Biological Sciences

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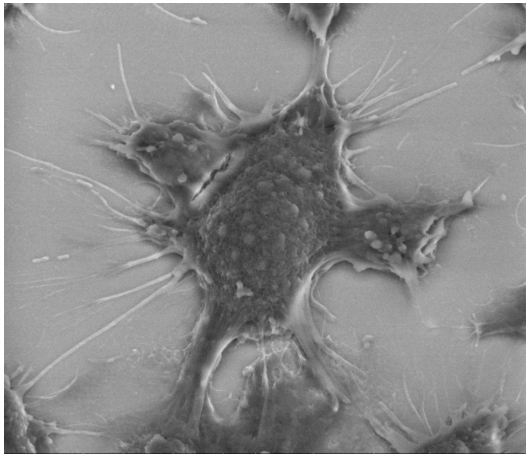
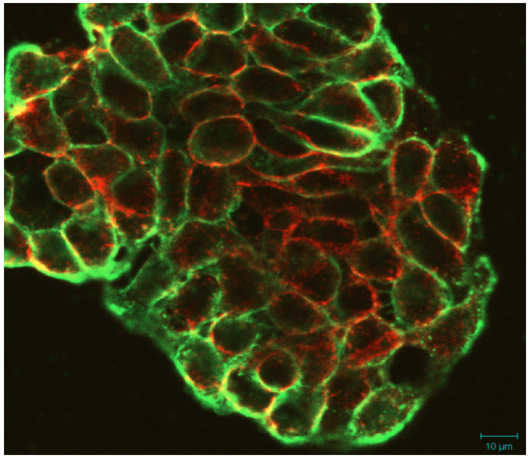
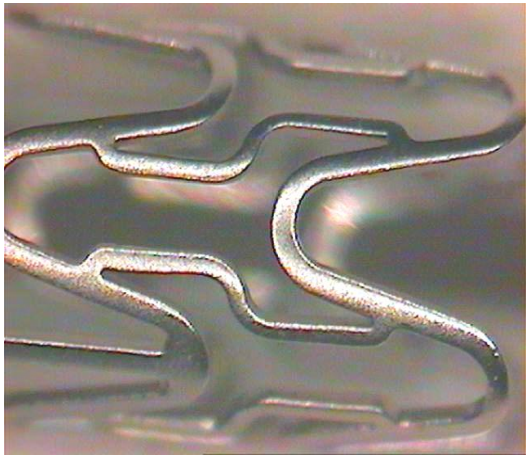






Part 1. Chemicals of life: Water, Amino acids, Carbohydrates, Lipids

Dr. Ratnesh Jain

Content

- The Foundations
    - Cellular Foundations
    - Chemical Foundations
    - Physical Foundations
    - Genetic Foundations
- Water
- Amino Acid
- Carbohydrate
- Lipids

Biomolecules

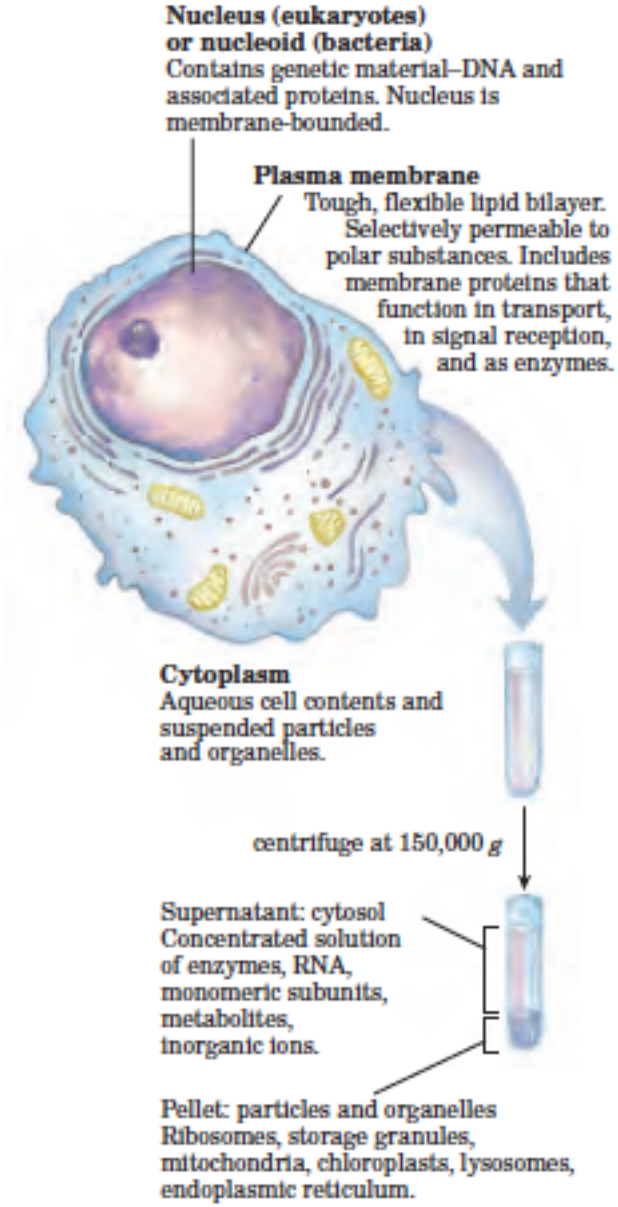
The Distinguishing features of living organisms:

- A high degree of chemical complexity and Microscopic organization.
- Systems for extracting, transforming, and using energy from the environment
- A capacity for precise self-replication and self-assembly
- Mechanisms for sensing and responding to alterations in their surroundings
- Defined functions for each of their components and regulated interactions among them
- A history of evolutionary change

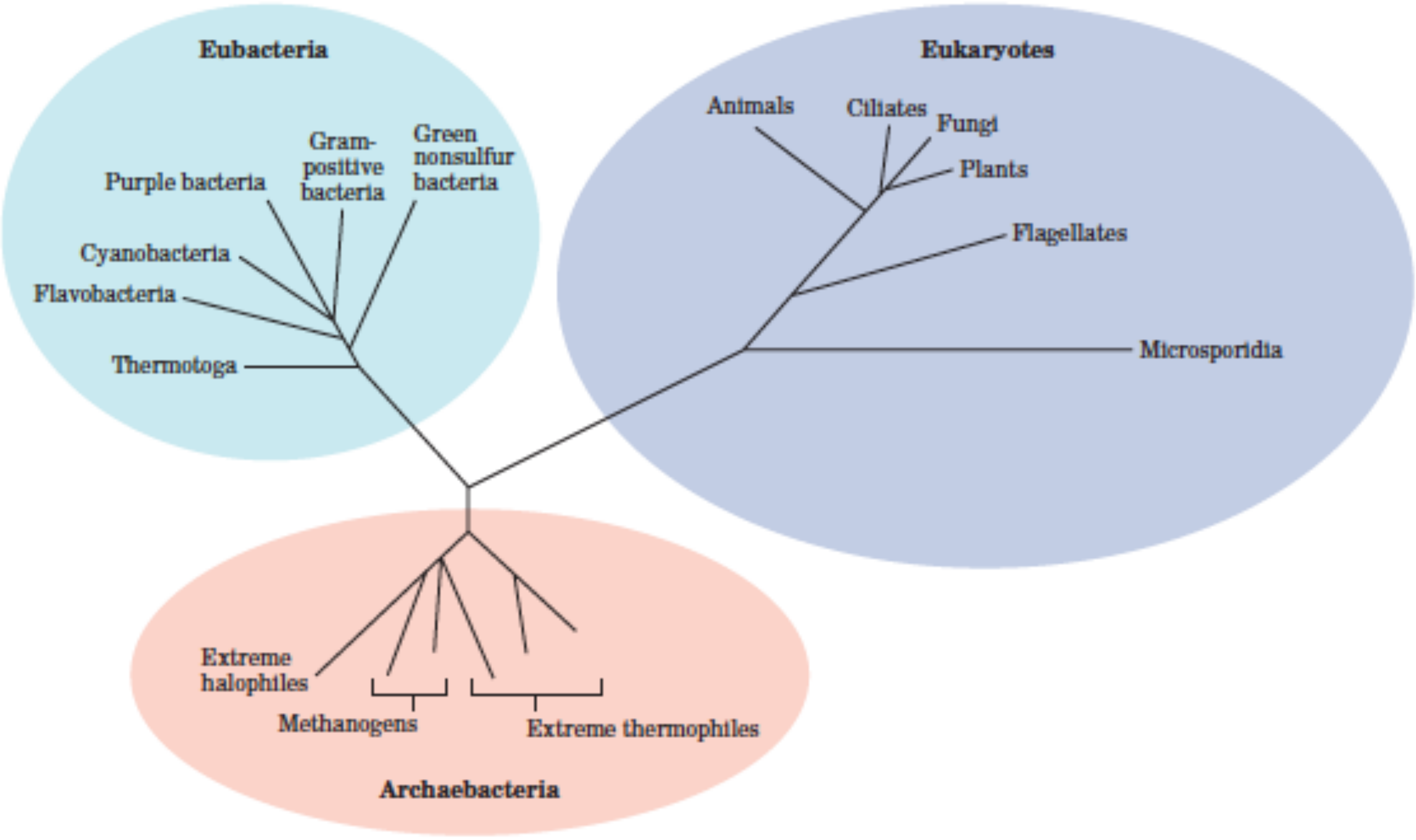
Cellular Foundations

Cells Are the Structural and Functional Units of All Living Organisms

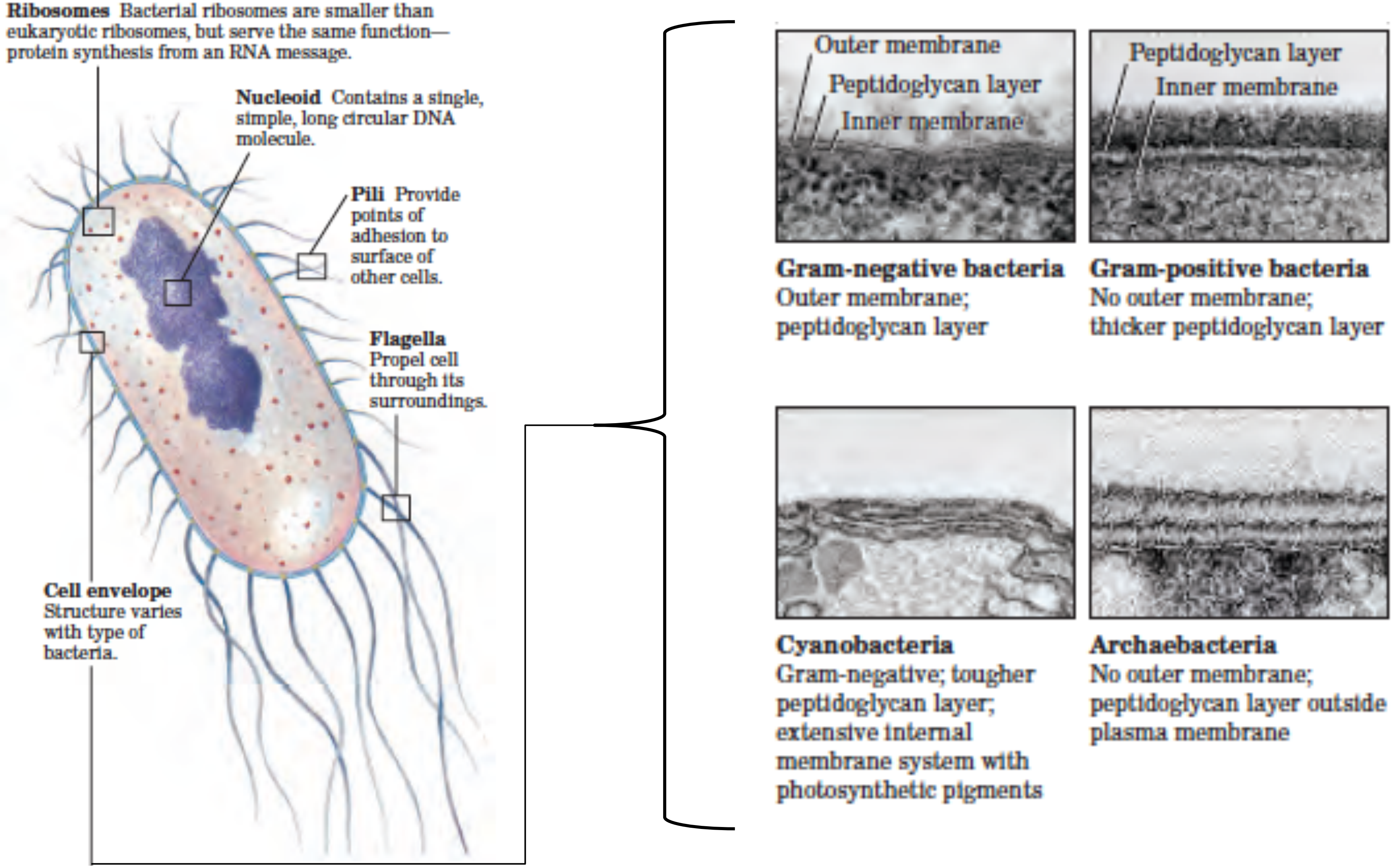
Cellular Dimensions Are Limited by Oxygen Diffusion



There Are Three Distinct Domains of Life



Escherichia coli Is the Most-Studied Prokaryotic Cell



Eukaryotic Cells Have a Variety of Membranous Organelles, Which Can Be Isolated for Study

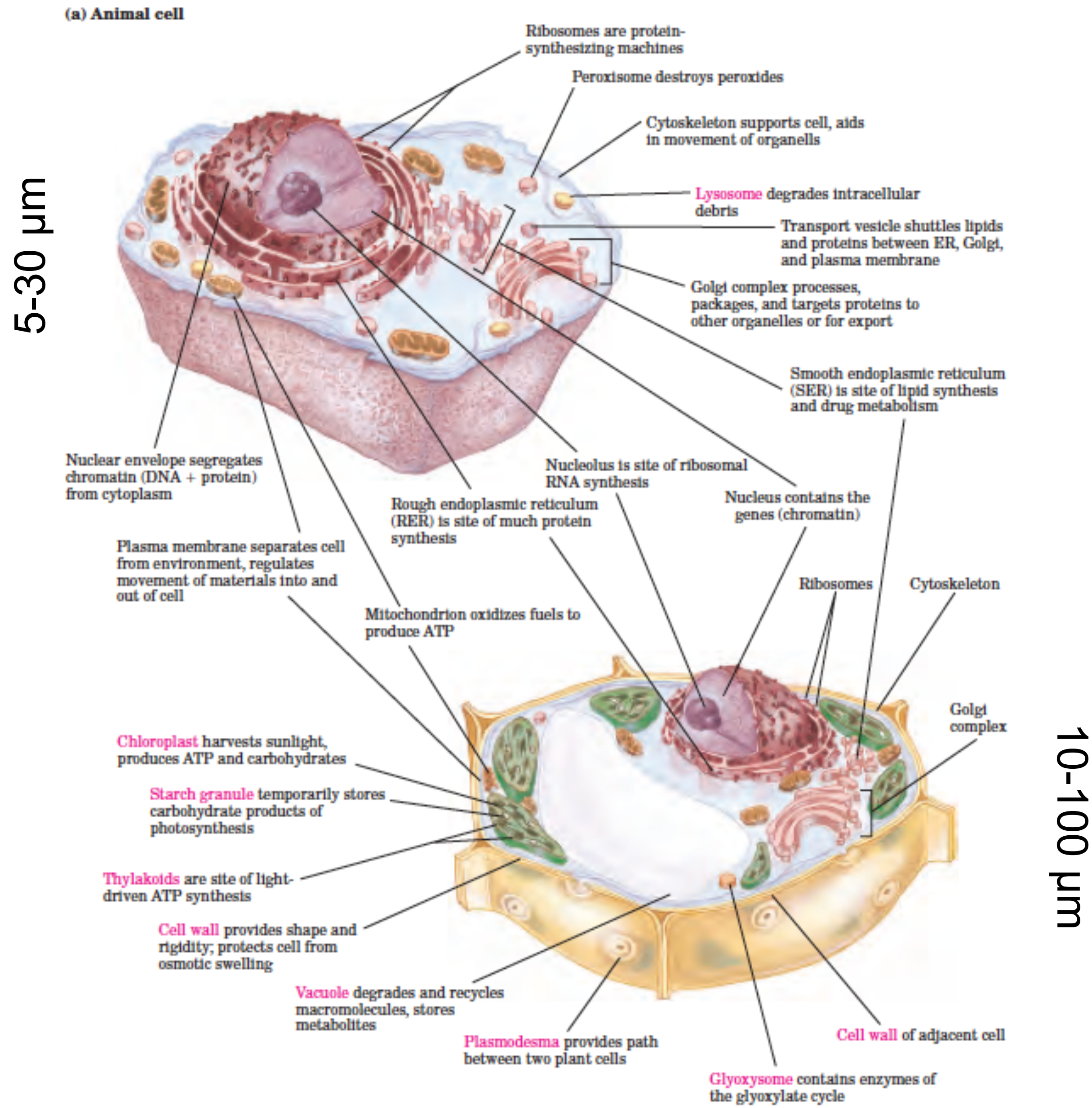
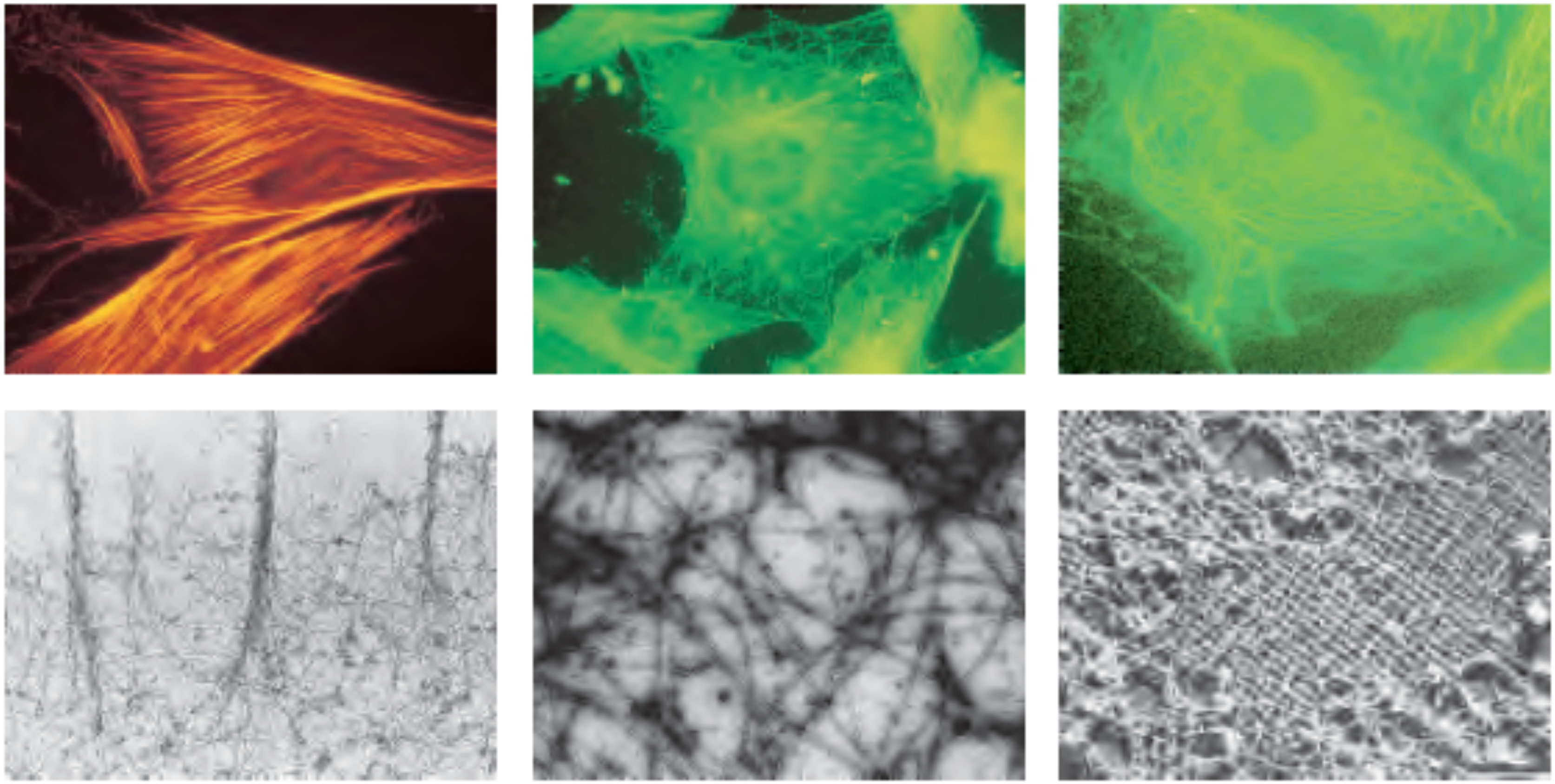


FIGURE 1–7 Eukaryotic cell structure. Schematic illustrations of the two major types of eukaryotic cell: **(a)** a representative animal cell and **(b)** a representative plant cell. Plant cells are usually 10 to 100 µm in diameter—larger than animal cells, which typically range from 5 to 30 µm. Structures labeled in red are unique to either animal or plant cells.

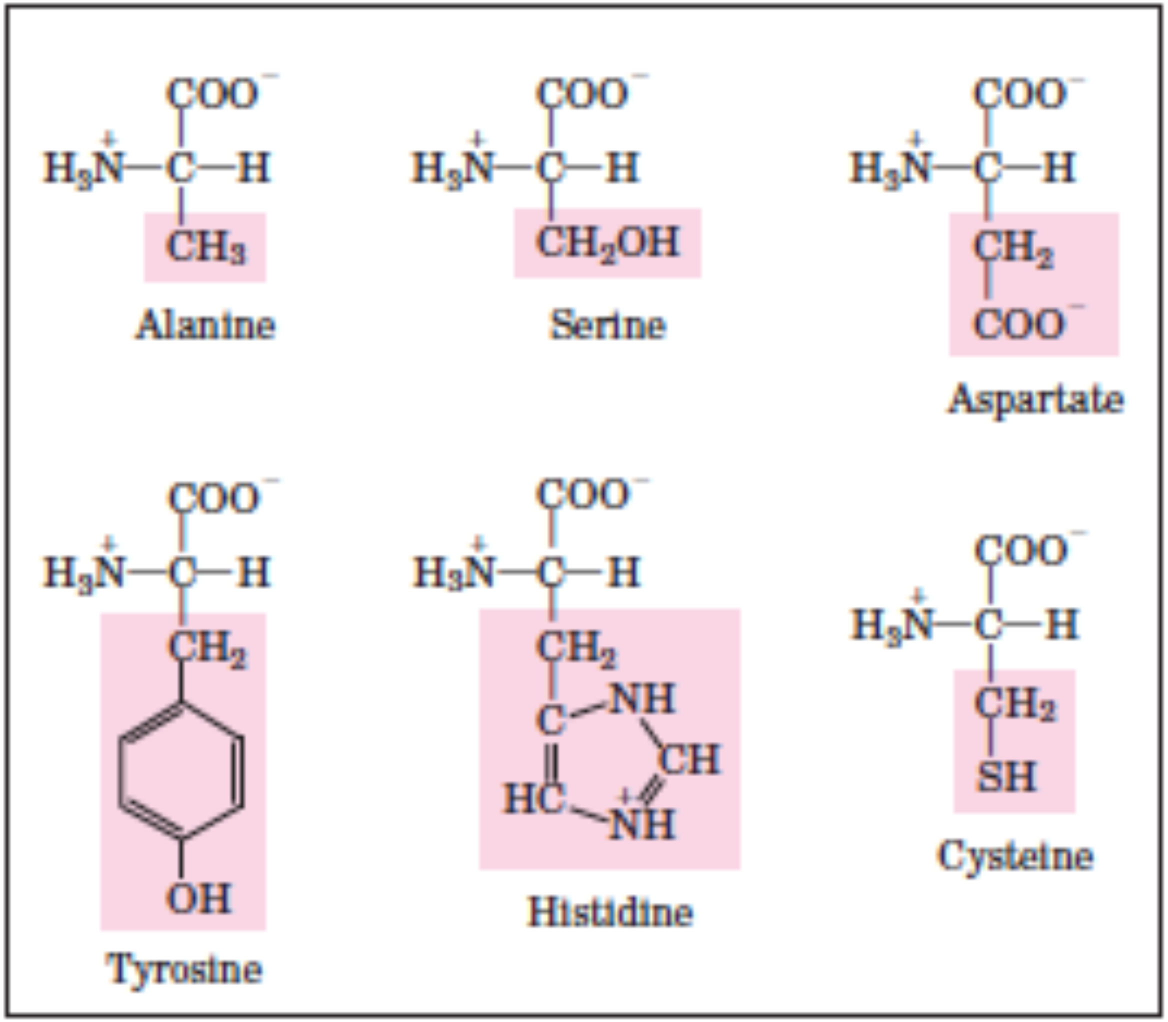
The Cytoplasm Is Organized by the Cytoskeleton and Is Highly Dynamic



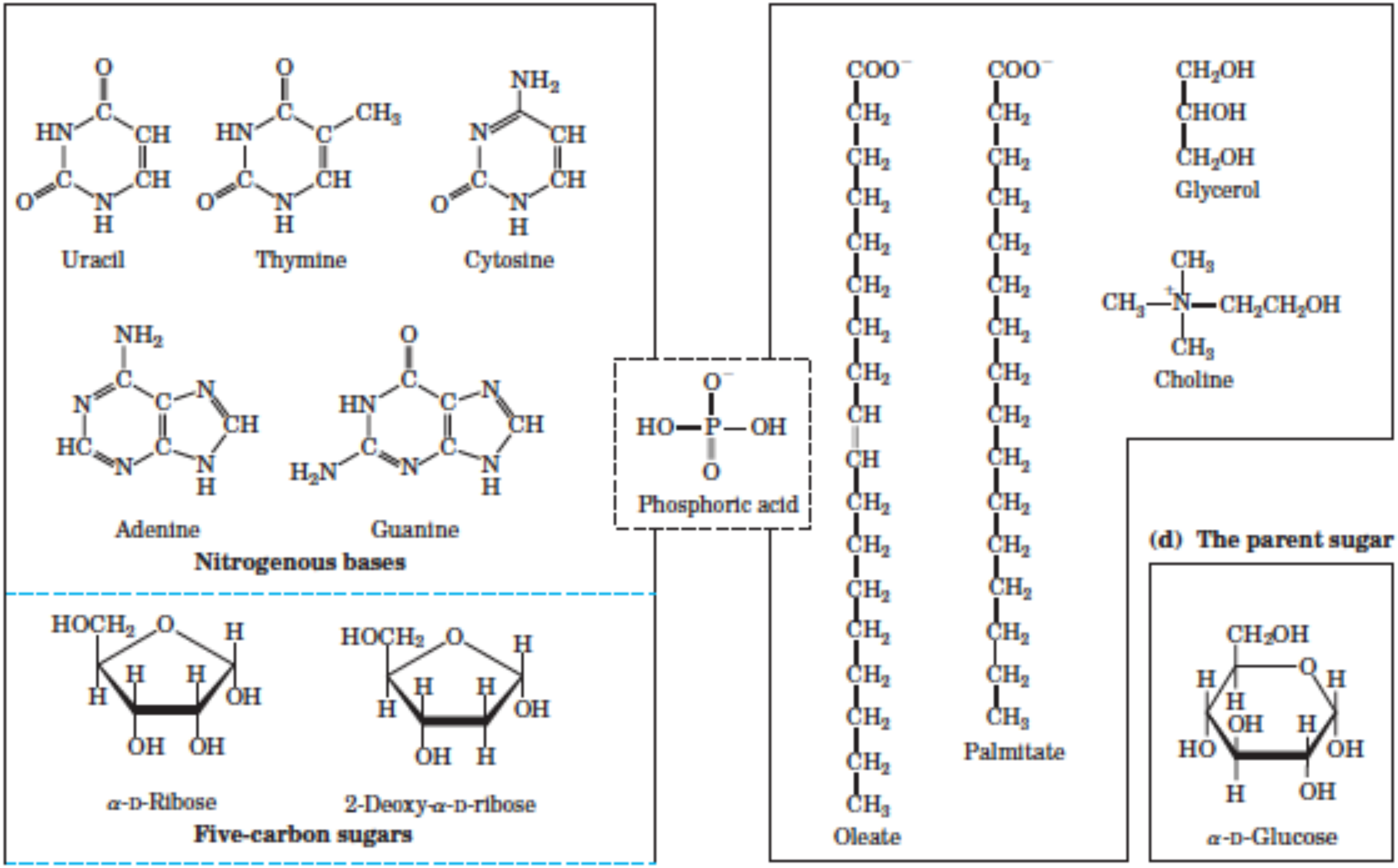
Actin stress fibers (a) | Microtubules (b) | Intermediate filaments (c)

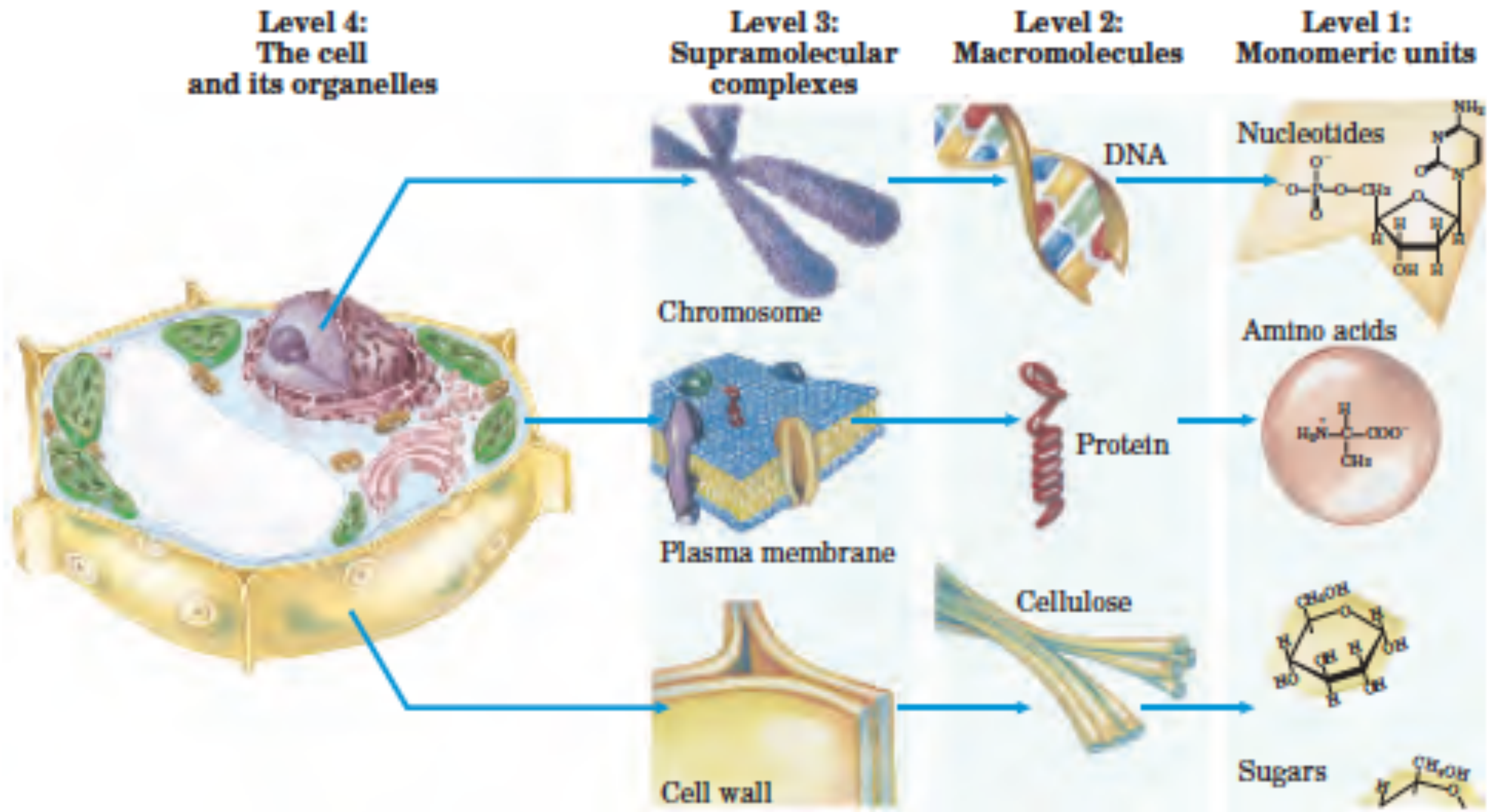
Cells Build Supramolecular Structures

(a) Some of the amino acids of proteins



(b) The components of nucleic acids **(c) Some components of lipids**





Level 4:
The cell
and its organelles
Level 3:
Supramolecular
complexes
Level 2:
Macromolecules
Level 1:
Monomeric units
Chromosome
DNA
Nucleotides
Plasma membrane
Protein
Amino acids
Cell wall
Cellulose
Sugars

Take home message..

■ All cells are bounded by a plasma membrane; have a cytosol containing metabolites, coenzymes, inorganic ions, and enzymes; and have a set of genes contained within a nucleoid (prokaryotes) or nucleus (eukaryotes).

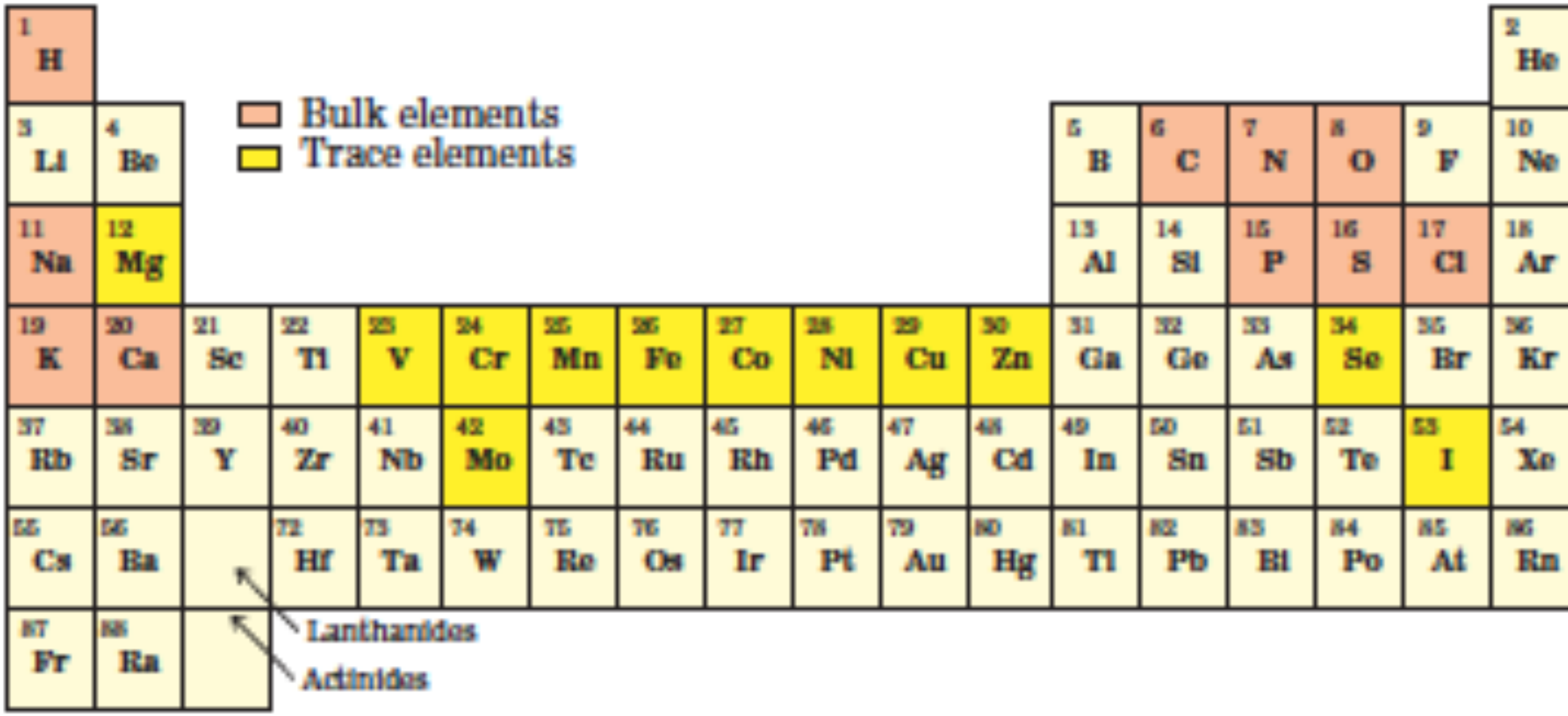
■ Phototrophs use sunlight to do work; chemotrophs oxidize fuels, passing electrons to good electron acceptors: inorganic compounds, organic compounds, or molecular oxygen.

■ Bacterial cells contain cytosol, a nucleoid, and plasmids. Eukaryotic cells have a nucleus and are multicompartmented, segregating certain processes in specific organelles, which can be separated and studied in isolation.

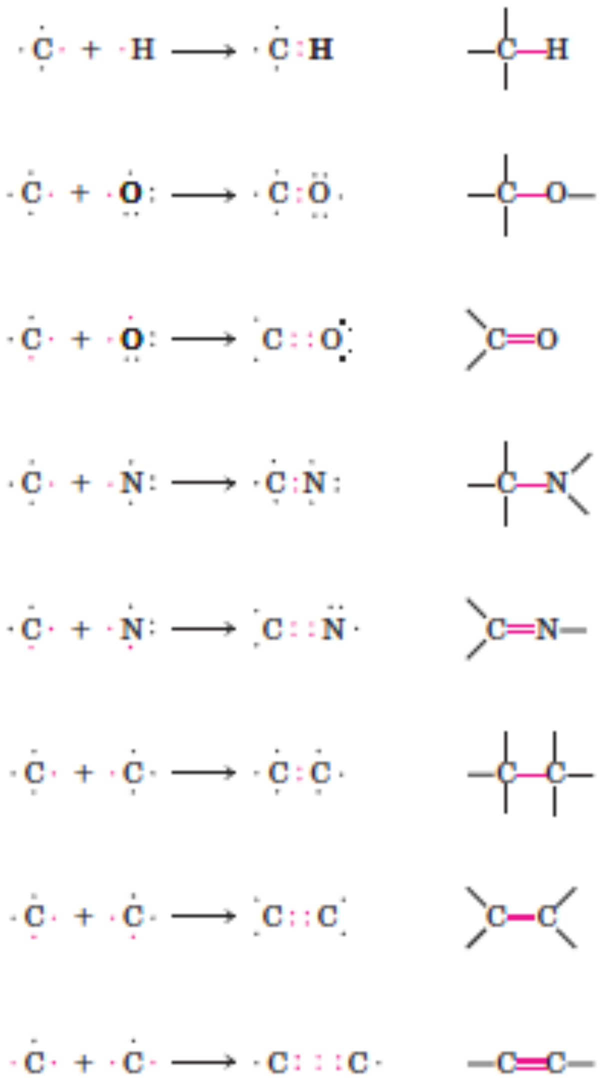
■ Cytoskeletal proteins assemble into long filaments that give cells shape and rigidity and serve as rails along which cellular organelles move throughout the cell.

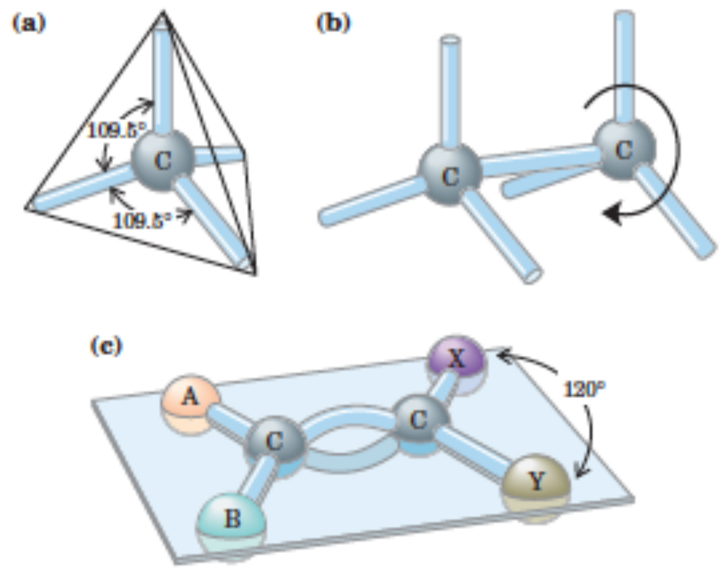
■ Supramolecular complexes are held together by noncovalent interactions and form a hierarchy of structures, some visible with the light microscope. When individual molecules are removed from these complexes to be studied in vitro, interactions important in the living cell may be lost.

Chemical Foundations

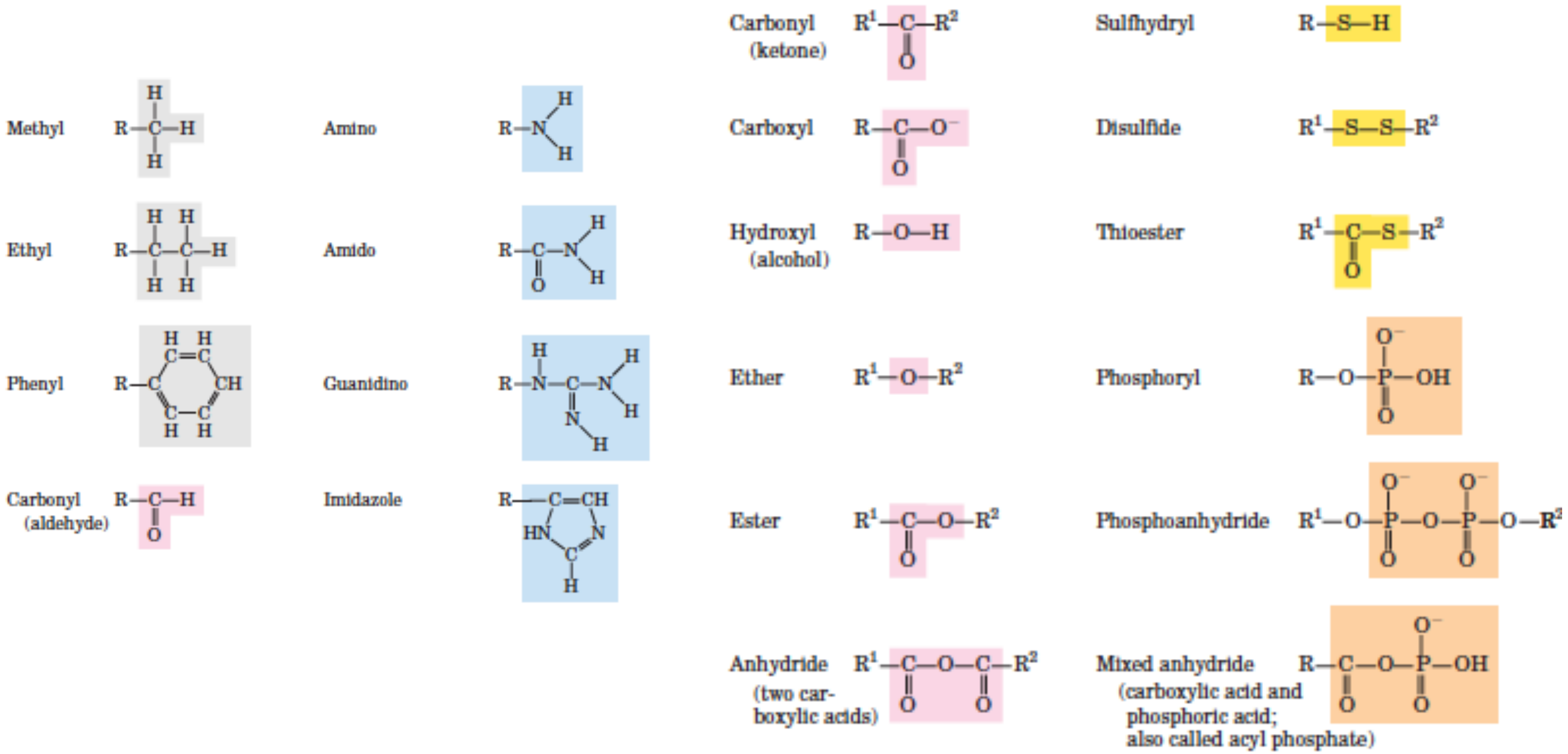


Biomolecules Are Compounds of Carbon with a Variety of Functional Groups





Cells Contain a Universal Set of Small Molecules



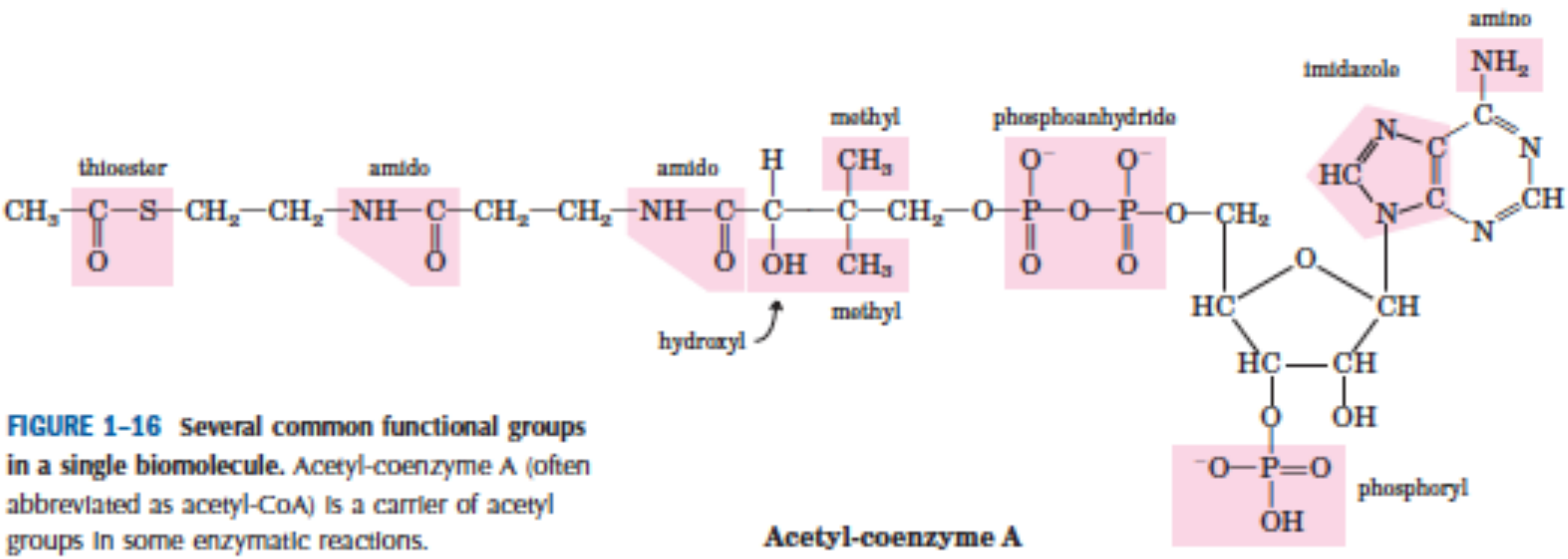


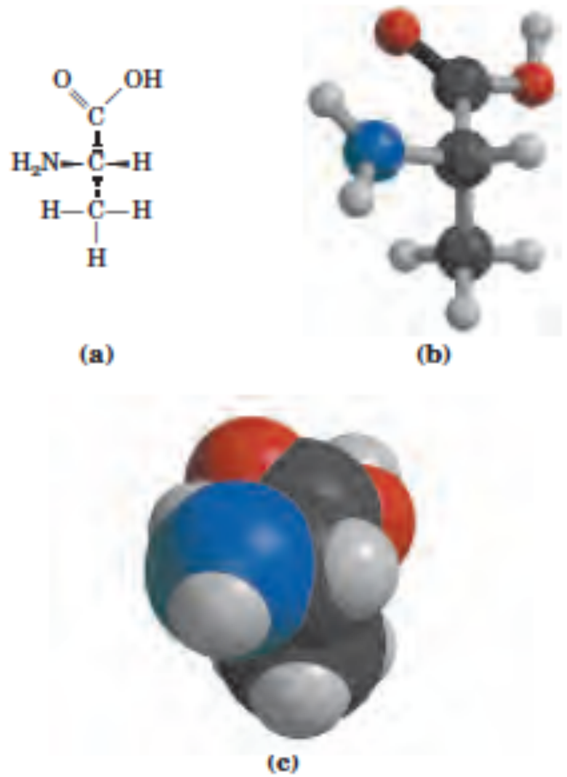
FIGURE 1–16 Several common functional groups in a single biomolecule. Acetyl-coenzyme A (often abbreviated as acetyl-CoA) is a carrier of acetyl groups in some enzymatic reactions.

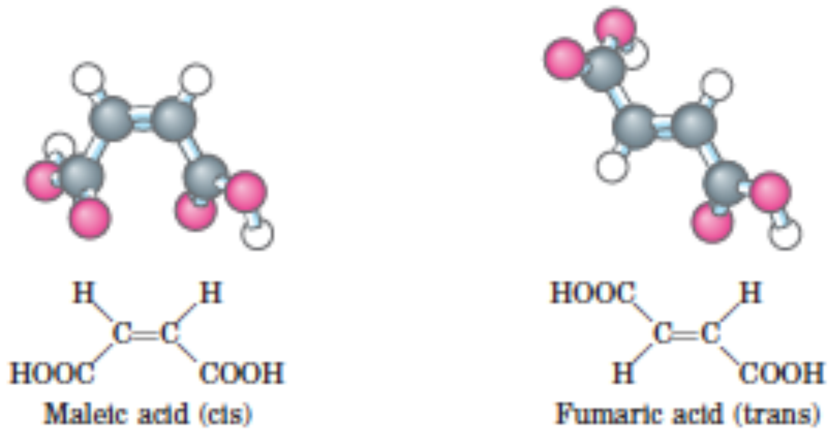
Macromolecules Are the Major Constituents of Cells

TABLE 1-2 **Molecular Components of an *E. coli* Cell**

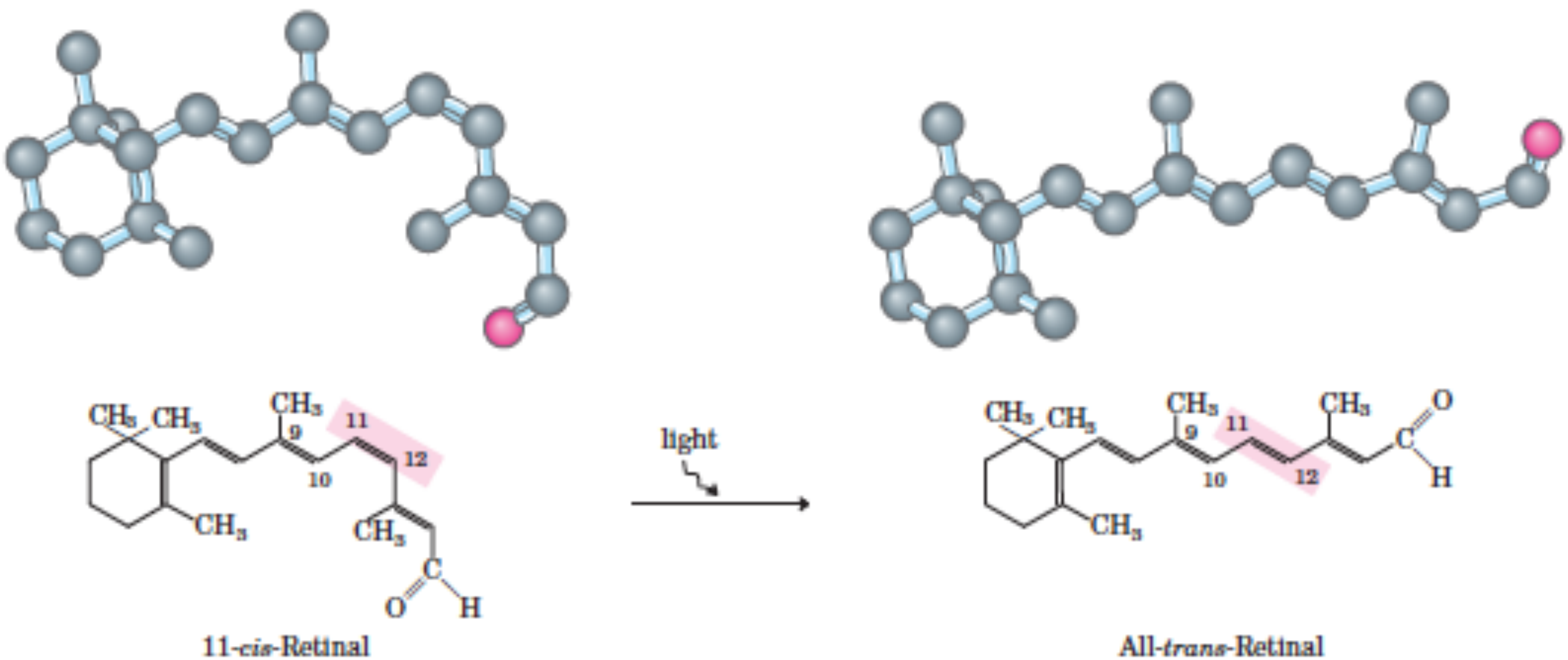
	Percentage of total weight of cell	*Approximate number of different molecular species*
Water	70	1
Proteins	15	3,000
Nucleic acids		
DNA	1	1
RNA	6	>3,000
Polysaccharides	3	5
Lipids	2	20
Monomeric subunits and intermediates	2	500
Inorganic ions	1	20

Three-Dimensional Structure Is Described by Configuration and Conformation

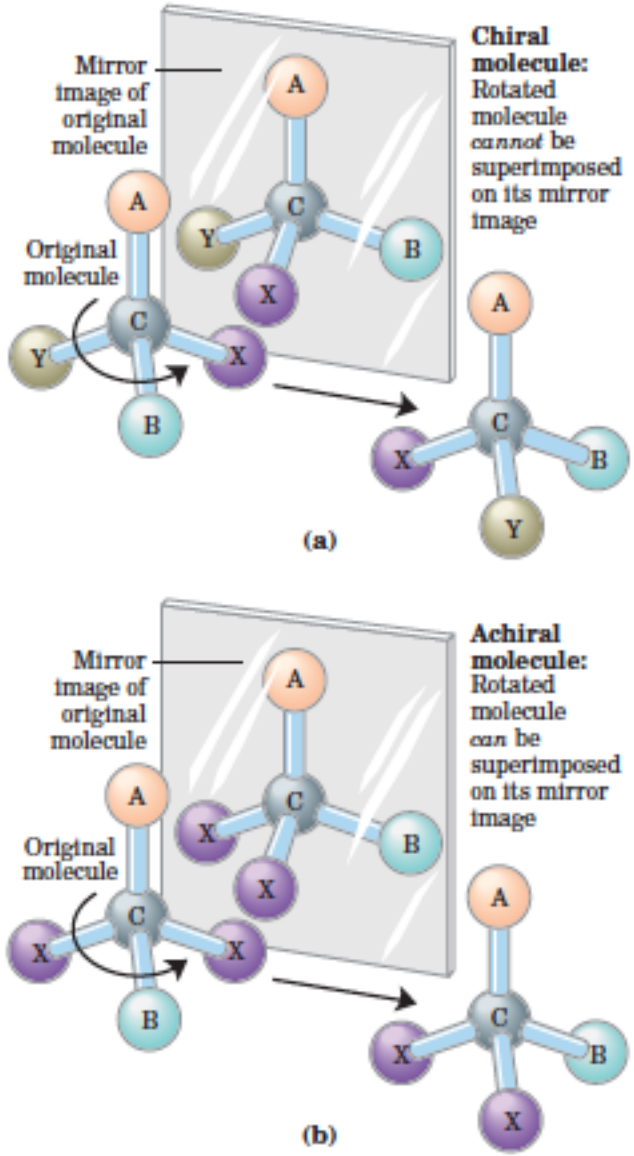



H
H
HOOC
COOH
Maleic acid (cis)
HOOC
H
H
COOH
Fumaric acid (trans)

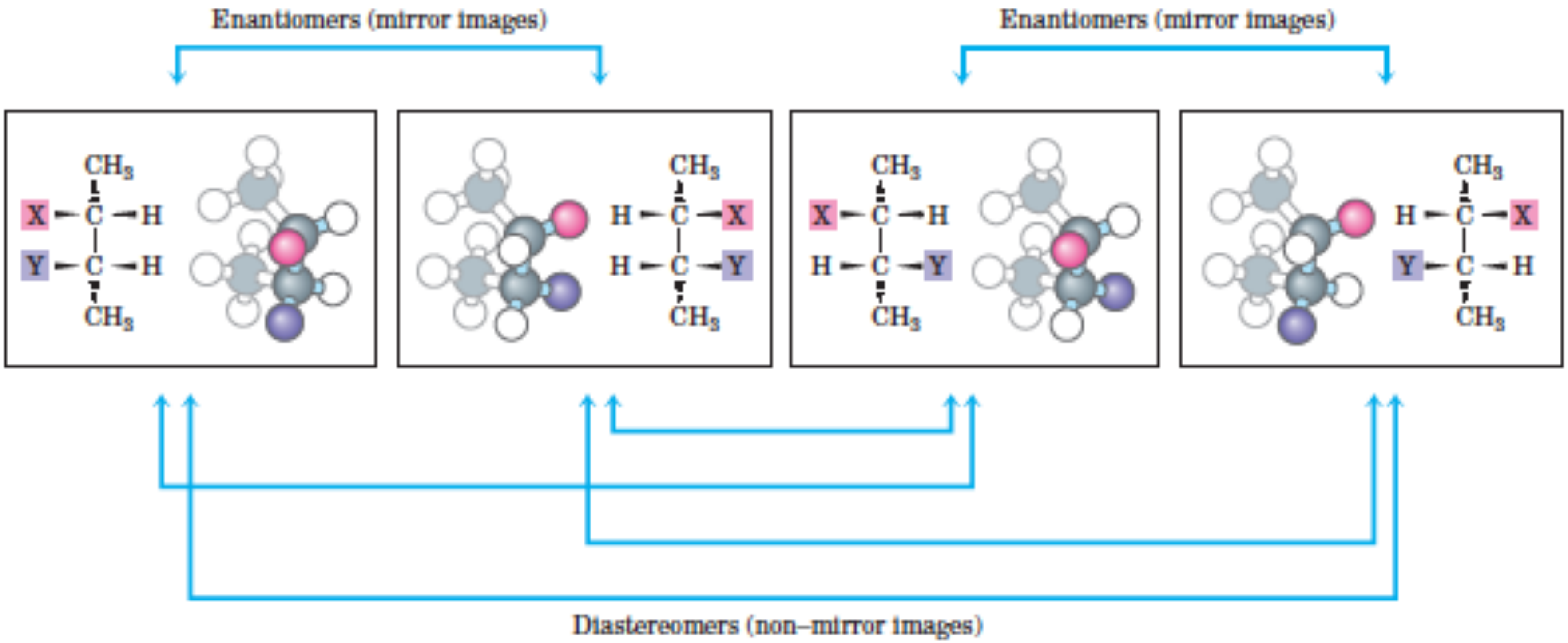
(a)


CH3 CH3
CH3
9
11
12
10
CH3
CH3
O
H
11-cis-Retinal
light
CH3 CH3
CH3
9
11
10
12
CH3
O
H
CH3
All-trans-Retinal

(b)

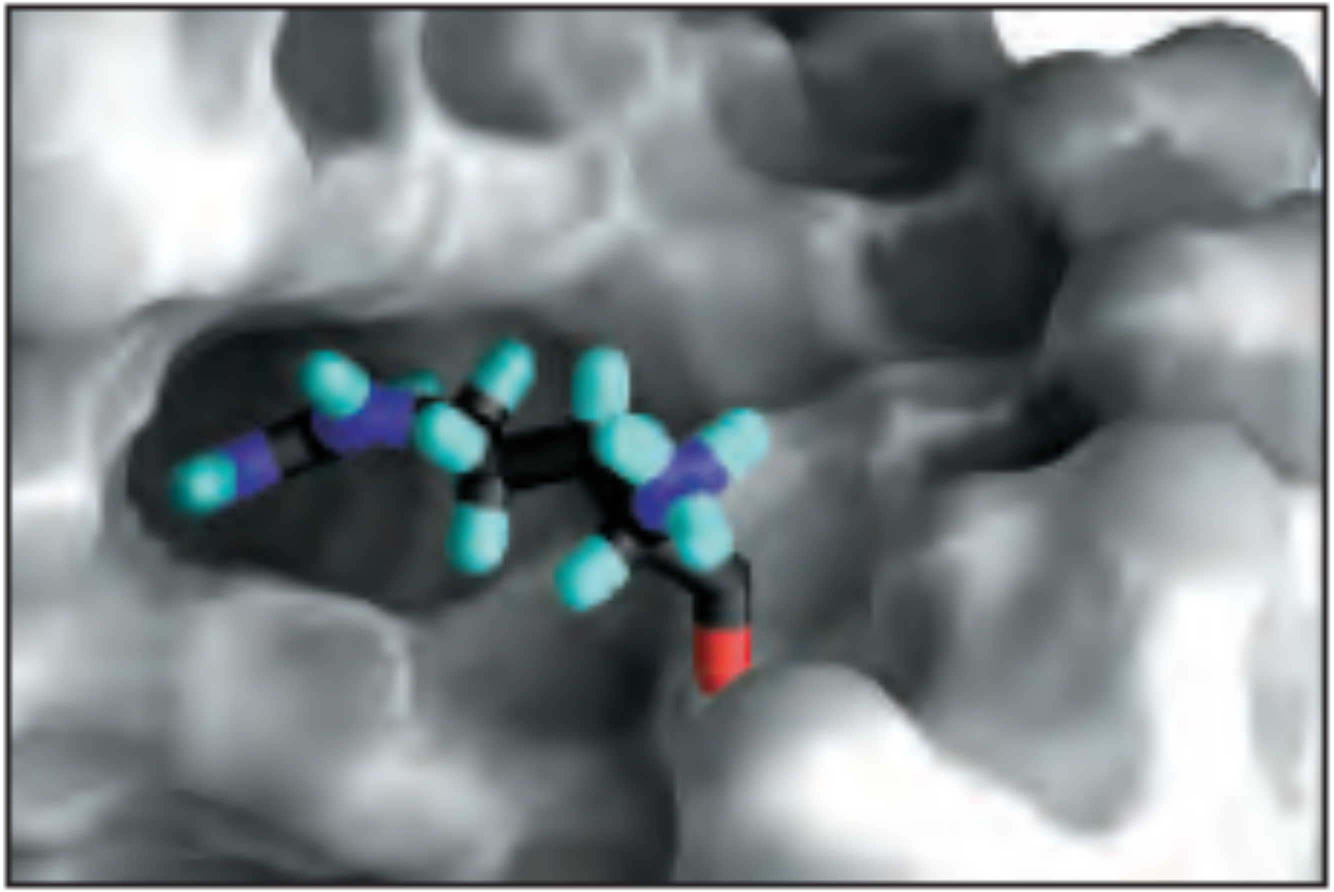


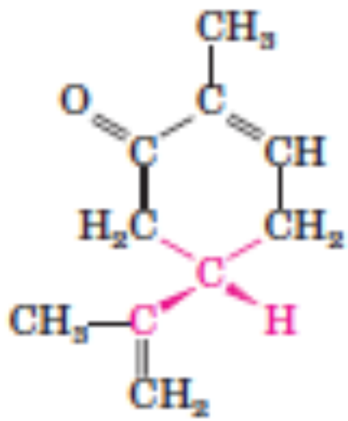
Molecular asymmetry: chiral and achiral molecules



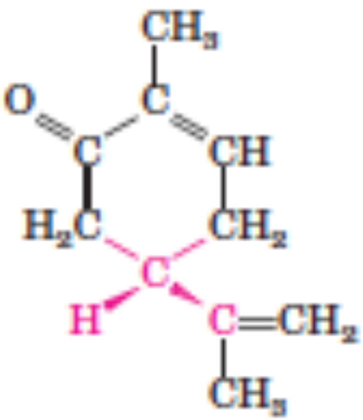
Enantiomers (mirror images)
Enantiomers (mirror images)
CH3
X C H
Y C H
CH3
CH3
H C X
H C Y
CH3
CH3
X C H
H C Y
CH3
CH3
H C X
Y C H
CH3
Diastereomers (non–mirror images)

Interactions between Biomolecules Are Stereospecific



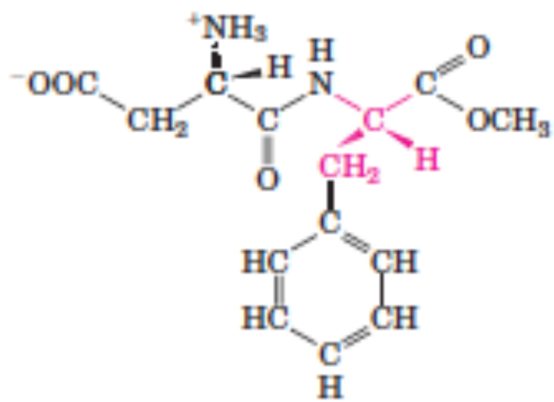


(*R*)-Carvone
(spearmint)

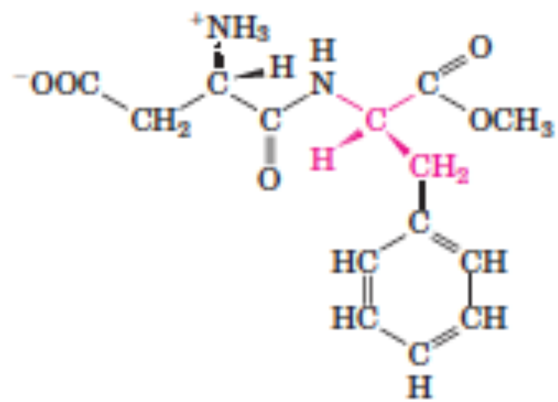


(*S*)-Carvone
(caraway)

(a)



L-Aspartyl-L-phenylalanine methyl ester
(aspartame) (sweet)



L-Aspartyl-D-phenylalanine methyl ester
(bitter)

(b)

Take home message..

■ Because of its bonding versatility, carbon can produce a broad array of carbon–carbon skeletons with a variety of functional groups; these groups give biomolecules their biological and chemical personalities.

■ A nearly universal set of several hundred small molecules is found in living cells; the interconversions of these molecules in the central metabolic pathways have been conserved in evolution.

■ Proteins and nucleic acids are linear polymers of simple monomeric subunits; their sequences contain the information that gives each molecule its three-dimensional structure and its biological functions.

■ Molecular configuration can be changed only by breaking covalent bonds. For a carbon atom with four different substituents (a chiral carbon), the substituent groups can be arranged in two different ways, generating stereoisomers with distinct properties. Only one stereoisomer is biologically active. Molecular conformation is the position of atoms in space that can be changed by rotation about single bonds, without breaking covalent bonds.

■ Interactions between biological molecules are almost invariably stereospecific: they require a complementary match between the interacting molecules.

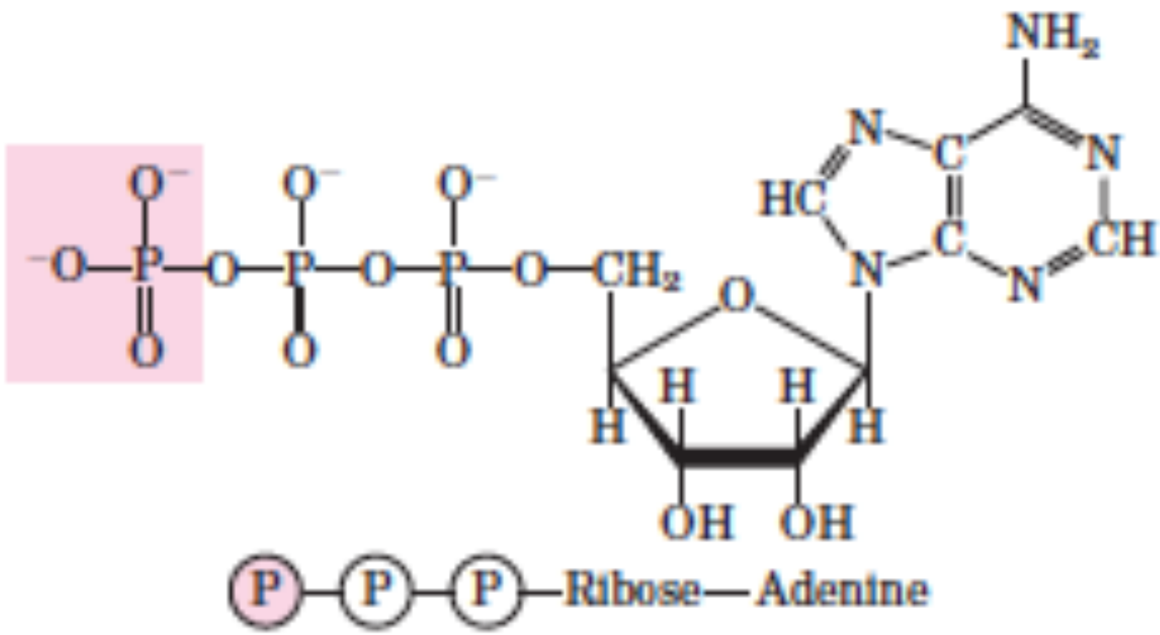
Physical Foundations

Living Organisms Exist in a Dynamic Steady State, Never at Equilibrium with Their Surroundings

Organisms Transform Energy and Matter from Their Surroundings

The Flow of Electrons Provides Energy for Organisms

Creating and Maintaining Order Requires Work and Energy



Energy Coupling Links Reactions in Biology

Take home message..

■ Living cells are open systems, exchanging matter and energy with their surroundings, extracting and channeling energy to maintain themselves in a dynamic steady state distant from equilibrium. Energy is obtained from sunlight or fuels by converting the energy from electron flow into the chemical bonds of ATP.

■ The tendency for a chemical reaction to proceed toward equilibrium can be expressed as the free-energy change, **G** , which has two components: enthalpy change, **H** , and entropy change, **S.** These variables are related by the equation **GH T S.**

■ When **G** of a reaction is negative, the reaction is exergonic and tends to go toward completion; when **G** is positive, the reaction is endergonic and tends to go in the reverse direction. When two reactions can be summed to yield a third reaction, the **G** for this overall reaction is the sum of the **G** s of the two separate reactions. This provides a way to couple reactions.

Take home message..

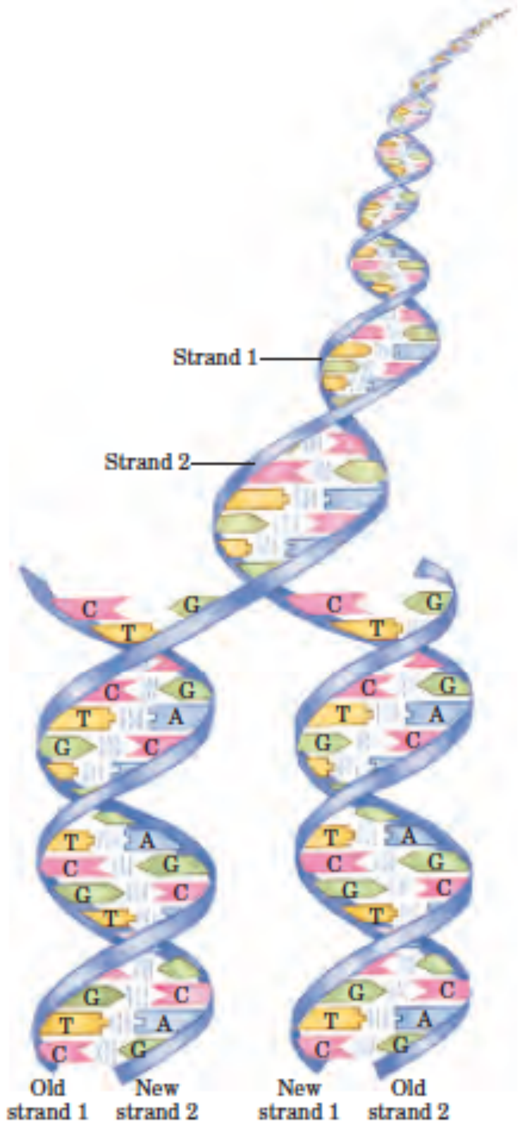
■ The conversion of ATP to Pi and ADP is highly exergonic (large negative **G**), and many endergonic cellular reactions are driven by coupling them, through a common intermediate, cto this reaction.

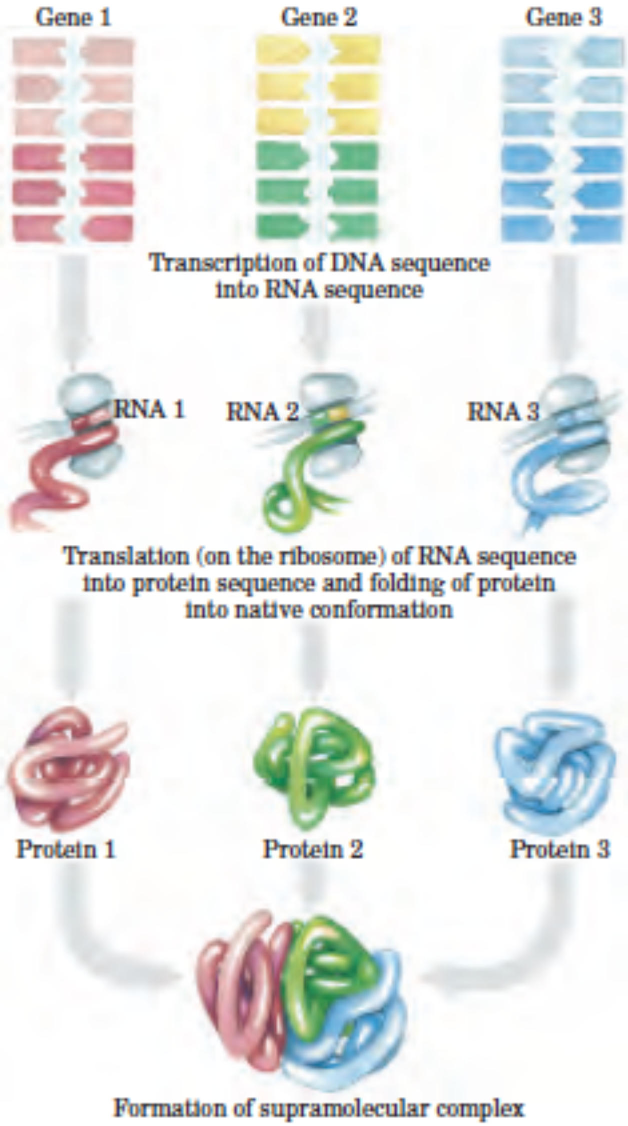
■ The standard free-energy change for a reaction, **G** , is a physical constant that is related to the equilibrium constant by the equation **G RT** ln **K**eq .

■ Most exergonic cellular reactions proceed at useful rates only because enzymes are present to catalyze them. Enzymes act in part by stabilizing the transition state, reducing the activation energy, **G‡** , and increasing the reaction rate by many orders of magnitude. The catalytic activity of enzymes in cells is regulated.

■ Metabolism is the sum of many interconnected reaction sequences that interconvert cellular metabolites. Each sequence is regulated so as to provide what the cell needs at a given time and to expend energy only when necessary.

Genetic Foundations





Take home message..

■ Genetic information is encoded in the linear sequence of four deoxyribonucleotides in DNA.

■ The double-helical DNA molecule contains an internal template for its own replication and repair.

■ The linear sequence of amino acids in a protein, which is encoded in the DNA of the gene for that protein, produces a protein’s unique three-dimensional structure.

■ Individual macromolecules with specific affinity for other macromolecules self-assemble into supramolecular complexes.

Evolutionary Foundations

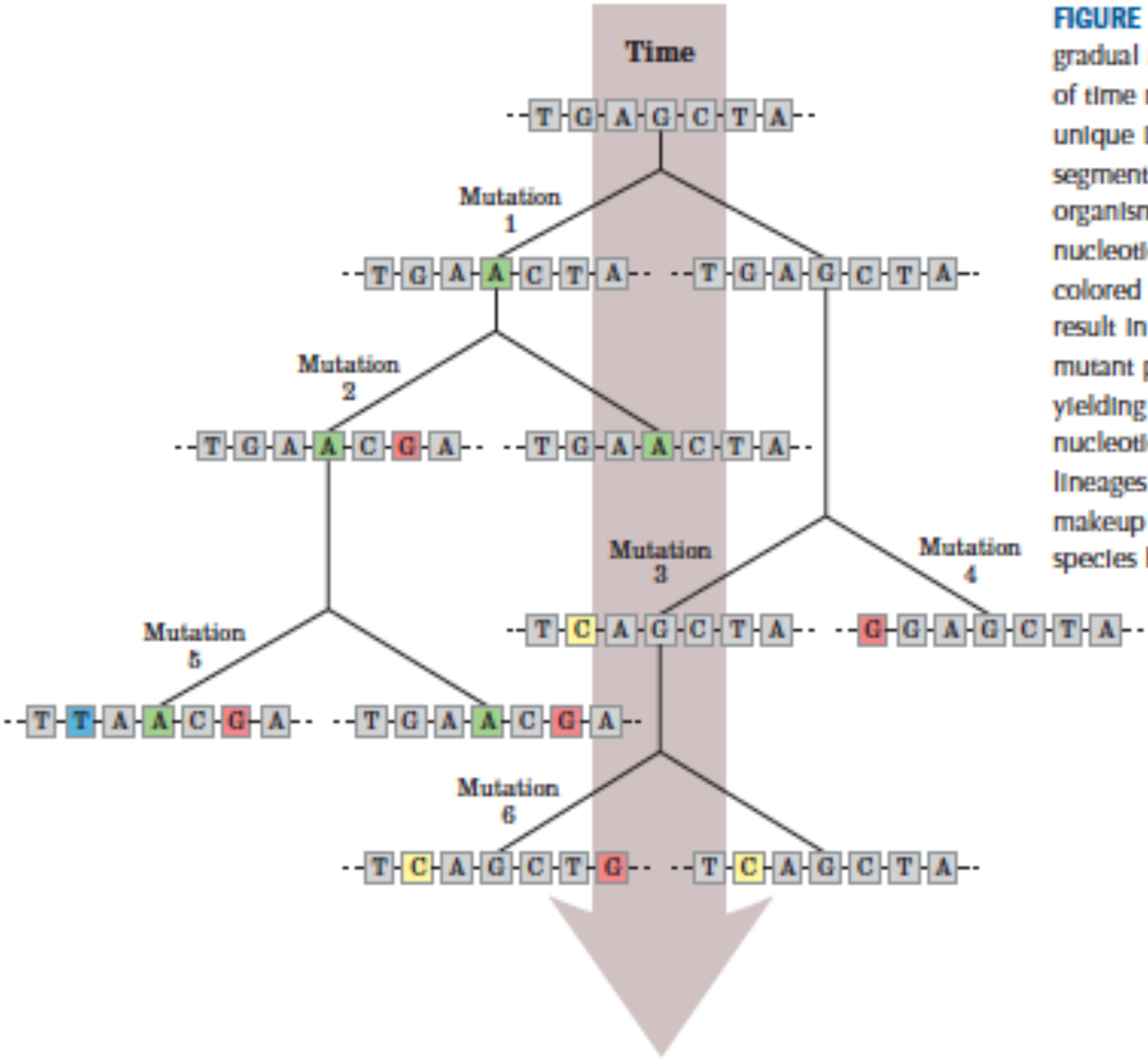
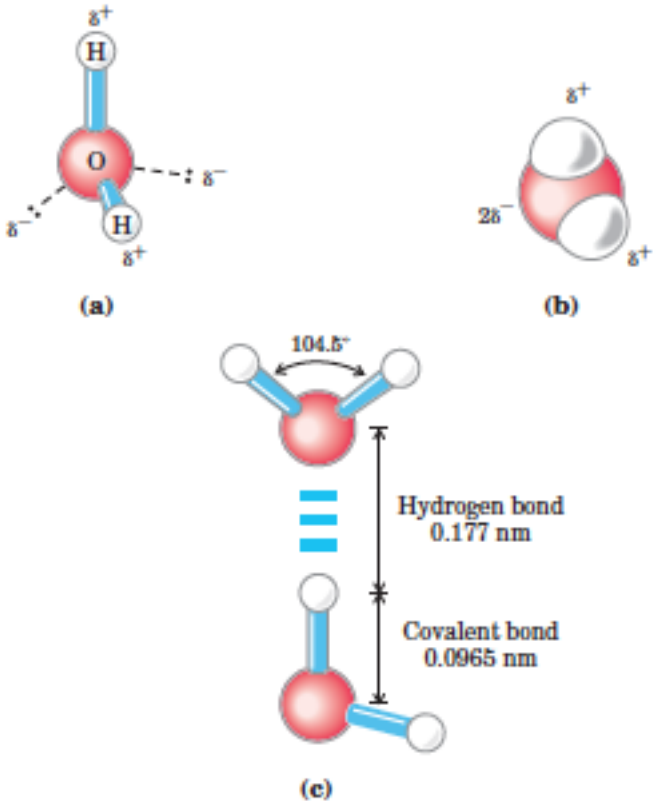


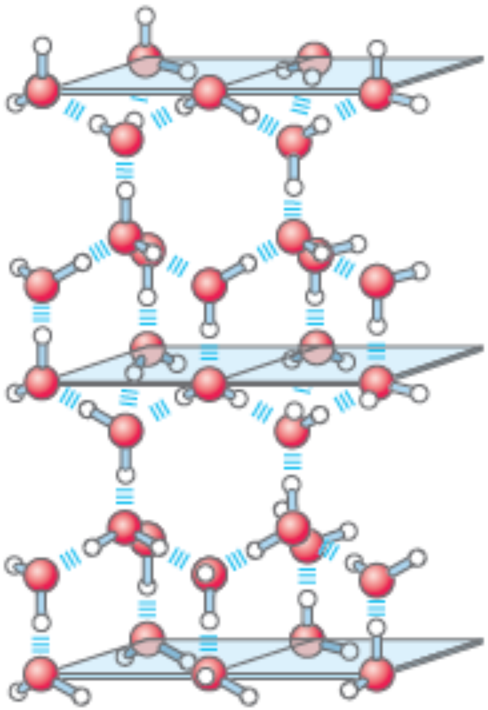
FIGURE 1–32 Role of mutation in evolution. The gradual accumulation of mutations over long periods of time results in new biological species, each with a unique DNA sequence. At the top is shown a short segment of a gene in a hypothetical progenitor organism. With the passage of time, changes in nucleotide sequence (mutations, indicated here by colored boxes), *occurring one nucleotide at a time*, result in progeny with different DNA sequences. These mutant progeny also undergo occasional mutations, yielding their own progeny that differ by two or more nucleotides from the progenitor sequence. When two lineages have diverged so much in their genetic makeup that they can no longer interbreed, a new species has been created.

Water

Water is the most abundant substance in living systems, making up 70% or more of the weight of most organisms.

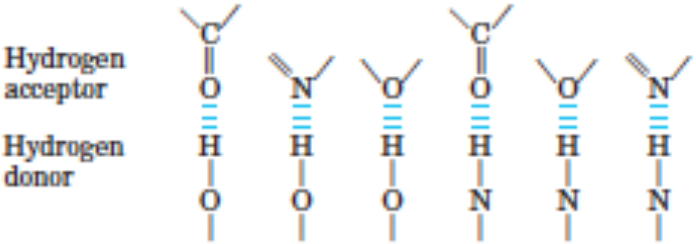
Weak Interactions in Aqueous Systems

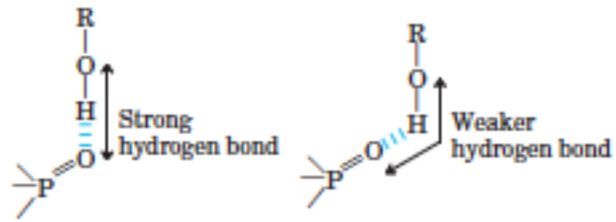


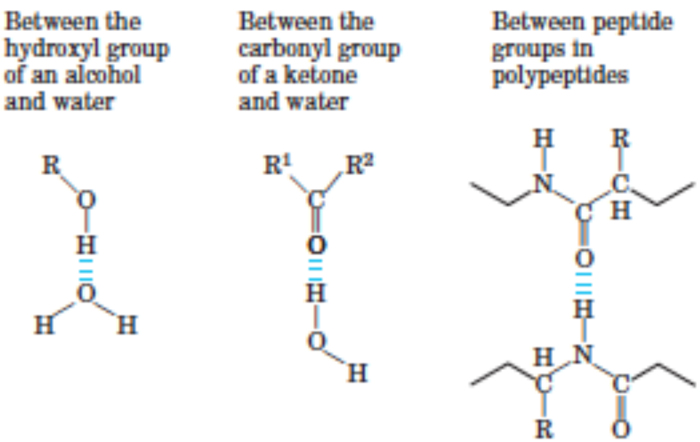


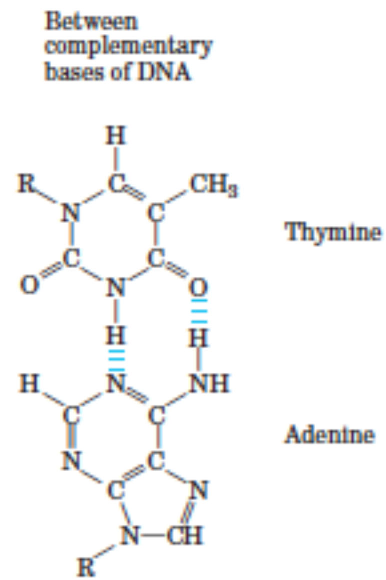
Hydrogen Bonding Gives Water Its Unusual Properties

Water Forms Hydrogen Bonds with Polar Solutes

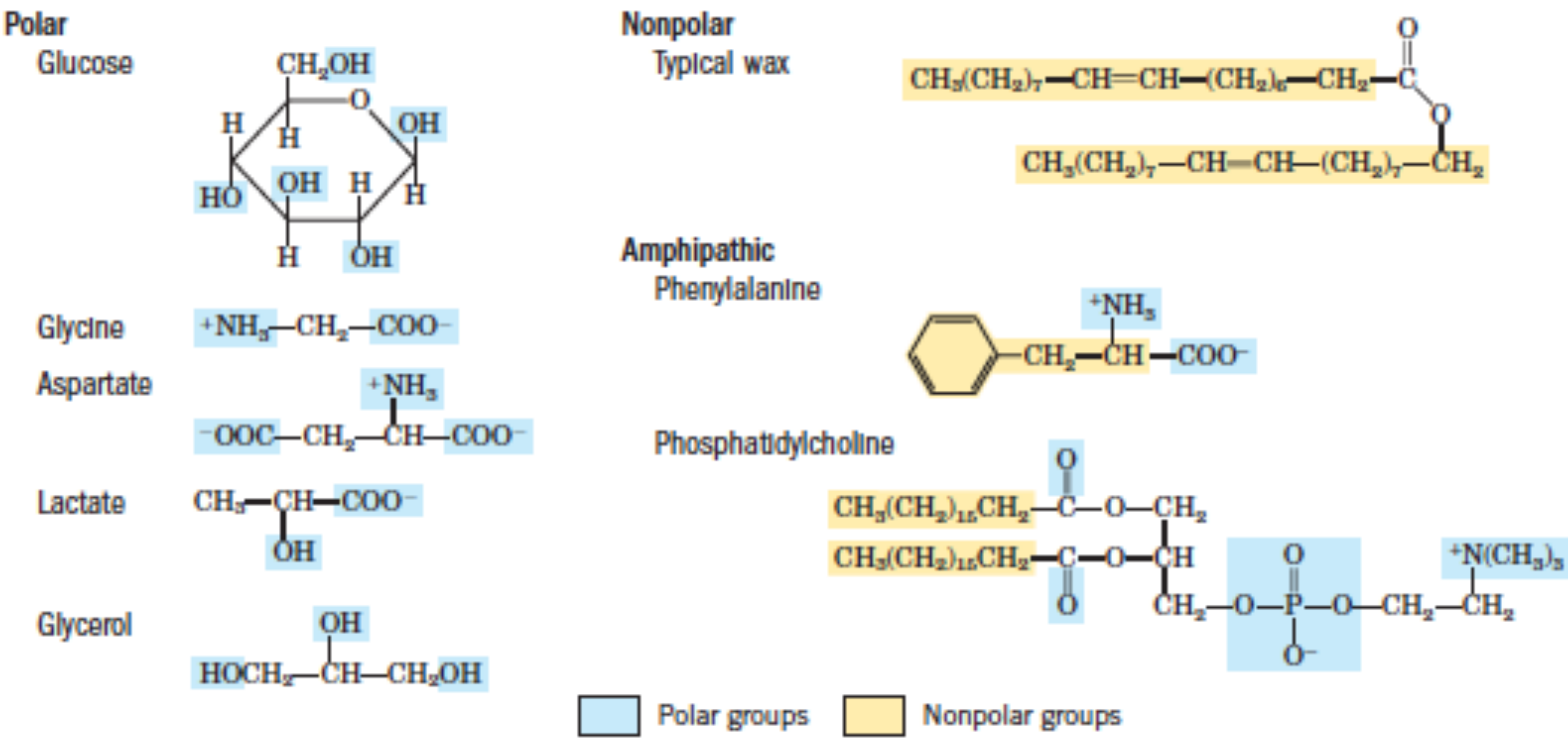








Water Interacts Electrostatically with Charged Solutes



Entropy Increases as Crystalline Substances Dissolve

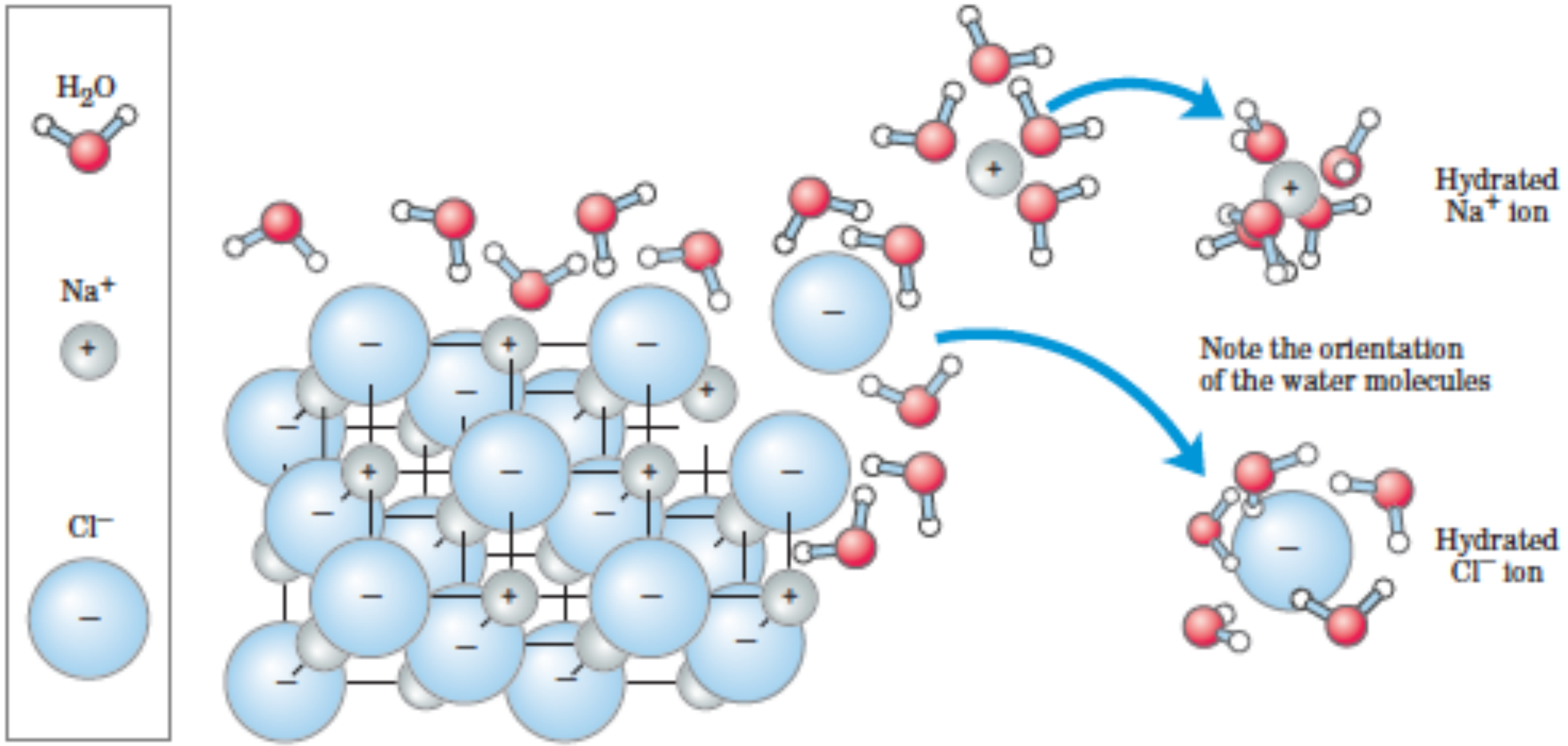
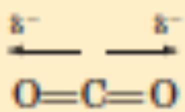
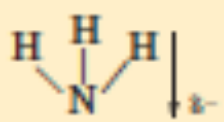
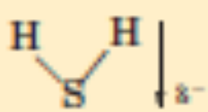
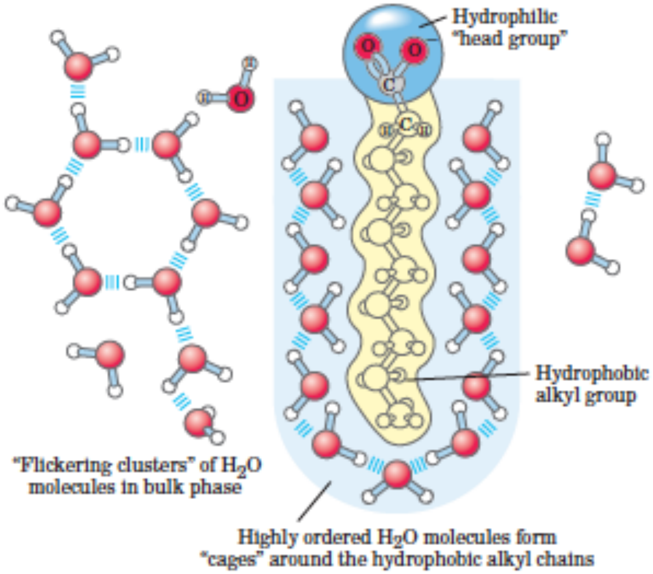
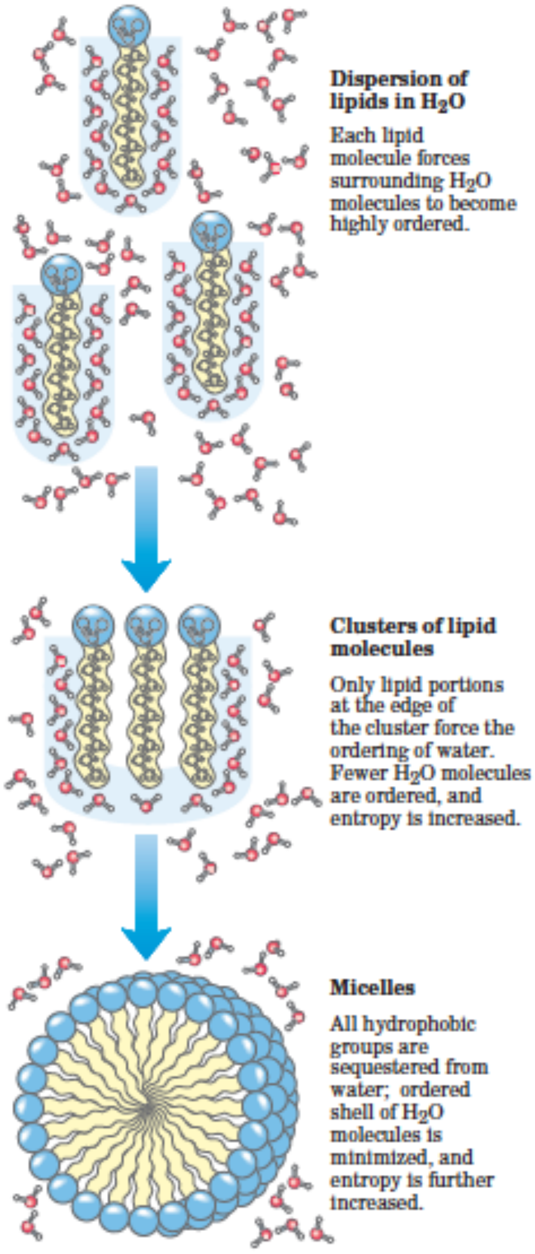


TABLE 2-3 Solubilities of Some Gases in Water

Gas	*Structure**	*Polarity*	*Solubility in water (g/L)*†
Nitrogen	N≡N	Nonpolar	0.018 (40 °C)
Oxygen	O=O	Nonpolar	0.035 (50 °C)
Carbon dioxide		Nonpolar	0.97 (45 °C)
Ammonia		Polar	900 (10 °C)
Hydrogen sulfide		Polar	1,860 (40 °C)



Amphipathic compounds in aqueous solution

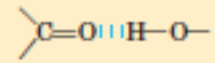
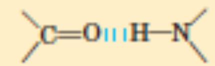
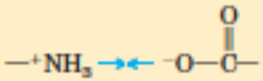
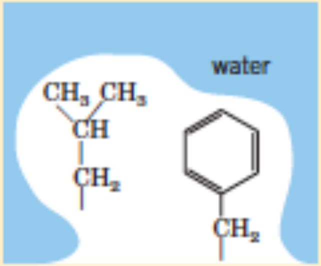


Weak Interactions Are Crucial to Macromolecular Structure and Function

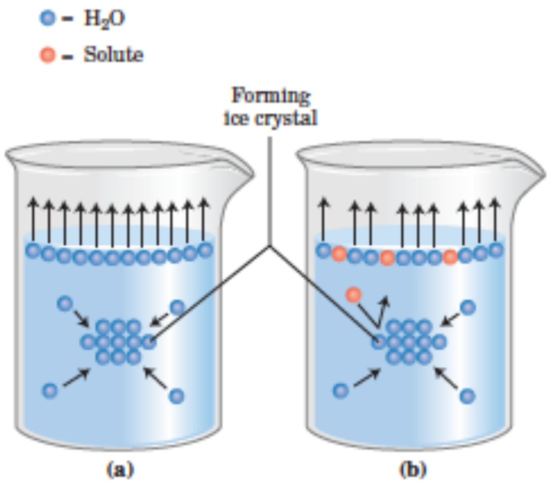
TABLE 2-4 van der Waals Radii and Covalent (Single-Bond) Radii of Some Elements

Element	*van der Waals radius (nm)*	*Covalent radius for single bond (nm)*
H	0.11	0.030
O	0.15	0.066
N	0.15	0.070
C	0.17	0.077
S	0.18	0.104
P	0.19	0.110
I	0.21	0.133

TABLE 2-5 Four Types of Noncovalent ("Weak") Interactions among Biomolecules in Aqueous Solvent

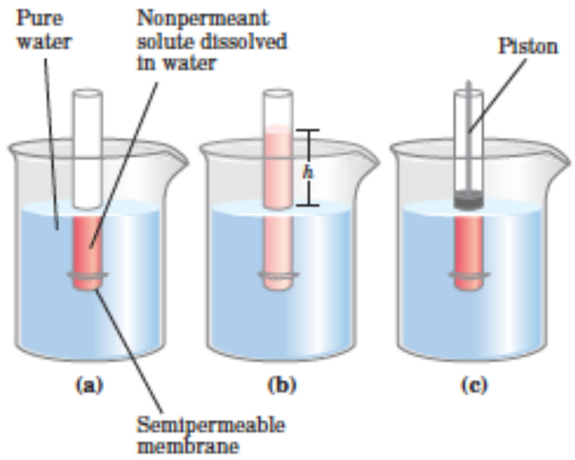
Hydrogen bonds	
Between neutral groups	
Between peptide bonds	
Ionic interactions	
Attraction	
Repulsion	
Hydrophobic interactions	
van der Waals interactions	Any two atoms in close proximity

Solutes Affect the Colligative Properties of Aqueous Solutions

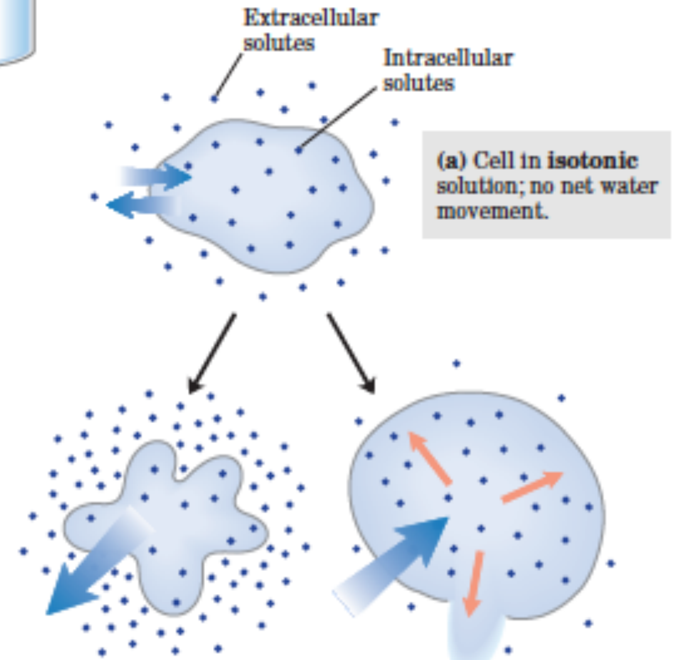


(a) In **pure water,** every molecule at the surface is H_2O, and all contribute to the vapor pressure. Every molecule in the bulk solution is H_2O, and can contribute to formation of ice crystals.

(b) In this **solution,** the effective concentration of H_2O is reduced; only 3 of every 4 molecules at the surface and in the bulk phase are H_2O. The vapor pressure of water and the tendency of liquid water to enter a crystal are reduced proportionately.



Osmosis



(a) Cell in **isotonic** solution; no net water movement.

(b) Cell in **hypertonic** solution; water moves out and cell shrinks.

(c) Cell in **hypotonic** solution; water moves in, creating outward pressure; cell swells, may eventually burst.

Ionization of Water, Weak Acids, and Weak Bases

Pure Water Is Slightly Ionized

$$H_2O \rightleftharpoons H^+ + OH^-$$

The Ionization of Water Is Expressed by an Equilibrium Constant

$$K_{eq} = \frac{[H^+][OH^-]}{[H_2O]}$$

$$(55.5\ \text{M})(K_{eq}) = [H^+][OH^-] = K_w$$

$$K_w = [H^+][OH^-] = (55.5\ \text{M})(1.8 \times 10^{-16}\ \text{M}) = 1.0 \times 10^{-14}\ \text{M}^2$$

$$K_w = [H^+][OH^-] = [H^+]^2$$

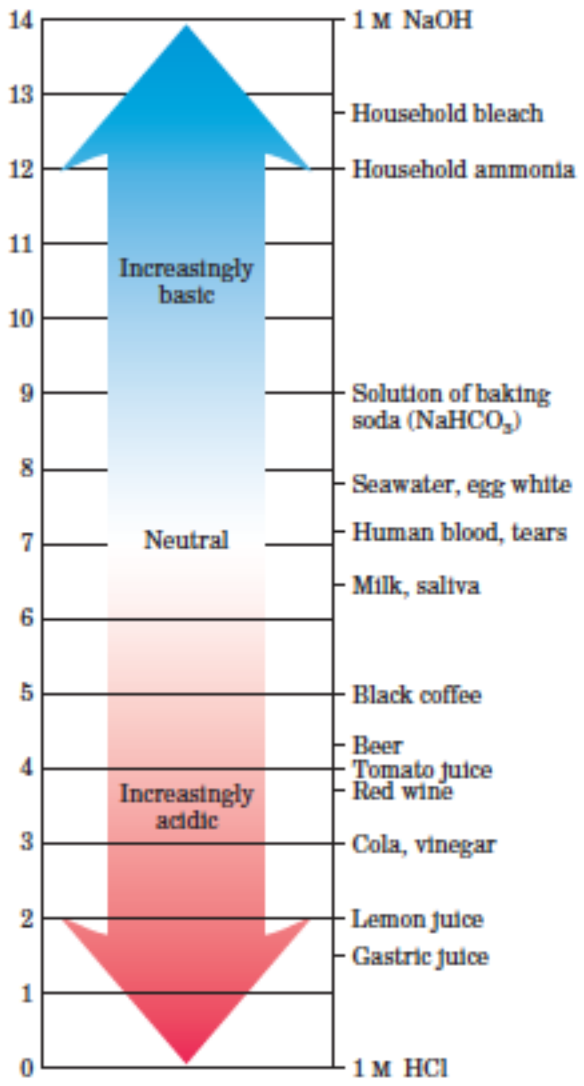
Solving for $[H^+]$ gives

$$[H^+] = \sqrt{K_w} = \sqrt{1 \times 10^{-14}\ \text{M}^2}$$

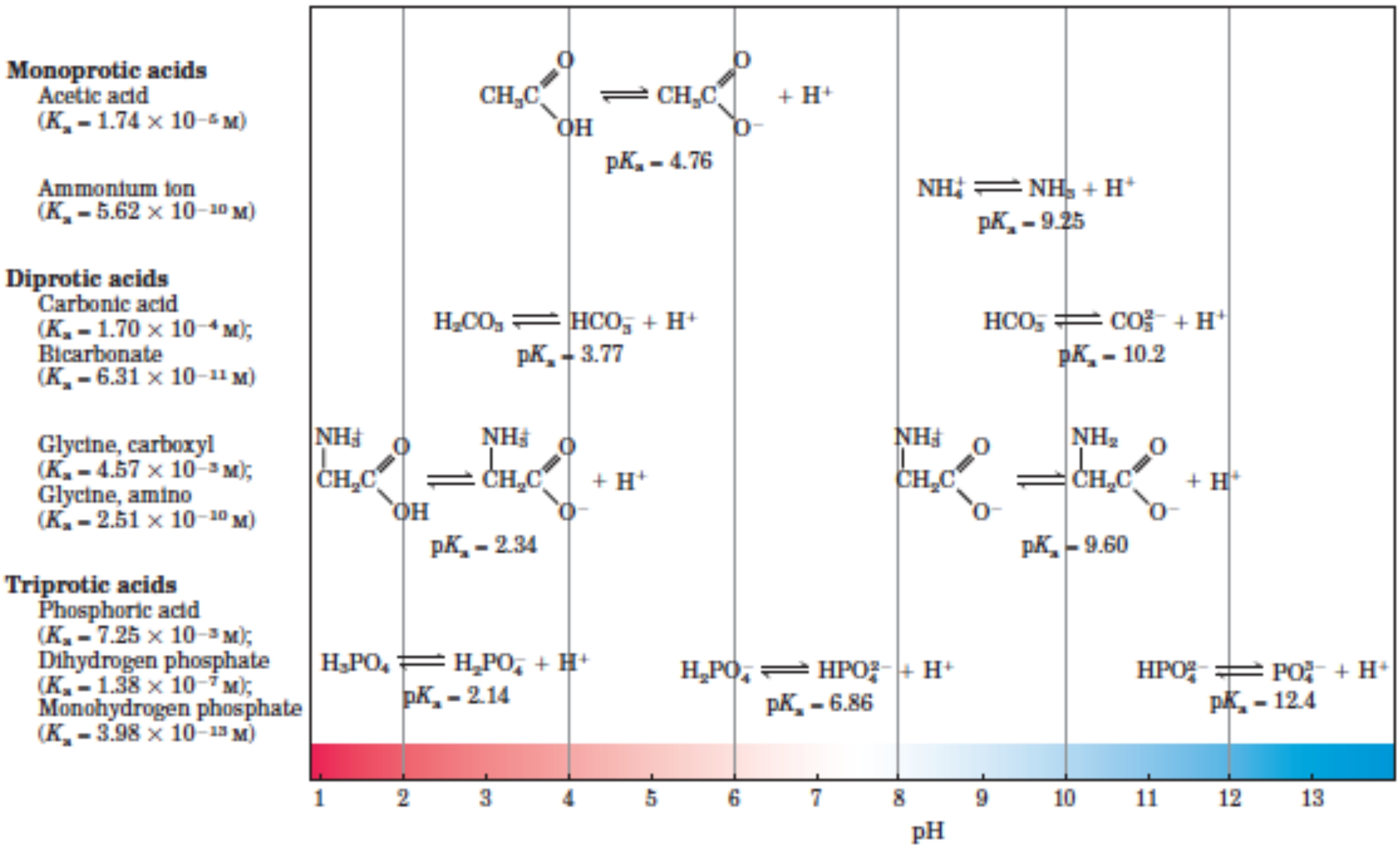
$$[H^+] = [OH^-] = 10^{-7}\ \text{M}$$

TABLE 2-6 The pH Scale

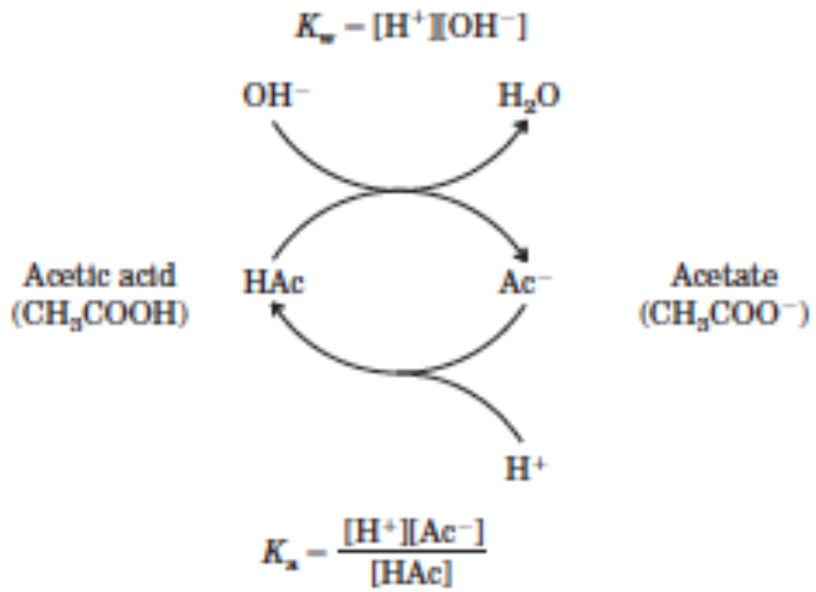
$[H^+]$ (M)	pH	$[OH^-]$ (M)	pOH*
10^0 (1)	0	10^{-14}	14
10^{-1}	1	10^{-13}	13
10^{-2}	2	10^{-12}	12
10^{-3}	3	10^{-11}	11
10^{-4}	4	10^{-10}	10
10^{-5}	5	10^{-9}	9
10^{-6}	6	10^{-8}	8
10^{-7}	7	10^{-7}	7
10^{-8}	8	10^{-6}	6
10^{-9}	9	10^{-5}	5
10^{-10}	10	10^{-4}	4
10^{-11}	11	10^{-3}	3
10^{-12}	12	10^{-2}	2
10^{-13}	13	10^{-1}	1
10^{-14}	14	10^0 (1)	0



Weak Acids and Bases Have Characteristic Dissociation Constants



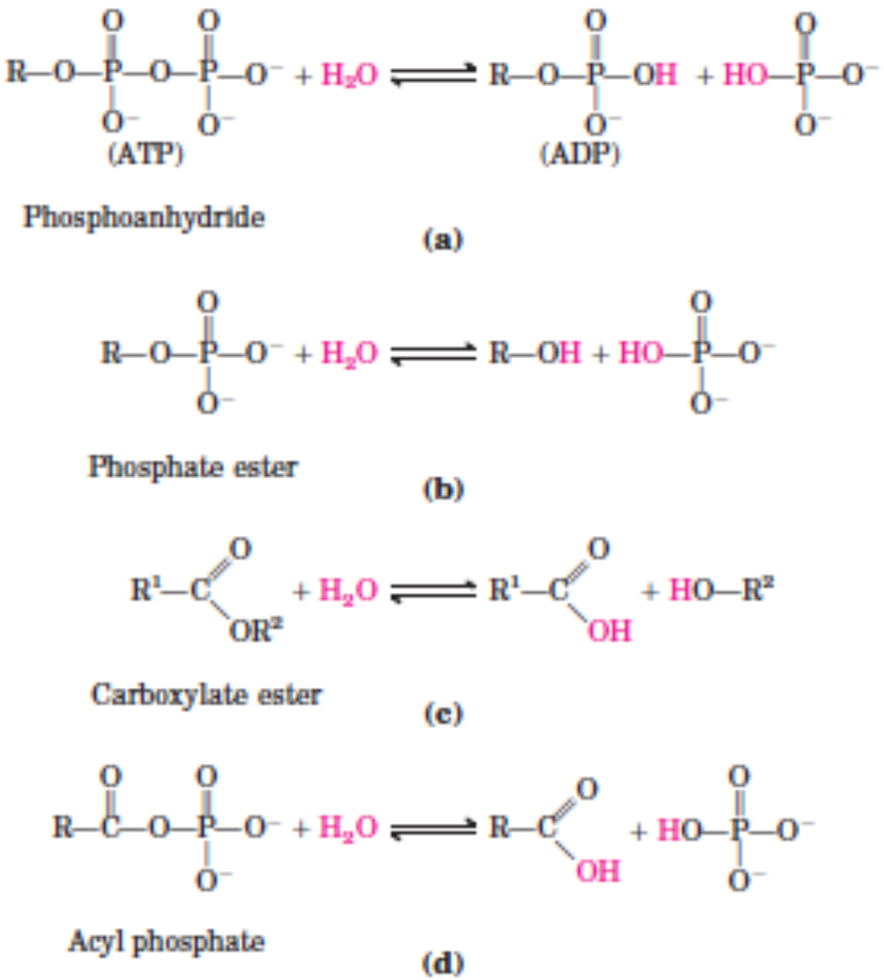
Buffering against pH Changes in Biological Systems



Hasselbalch equation

$$pH = pK_a + \log \frac{[\text{proton acceptor}]}{[\text{proton donor}]}$$

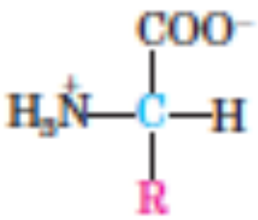
Water as a Reactant

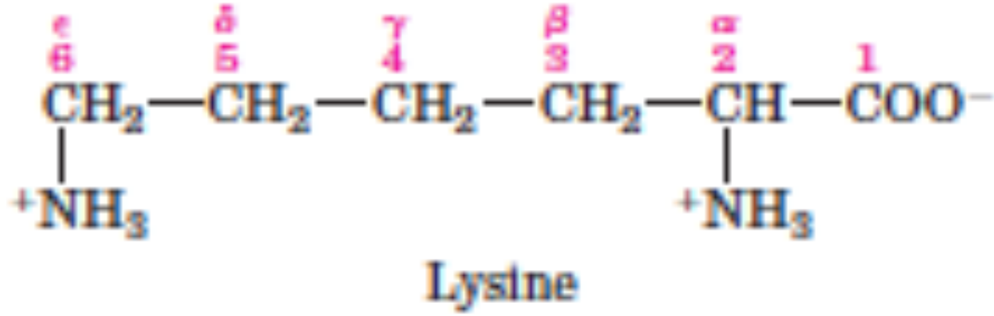


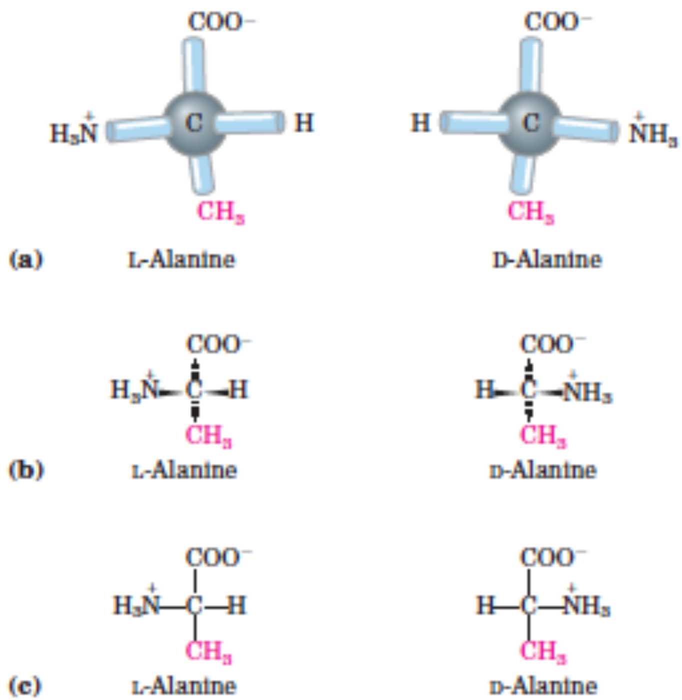
Water is both the solvent in which metabolic reactions occur and a reactant in many biochemical processes, including hydrolysis, condensation, and oxidation-reduction reactions.

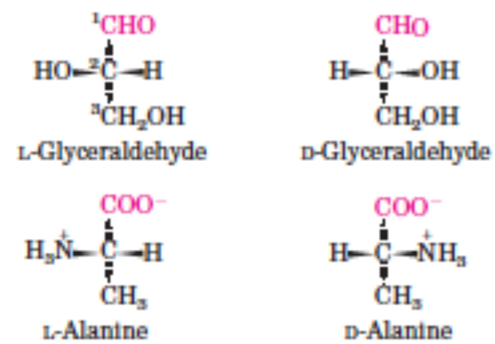
Amino Acid

Amino Acids Share Common Structural Features







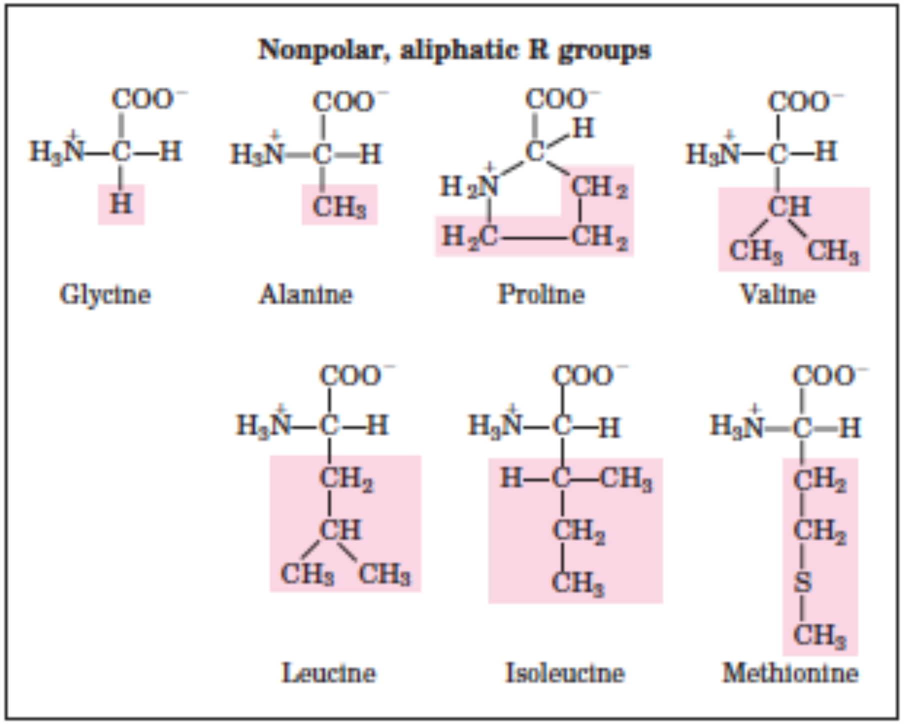


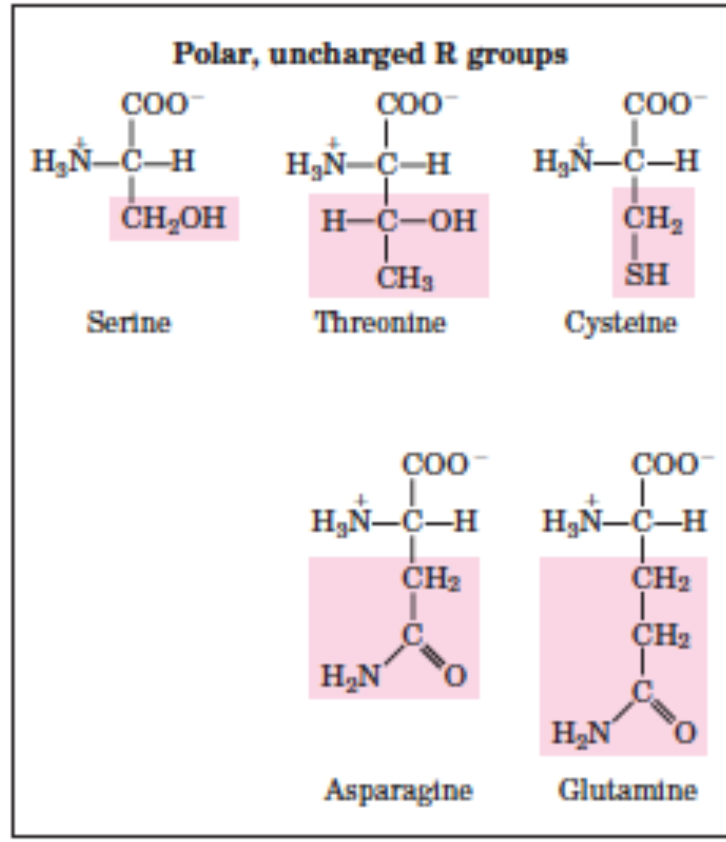
Amino Acids Can Be Classified by R Group

TABLE 3-1 Properties and Conventions Associated with the Common Amino Acids Found in Proteins

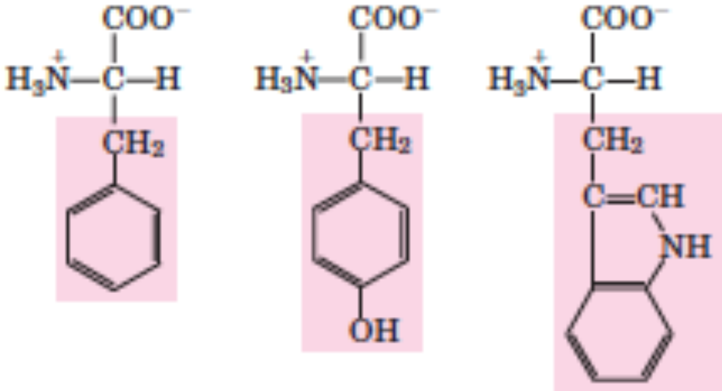
Amino acid	Abbreviation/ symbol	M_r	pK_a values: pK_1 (—COOH)	pK_2 ($—NH_3^+$)	pK_R (R group)	pI	Hydropathy index*	Occurrence in proteins (%)†
Nonpolar, aliphatic R groups								
Glycine	Gly G	75	2.34	9.60		5.97	−0.4	7.2
Alanine	Ala A	89	2.34	9.69		6.01	1.8	7.8
Proline	Pro P	115	1.99	10.96		6.48	1.6	5.2
Valine	Val V	117	2.32	9.62		5.97	4.2	6.6
Leucine	Leu L	131	2.36	9.60		5.98	3.8	9.1
Isoleucine	Ile I	131	2.36	9.68		6.02	4.5	5.3
Methionine	Met M	149	2.28	9.21		5.74	1.9	2.3
Aromatic R groups								
Phenylalanine	Phe F	165	1.83	9.13		5.48	2.8	3.9
Tyrosine	Tyr Y	181	2.20	9.11	10.07	5.66	−1.3	3.2
Tryptophan	Trp W	204	2.38	9.39		5.89	−0.9	1.4
Polar, uncharged R groups								
Serine	Ser S	105	2.21	9.15		5.68	−0.8	6.8
Threonine	Thr T	119	2.11	9.62		5.87	−0.7	5.9
Cysteine	Cys C	121	1.96	10.28	8.18	5.07	2.5	1.9
Asparagine	Asn N	132	2.02	8.80		5.41	−3.5	4.3
Glutamine	Gln Q	146	2.17	9.13		5.65	−3.5	4.2
Positively charged R groups								
Lysine	Lys K	146	2.18	8.95	10.53	9.74	−3.9	5.9
Histidine	His H	155	1.82	9.17	6.00	7.59	−3.2	2.3
Arginine	Arg R	174	2.17	9.04	12.48	10.76	−4.5	5.1
Negatively charged R groups								
Aspartate	Asp D	133	1.88	9.60	3.65	2.77	−3.5	5.3
Glutamate	Glu E	147	2.19	9.67	4.25	3.22	−3.5	6.3

20 Common Amino Acids



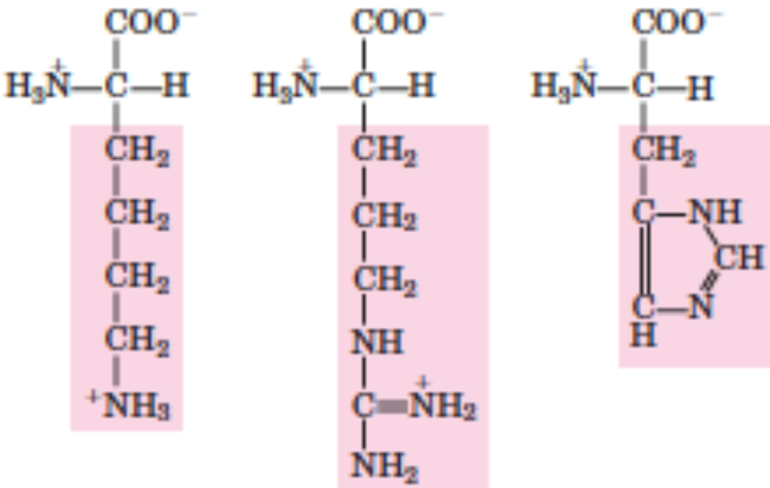


Aromatic R groups



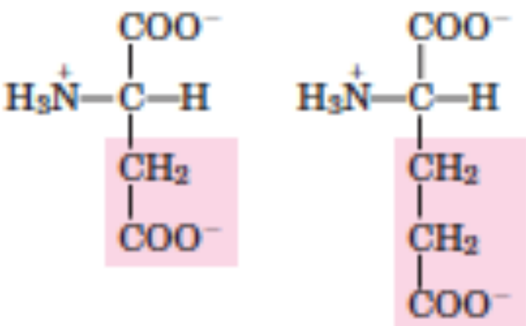
Phenylalanine Tyrosine Tryptophan

Positively charged R groups



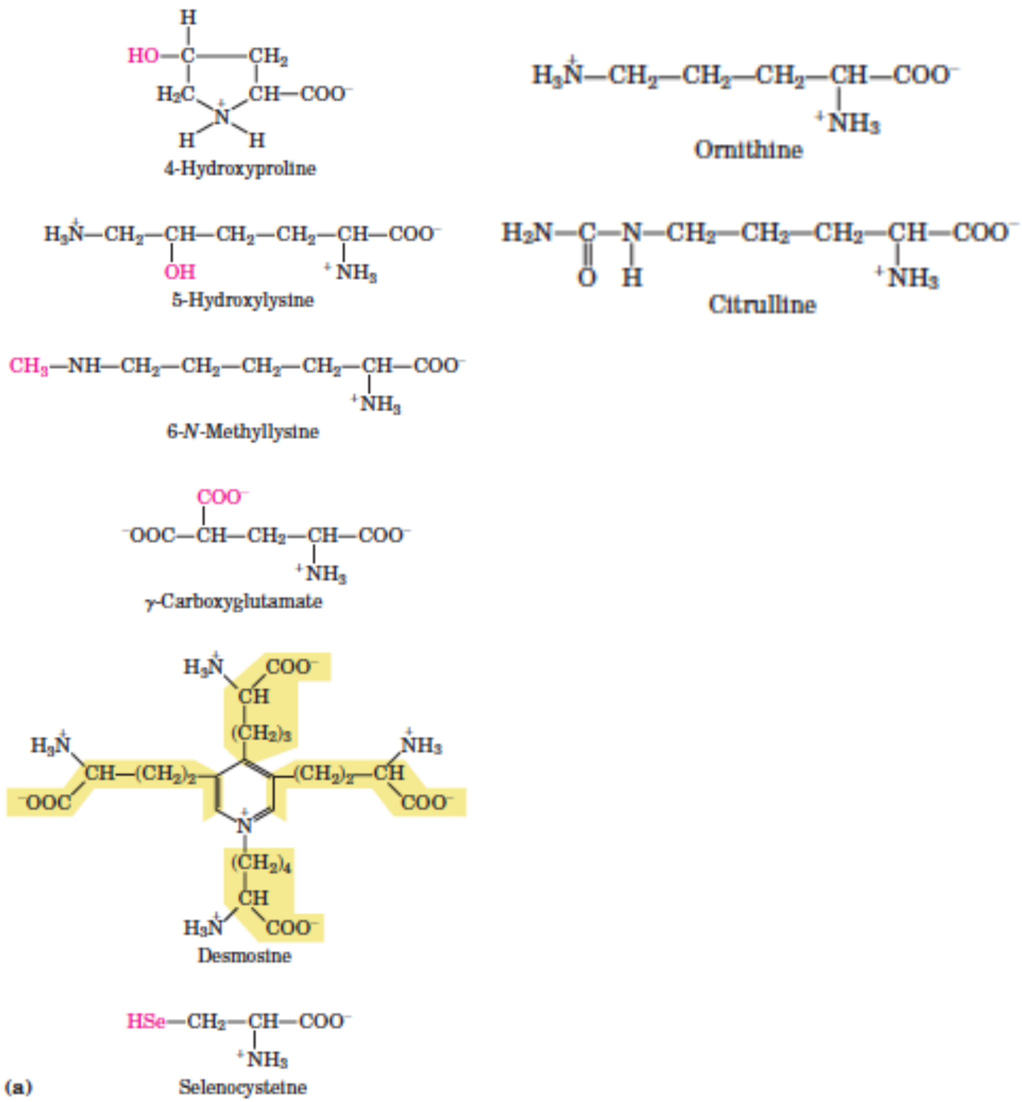
Lysine Arginine Histidine

Negatively charged R groups

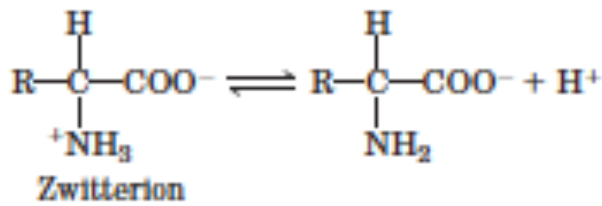


Aspartate Glutamate

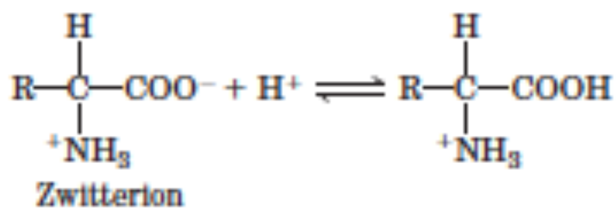
Uncommon Amino Acids Also Have Important Functions



Amino Acids Can Act as Acids and Bases



or a base (proton acceptor):



■ The 20 amino acids commonly found as residues in proteins contain an –carboxyl group, an -amino group, and a distinctive R group substituted on the -carbon atom. The -carbon atom of all amino acids except glycine is asymmetric, and thus amino acids can exist in at least two stereoisomeric forms. Only the L stereoisomers, with a configuration related to the absolute configuration of the reference molecule L-glyceraldehyde, are found in proteins.

■ Other, less common amino acids also occur, either as constituents of proteins (through modification of common amino acid residues after protein synthesis) or as free metabolites.

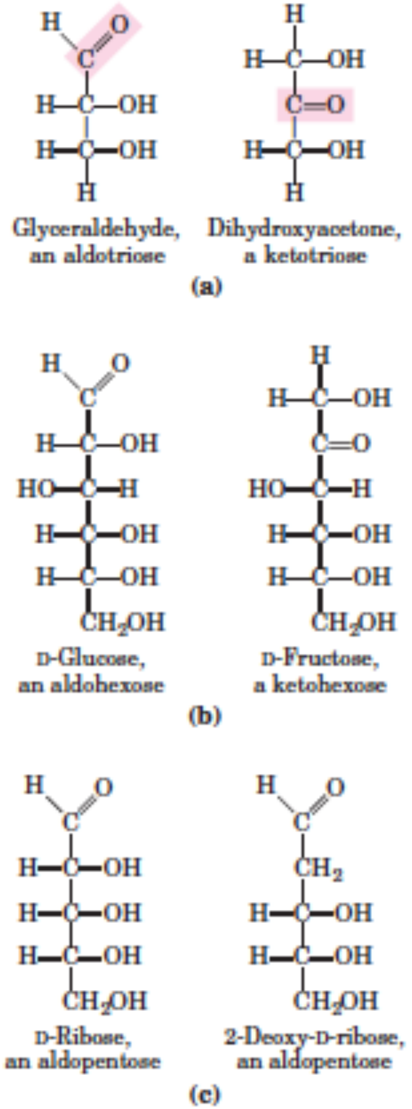
■ Amino acids are classified into five types on the basis of the polarity and charge (at pH 7) of their R groups.

■ Amino acids vary in their acid-base properties and have characteristic titration curves. Monoamino monocarboxylic amino acids (with nonionizable R groups) are diprotic acids (H3NCH(R)COOH) at low pH and exist in several different ionic forms as the pH is increased. Amino acids with ionizable R groups have additional ionic species, depending on the pH of the medium and the p**K**a of the R group.

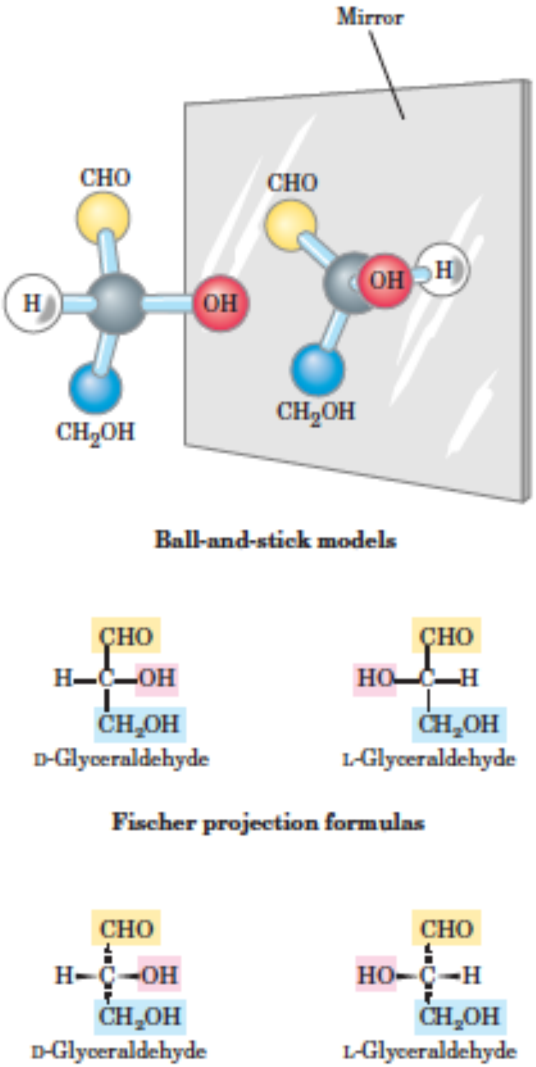
Carbohydrate

Monosaccharides and Disaccharides

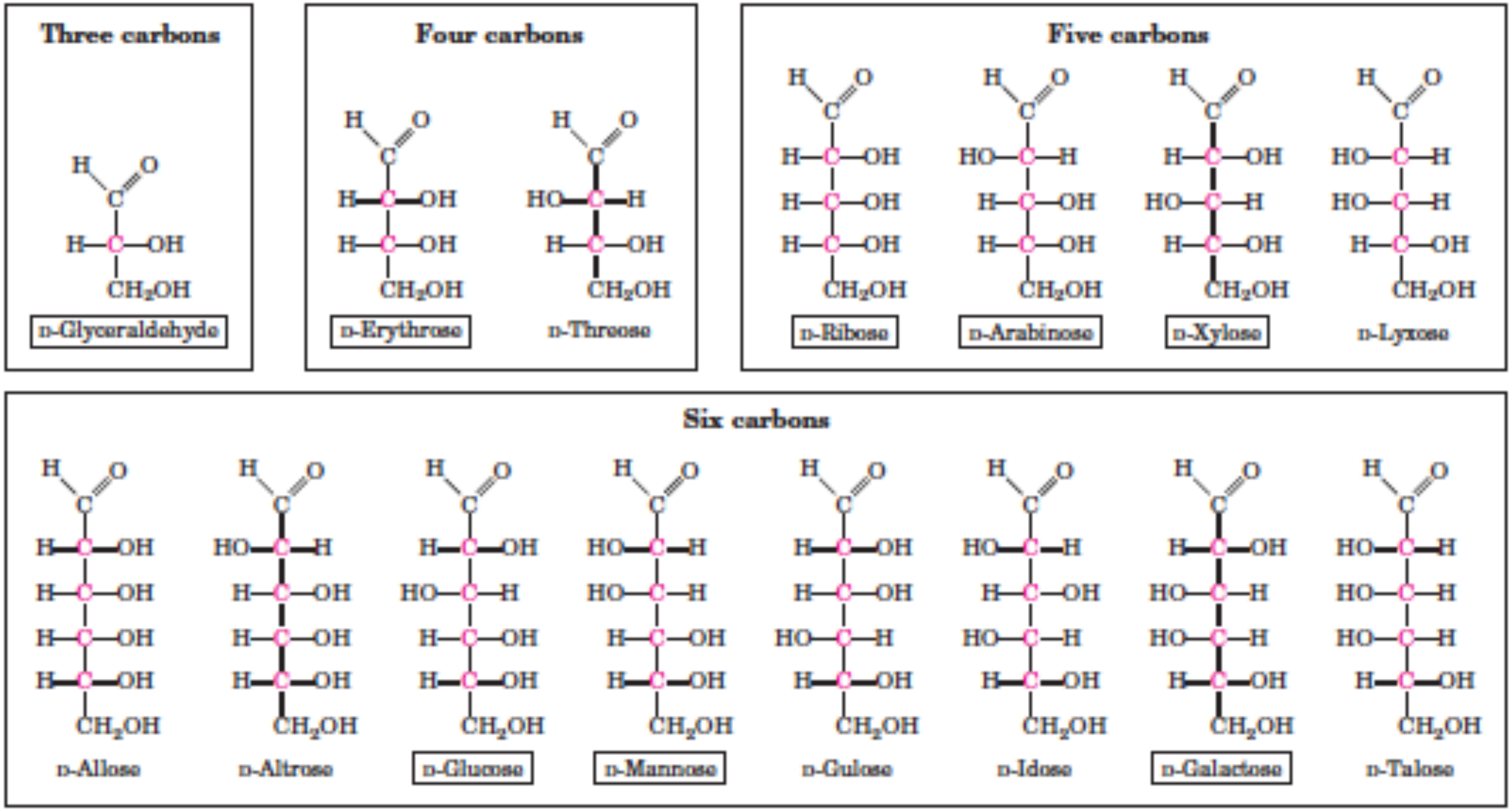
The Two Families of Monosaccharides Are Aldoses and Ketoses



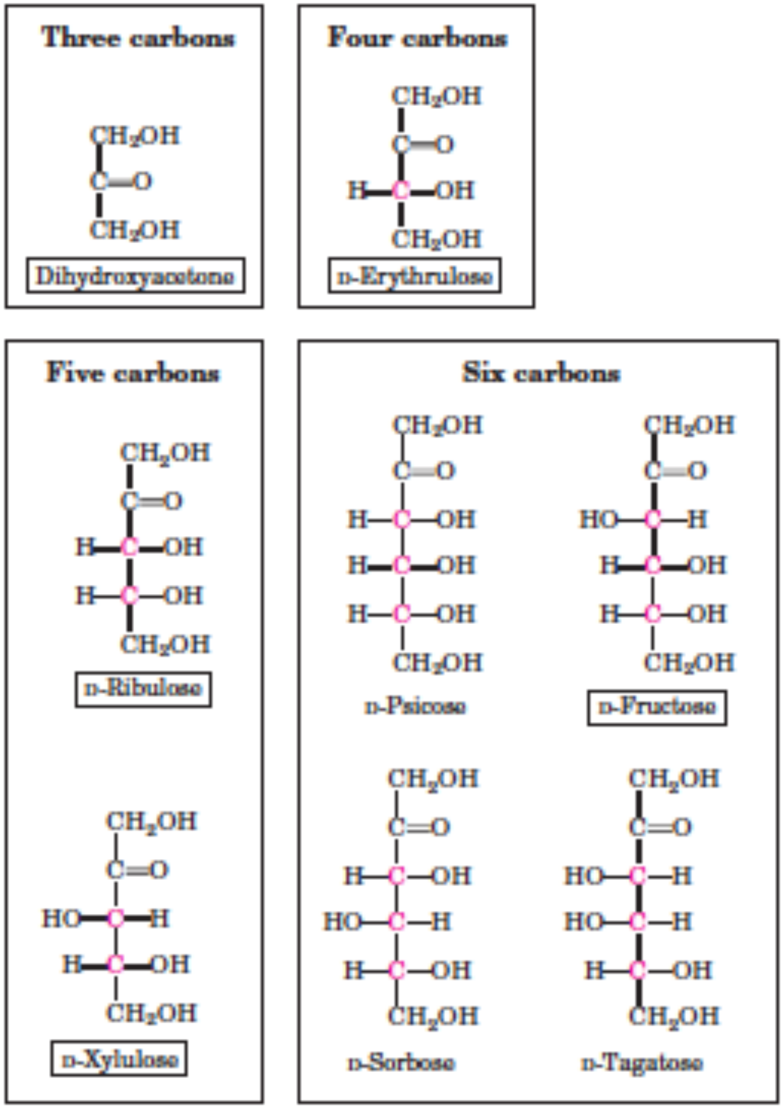
Monosaccharides Have Asymmetric Centers



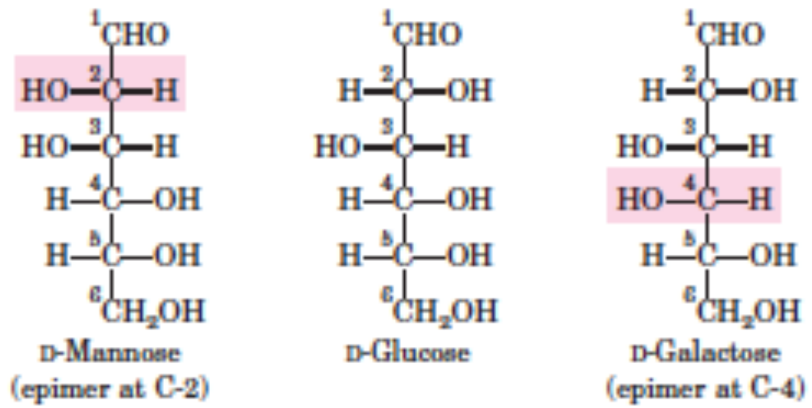
Aldoses


Three carbons
D-Glyceraldehyde
Four carbons
D-Erythrose
D-Threose
Five carbons
D-Ribose
D-Arabinose
D-Xylose
D-Lyxose
Six carbons
D-Allose
D-Altrose
D-Glucose
D-Mannose
D-Gulose
D-Idose
D-Galactose
D-Talose

Ketoses

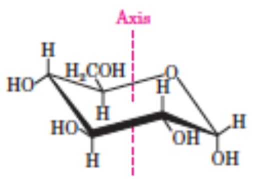


D-Ketoses
(b)

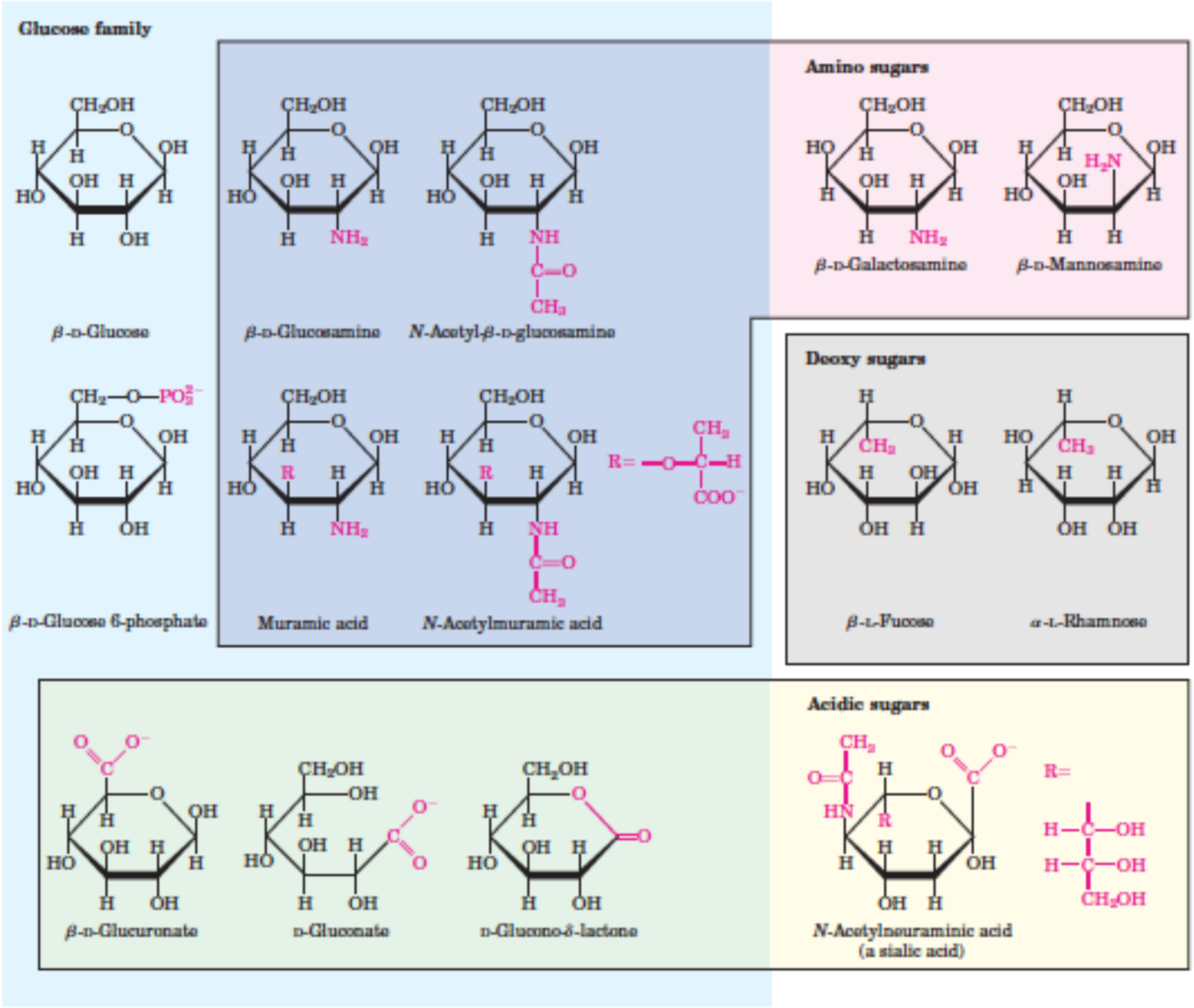


Organisms Contain a Variety of Hexose Derivatives

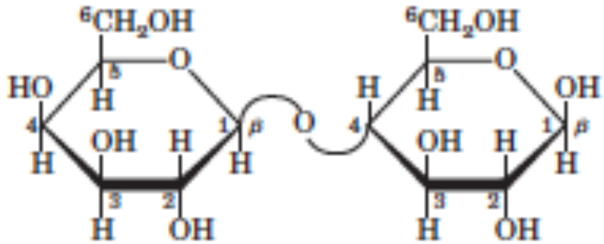
Two possible chair forms
(a)



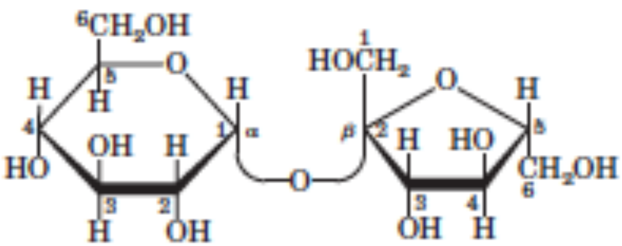
α-D-Glucopyranose
(b)



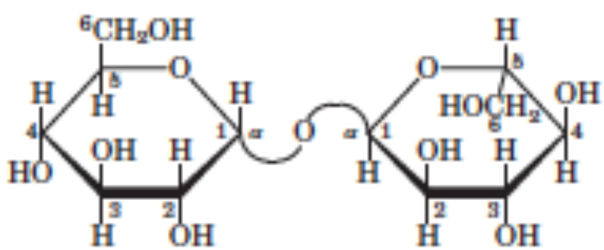
Disaccharides Contain a Glycosidic Bond



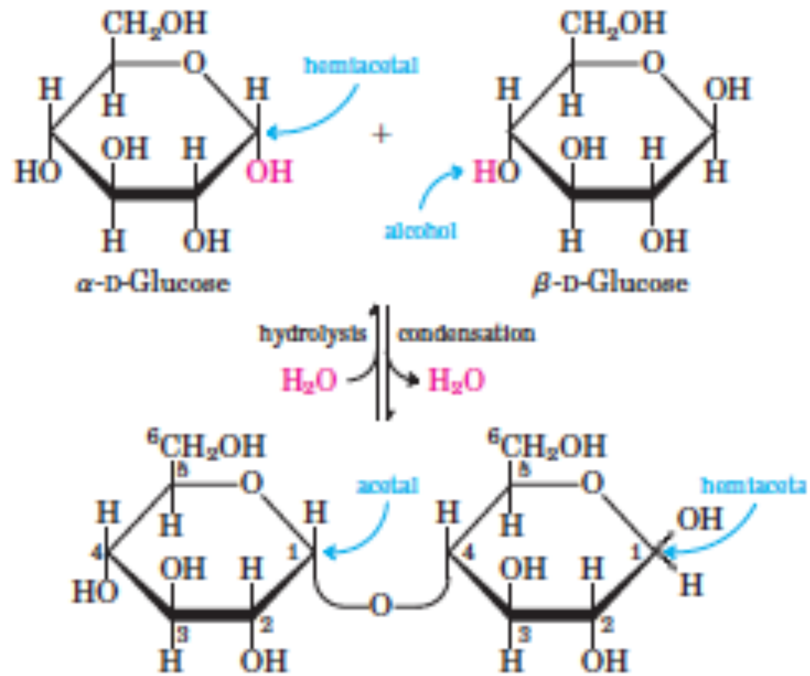
Lactose (β form)
β-D-galactopyranosyl-(1→4)-β-D-glucopyranose
Gal(β1→4)Glc



Sucrose
α-D-glucopyranosyl β-D-fructofuranoside
Glc(α1↔2β)Fru



Trehalose
α-D-glucopyranosyl α-D-glucopyranoside
Glc(α1↔1α)Glc



Maltose
α-D-glucopyranosyl-(1→4)-D-glucopyranose

■ Sugars (also called saccharides) are compounds containing an aldehyde or ketone group and two or more hydroxyl groups.

■ Monosaccharides generally contain several chiral carbons and therefore exist in a variety of stereochemical forms, which may be represented on paper as Fischer projections. Epimers are sugars that differ in configuration at only one carbon atom.

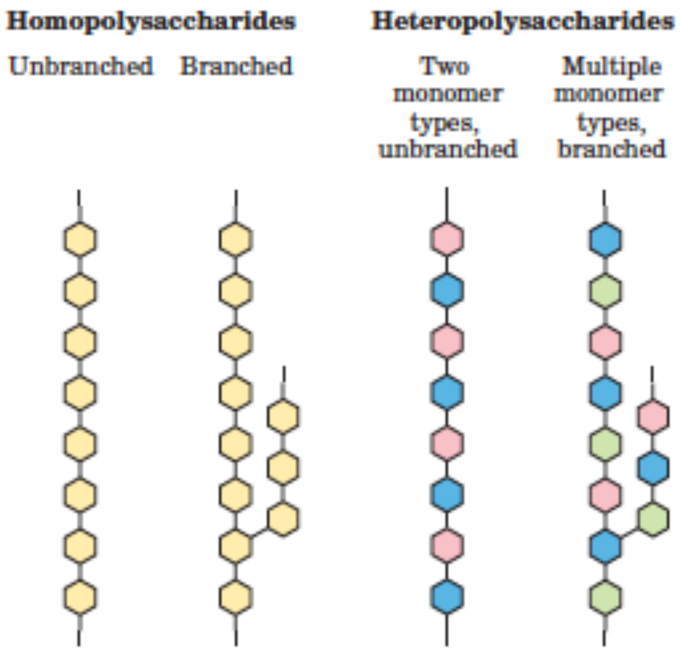
■ Monosaccharides commonly form internal hemiacetals or hemiketals, in which the aldehyde or ketone group joins with a hydroxyl group of the same molecule, creating a cyclic structure; this can be represented as a Haworth perspective formula. The carbon atom originally found in the aldehyde or ketone group (the anomeric carbon) can assume either of two configurations, and , which are interconvertible by mutarotation. In the linear form, which is in equilibrium with the cyclized forms, the anomeric carbon is easily oxidized.

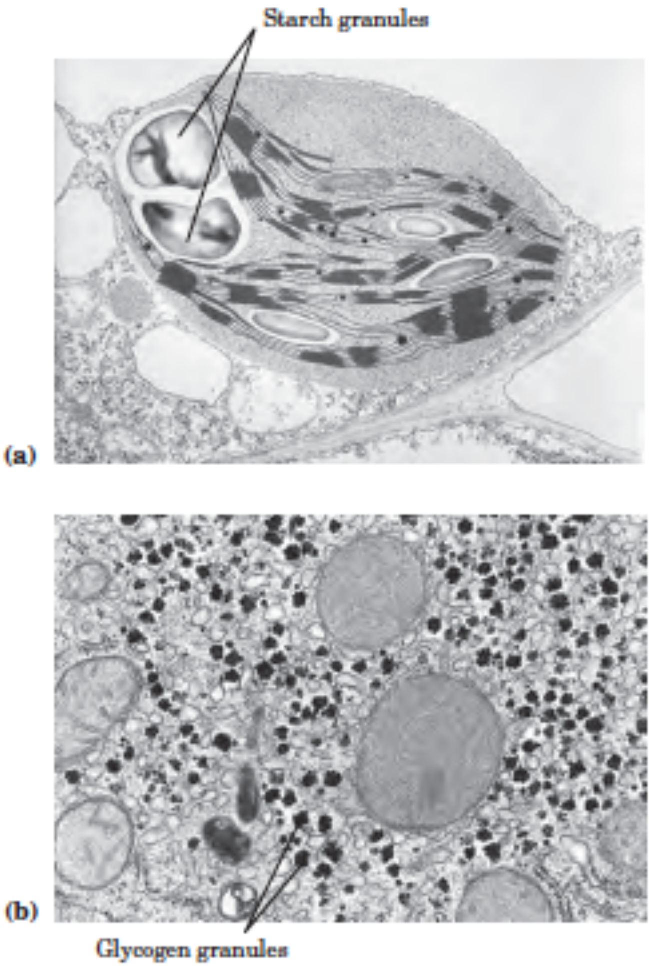
■ A hydroxyl group of one monosaccharide can add to the anomeric carbon of a second monosaccharide to form an acetal. In this disaccharide, the glycosidic bond protects the anomeric carbon from oxidation.

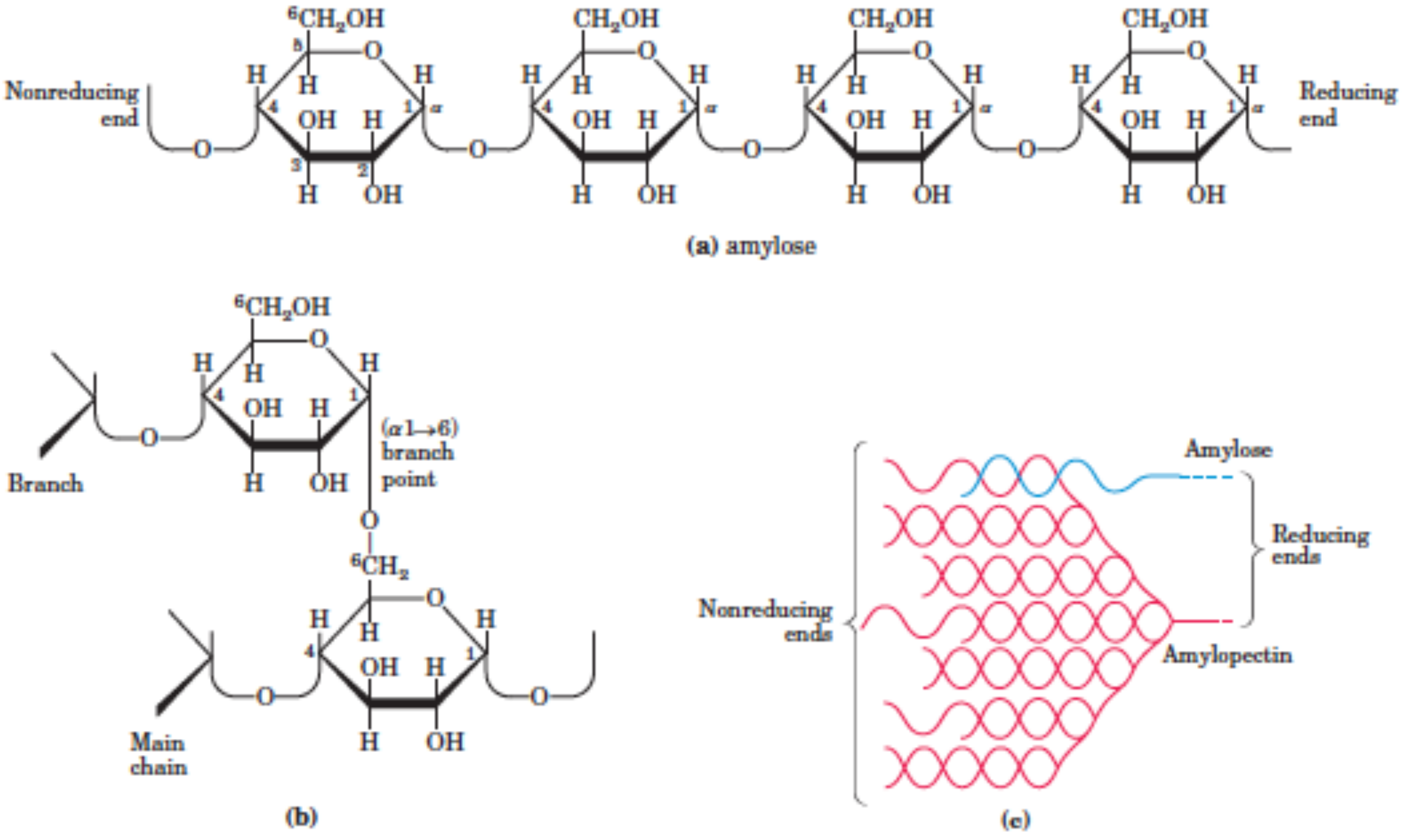
■ Oligosaccharides are short polymers of several monosaccharides joined by glycosidic bonds. At one end of the chain, the reducing end, is a monosaccharide unit whose anomeric carbon is not involved in a glycosidic bond.

■ The common nomenclature for di- or oligosaccharides specifies the order of monosaccharide units, the configuration at each anomeric carbon, and the carbon atoms involved in the glycosidic linkage(s).

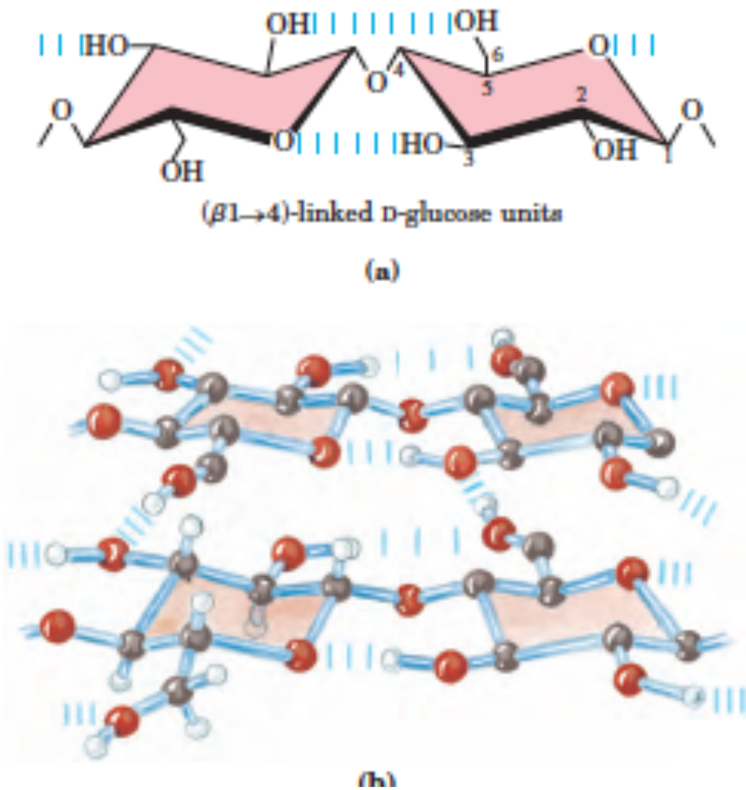
Polysaccharides





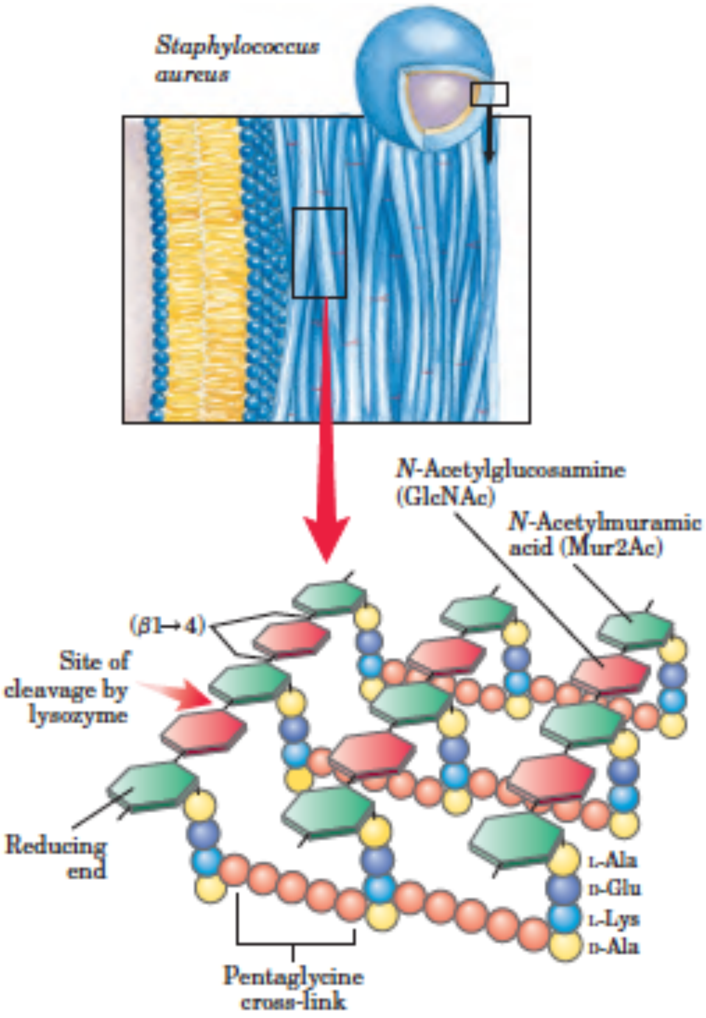


Amylose and amylopectin, the polysaccharides of starch



The structure of cellulose

Bacterial and Algal Cell Walls Contain Structural Heteropolysaccharides



Peptidoglycan of the cell wall of Staphylococcus aureus, a gram-positive bacterium. Peptides (strings of colored spheres) covalently link N-acetylmuramic acid residues in neighboring polysaccharide chains.

Glycosaminoglycans Are Heteropolysaccharides of the Extracellular Matrix

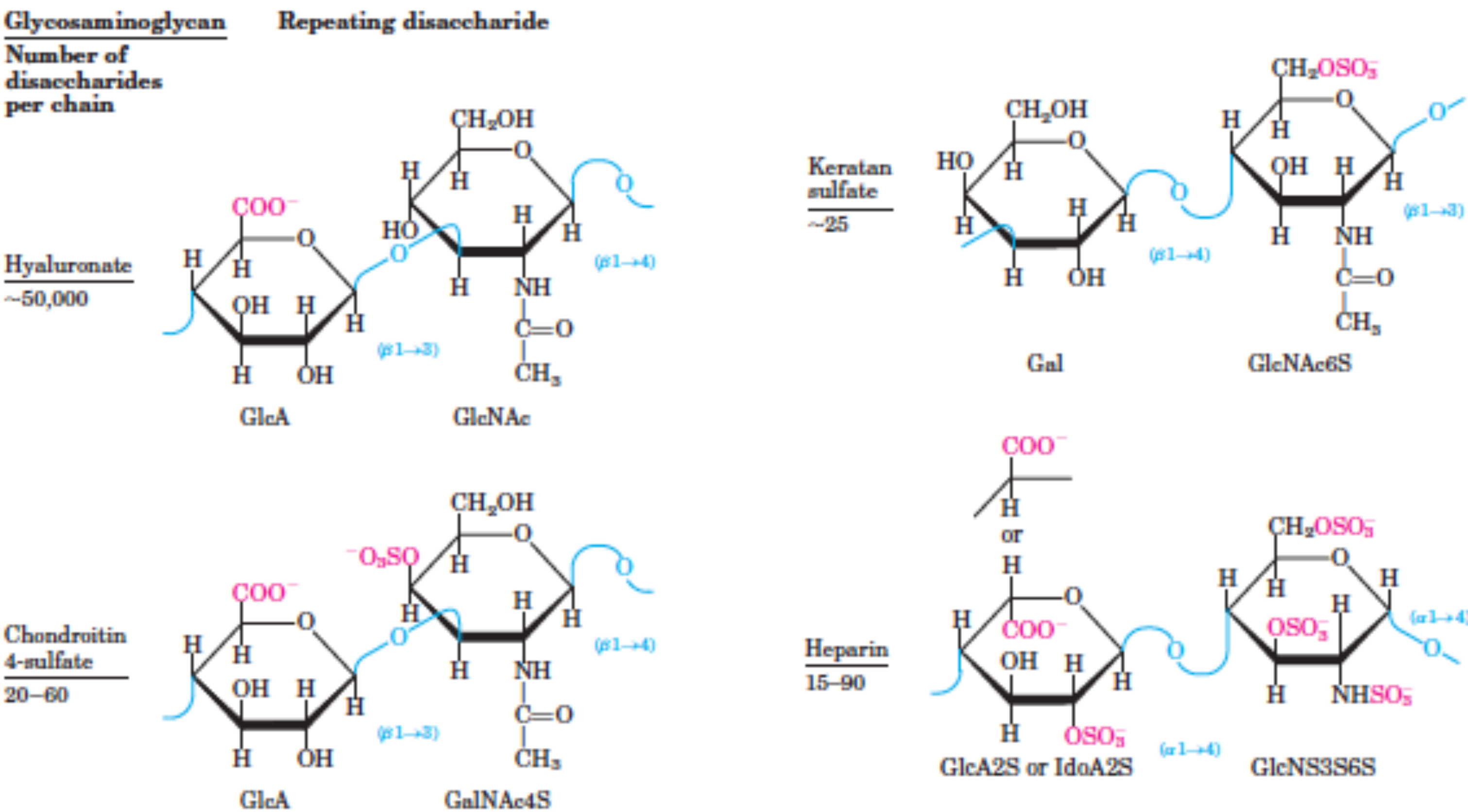
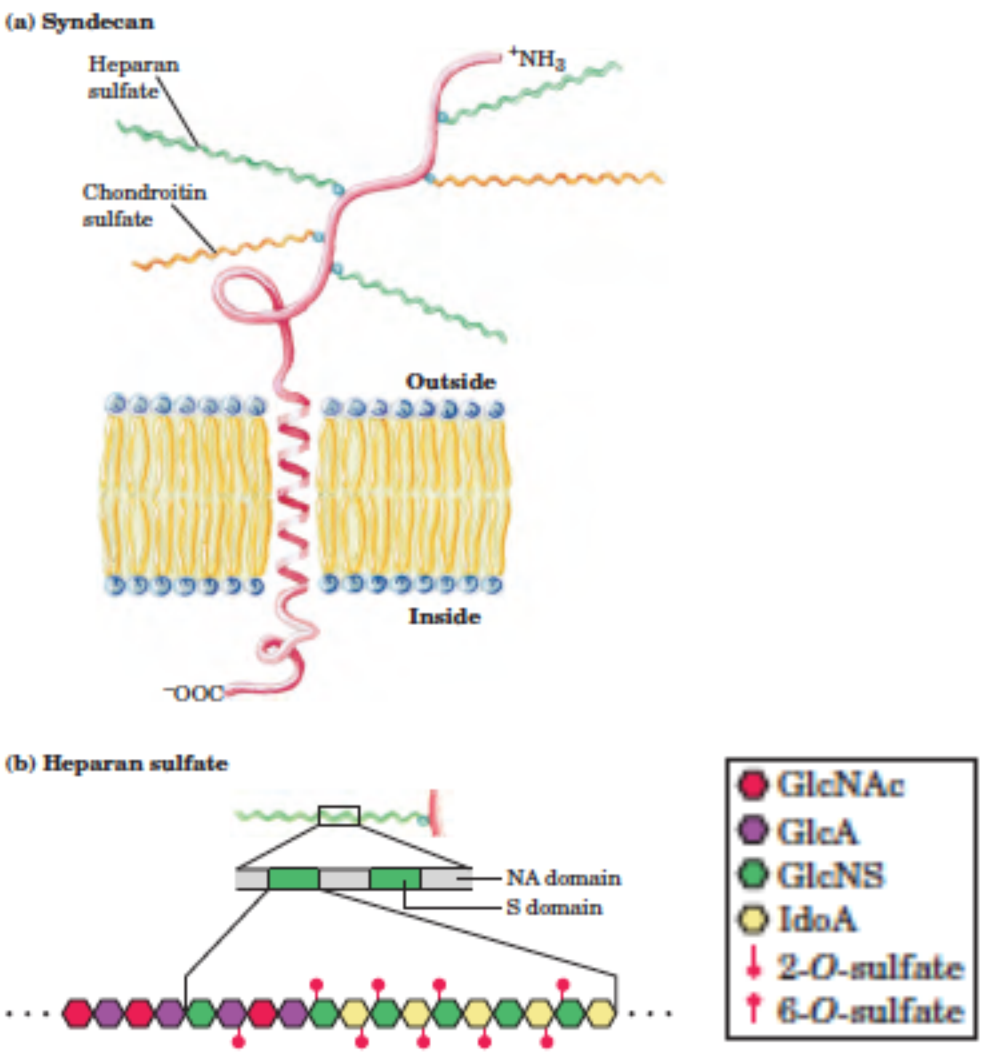


TABLE 7–2 Structures and Roles of Some Polysaccharides

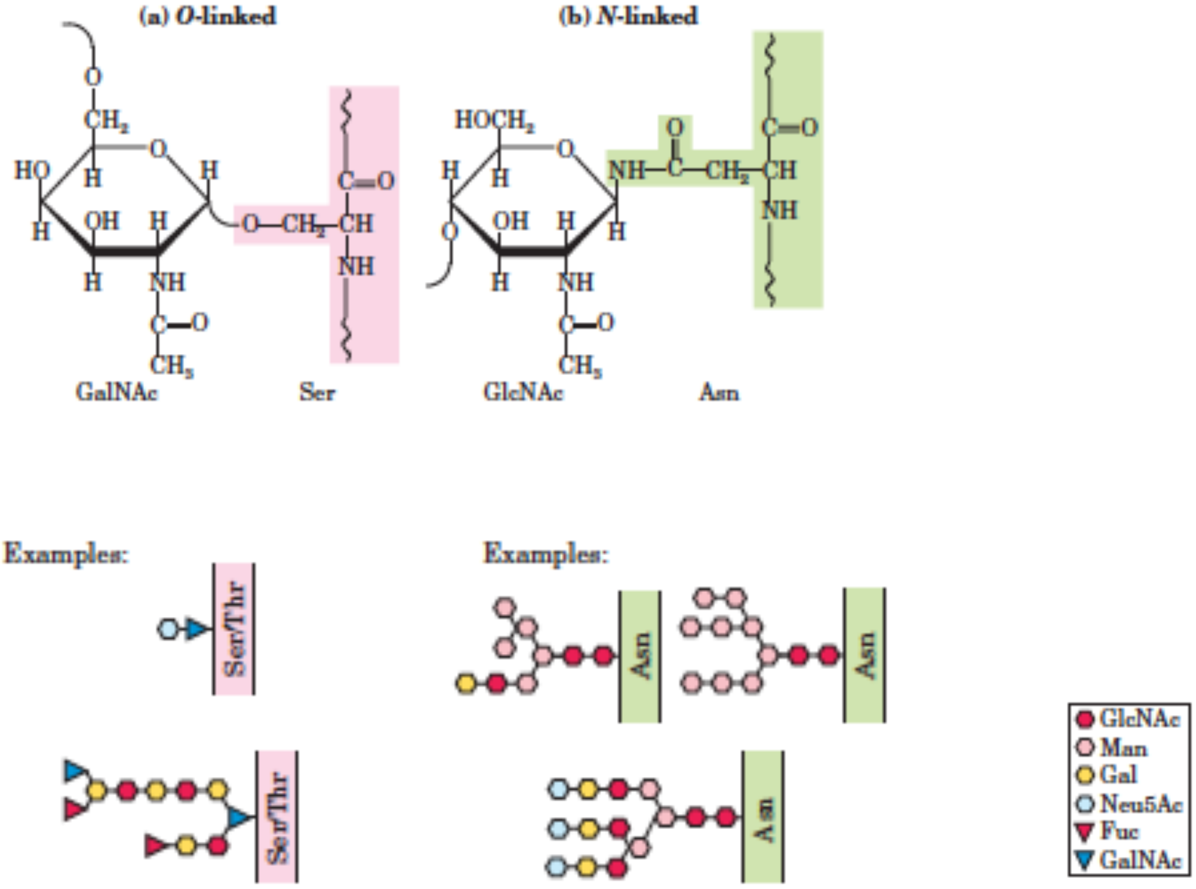
Polymer	*Type**	*Repeating unit*[†]	*Size (number of monosaccharide units)*	*Roles/significance*
Starch				Energy storage: in plants
Amylose	Homo-	(α1→4)Glc, linear	50–5,000	
Amylopectin	Homo-	(α1→4)Glc, with (α1→6)Glc branches every 24–30 residues	Up to 10^6	
Glycogen	Homo-	(α1→4)Glc, with (α1→6)Glc branches every 8–12 residues	Up to 50,000	Energy storage: in bacteria and animal cells
Cellulose	Homo-	(β1→4)Glc	Up to 15,000	Structural: in plants, gives rigidity and strength to cell walls
Chitin	Homo-	(β1→4)GlcNAc	Very large	Structural: in insects, spiders, crustaceans, gives rigidity and strength to exoskeletons
Dextran	Homo-	(α1→6)Glc, with (α1→3) branches	Wide range	Structural: in bacteria, extracellular adhesive
Peptidoglycan	Hetero-; peptides attached	4)Mur2Ac(β1→4) GlcNAc(β1	Very large	Structural: in bacteria, gives rigidity and strength to cell envelope
Agarose	Hetero-	3)D-Gal(β1→4)3,6-anhydro-L-Gal(α1	1,000	Structural: in algae, cell wall material
Hyaluronate (a glycosamino-glycan)	Hetero-; acidic	4)GlcA(β1→3) GlcNAc(β1	Up to 100,000	Structural: in vertebrates, extracellular matrix of skin and connective tissue; viscosity and lubrication in joints

Glycoconjugates: Proteoglycans, Glycoproteins, and Glycolipids

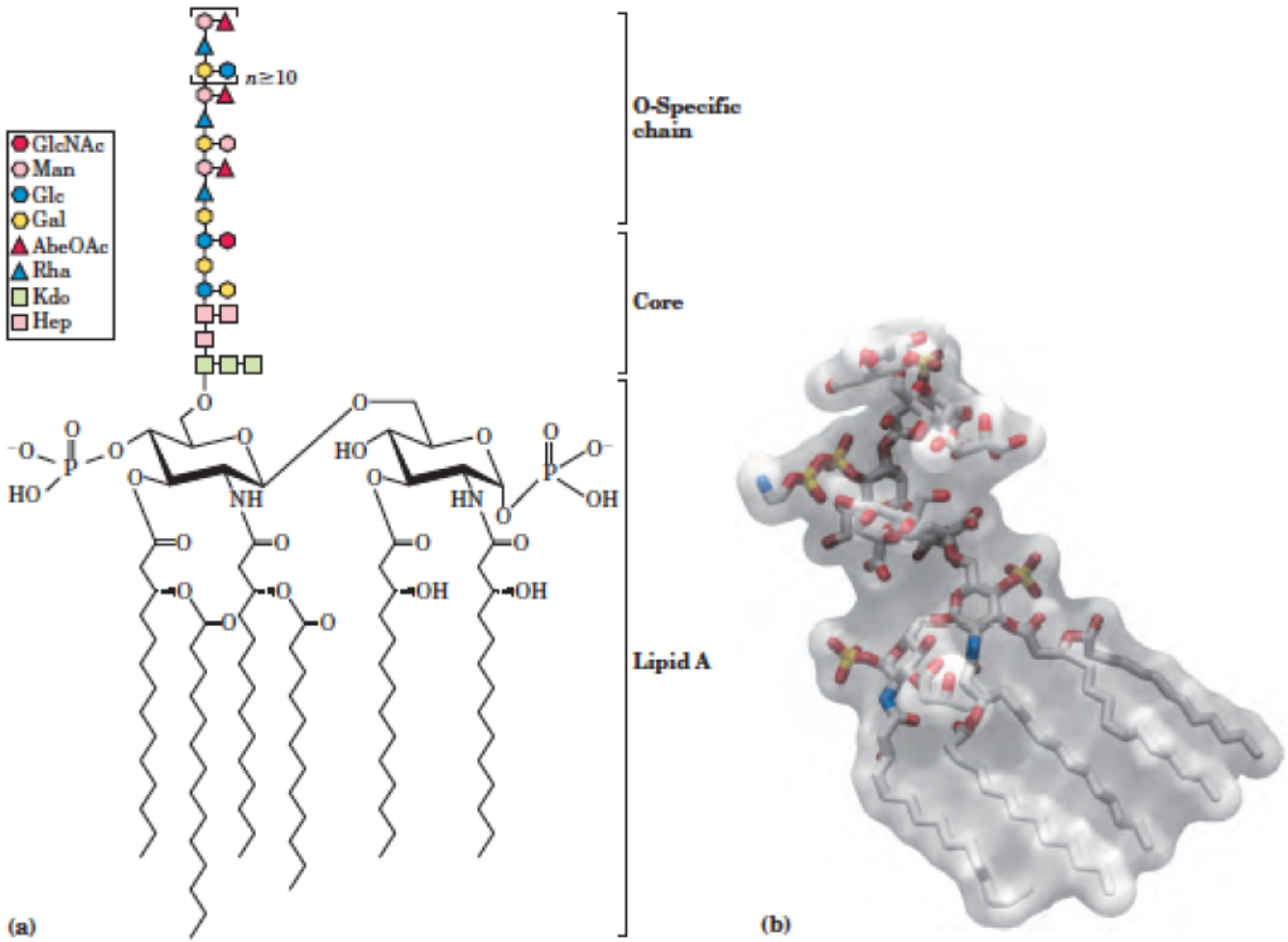


Proteoglycans Are Glycosaminoglycan-Containing Macromolecules of the Cell Surface and Extracellular Matrix

Oligosaccharide linkages in glycoproteins



Glycolipids and Lipopolysaccharides Are Membrane Components



Working with Carbohydrates

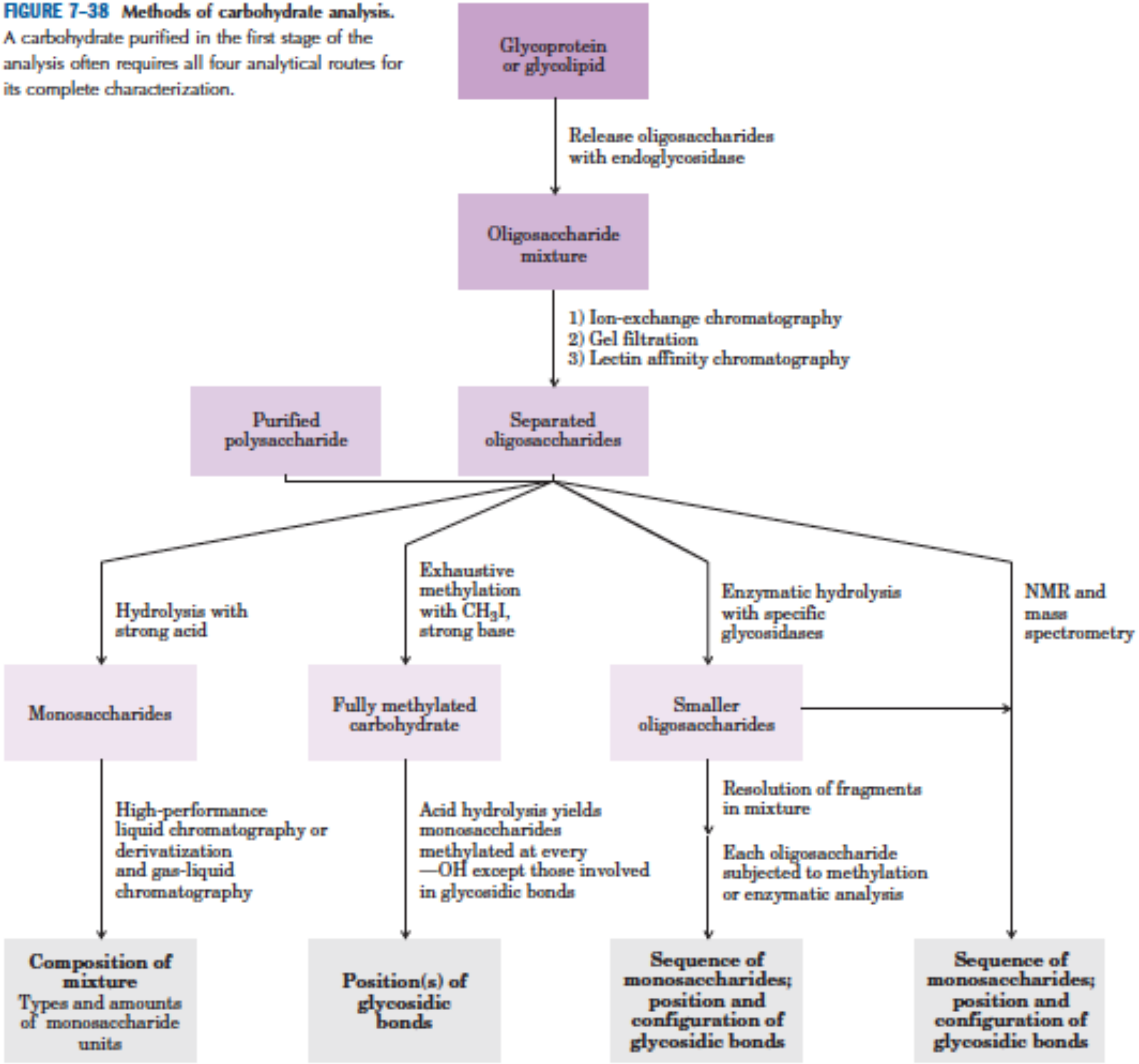


FIGURE 7–38 Methods of carbohydrate analysis. A carbohydrate purified in the first stage of the analysis often requires all four analytical routes for its complete characterization.

Lipid

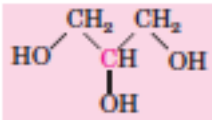
Storage Lipids

Fatty Acids Are Hydrocarbon Derivatives

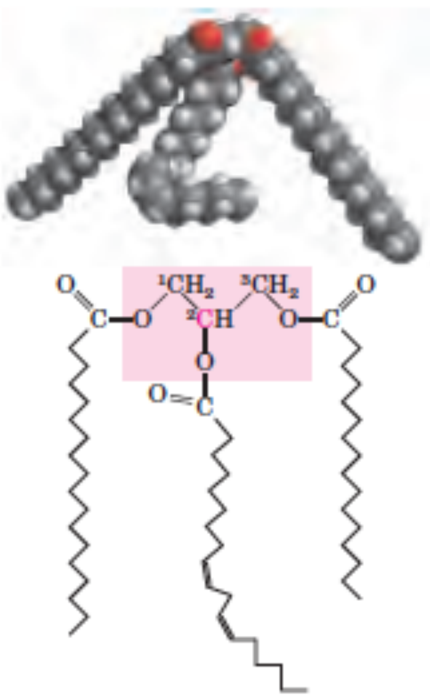
TABLE 10–1 Some Naturally Occurring Fatty Acids: Structure, Properties, and Nomenclature

Carbon skeleton	Structure*	Systematic name†	Common name (derivation)	Melting point (°C)	Solubility at 30 °C (mg/g solvent)	
					Water	Benzene
12:0	$CH_3(CH_2)_{10}COOH$	*n*-Dodecanoic acid	Lauric acid (Latin *laurus*, "laurel plant")	44.2	0.063	2,600
14:0	$CH_3(CH_2)_{12}COOH$	*n*-Tetradecanoic acid	Myristic acid (Latin *Myristica*, nutmeg genus)	53.9	0.024	874
16:0	$CH_3(CH_2)_{14}COOH$	*n*-Hexadecanoic acid	Palmitic acid (Latin *palma*, "palm tree")	63.1	0.0083	348
18:0	$CH_3(CH_2)_{16}COOH$	*n*-Octadecanoic acid	Stearic acid (Greek *stear*, "hard fat")	69.6	0.0034	124
20:0	$CH_3(CH_2)_{18}COOH$	*n*-Eicosanoic acid	Arachidic acid (Latin *Arachis*, legume genus)	76.5		
24:0	$CH_3(CH_2)_{22}COOH$	*n*-Tetracosanoic acid	Lignoceric acid (Latin *lignum*, "wood" + *cera*, "wax")	86.0		
16:1(Δ^9)	$CH_3(CH_2)_5CH{=}CH(CH_2)_7COOH$	*cis*-9-Hexadecenoic acid	Palmitoleic acid	1–0.5		
18:1(Δ^9)	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$	*cis*-9-Octadecenoic acid	Oleic acid (Latin *oleum*, "oil")	13.4		
18:2($\Delta^{9,12}$)	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	*cis*-,*cis*-9,12-Octadecadienoic acid	Linoleic acid (Greek *linon*, "flax")	1–5		
18:3($\Delta^{9,12,15}$)	$CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	*cis*-,*cis*-,*cis*-9,12,15-Octadecatrienoic acid	α-Linolenic acid	−11		
20:4($\Delta^{5,8,11,14}$)	$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_3COOH$	*cis*-,*cis*-,*cis*-,*cis*-5,8,11,14-Icosatetraenoic acid	Arachidonic acid	−49.5		

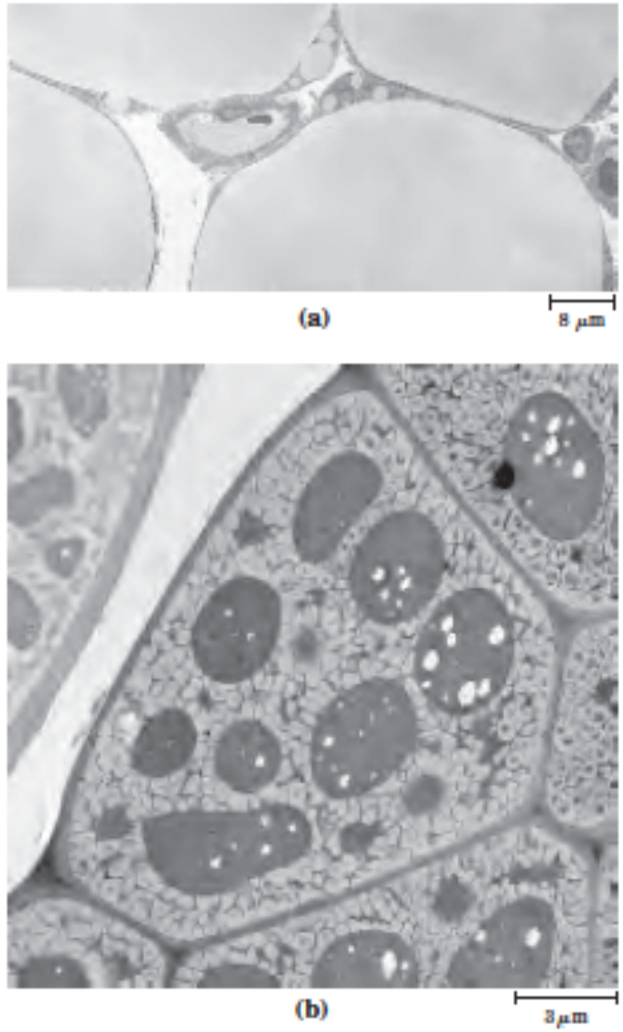
Triacylglycerols Provide Stored Energy and Insulation

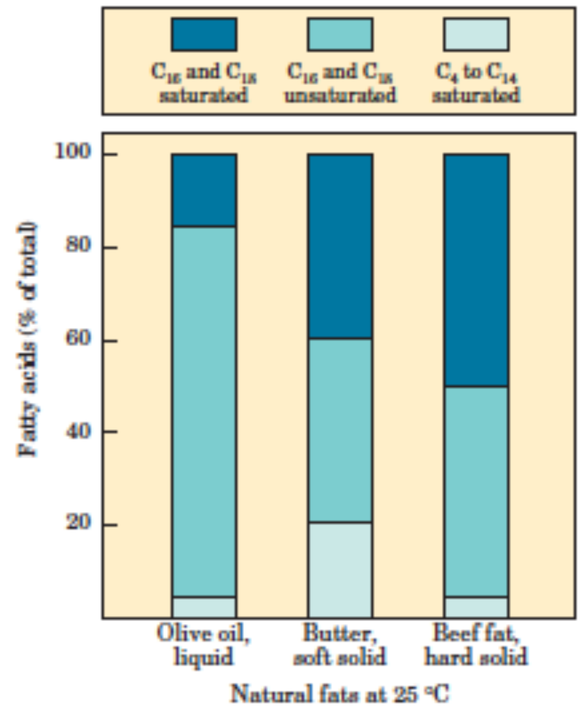


Glycerol

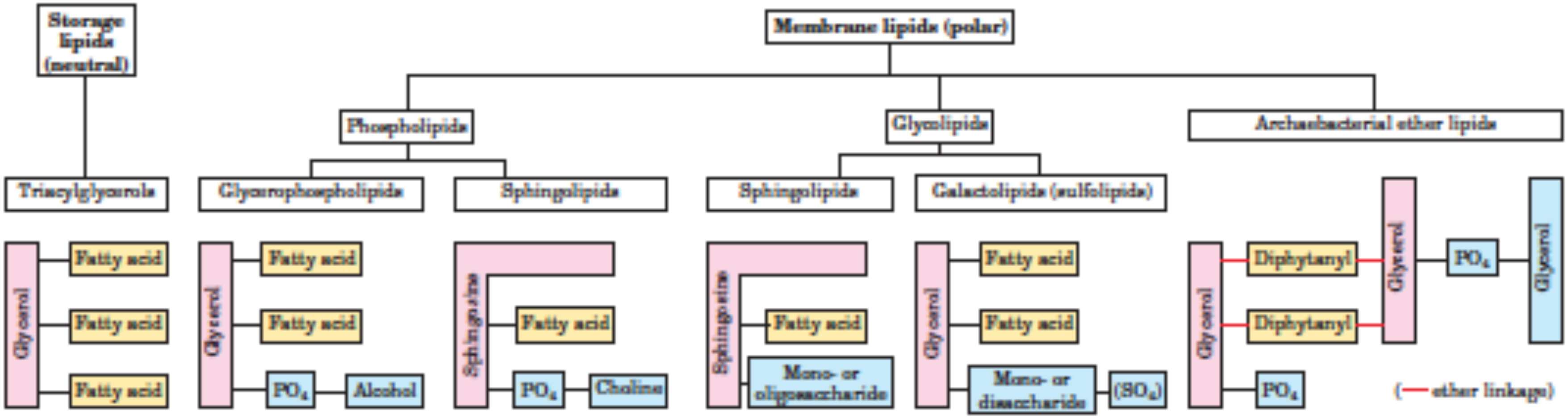


1-Stearoyl, 2-linoleoyl, 3-palmitoyl glycerol, a mixed triacylglycerol

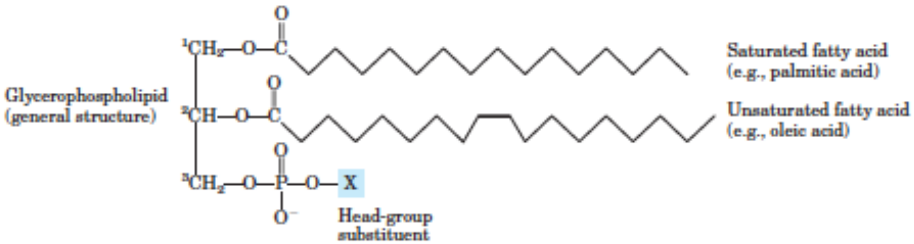


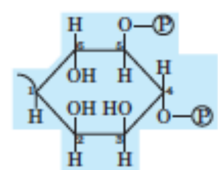
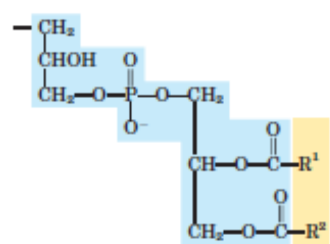


Structural Lipids in Membranes

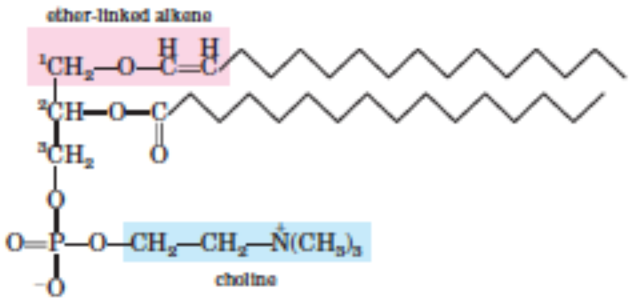


Glycerophospholipids Are Derivatives of Phosphatidic Acid

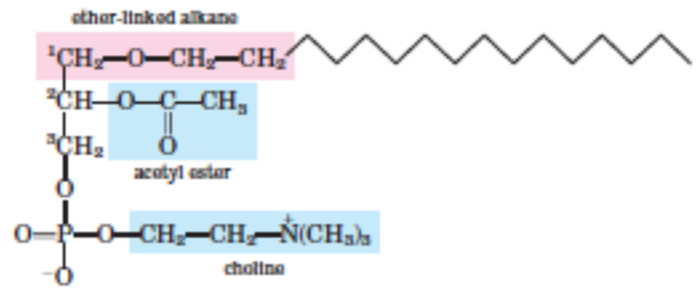


Name of glycerophospholipid	Name of X	Formula of X	Net charge (at pH 7)
Phosphatidic acid	—	$-H$	−1
Phosphatidylethanolamine	Ethanolamine	$-CH_2-CH_2-\overset{+}{N}H_3$	0
Phosphatidylcholine	Choline	$-CH_2-CH_2-\overset{+}{N}(CH_3)_3$	0
Phosphatidylserine	Serine	$-CH_2-CH(COO^-)-\overset{+}{N}H_3$	−1
Phosphatidylglycerol	Glycerol	$-CH_2-CH(OH)-CH_2-OH$	−1
Phosphatidylinositol 4,5-bisphosphate	*myo*-Inositol 4,5-bisphosphate		−4
Cardiolipin	Phosphatidyl-glycerol		−2

Some Phospholipids Have Ether-Linked Fatty Acids

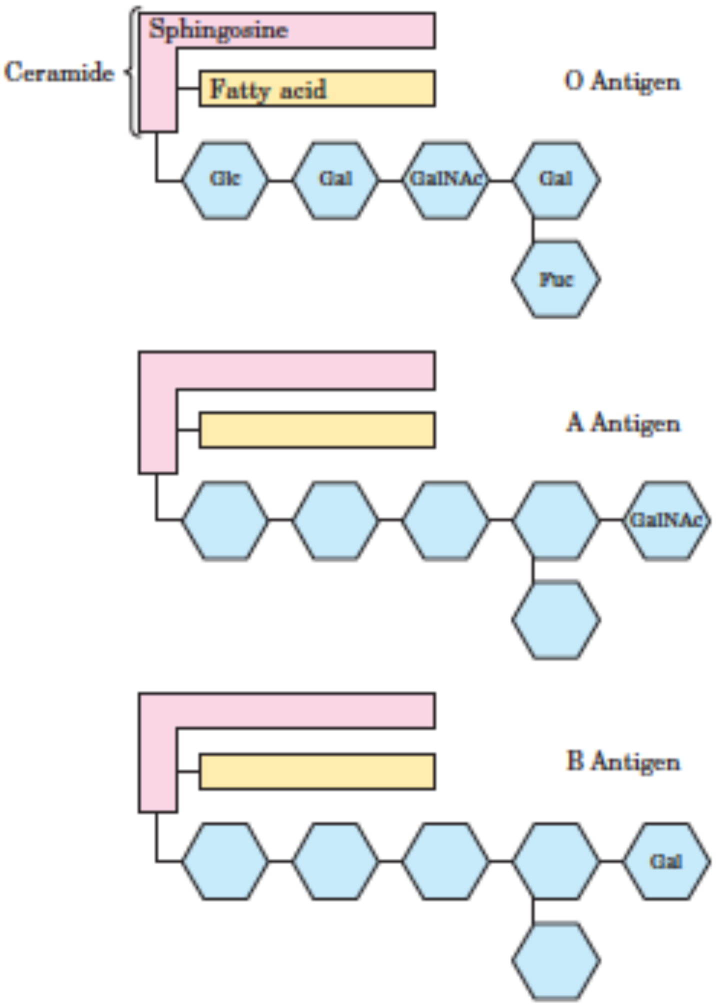


Plasmalogen

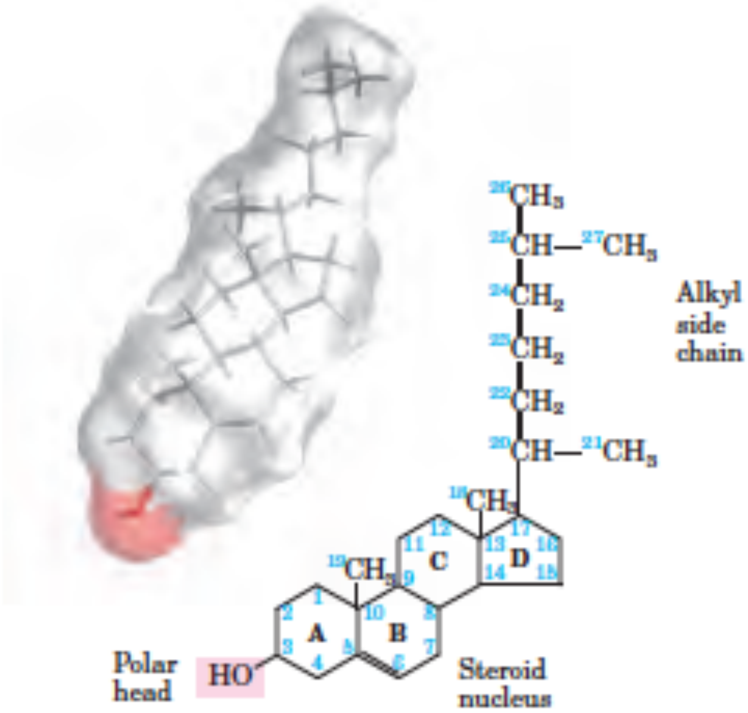


Platelet-activating factor

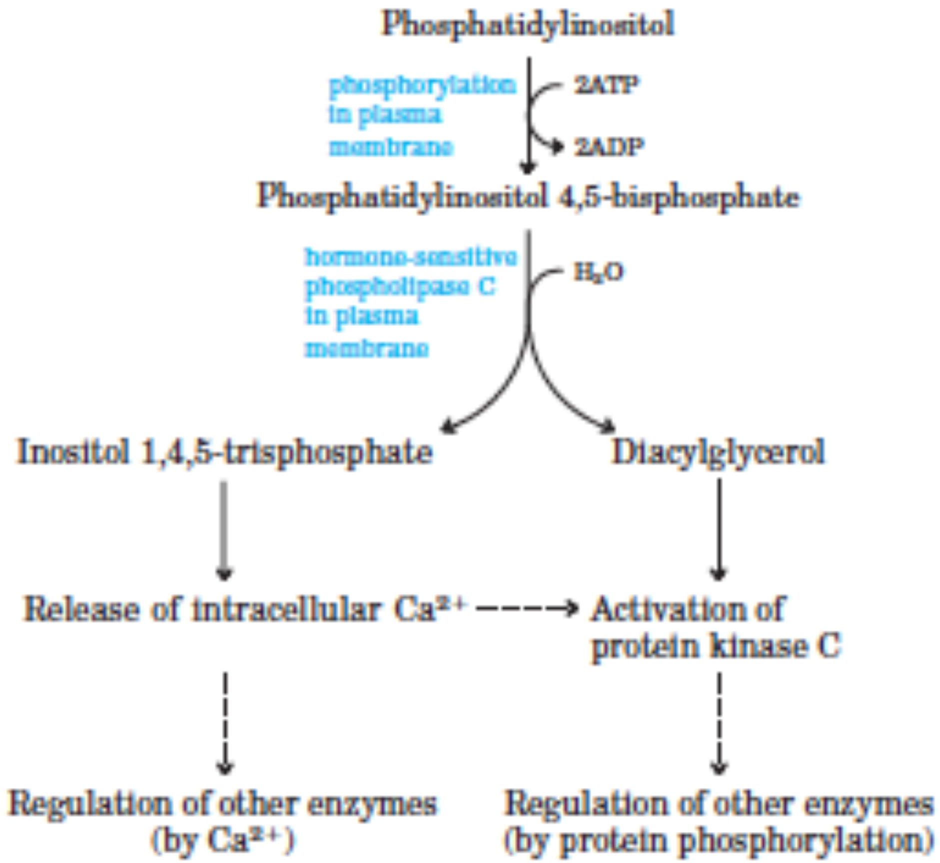
Sphingolipids at Cell Surfaces Are Sites ofBiological Recognition



Sterols Have Four Fused Carbon Rings

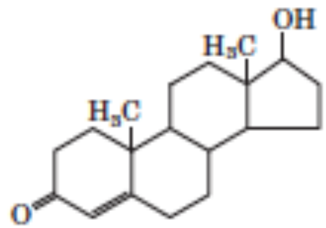


Lipids as Signals, Cofactors, and Pigments

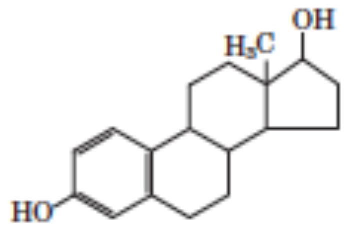


Phosphatidylinositols and Sphingosine Derivatives Act as Intracellular Signals

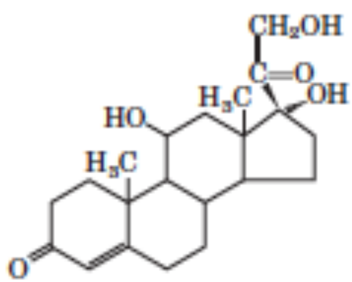
Steroid Hormones Carry Messages between Tissues



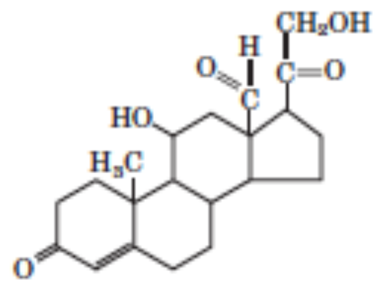
Testosterone



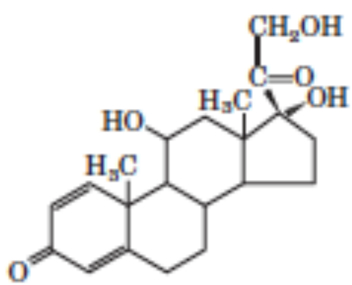
Estradiol



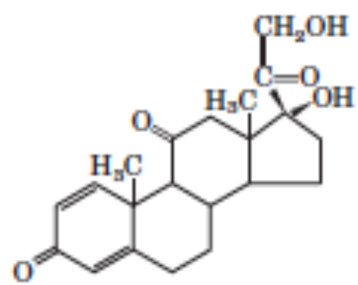
Cortisol



Aldosterone



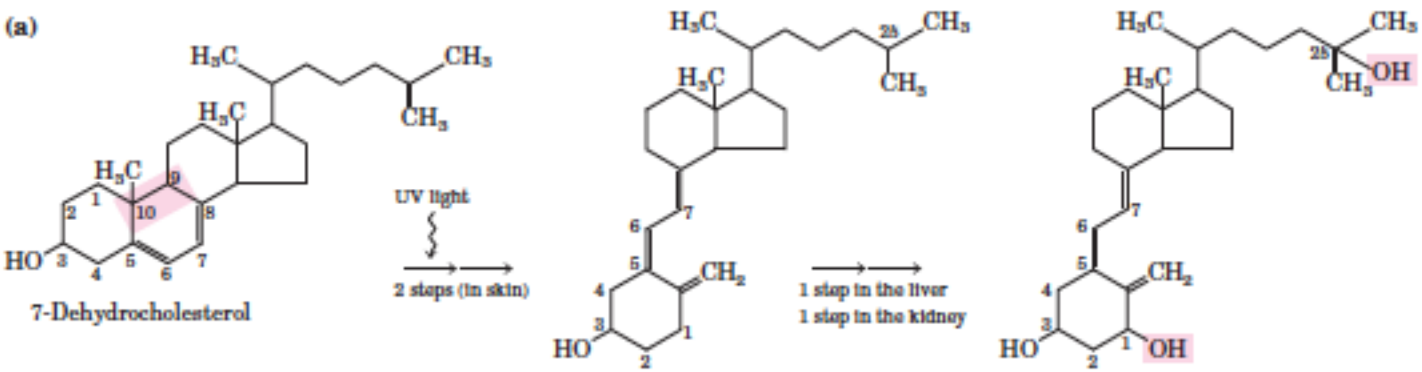
Prednisolone



Prednisone

Vitamins A and D Are Hormone Precursors

(a)



7-Dehydrocholesterol

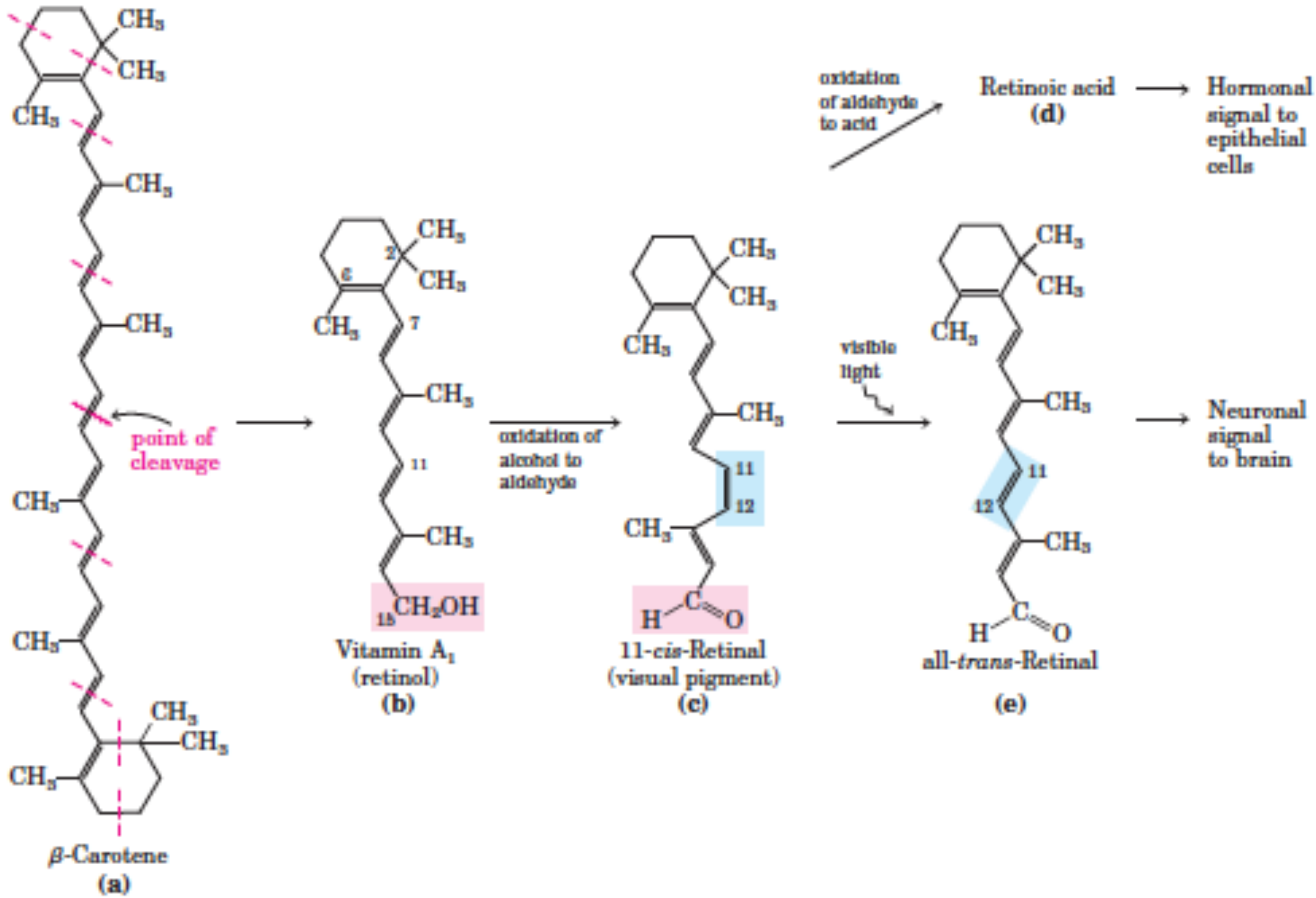
Cholecalciferol (vitamin D_3)

1,25-Dihydroxycholecalciferol
(1,25-dihydroxyvitamin D_3)

Before vitamin D treatment

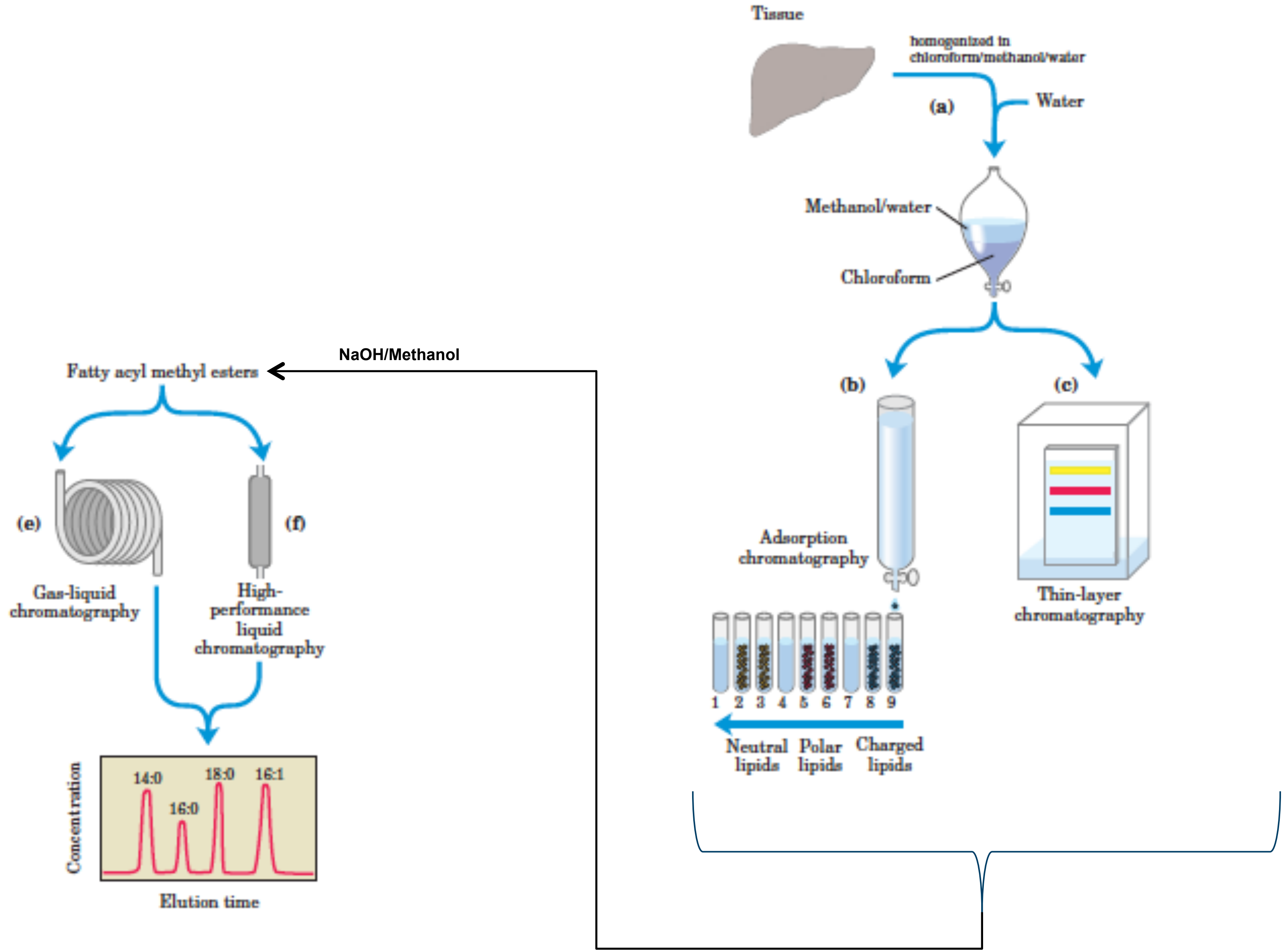
After 14 months of vitamin D treatment

(b)



CH3
CH3
CH3
CH3
CH3
point of cleavage
CH3
CH3
CH3
CH3
CH3
β-Carotene
(a)
CH3
2
CH3
6
CH3
7
CH3
11
CH3
15 CH2OH
Vitamin A1
(retinol)
(b)
oxidation of alcohol to aldehyde
CH3
CH3
CH3
CH3
11
12
CH3
H
C
O
11-cis-Retinal
(visual pigment)
(c)
oxidation of aldehyde to acid
Retinoic acid
(d)
Hormonal signal to epithelial cells
visible light
CH3
CH3
CH3
CH3
11
12
CH3
H
C
O
all-trans-Retinal
(e)
Neuronal signal to brain

Working with Lipids



Wish you acedemic success!