Review I: Chemistry & Biology Fundamentals

Judy Wieber

BBSI @ Pitt 2007

Department of Computational Biology
University of Pittsburgh School of Medicine

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Introduction

- What is biochemistry?
- Why study biochemistry?
- Ways to study biochemistry

Biochemistry

- “The science concerned with the chemical constituents of living cells and with the reactions and processes they undergo”

Reference

Life as we know it

- How did life arise?
- Classification of organisms
- The basic unit of life: the cell

(How did life arise?)

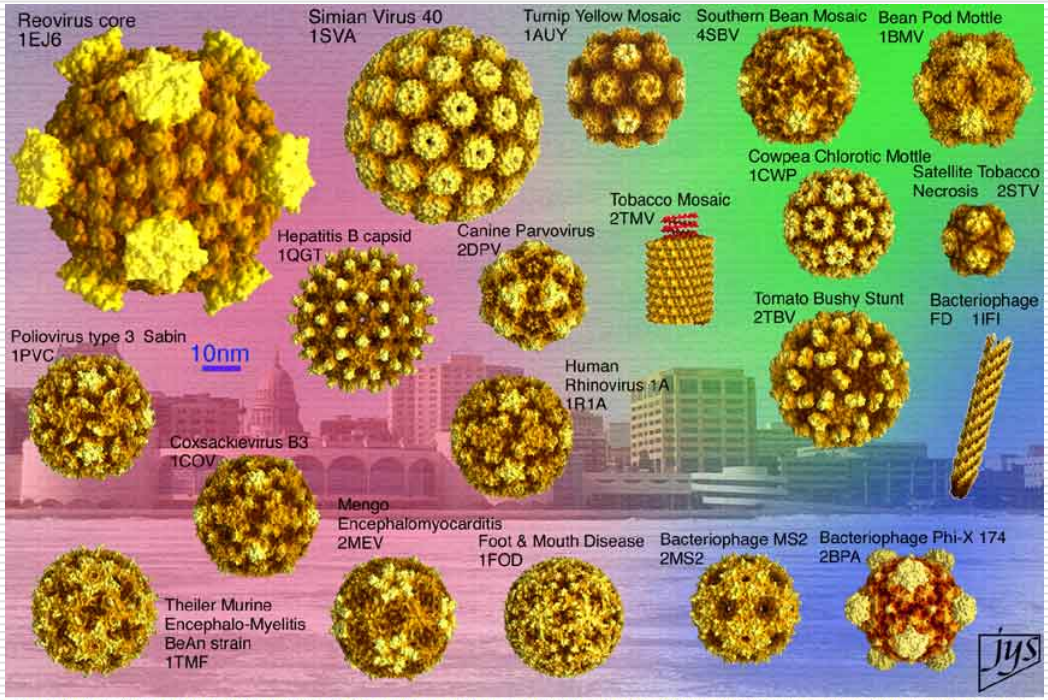
(The three domains)

Cells

- Prokaryotic vs. Eukaryotic
- Plant vs. Animal
- Organelles
- Viruses

(Cells Alive!)

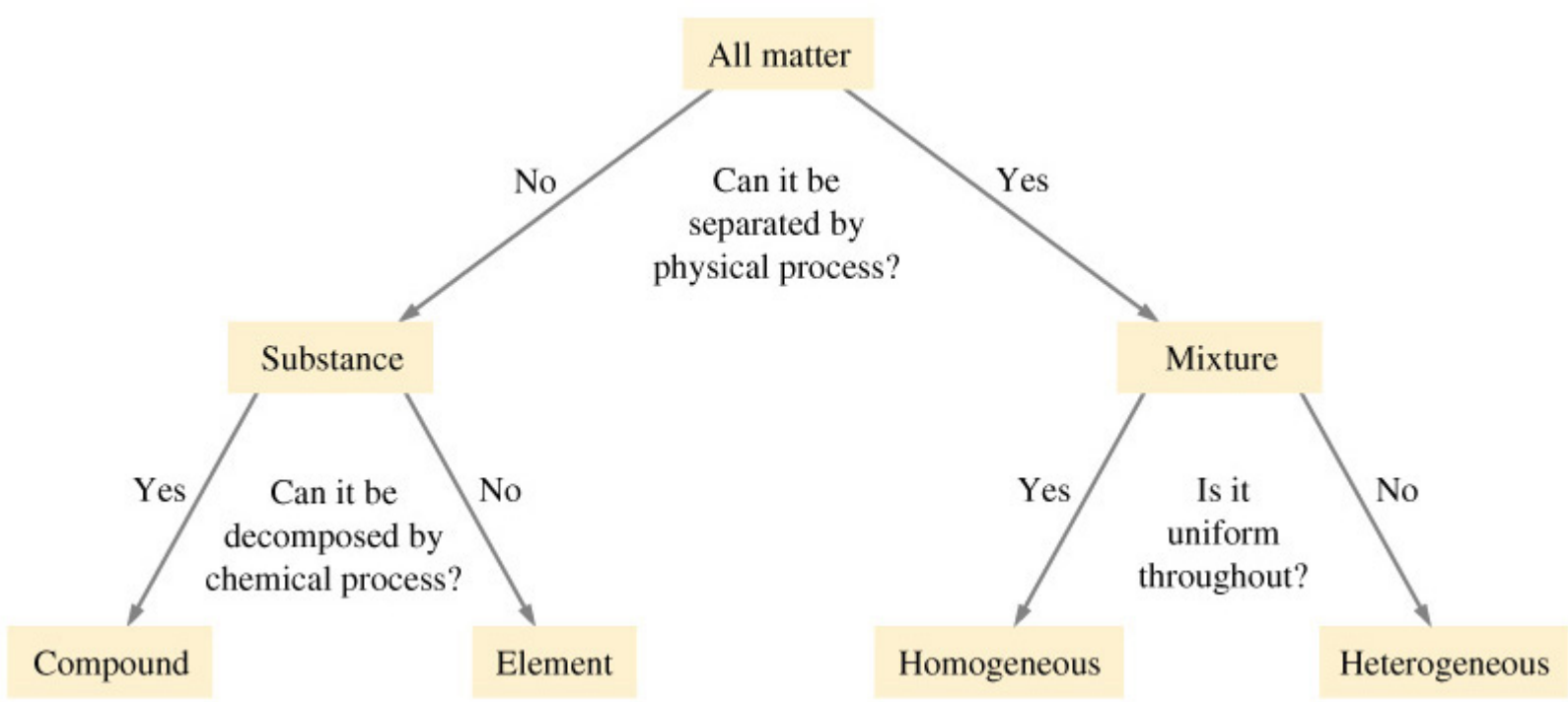
Viruses



Animal (red area), plant (green area) and bacteriophages (blue area) are depicted to scale (see 10nm bar) as GRASP surfaces from published X-cray crystallography coordinates. Virus names are followed by their PDB entry code (see www.rcsb.org or mmtsb.scripps.edu/viper).
For downloadable images see also www.bocklabs.wisc.edu. Background: Madison landscape seen from Monona lake.
All images by Dr. Jean-Yves Sgro, Institute for Molecular Virology, UW-Madison.

(Relative size of bacteria and viruses movie)

Matter


All matter
Can it be separated by physical process?
No
Yes
Substance
Mixture
Yes
Can it be decomposed by chemical process?
No
Yes
Is it uniform throughout?
No
Compound
Element
Homogeneous
Heterogeneous

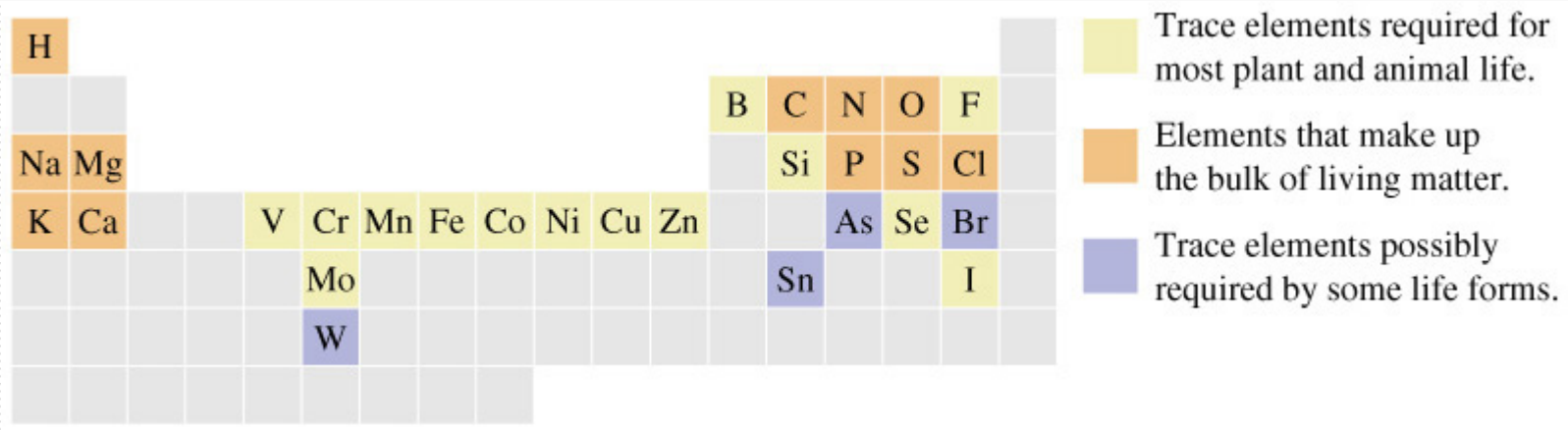
Atoms

- Composition
- Isotopes
- The periodic table

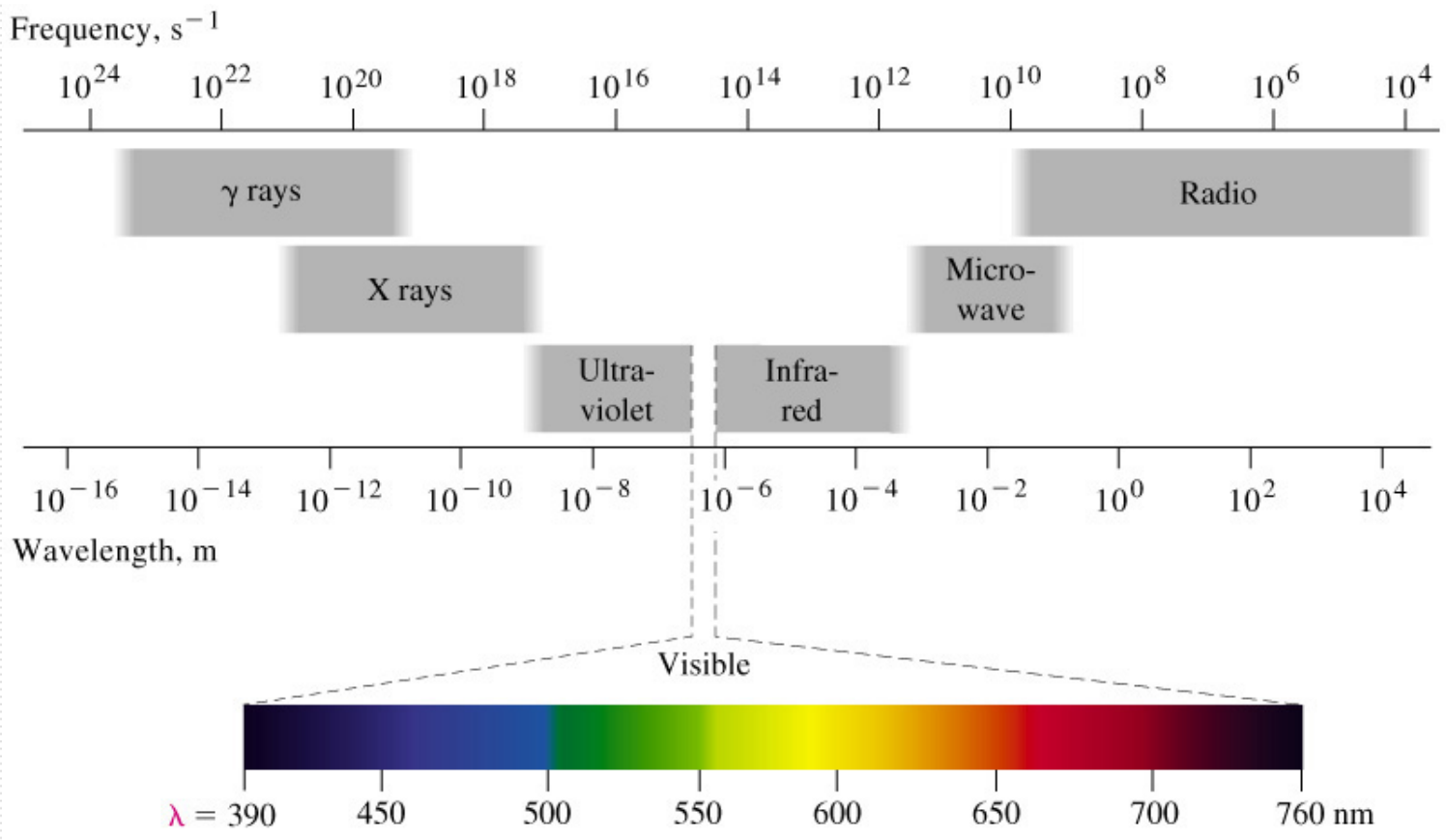
(Periodic properties movie)

(Web Elements™ Periodic Table)

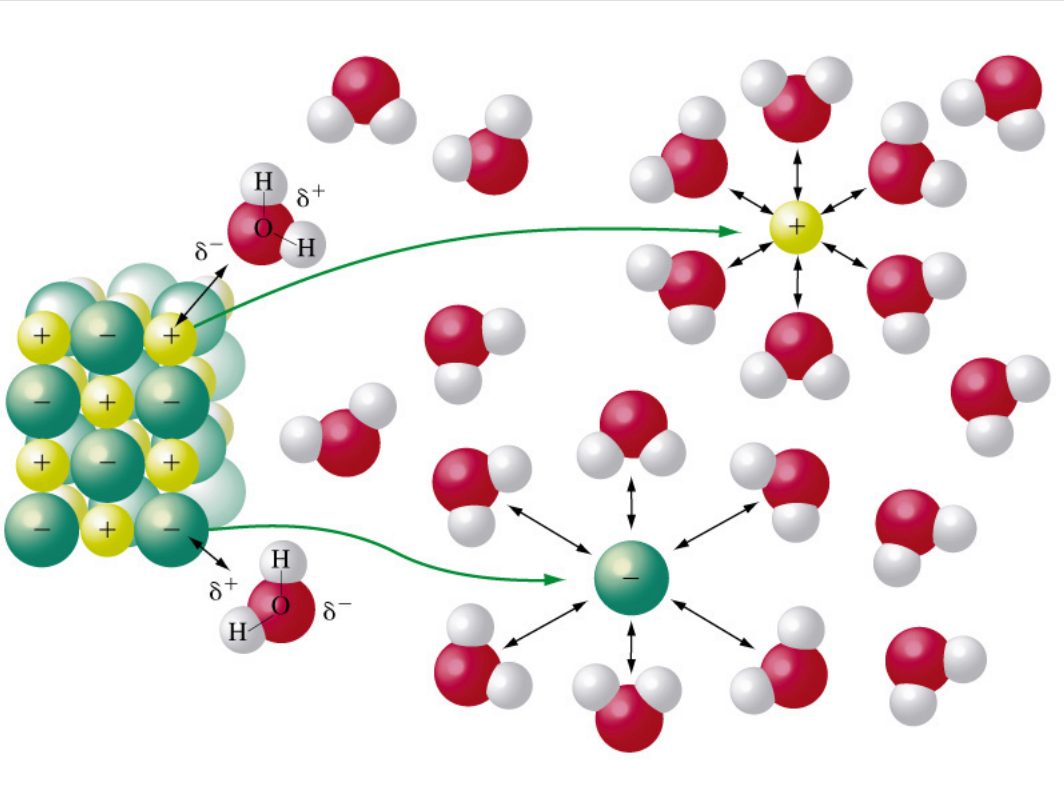
Elements of Life



Electromagnetic Spectrum



Ions



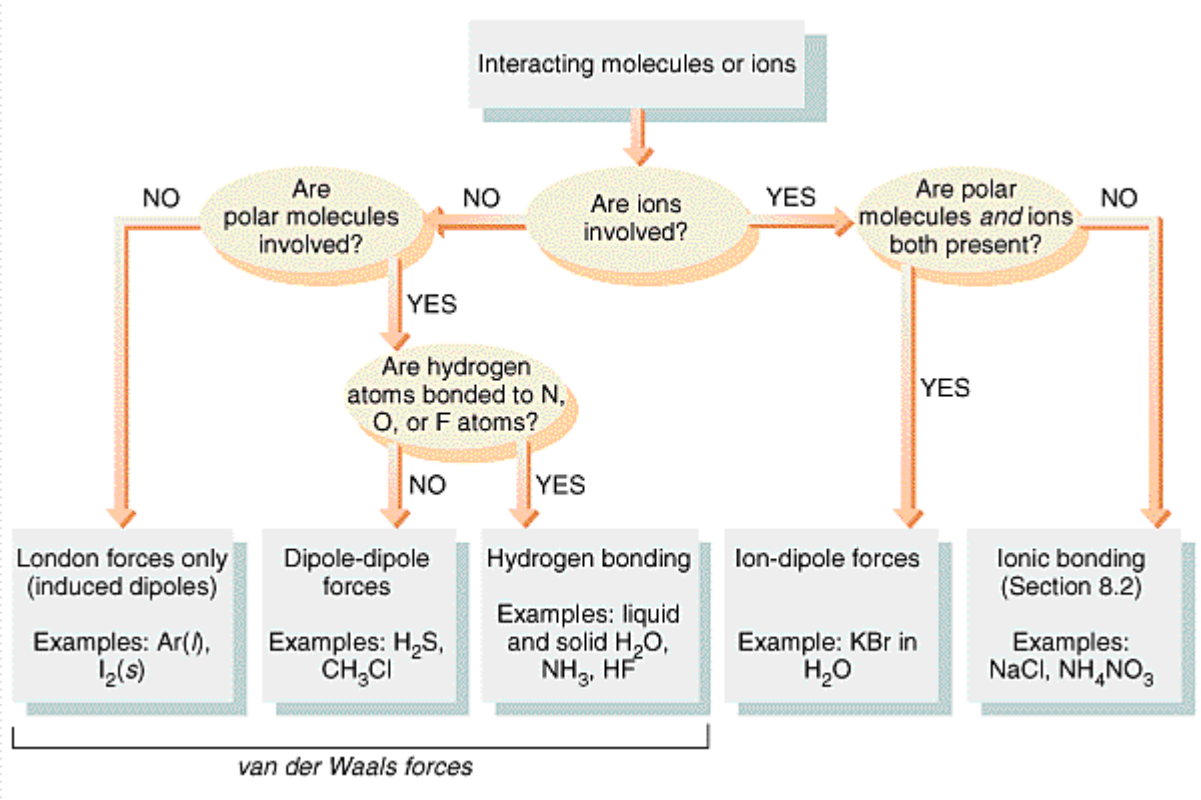
Molecules

- Bonds
- Molecular structure
- Types of compounds
- Water
- Organic chemicals
- Isomerism

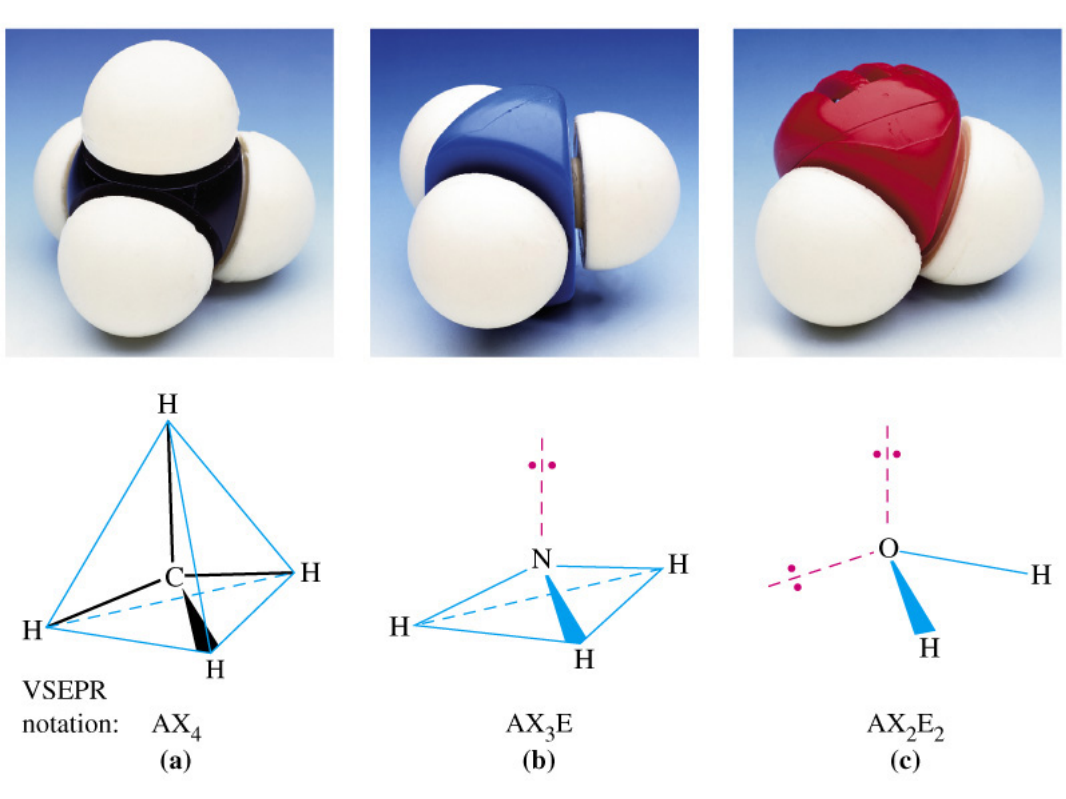
(Representing chemical structures movie)

(Intermolecular forces)

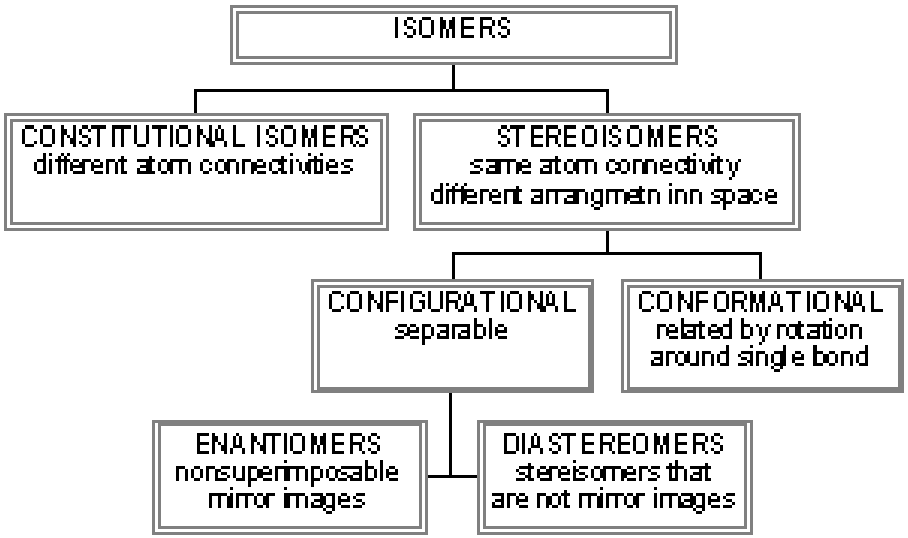
Intermolecular Forces



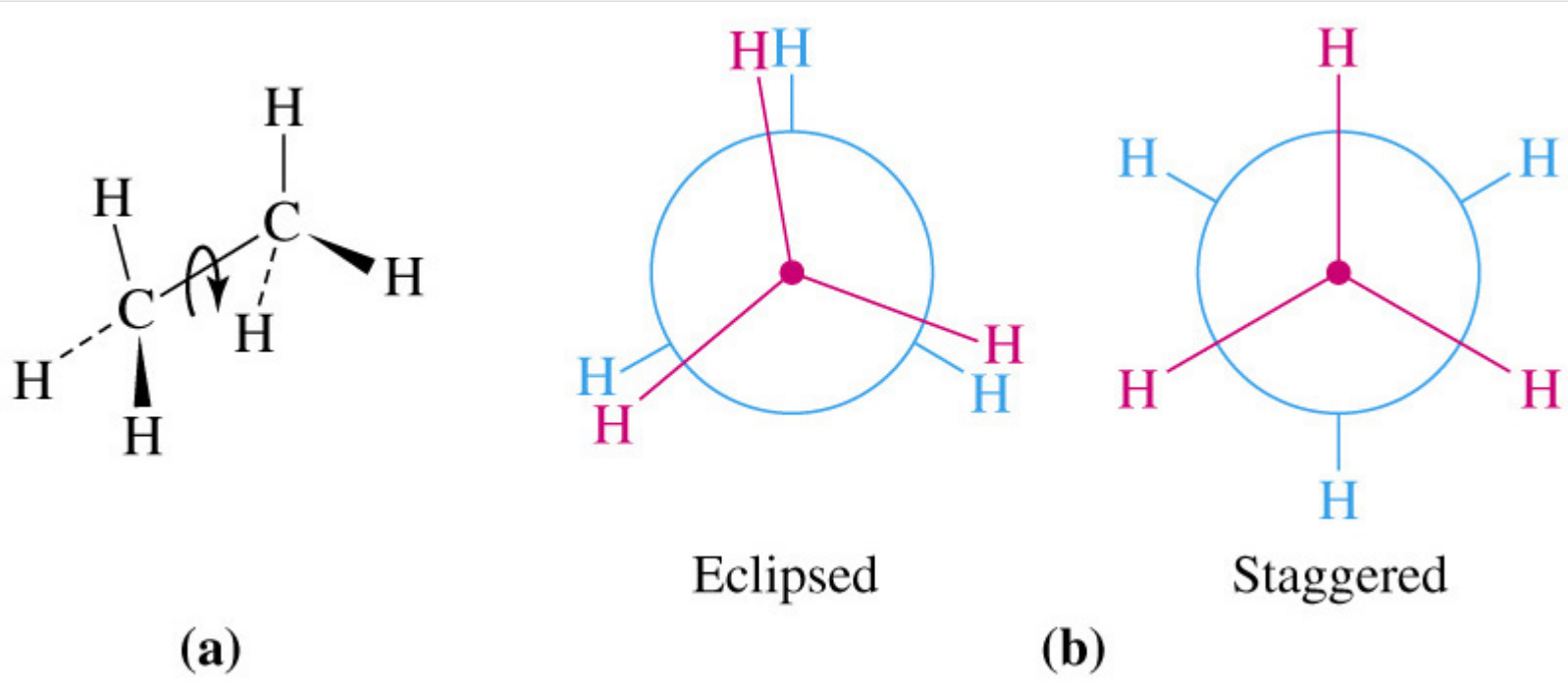
Chemical Structures



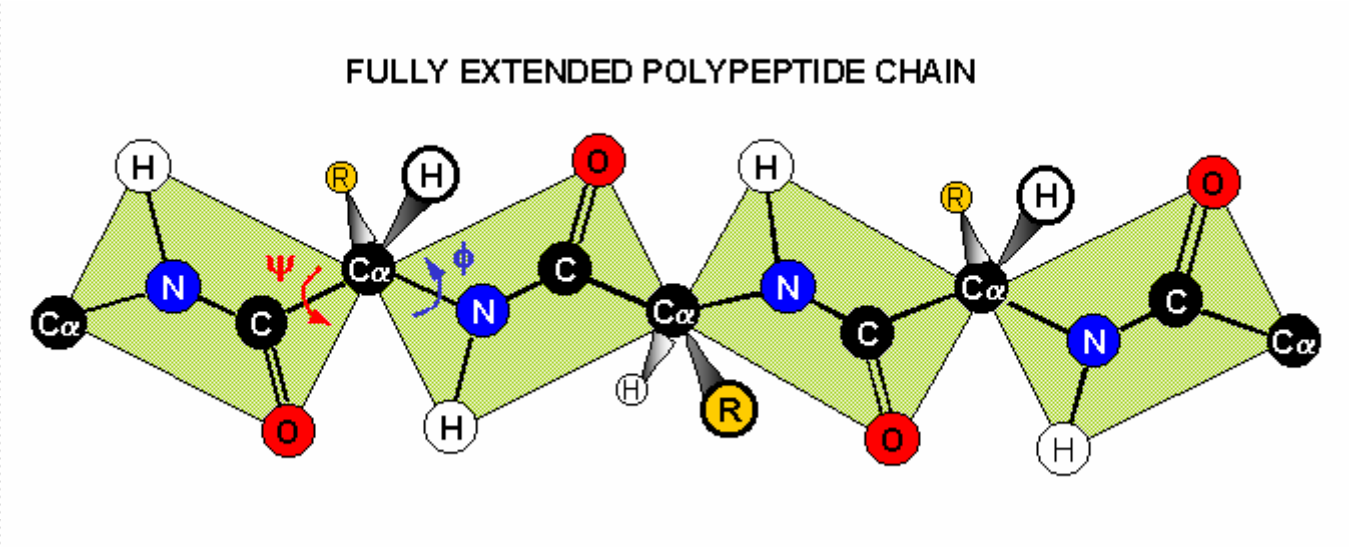
Isomers


ISOMERS
CONSTITUTIONAL ISOMERS
different atom connectivities
STEREOISOMERS
same atom connectivity
different arrangmetn inn space
CONFIGURATIONAL
separable
CONFORMATIONAL
related by rotation
around single bond
ENANTIOMERS
nonsuperimposable
mirror images
DIASTEREOMERS
stereisomers that
are not mirror images

Ethane Conformations



Polypeptide Chain



Organic Chemicals

TABLE 27.1 Some Common Alkyl Groups

Name	Structural Formula
Methyl	$-CH_3$
Ethyl	$-CH_2CH_3$
Propyl[a]	$-CH_2CH_2CH_3$
Isopropyl	CH_3CHCH_3 (CH on the second carbon)
Butyl[a]	$-CH_2CH_2CH_2CH_3$
Isobutyl	$-CH_2CHCH_3$ (CH_3 on the second carbon)
s-Butyl[b]	$CH_3CHCH_2CH_3$ (CH on the second carbon)
t-Butyl[c]	CH_3CCH_3 (CH_3 on the second carbon)

[a] In the past, the prefix *normal* or *n*- was used for a straight-chain alkyl group, such as *n*-propyl or *n*-butyl.
[b] *s* = secondary.
[c] *t* = tertiary.

Bond Lengths

TABLE 11.2 Some Average Bond Lengths[a]

Bond	Bond Length, pm	Bond	Bond Length, pm	Bond	Bond Length, pm
H—H	74.14	C—C	154	N—N	145
H—C	110	C=C	134	N=N	123
H—N	100	C≡C	120	N≡N	109.8
H—O	97	C—N	147	N—O	136
H—S	132	C=N	128	N=O	120
H—F	91.7	C≡N	116	O—O	145
H—C1	127.4	C—O	143	O=O	121
H—Br	141.4	C=O	120	F—F	143
H—I	160.9	C—C1	178	C1—C1	199
				Br—Br	228
				I—I	266

[a]Most values (C—H, N—H, C—H, . . .) are averaged over a number of species containing the indicated bond and may vary by a few picometers. Where a diatomic molecule exists, the value given is the actual bond length in that molecule (H_2, N_2, HF, . . .) and is known more precisely.

Types of Compounds

TABLE 13.7 Characteristics of Crystalline Solids

Type	Structural Particles	Intermolecular Forces	Typical Properties	Examples
Metallic	Cations and delocalized electrons	Metallic bonds	Hardness varies from soft to very hard; melting point varies from low to very high; lustrous; ductile; malleable; very good conductors of heat and electricity	Na, Mg, Al, Fe, Sn, Cu, Ag, W
Ionic	Cations and anions	Electrostatic attractions	Hard; moderate to very high melting points; nonconductors as solids, but good electric conductors as liquids; many are soluble in polar solvents like water.	NaCl, MgO, $NaNO_3$
Network covalent	Atoms	Covalent bonds	Most are very hard and either sublime or melt at very high temperatures; most are nonconductors of electricity	C (diamond), C (graphite), SiC, AlN, SiO_2
Molecular *Nonpolar*	Atoms or nonpolar molecules	Dispersion forces	Soft; extremely low to moderate melting points (depending on molar mass); sublime in some cases; soluble in some nonpolar solvents	He, Ar, H_2, CO_2, CCl_4, CH_4, I_2
Polar	Polar molecules	Dispersion forces and dipole–dipole attractions	Low to moderate melting points; soluble in some polar and some nonpolar solvents	$(CH_3)_2O$, $CHCl_3$, HCl
Hydrogen–Bonded	Molecules with H bonded to N, O, or F	Hydrogen bonds	Low to moderate melting points; soluble in some hydrogen-bonded solvents and some polar solvents	H_2O, NH_3

Relative Sizes of Atoms, Molecules, Organelles, and Cells

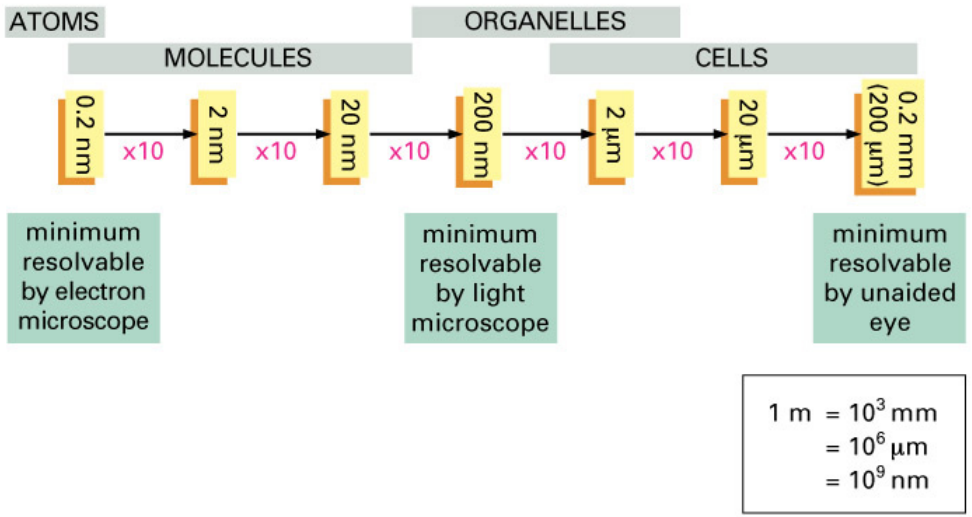


Figure 1-6 Essential Cell Biology, 2/e. (© 2004 Garland Science)

Chemical Reactions

- Types of reactions
- Mechanisms
- Balancing

Thermodynamics

- Free energy, enthalpy, entropy
- Equilibrium constant
- Spontaneity

Spontaneity

TABLE 20.1 Criteria for Spontaneous Change: $\Delta G = \Delta H - T\Delta S$

Case	ΔH	ΔS	ΔG	Result	Example
1	−	+	−	spontaneous at all temp	$2\ N_2O(g) \longrightarrow 2\ N_2(g) + O_2(g)$
2	−	−	−	spontaneous at low temp	$H_2O(l) \longrightarrow H_2O(s)$
			+	nonspontaneous at high temp	
3	+	+	+	nonspontaneous at low temp	$2\ NH_3(g) \longrightarrow N_2(g) + 3\ H_2(g)$
			−	spontaneous at high temp	
4	+	−	+	nonspontaneous at all temp	$3\ O_2(g) \longrightarrow 2\ O_3(g)$

Kinetics

- Rate equations
- Activation energy
- Catalysis

(Catalysis)