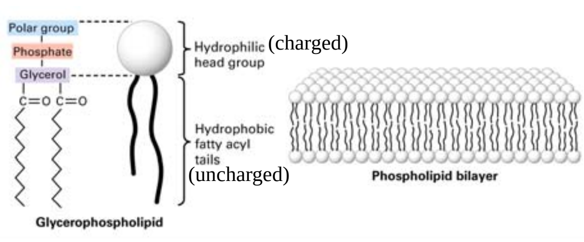


Fig. 2-13 (5th ed.): Biological macromolecules are typically formed by dehydration reactions.



Driven by entropy, phospholipid monomers in water spontaneously and non-covalently assemble into bilayer structures in aqueous solution. Hydrophobic moieties prefer to associate with each other rather than with hydrophilic water molecules.



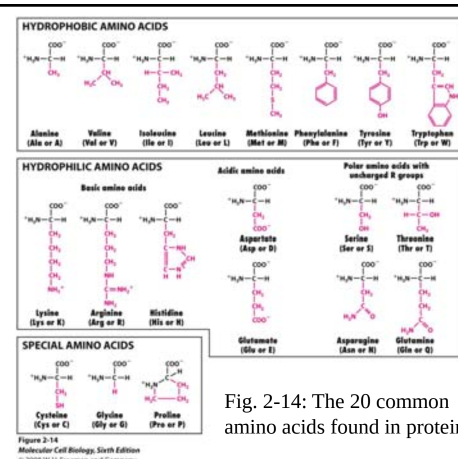
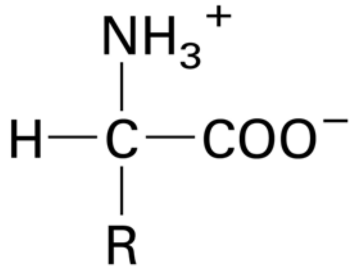


Fig. 2-14: The 20 common amino acids found in proteins.

Amino acids typically exist as a neutral zwitterion at pH 7.



As the pH decreases, an H^+ ion will be added to the carboxylate; as the pH increases the H^+ will be removed from the NH_3^+,

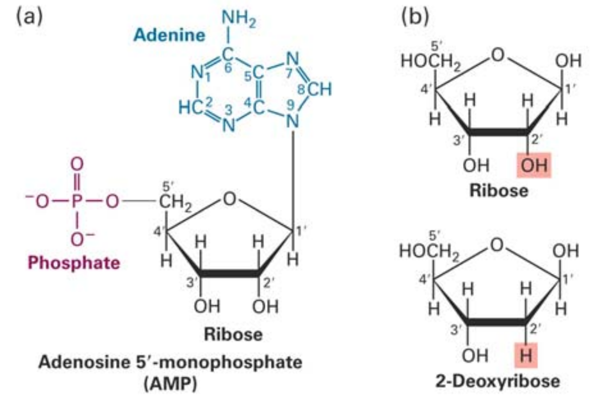


Fig. 2-16: Constituents of nucleotides (ribo or deoxyribo).

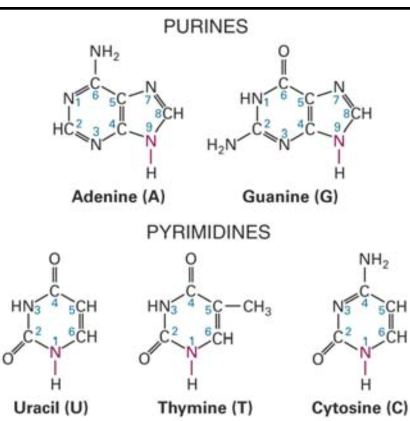
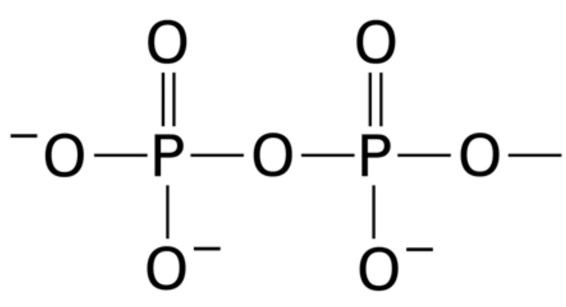


Fig 2-15: Structures of the “bases” in nucleic acids.

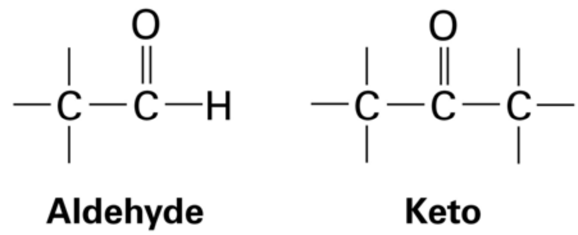


Pyrophosphate

TABLE 2-2 Terminology of Nucleosides and Nucleotides

		Bases			
		Purines		Pyrimidines	
		Adenine (A)	Guanine (G)	Cytosine (C)	Uracil (U) Thymine [T]
Nucleosides	in RNA	Adenosine	Guanosine	Cytidine	Uridine
	in DNA	Deoxyadenosine	Deoxyguanosine	Deoxycytidine	Deoxythymidine
Nucleotides	in RNA	Adenylate	Guanylate	Cytidylate	Uridylate
	in DNA	Deoxyadenylate	Deoxyguanylate	Deoxycytidylate	Deoxythymidylate
Nucleoside monophosphates		AMP	GMP	CMP	UMP
Nucleoside diphosphates		ADP	GDP	CDP	UDP
Nucleoside triphosphates		ATP	GTP	CTP	UTP
Deoxynucleoside mono-, di-, and triphosphates		dAMP, etc.			

(This is Table 2-3 in the 6th edition.)



(e.g. formaldehyde) (e.g. acetone)

Fig. 2-18: Chemical structures of hexoses (6-carbon sugars).

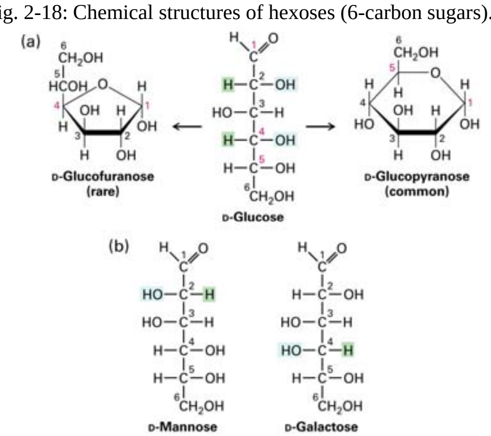
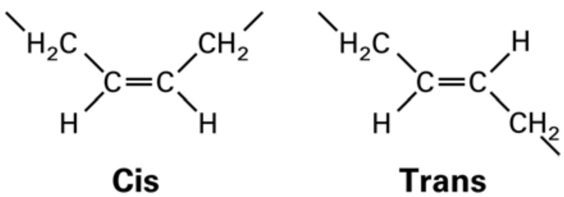


TABLE 2-3 Fatty Acids That Predominate in Phospholipids

Common Name of Acid (Ionized Form in Parentheses)	Abbreviation	Chemical Formula
SATURATED FATTY ACIDS		
Myristic (myristate)	C14:0	$CH_3(CH_2)_{12}COOH$
Palmitic (palmitate)	C16:0	$CH_3(CH_2)_{14}COOH$
Stearic (stearate)	C18:0	$CH_3(CH_2)_{16}COOH$
UNSATURATED FATTY ACIDS		
Oleic (oleate)	C18:1	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
Linoleic (linoleate)	C18:2	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$
Arachidonic (arachidonate)	C20:4	$CH_3(CH_2)_4(CH{=}CHCH_2)_3CH{=}CH(CH_2)_3COOH$

(5th ed)

Geometric Isomers



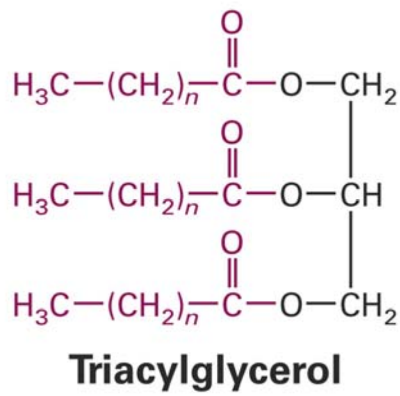
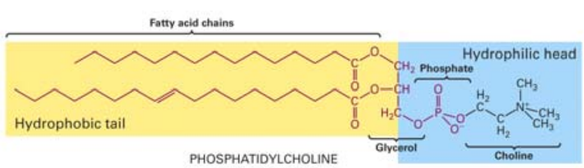


Fig. 2-20: Phosphoglyceride structure.
Phosphoglycerides typically consist of two fatty acids and a “head group” linked to glycerol.



Other head groups include ethanolamine, serine and inositol. See Table 2-5 for the structures, which you should learn.

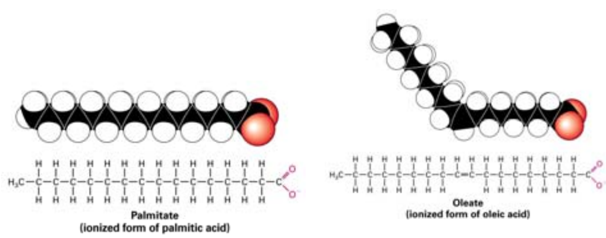


Fig. 2-21: The effect of a double bond on the conformation of a fatty acid. This determines how closely the lipids can pack in the lipid bilayer and affects the fluidity of the membrane.