Notes 9/28

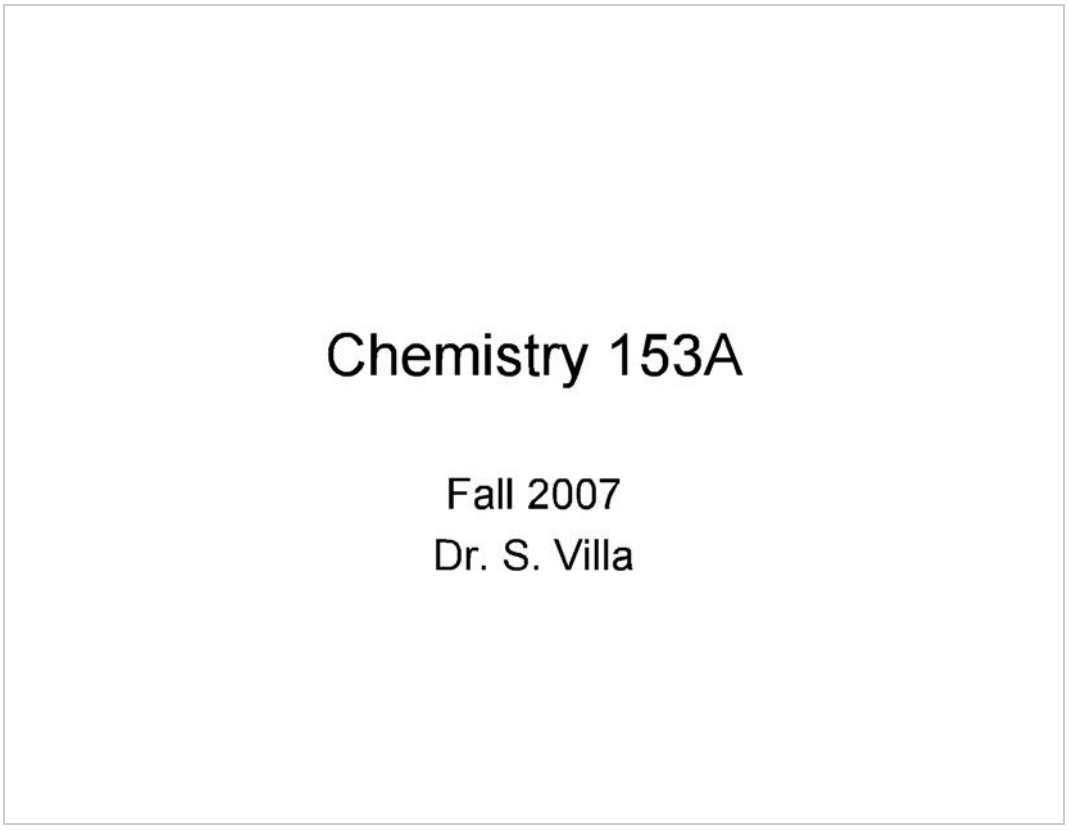
Friday, September 28, 2007
8:58 AM

Covel Tutorial RM 230
M-W 12-4PM

http://voh.chem.ucla.edu

Dr. Villa's Office Hours
YH3077B
Mon 11-noon
Tues 11-noon
Wed 3-4pm
Fri 1-2pm

6 Quizzes in discussion. 1 may be dropped.
Check VOH regularly.



Schedule for Chemistry 153A, Fall 2007

Instructor: Dr. Sarah T. Villa Office: Young Hall 3077B
Email: sarah.villa@ucla.edu Phone: 310 825-1670
Virtual Office Hours (VOH): http://voh.chem.ucla.edu/

Dr. Villa's Office Hours (YH 3077B unless otherwise announced):
Mon. 11 AM to noon
Tues. 11 AM to noon
Wed. 3 PM to 4 PM
Fri. 1 PM to 2 PM

To make sure EVERYONE can make it to office hours, no Chem. 153A discussion sections are scheduled during my office hours. Your teaching assistant will also announce his or her office hours.

Please check VOH regularly for announcements and notes. You must have reliable access to VOH throughout the quarter. Reading assignments and other materials will be posted there.

Week	Date	Day	Topic
0	28	F	Introduction; Aqueous Solutions: General Properties
1	Oct. 1	M	Aqueous Solutions: Acids, Bases, and Buffers
	2	T	Amino Acids: General Properties
	3	W	Amino Acids: Acid-Base Properties
	5	F	Proteins: Primary Structure
2	**Discussion Section Quiz 1: Aqueous Solutions, Amino Acids (20 points)**		
	Oct. 8	M	Proteins: Secondary Structure
	9	T	Proteins: Tertiary & Quaternary Structure
	10	W	Proteins: Hemoglobin Part I
	12	F	Proteins: Hemoglobin Part II
3	**Discussion Section Quiz 2: Proteins (20 pts)**		
	Oct. 15	M	Carbohydrates: Monosaccharides, Disaccharides
	16	T	Carbohydrates: Polysaccharides
	17	W	Lipids: Classification
	19	F	Lipids: Properties
4	**Discussion Section Quiz 3: Carbohydrates & Lipids (20 pts)**		
	Oct. 22	M	Lipids: Biological Membranes
	23	T	Enzymes: Introduction
	24	W	Enzymes: Rates of Reactions Part I
	26	F	Enzymes: Rates of Reactions Part II
5	**Discussion Section Quiz 4: Enzymes (20 pts)**		
	29	M	Enzymes: Catalytic Mechanisms Part I
	30	T	Enzymes: Catalytic Mechanisms Part II
	31	W	Enzymes: Serine Proteases Part I
	Nov. 2	F	Enzymes: Serine Proteases Part II
Week	**Date**	**Day**	**Topic**
6	Nov. 5	M	Enzymes: Regulation
	6	T	Metabolism: Introduction Part I
	7	W	**MIDTERM (100 pts)**
	9	F	Metabolism: Introduction Part II
7	Nov. 12	M	NO CLASS
	13	T	Glycolysis: Reactions Part I
	14	W	Glycolysis: Reactions Part II
	16	F	Glycolysis: Fermentation
8	Nov. 19	M	Glycolysis: Regulation and Control
	20	T	Pyruvate Dehydrogenase Complex Part I
	21	W	Pyruvate Dehydrogenase Complex Part II
	23	F	NO CLASS
9	**Discussion Section Quiz 5: Pyruvate Dehydrogenase Complex (20 pts)**		
	Nov. 26	M	TCA Cycle: Overview
	27	T	TCA Cycle: Enzymes of the Cycle Part I
	28	W	TCA Cycle: Enzymes of the Cycle Part II
	30	F	TCA Cycle: Regulation, Amphibolic Nature of the Cycle
10	**Discussion Section Quiz 6: TCA Cycle (20 pts)**		

- Please read the whole syllabus (see VOH)
- Lecture
- Discussion
- Exams
- Quizzes
- Grading
- Academic Integrity
- Monday

Frequently asked questions

- Do I have to go to lecture/discussion/office hours?
- Do I have to buy the book?
- Are you using Dr. Bates's materials?
- How do I get an "A" in the class?
- How do I study?

Biochemistry

- Can life and its many biological functions ultimately be broken down into chemical terms?

Outline

- What Are the Distinctive Properties of Living Systems?
- What Is the Organization and Structure of Cells?
- What Kinds of Molecules Are Biomolecules?
- What Is the Structural Organization of Complex Biomolecules?
- What Are the Properties of Water?

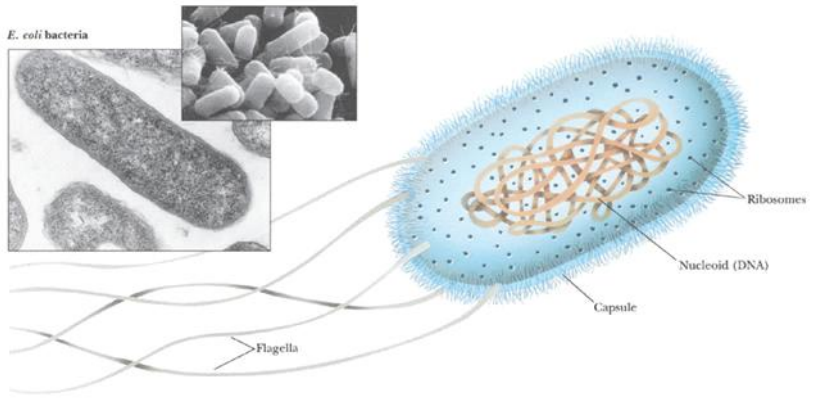
Distinctive Properties of Living Systems

- Organisms are complicated and highly organized
- Biological structures serve functional purposes
- Living systems are actively engaged in energy transformations
- Living systems have the capacity for self-replication

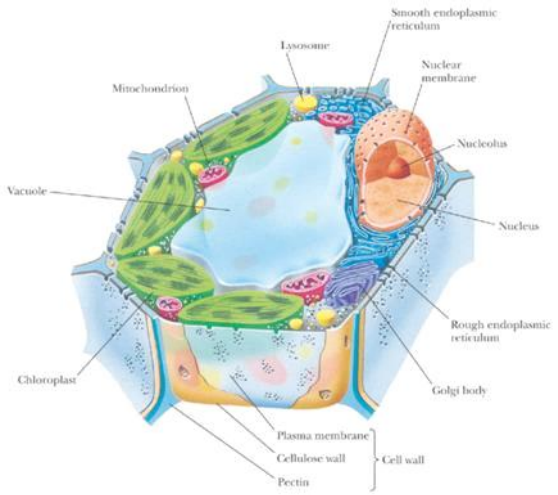
Organization and Structure of Cells

- Prokaryotic cells
  - unicellular
  - no nucleus or organelles
  - Half of Earth's biomass
- Eukaryotic cells
  - Unicellular and multicellular
  - 10^3-10^4 times larger!
  - Nucleus plus many organelles
  - ER, Golgi, mitochondria, etc.

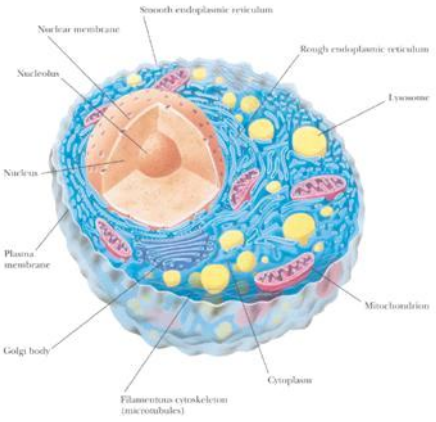
Bacterial Cell



Plant Cell



Animal Cell



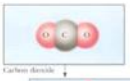
A Biomolecular Hierarchy

Simple Molecules are the Units for Building Complex Structures

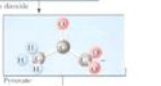
- Metabolites and Macromolecules
- Organelles
- Membranes
- The Unit of Life is the Cell

1 D = mass of one H

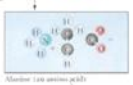
Inorganic precursors (18-64 D)
Carbon dioxide, water, ammonia (ammounium ion), nitrogen (N_2), nitrate (NO_3^-)



Metabolites (50-250 D)
Pyruvate, citrate, succinate, glyceraldehyde-3-phosphate



Building blocks (100-350 D)
Amino acids, nucleotides, monosaccharides, fatty acids, glycerol



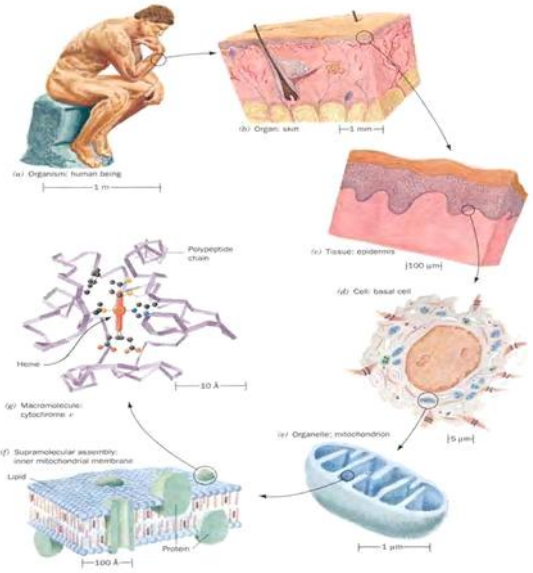
Macromolecules (10^3-10^9 D)
Proteins, nucleic acids, polysaccharides, lipids (not strictly)

Supramolecular complexes (10^6-10^9 D)
Ribosomes, cytoskeleton, multienzyme complexes

Organelles
Ribosomes, cytoskeleton, multienzyme complexes

Molecular organization in the cell.

Example of the hierarchical organization of biological structures.



10^{-10} m = 1 angstrom

On Life and Chemistry...

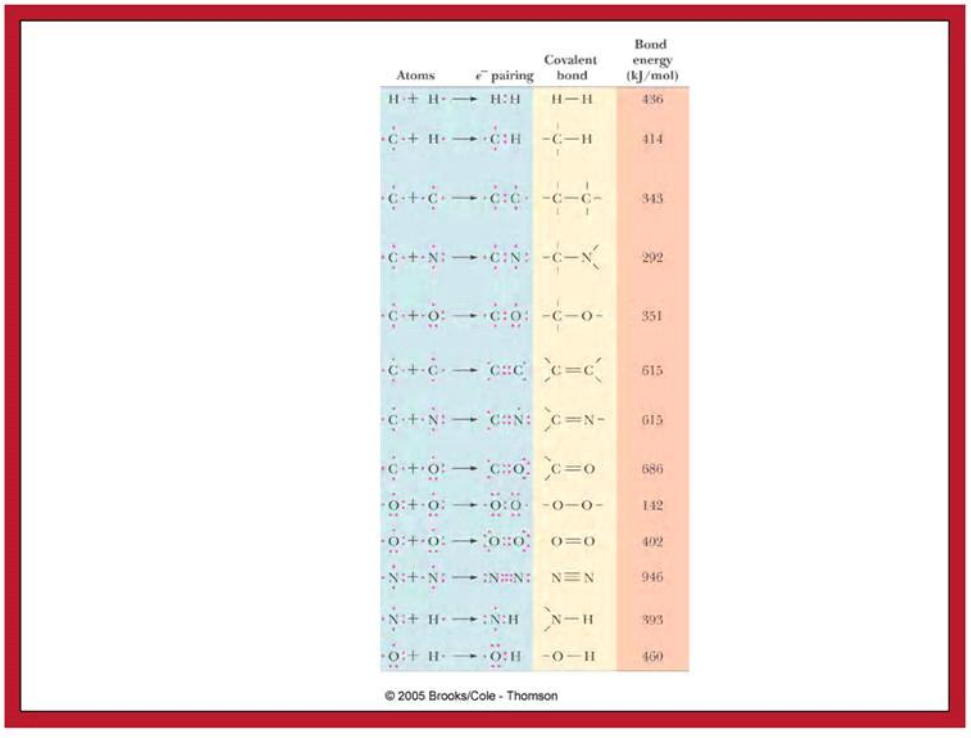
- "Living things are composed of lifeless molecules" (Albert Lehninger)

Elemental Composition of the Human Body.

Element	Dry Weight (%)[a]	Elements Present in Trace Amounts
C	61.7	B
N	11.0	F
O	9.3	Si
H	5.7	V
Ca	5.0	Cr
P	3.3	Mn
K	1.3	Fe
S	1.0	Co
Cl	0.7	Cu
Na	0.7	Zn
Mg	0.3	Se
		Mo
		Sn
		I

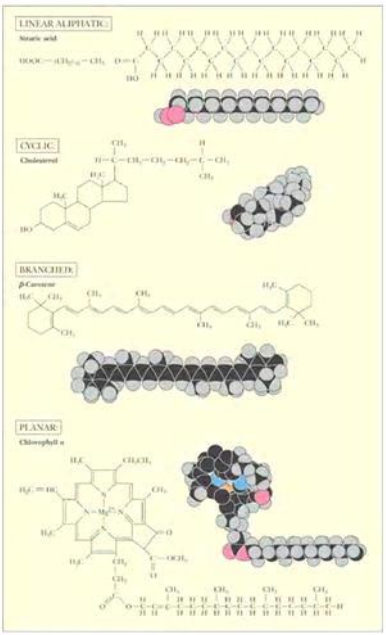
[a] Calculated from Frieden, *E., Sci. Am.* **227**(1), 54–55 (1972).

- Why are H, O, C and N so prevalent in the chemistry of life?
- Answer: They can form covalent bonds by electron-pair sharing.



Atoms	e^- pairing	Covalent bond	Bond energy (kJ/mol)
H· + H· →	H:H	H—H	436
·C· + H· →	·C:H	–C—H	414
·C· + ·C· →	·C:C·	–C—C–	343
·C· + ·N: →	·C:N:	–C—N<	292
·C· + ·O: →	·C:O:	–C—O–	351
·C· + ·C· →	C::C	>C=C<	615
·C· + ·N: →	C::N:	>C=N–	615
·C· + ·O: →	C::O	>C=O	686
·O: + ·O: →	·O:O·	–O—O–	142
·O: + ·O: →	O::O	O=O	402
·N: + ·N: →	:N:::N:	N≡N	946
·N: + H· →	:N:H	>N—H	393
·O: + H· →	·O:H	–O—H	460

Examples of the versatility of C—C bonds in building complex structures: linear aliphatic, cyclic, branched, and planar.



Molecular Composition of *E. Coli*.

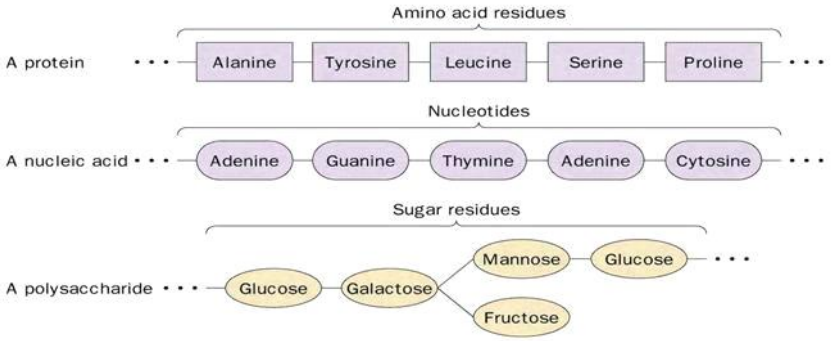
Component	Percentage by Weight	Approximate number of different molecular species
H_2O	70	1
Protein	15	3,000
Nucleic acids:		
DNA	1	1
RNA	6	>3000
Polysaccharides and precursors	3	5
Lipids and precursors	2	20
Other small organic molecules	1	500
Inorganic ions	1	20

Major classes of biological molecules

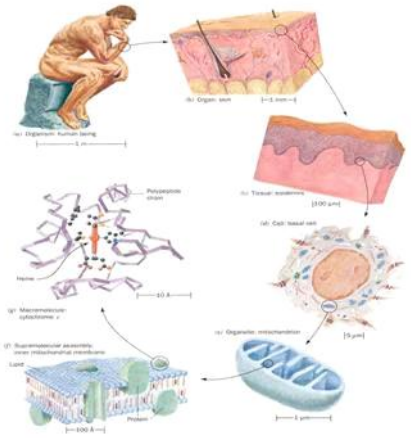
- Proteins
- Nucleic acids
- Polysaccharides
- Lipids

} Macromolecules

Polymeric organization of proteins, nucleic acids, and polysaccharides.



Example of the hierarchical organization of biological structures.



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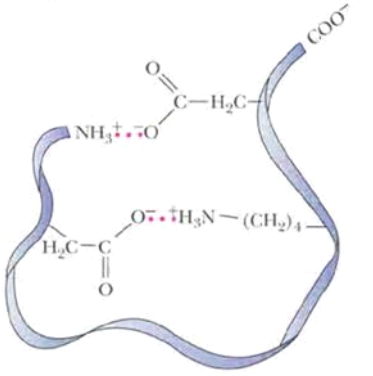
What makes biomolecules form intermolecular and intramolecular interactions?

Noncovalent bonds (a.k.a. weak chemical forces or electrostatic forces)

- van der Waals (0.4-4.0 kJ/mol)
- Hydrogen bonds (12-30 kJ/mol)
- Ionic bonds (20 kJ/mol)
- Hydrophobic interactions (<40 kJ/mol)

An example of noncovalent bonding.

Intramolecular ionic bonds between oppositely charged groups on amino acid residues in a protein



Protein strand

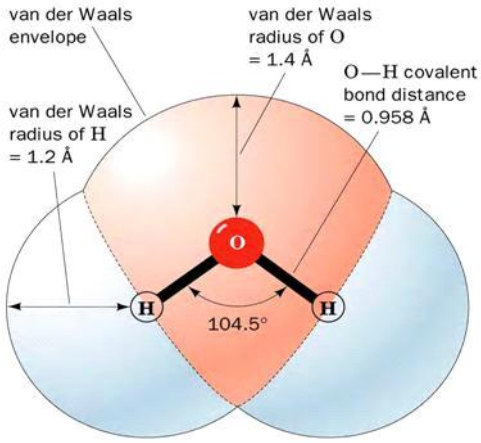
Water

- Life depends on it!
- 70-90% of the body weight of organisms is water
- 75% of the earth is covered in it
- Excellent solvent
  - Salts, sugars, aldehydes, ketones, alcohols, amines
- Water directly affects the structural conformations of biomolecules

What Are the Properties of Water?

- High b.p., m.p., heat of vaporization, surface tension
- Bent structure makes it polar
- Non-tetrahedral bond angles
- H-bond donor and acceptor
- Potential to form four H-bonds per water

Structure of the water molecule



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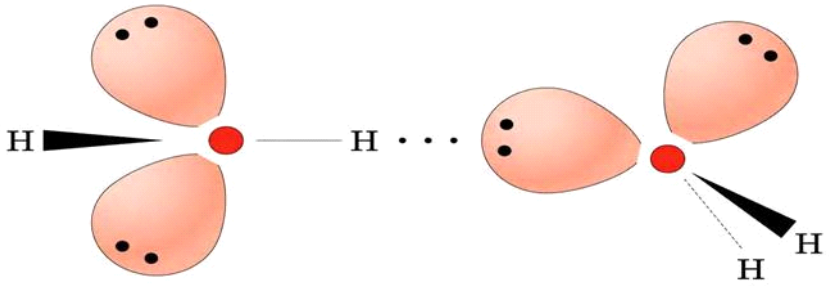
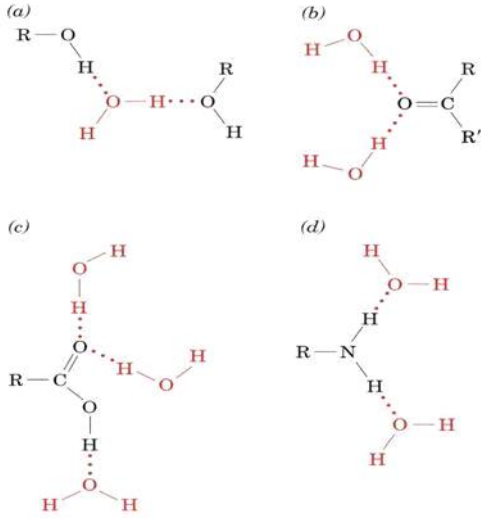
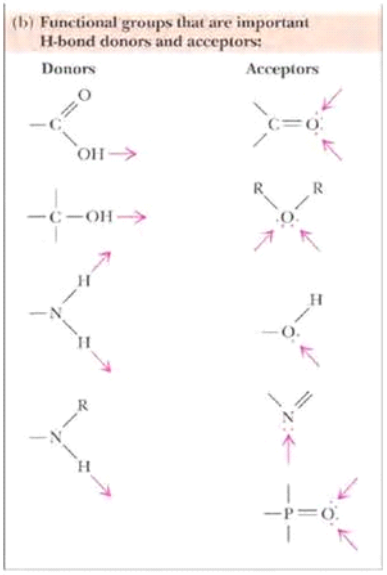
Hydrogen bond between two water molecules



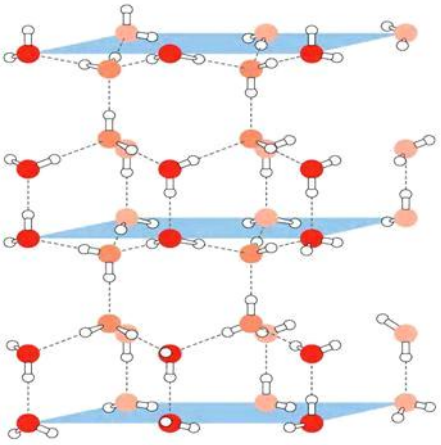
Water hydrogen bonding with functional groups



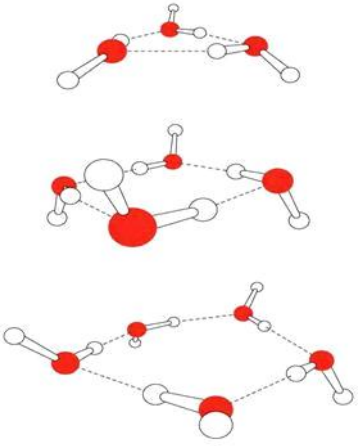
Functional groups that serve as H bond donors and acceptors.



Structure of ice



Theoretically predicted and spectroscopically confirmed structures of the water trimer, tetramer, and pentamer



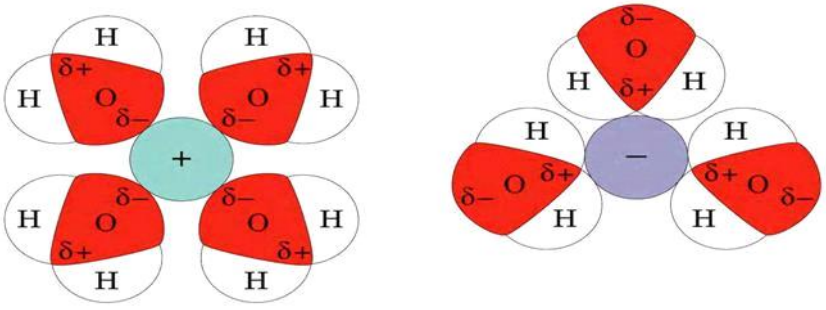
Comparison of Ice and Water

Issues: H-bonds and Motion

- Ice: 4 H-bonds per water molecule
- Water: 2.3 H-bonds per water molecule

Can you figure out why they are different?

Solvation of ions by oriented water molecules



Next

- Aqueous Solutions: Acids, Bases, Buffers
- Do your assigned reading (see VOH)
- Do Problem Set #1 (see VOH)
- Print next lecture's slides, which will be available Oct. 30th after 6 PM (see VOH)