• Reading
• Today: pp 80-87
• Thursday: pp 101-104
• Friday pp 104(bottom)-107
Non-Covalent “Reactions”

important for the *DYNAMICS* of life processes

a. Ionic,
   “hydrogen bonding”,
   hydrophobic *(not)* bonding
   London dispersion forces (“spooky”)

b. proteins: what are they?
   what do they do?
London dispersion forces

Quantum behavior

Electrons in atoms act like particles, although the orbital picture makes them seem like spherical clouds with no dipole.

Particle behavior means helium atoms have large fluctuating dipoles.

Two helium atoms side by side attract because the fluctuations are correlated to reduce electron repulsion between the atoms.

*instantaneous dipole-induced dipole*

+ - - +

- + or + -
All of chemistry is built from **Coulomb’s Law:** The very strong attraction of opposite charges and repulsion of like charges.

**van der Waals:** a **mixture** of London and permanent dipole-dipole interactions
Hydrogen Bonding

Hydrogen bonding is almost all **electrostatic attraction** of partial charges. It is strong because of **smallness** of H.
IN WATER

\[
\text{C}_3\text{H}_6(l) + \infty \text{H}_2\text{O}(l) \rightarrow \text{C}_3\text{H}_6(aq)
\]

Hydrophobic \(-10\)

\[
\text{Benzene}(l) + \infty \text{H}_2\text{O}(l) \rightarrow \text{benzene}(aq)
\]

Hydrophobic \(0\)
Hydrogen bonding is almost all electrostatic attraction of partial charges. It is strong because of the smallness of H; H gets closer than any other atom!

\[
(V_{\text{coul}})_{ij} = \frac{Ze_i Q_j}{r_{ij}} \times (9 \times 10^9) \text{ Joules}
\]

for \( Z \) in coulombs, \( Q \) in meters,

\[= 1328 \text{ kJ/mol} \text{ per } \frac{e^2}{A^0} \]

Atoms are treated as point charges and point masses.

Some typical values:

- Water
- Glu or Asp
- Gln or Asn
Hydrophobic "Interactions"

\[ \text{H}_2\text{C} - \text{C} - \text{H}(\ell) \rightarrow (\text{H}-\text{C} - \text{C} - \text{H})_{\text{aq}} \]

\[ \Delta H^\circ = -8 \text{ kJ/mol} \]

\[ \Delta S^\circ = -80 \text{ J/mol K} \]

\[ \Delta G^\circ = \Delta H^\circ - 298(\Delta S^\circ) = +16 \text{ kJ/mol.} \]

- Water orders around the hydrocarbon.
- Heat given off as in freezing of water.
Soap & Detergent

Na$^+$

Hydrocarbon tail

micelle

Na$^+$

Na$^+$ Counter Ions
Biological Soaps = Lipids = Fats

Form Bilayers = Membranes

AND Vesicles (for transport)

E.g. Neural transmitters
Note: The London forces between water and ethane are same as between two ethanes. Total ordered water is reduced by association of ethanes. The force is much the same as what causes water droplets in air to be spherical and makes them combine into larger drops, i.e., surface tension. Reducing surface area is spontaneous.
What are proteins and what do they do?

The poetic answer:

"We now see that proteins are highly sophisticated molecular machines that process energy, matter, and information. Their beautiful molecular ballet is coming into view."

-Lubert Stryer

*Biochemistry, 4th Ed.*
What do proteins do? **The list answer:**

(Gene == basic Protein) but there are many forms of most basic proteins created by *post translational* processes

- Mechanical support
- Motion
- Transport and storage
- Immune protection
- Signaling (nerve impulses, response to hormones, vision, ……)
- **Catalysis and recognition** -- pervade most of the above
  (in particular, hydrolysis of ATP and GTP provides the energy for switching and timing of the complex circuits)

and much, much more—yet to be discovered.
The visual answer

Ecoli Bacterium
What are proteins? **The chemical answer:**
- Linear polymers of amino acids
- The sequence is from the genetic code
- ~100,000 proteins are responsible for the life process

**Backbone**

**Sidechains**

H on each C<sub>α</sub> not shown
Tiny

Gly  Ala

Negatively Charged

Asp (vingar)

Glu (MSG)

Lys (ammonia)

Arg

Positively Charged

Polar, uncharged

Ser (alcohol, drinking)

Thr (alcohol, rubbing)

Asn

Gln
Aromatic Hydrophobic \((UV\) absorbing\)

Phenylalanine
\((\text{benzene})\)

Tyrosine \((\text{phenol})\)

Tryptophan
\((\text{sleep aid})\)

Banned. Cannot be made safe commercially

Really???
Aromatic
Aliphatic
Neg
Pos
alcohol
amide
Methionine