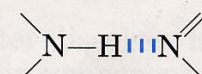
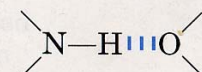
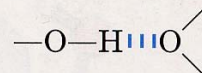


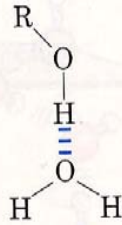
Table 4–1 Melting point, boiling point, and heat of vaporization of some common liquids

	Melting point (°C)	Boiling point (°C)	Heat of vaporization (J/g)*
Water	0	100	2,260
Methanol (CH ₃ OH)	−98	65	1,100
Ethanol (CH ₃ CH ₂ OH)	−117	78	854
Propanol (CH ₃ CH ₂ CH ₂ OH)	−127	97	687
Butanol (CH ₃ (CH ₂) ₂ CH ₂ OH)	−90	117	590
Acetone (CH ₃ COCH ₃)	−95	56	523
Hexane (CH ₃ (CH ₂) ₄ CH ₃)	−98	69	423
Benzene (C ₆ H ₆)	6	80	394
Butane (CH ₃ (CH ₂) ₂ CH ₃)	−135	−0.5	381
Chloroform (CHCl ₃)	−63	61	247

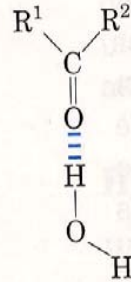
Hydrogen donor Hydrogen acceptor



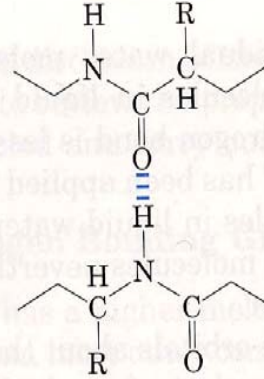
Between the hydroxyl group of an alcohol and water



Between the carbonyl group of a ketone and water



Between two polypeptide chains



Between two complementary bases of two strands of DNA

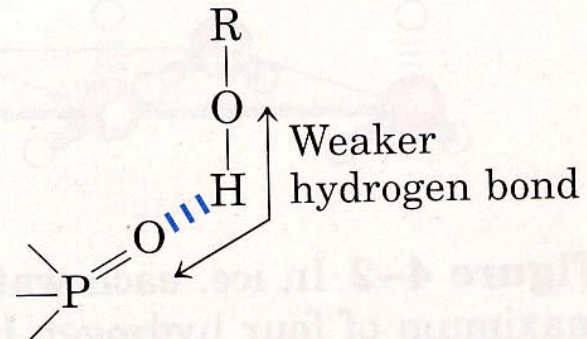
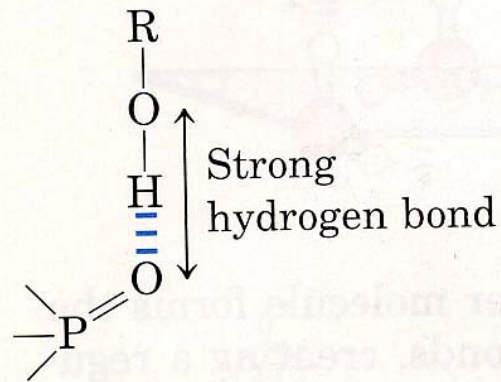
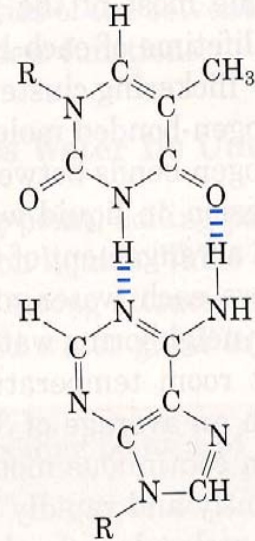
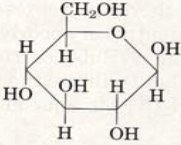
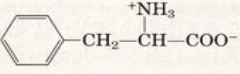
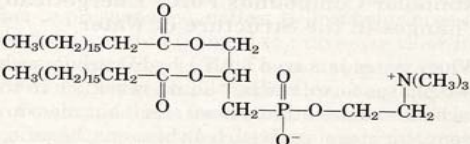


Table 4-2 Some examples of polar, nonpolar, and amphipathic biomolecules

Biomolecule	Ionic form at pH 7
<i>Polar</i>	
Glucose	
Glycine	$^+\text{NH}_3\text{—CH}_2\text{—COO}^-$
Aspartic acid	$^+\text{NH}_3$ $^-\text{OOC—CH}_2\text{—CH—COO}^-$
Lactic acid	$\text{CH}_3\text{—CH—COO}^-$ OH
Glycerol	OH $\text{HOCH}_2\text{—CH—CH}_2\text{OH}$
<i>Nonpolar</i>	
Typical wax	$\text{CH}_3(\text{CH}_2)_7\text{—CH=CH—}(\text{CH}_2)_6\text{—CH}_2\text{—C(=O)—O—CH}_2$ $\text{CH}_3\text{—}(\text{CH}_2)_7\text{—CH=CH—}(\text{CH}_2)_7\text{—CH}_2$
<i>Amphipathic</i>	
Phenylalanine	
Phosphatidylcholine	

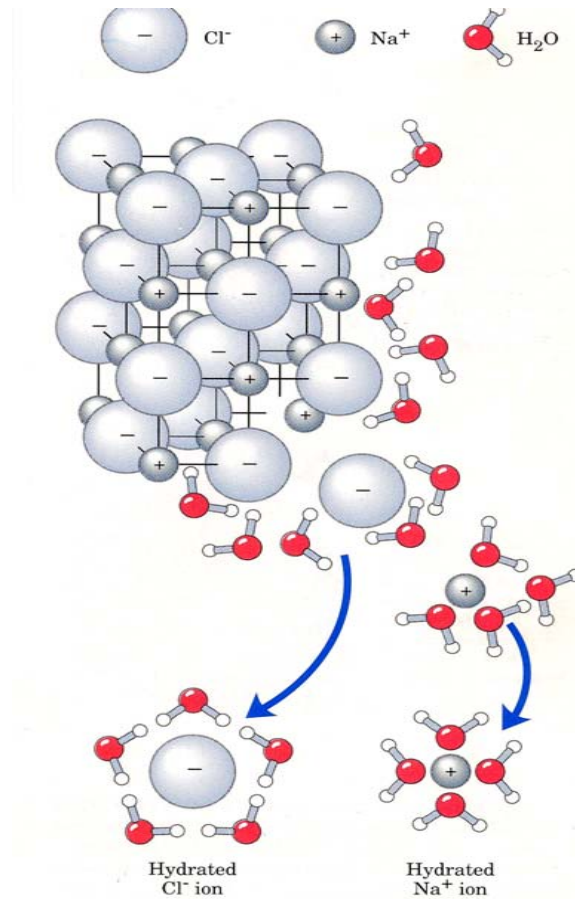


Table 4-3 Solubilities of some gases in water

Gas	Structure*	Polarity	Solubility in water (g/L)	Temperat (°C)
Nitrogen	$\text{N}\equiv\text{N}$	Nonpolar	0.018	40
Oxygen	$\text{O}=\text{O}$	Nonpolar	0.035	50
Carbon dioxide	$\overset{\delta^-}{\text{O}}=\text{C}=\overset{\delta^-}{\text{O}}$	Nonpolar	0.97	45
Ammonia	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \diagdown \quad \quad / \\ \text{N} \end{array} \downarrow \delta^-$	Polar	900	10
Hydrogen sulfide	$\begin{array}{c} \text{H} \quad \text{H} \\ \diagdown \quad / \\ \text{S} \end{array} \downarrow \delta^-$	Polar	1,860	40

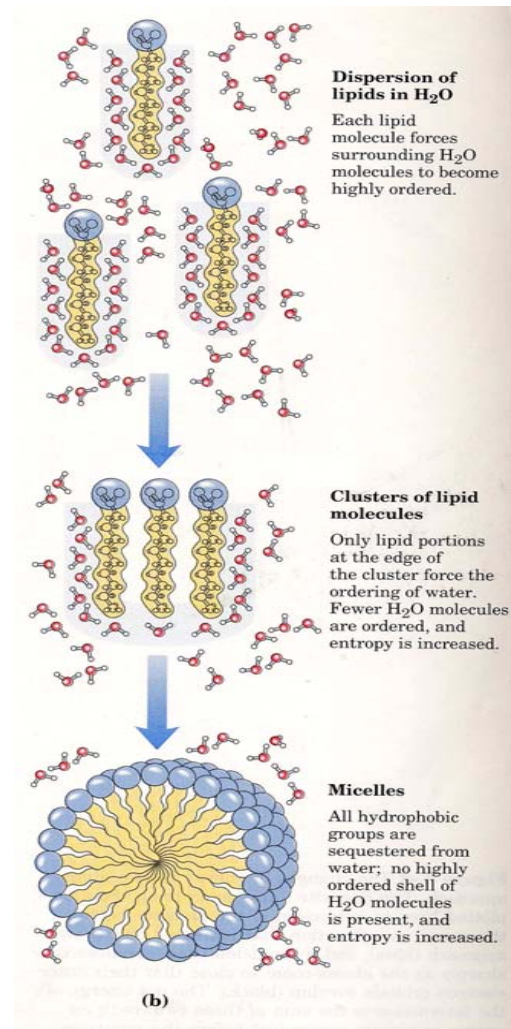
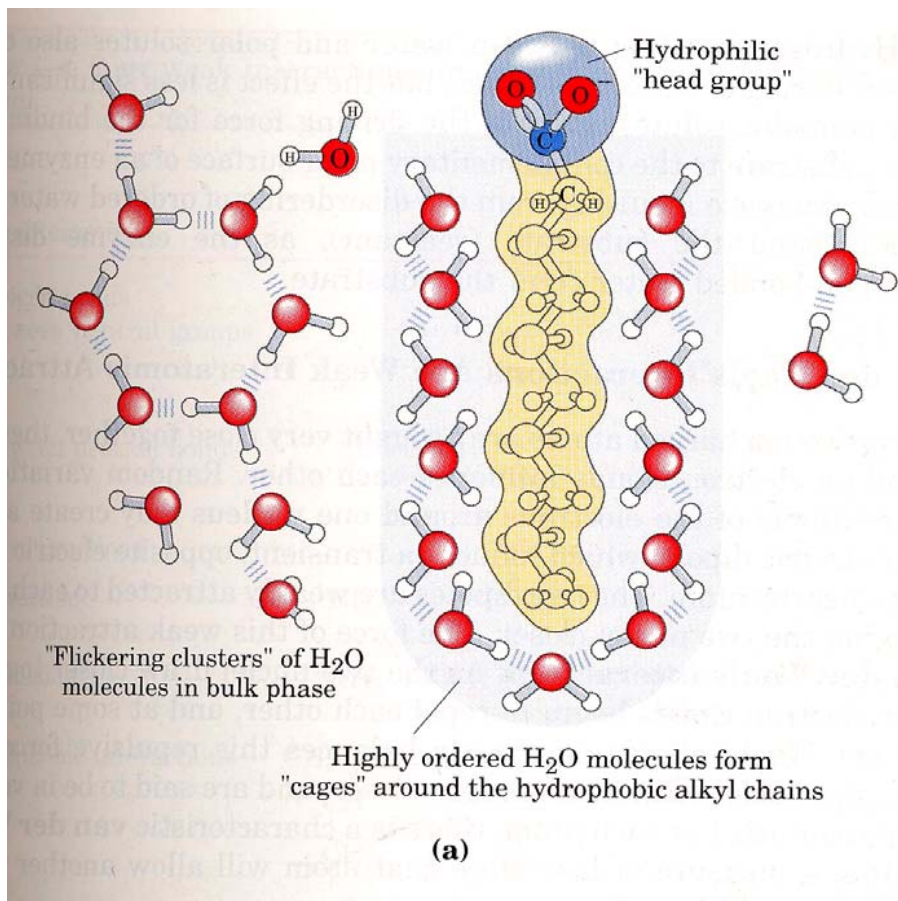


Table 4-4 Four weak interactions among biomolecules in aqueous solvent

Weak interaction		Stabilization energy (kJ/mol)
Hydrogen bonds	Between neutral groups $\diagup \text{C}=\text{O} \cdots \text{H}-\text{O}-$	8-21
	Between peptide bonds $\diagup \text{C}=\text{O} \cdots \text{H}-\text{N} \diagdown$	8-21
Ionic interactions	Attraction $-\text{NH}_3^+ \rightarrow \leftarrow \text{O}-\overset{\text{O}}{\parallel}{\text{C}}-$	42
	Repulsion $-\text{NH}_3^+ \longleftrightarrow \text{H}_3\text{N}^+-$	≈ -21
Hydrophobic interactions	$ \begin{array}{cc} \text{CH}_3 & \text{CH}_3 \\ & \diagdown \quad \diagup \\ & \text{CH} \\ & \\ & \text{CH}_2 \end{array} \quad \begin{array}{cc} \text{CH}_3 & \text{CH}_3 \\ & \diagdown \quad \diagup \\ & \text{CH} \\ & \\ & \text{CH}_2 \end{array} $	4-8
van der Waals interactions	Any two atoms in close proximity	4

Table 4-5 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

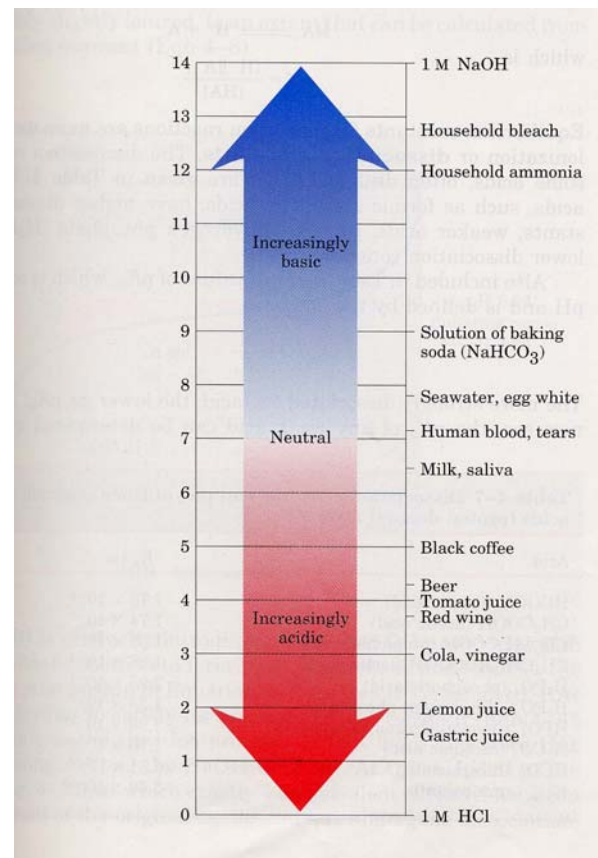
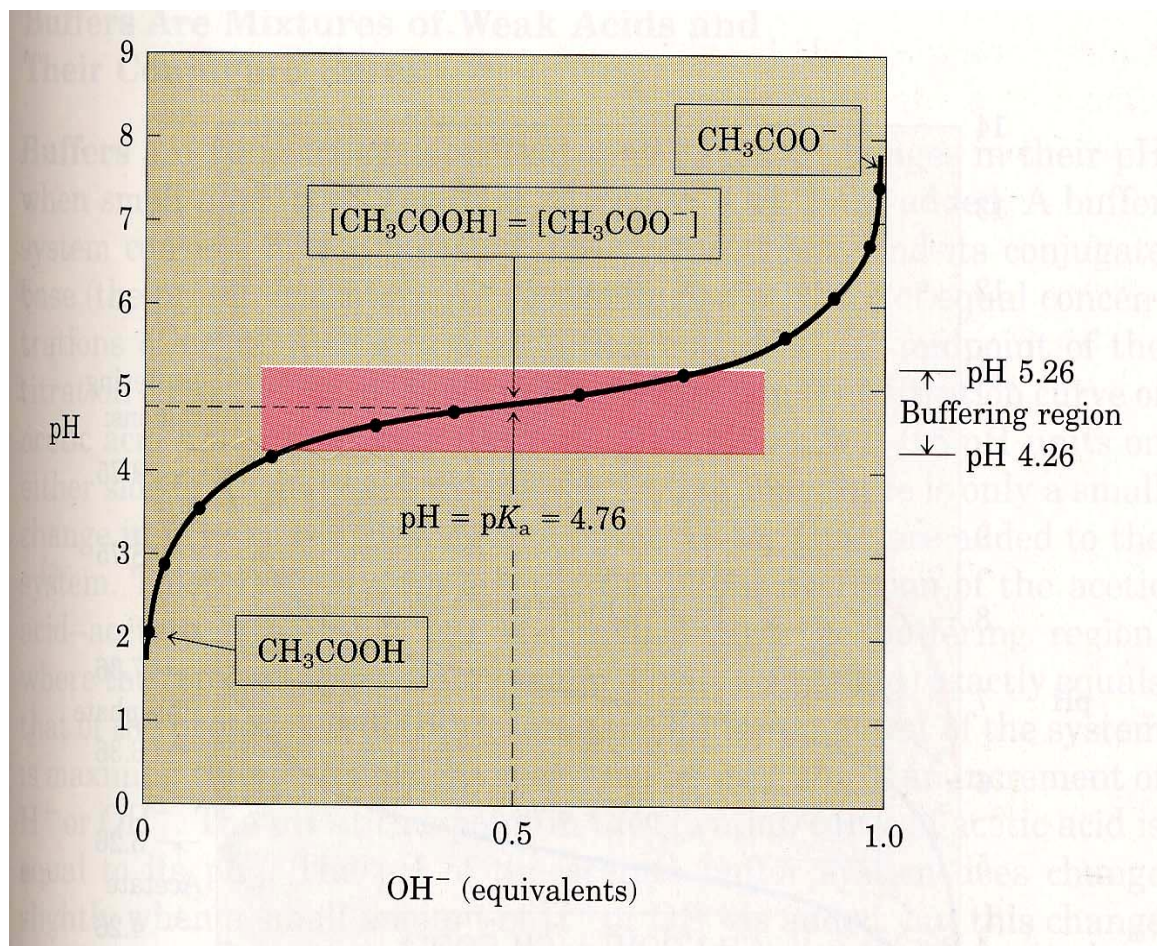


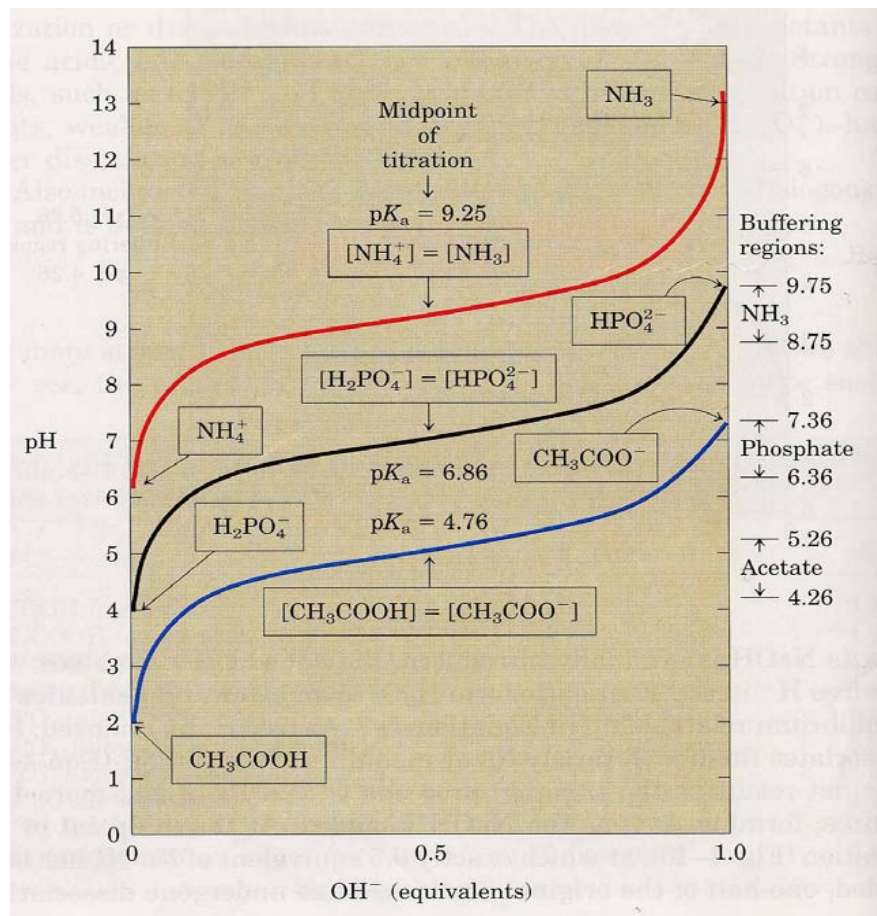
Table 4-6 Some conjugate acid-base pairs*

Proton donor	Proton acceptor
CH_3COOH (acetic acid)	CH_3COO^-
H_3PO_4 (phosphoric acid)	H_2PO_4^-
H_2PO_4^- (dihydrogen phosphate)	HPO_4^{2-}
HPO_4^{2-} (hydrogen phosphate)	PO_4^{3-}
NH_4^+ (ammonium)	NH_3
H_2CO_3 (carbonic acid)	HCO_3^-
HCO_3^- (bicarbonate)	CO_3^{2-}
$\begin{array}{c} ^+\text{NH}_3 \\ \\ \text{CH}_2-\text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{OH} \end{array} \end{array} \quad (\text{glycine})$	$\begin{array}{c} ^+\text{NH}_3 \\ \\ \text{CH}_2-\text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{O}^- \end{array} \end{array}$
$\begin{array}{c} ^+\text{NH}_3 \\ \\ \text{CH}_2-\text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{O}^- \end{array} \end{array}$	$\begin{array}{c} \text{NH}_2 \\ \\ \text{CH}_2-\text{C} \begin{array}{l} \nearrow \text{O} \\ \searrow \text{O}^- \end{array} \end{array}$

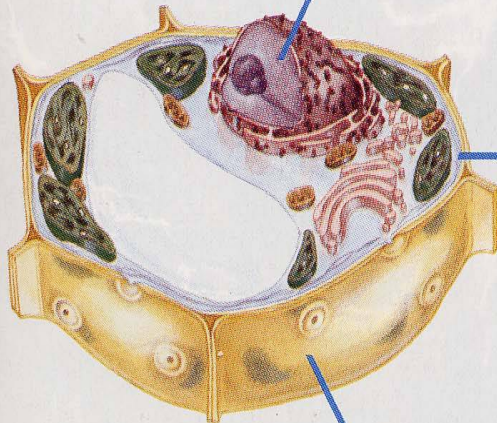
Table 4–7 Dissociation constant and pK_a of some common weak acids (proton donors) at 25 °C

Acid	K_a (M)	pK_a
HCOOH (formic acid)	1.78×10^{-4}	3.75
CH ₃ COOH (acetic acid)	1.74×10^{-5}	4.76
CH ₃ CH ₂ COOH (propionic acid)	1.35×10^{-5}	4.87
CH ₃ CH(OH)COOH (lactic acid)	1.38×10^{-4}	3.86
H ₃ PO ₄ (phosphoric acid)	7.25×10^{-3}	2.14
H ₂ PO ₄ ⁻ (dihydrogen phosphate)	1.38×10^{-7}	6.86
HPO ₄ ²⁻ (monohydrogen phosphate)	3.98×10^{-13}	12.4
H ₂ CO ₃ (carbonic acid)	1.70×10^{-4}	3.77
HCO ₃ ⁻ (bicarbonate)	6.31×10^{-11}	10.2
NH ₄ ⁺ (ammonium)	5.62×10^{-10}	9.25

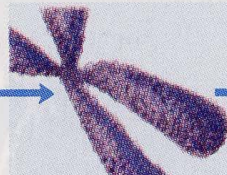




**Level 4:
The cell
and its organelles**



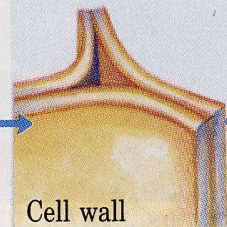
**Level 3:
Supramolecular
complexes**



Chromosome

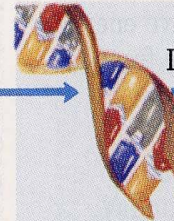


Plasma membrane



Cell wall

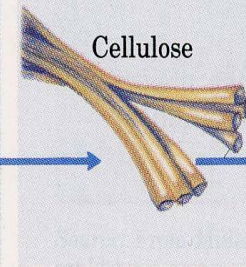
**Level 2:
Macromolecules**



DNA

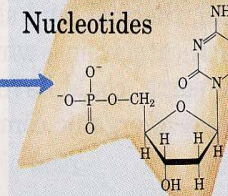


Protein

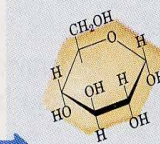
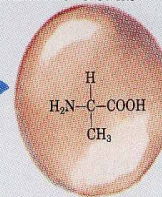


Cellulose

**Level 1:
Biomolecules**



Amino acids



Sugars



Table 3–1 Elemental abundance in seawater, the human body, and the earth's crust*

Seawater (%)		Human body (%)		Earth's crust (%)	
H	66	H	63	O	47
O	33	O	25.5	Si	28
Cl	0.33	C	9.5	Al	7.9
Na	0.28	N	1.4	Fe	4.5
Mg	0.033	Ca	0.31	Ca	3.5
S	0.017	P	0.22	Na	2.5
Ca	0.0062	Cl	0.08	K	2.5
K	0.0060	K	0.06	Mg	2.2
C	0.0014				

* Values are given as percentage of total number of atoms.

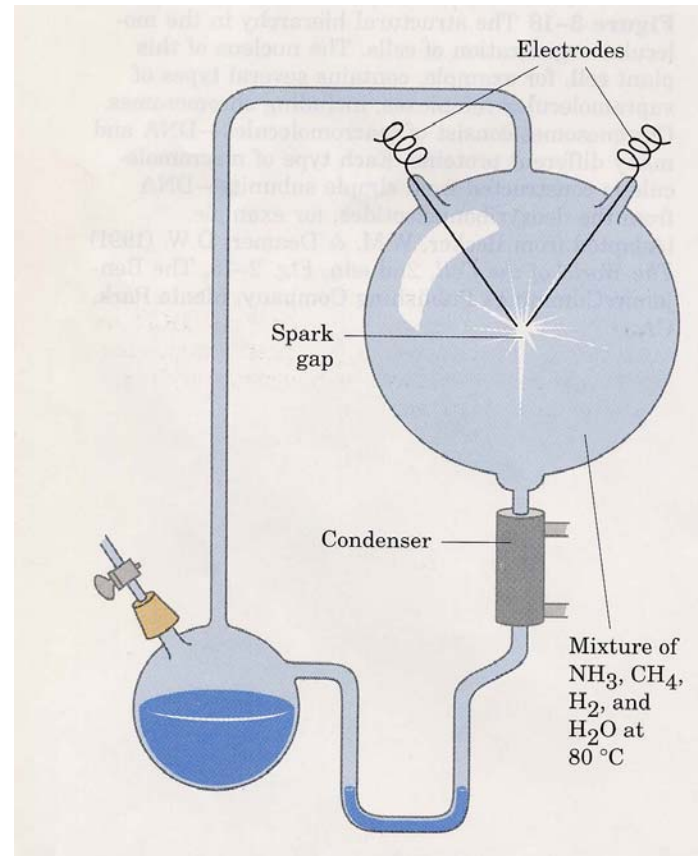


Table 3–8 Some of the products shown to form under prebiotic conditions

Amino acids

Glycine
Alanine
 α -Aminobutyric acid
Valine
Leucine
Isoleucine
Proline
Aspartic acid
Glutamic acid
Serine
Threonine

Sugars

Straight and branched
pentoses and hexoses

Carboxylic acids

Formic acid
Acetic acid
Propionic acid
Straight and branched
fatty acids (C_4 – C_{10})
Glycolic acid
Lactic acid
Succinic acid

Nucleic acid bases

Adenine
Guanine
Xanthine
Hypoxanthine
Cytosine
Uracil

