

ADVANCED CELL BIOLOGY/MOLECULAR BIOLOGY OF CELLS
Fall 2008 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. 6^{ed}, WH Freeman & Co,
 Course Website URL: <http://lifesci.rutgers.edu/~denhardt/course/cellmolbiol.htm>
 (for Dr. 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.

For the third year we are experimenting with making audiotapes of each lecture. Dr. Hart will explain how this works next Monday.

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 Monday, send me an email.

Today: [Course overview, review of cell structure and function \(Chapters 1, 2\)](#)

(a) Prokaryotic cell (no nuclear membrane)

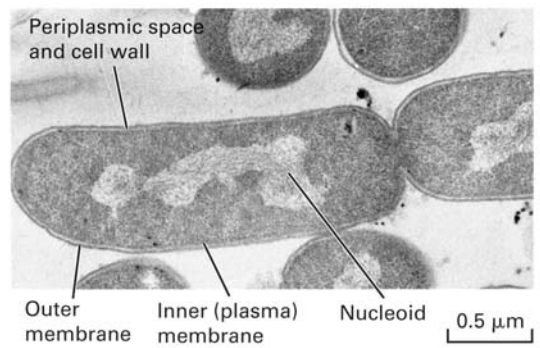
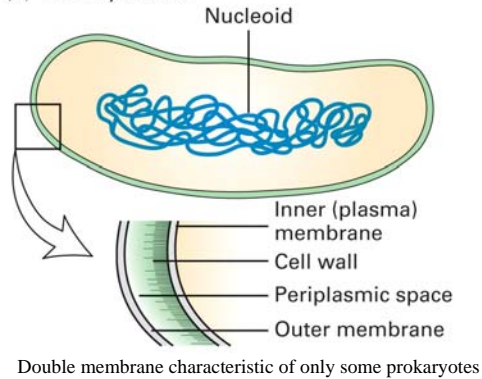
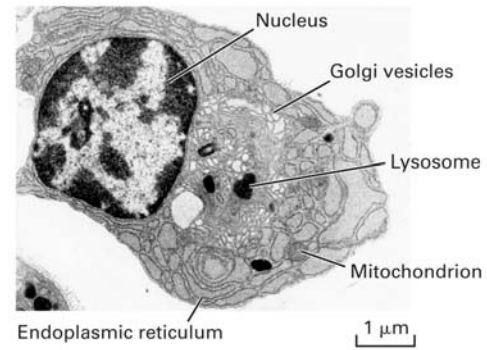


Fig. 1-2

(a) Prokaryotic cell

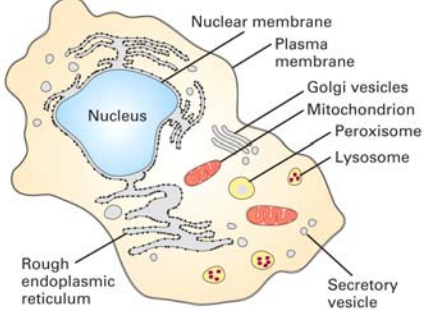


(b) Eukaryotic cell ("True" cell)



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

(b) Eukaryotic cell



Likely a single origin of living systems on earth.

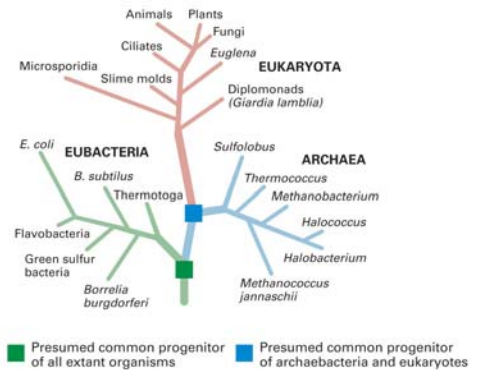


Fig. 1-3

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

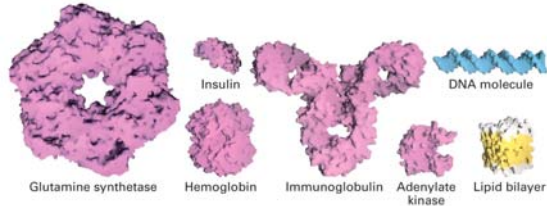


Fig. 1-9. Three-dimensional shapes are the consequences of macromolecular folding determined by the constituent monomeric subunits.

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

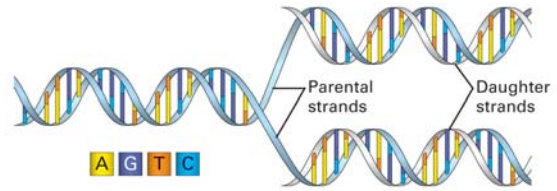


Fig. 1-10. THE GENETIC MATERIAL

Overview (simplified) of the decoding of the genetic information

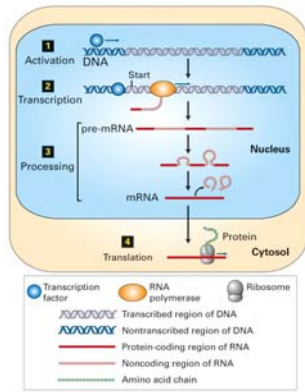


Fig. 1-11

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.

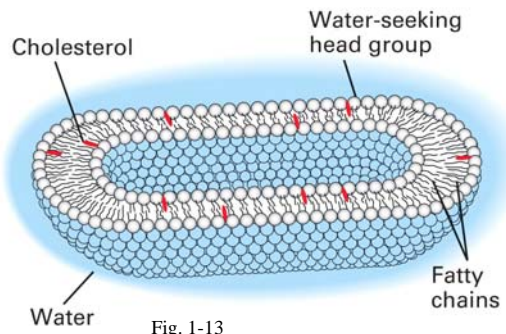


Fig. 1-13

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

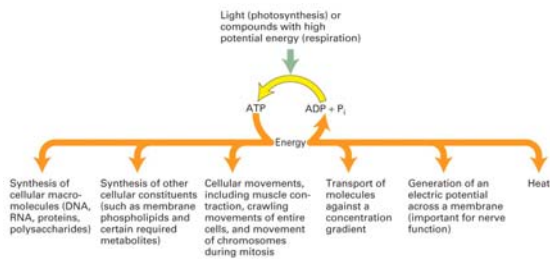


Fig. 1-14

The three types of cytoskeletal filaments found in eukaryotic cells.

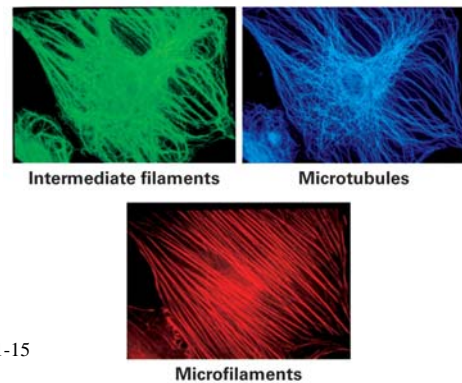
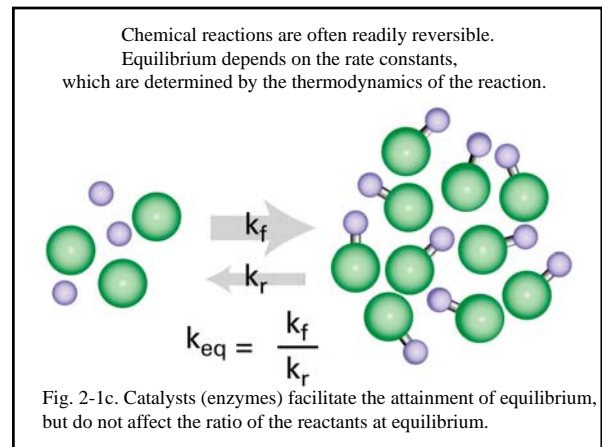
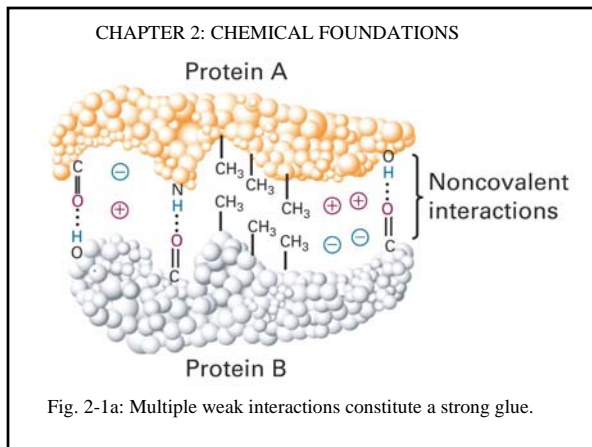
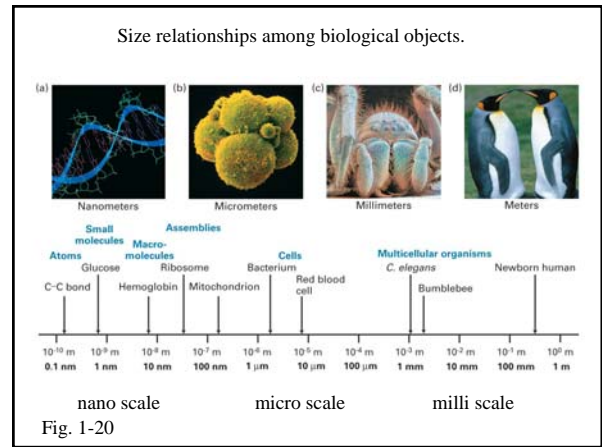
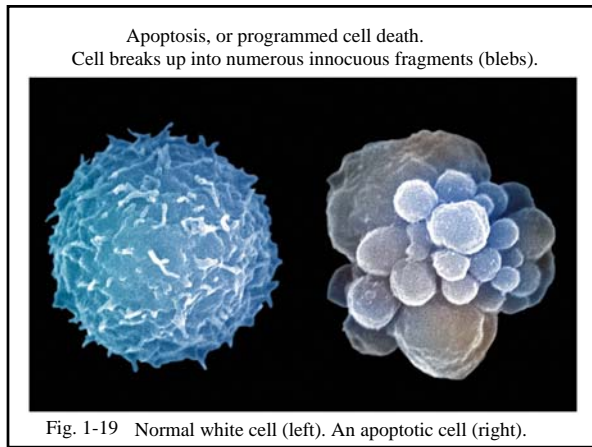
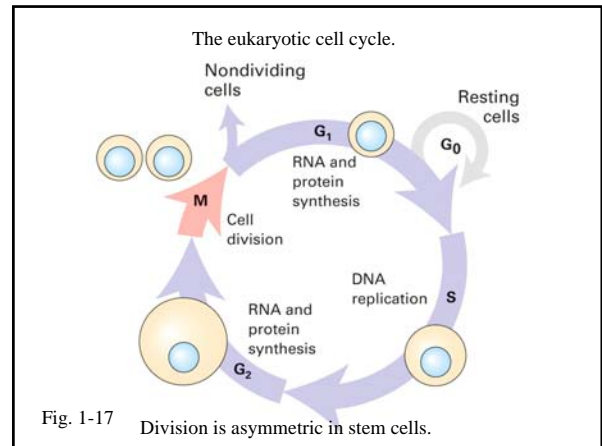
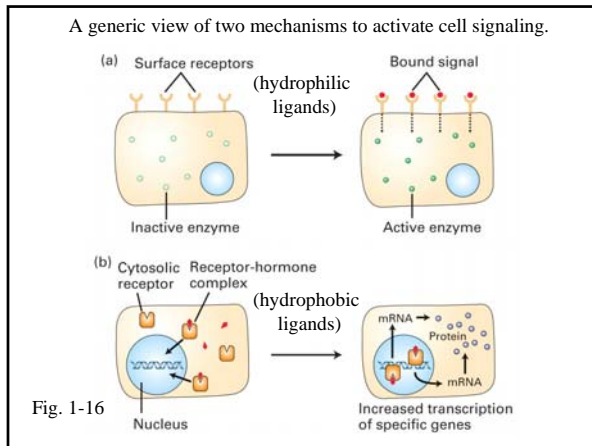


Fig. 1-15



The source of energy for many biochemical reactions - ATP.

"High-energy" phosphoanhydride bonds

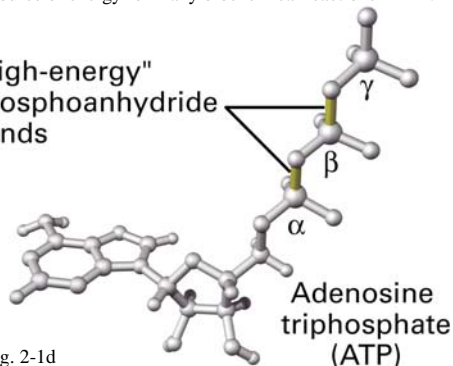


Fig. 2-1d

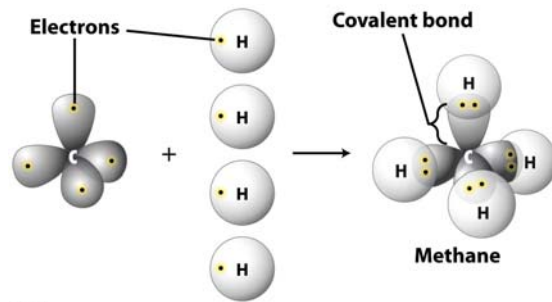
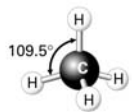


Figure 2-2
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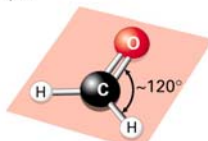
Fig. 2-2: Covalent bonds form by the sharing of electrons, which "like" to paired with opposite spins.

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

(a) Methane



(b) Formaldehyde



Chemical structure

Ball-and-stick model

Space-filling model

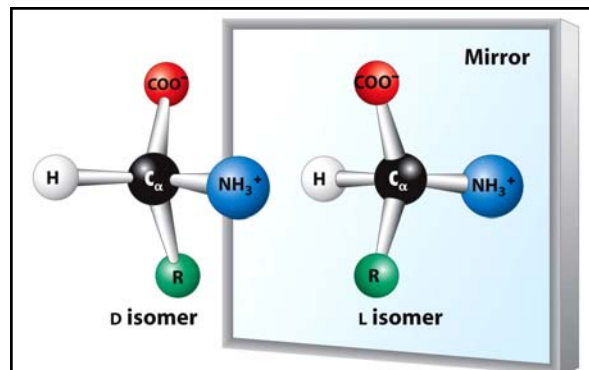


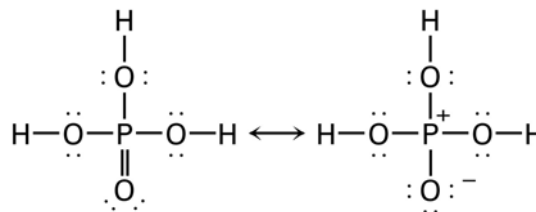
Figure 2-4
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Fig. 2-4: Stereoisomers (chirality): Mirror images – depends on an asymmetric atom.

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

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

Resonance structure of phosphoric acid

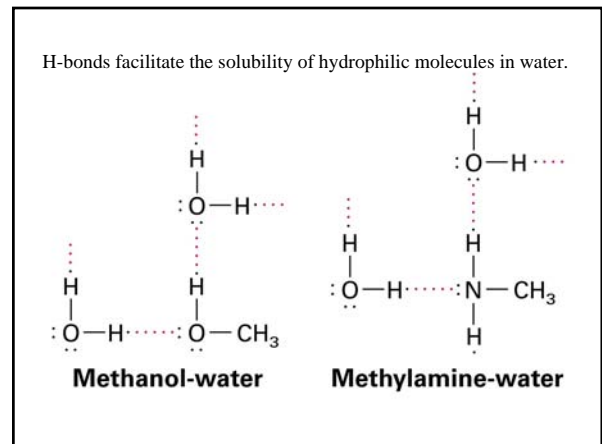
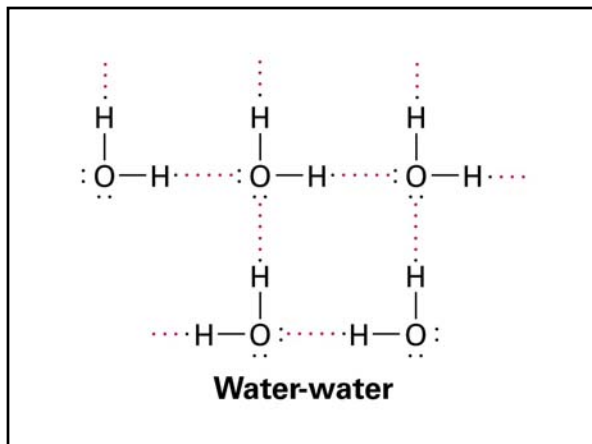
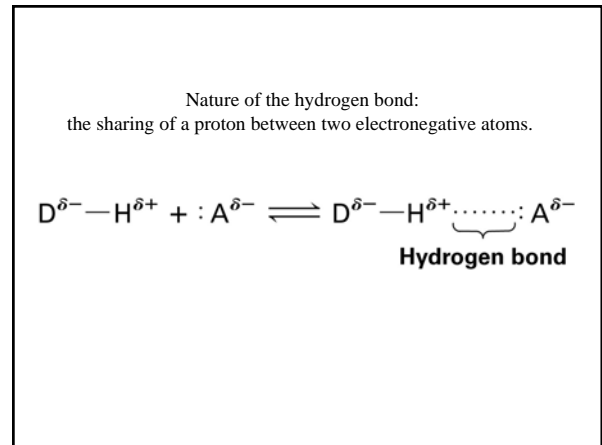
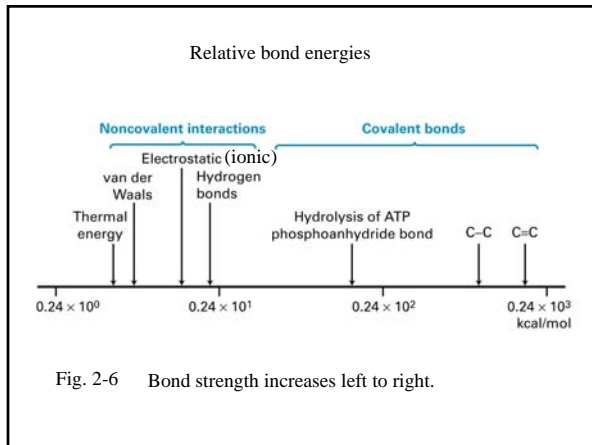
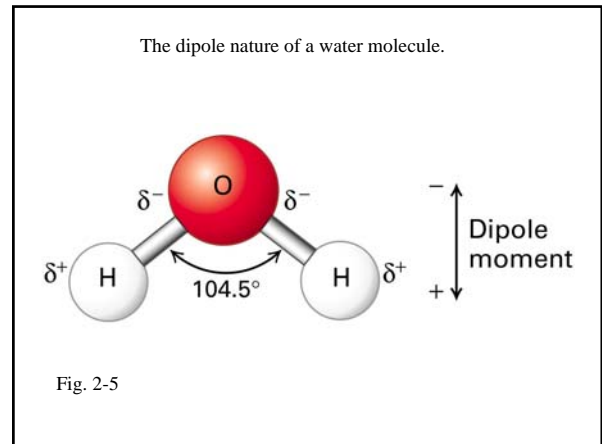


Dipole structures (asymmetric electron distribution) are important in noncovalent interactions.

TABLE 2-2 Common Functional Groups and Linkages in Biomolecules

FUNCTIONAL GROUPS			
—OH Hydroxyl (alcohol)	$\begin{array}{c} \text{O} \\ \\ \text{—C—R} \end{array}$ Acyl (triacylglycerol)	$\begin{array}{c} \text{O} \\ \\ \text{—C—} \end{array}$ Carbonyl (ketone)	$\begin{array}{c} \text{O} \\ \\ \text{—C—O}^- \end{array}$ Carboxyl (carboxylic acid)
—SH Sulphydryl (thiol)	—NH ₂ or —NH— Amino (amines)	$\begin{array}{c} \text{O} \\ \\ \text{—O—P—O}^- \\ \\ \text{O} \end{array}$ Phosphate (phosphorylated molecule)	$\begin{array}{c} \text{O} \quad \text{O} \\ \quad \\ \text{—O—P—O—P—O}^- \\ \quad \\ \text{O} \quad \text{O} \end{array}$ Pyrophosphate (diphosphate)
LINKAGES			
$\begin{array}{c} \text{O} \\ \\ \text{—C—O—C—} \end{array}$ Ester	$\begin{array}{c} \text{—O—} \\ \\ \text{—C—} \end{array}$ Ether		$\begin{array}{c} \text{O} \\ \\ \text{—N—C—} \end{array}$ Amide

Table 2-2
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Two oxygen molecules (permanent dipoles) in van der Waals contact.

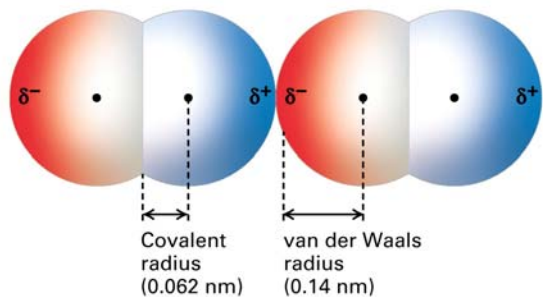


Fig. 2-10. Transient dipoles in the electron clouds of all atoms give rise to weak attractive forces called van der Waals interactions.

Fig. 2-11: The hydrophobic effect: the consequence of a reduction in entropy.

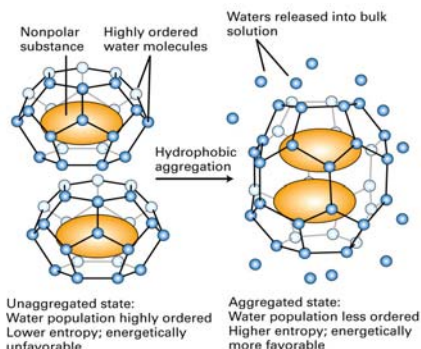


Fig. 2-12: The power of molecular complementarity. Multiple weak interactions give rise to strong binding.

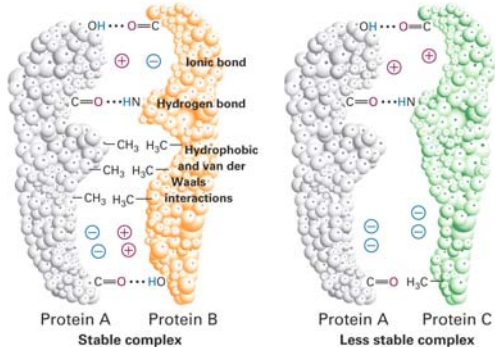
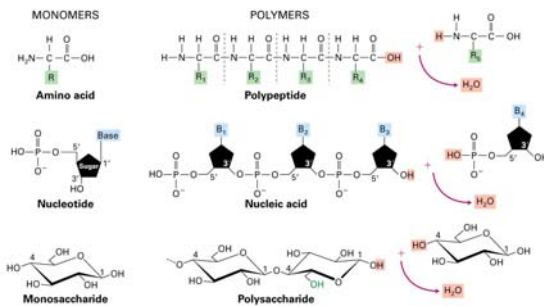


Fig. 2-13 (5th ed.): Biological macromolecules are typically formed by dehydration reactions.



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.

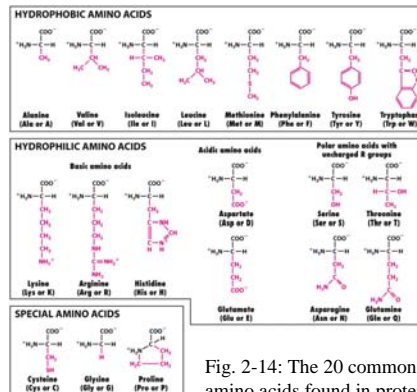
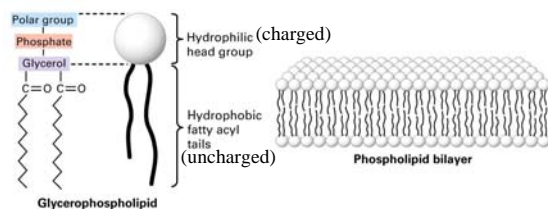
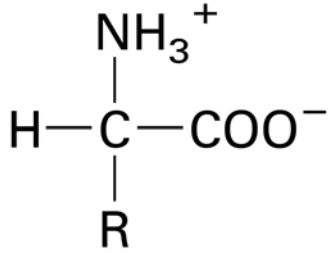


Fig. 2-14: The 20 common amino acids found in proteins.

Figure 2-14
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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 NH₃⁺, forming what?

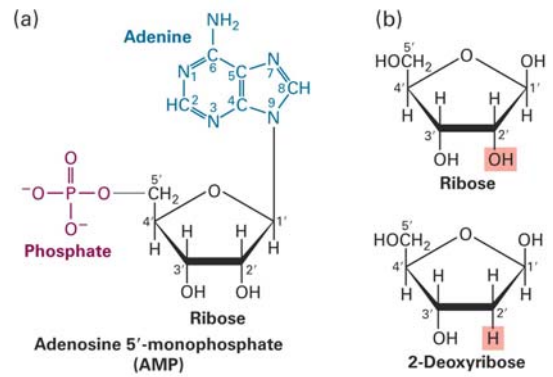


Fig. 2-16: Constituents of nucleotides (ribo or deoxyribo).

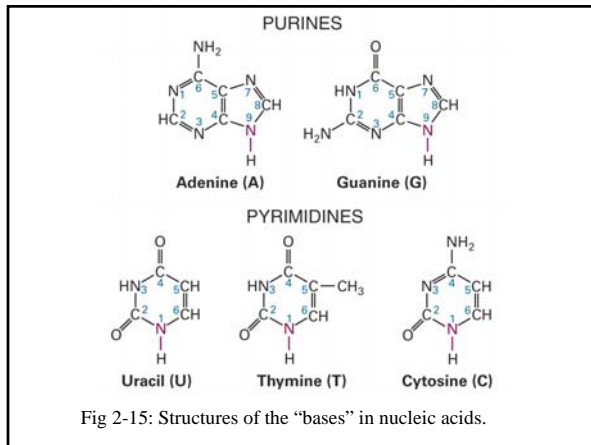
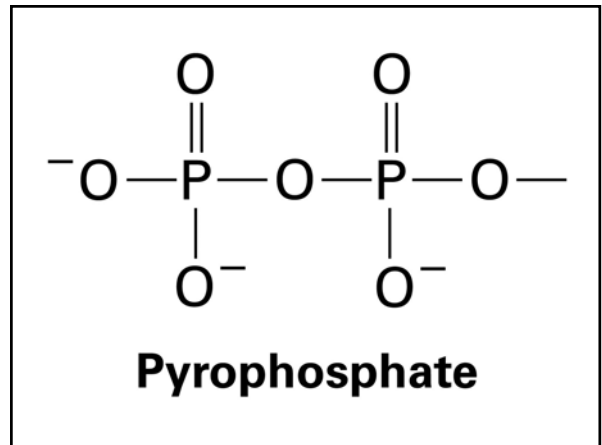


Fig 2-15: Structures of the “bases” in nucleic acids.



		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	Adenylylate	Guanlylate	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.)

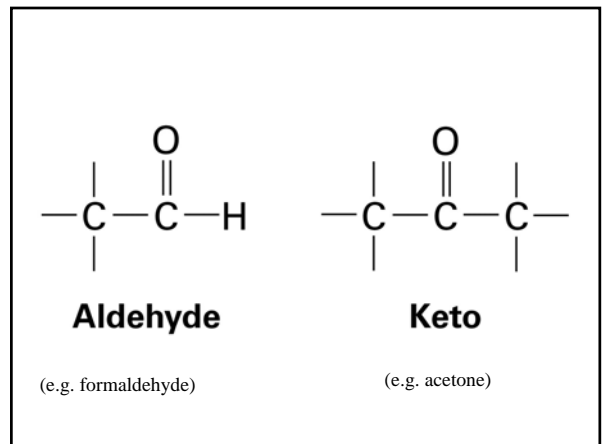


Fig. 2-18: Chemical structures of hexoses (6-carbon sugars).

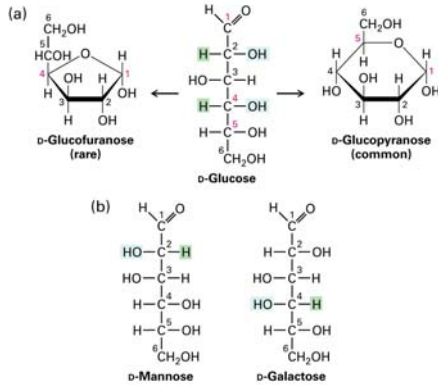


TABLE 2-3 Fatty Acids That Predominate in Phospholipids

Common Name of Acid (Ionized Form in Parentheses)	Abbreviation	Chemical Formula
SATURATED FATTY ACIDS		
Myristic (myristate)	C14:0	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$
Palmitic (palmitate)	C16:0	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
Stearic (stearate)	C18:0	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
UNSATURATED FATTY ACIDS		
Oleic (oleate)	C18:1	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Linoleic (linoleate)	C18:2	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$
Arachidonic (arachidonate)	C20:4	$\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CHCH}_2)_4\text{COOH}$

(5th ed)

Geometric Isomers

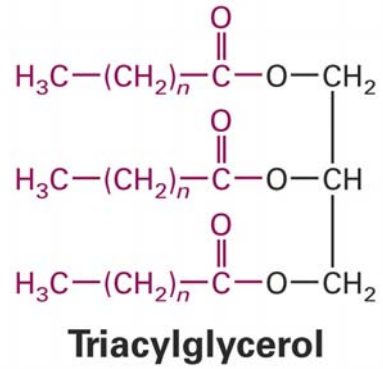
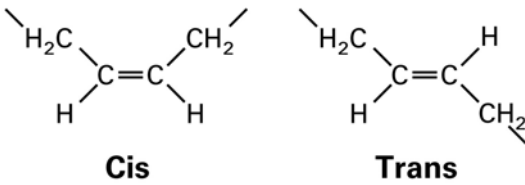
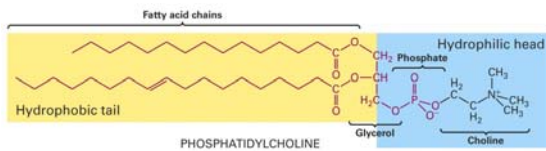


Fig. 2-20: Phosphoglyceride structure. Phosphoglycerides typically consist of two fatty acids and a "head group" linked to glycerol.



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

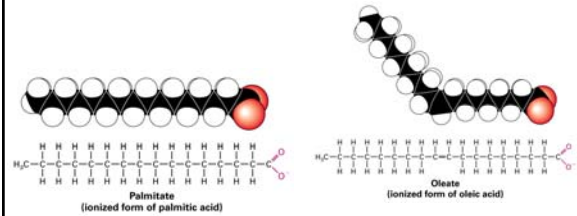


Fig. 2-21: The effect of a double bond on the conformation of a fatty acid. This determines how closely the lipids can pack in the lipid bilayer and effects the fluidity of the membrane.