SGCEP BIOL 1010K
Introduction to Biology I
Spring 2012 Sections 20585 & 20586

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OK, so know you should know that...

Science is the systematic collection and assimilation of knowledge about the observable, natural universe. That systematic system is called the scientific method, and it consists of an interplay of: observation, hypothesis, experimentation, data collection, analysis, and peer review.

And life is something that: is organized, has homeostasis, uses energy, reproduces, evolves, and dies.
So now, biochemistry: the chemistry of life — but first a little inorganic chemistry

- All matter is made of **atoms**, either in its elemental form individually (e.g. pure sulfur, S), or in multiples (**molecules**, e.g. oxygen gas, O$_2$); or in combination with other atoms (**molecular compounds**, e.g. water, H$_2$O).

- **25 elements** are essential to life. Of these . . .

- Bulk elements — make up majority of living things. And . . .

- Trace elements — are required in smaller amounts.
The Periodic Table...

Organizes elements by physical properties.

Some elements are missing for clarity sake.
Even atoms have parts.

But when you break down an atom, that's either a fission reaction (atomic bomb) or radioactive decay, and the results are no longer the same element (or isotope); e.g. Carbon has the **atomic number** 6, i.e. it has six protons.
Well Carbon usually has six neutrons; therefore, it has an **atomic mass** of 12 (6 protons + 6 neutrons). However, some Carbon atoms have eight neutrons, for a mass of 14. These are called **isotopes**.

Carbon-14 dating uses the natural radioactive [beta] decay of these into ‘normal’ Nitrogen, with its mass of 14 to estimate the age of biological artifacts.
Atoms can also gain or lose electrons. When this happens, the atoms are called ions, and many are essential to much of life; e.g. Sodium, Na⁺; Potassium, K⁺; Calcium, Ca²⁺; and Chloride, Cl⁻.
How do atoms combine?

* Molecules are combinations of atoms held together by chemical (covalent) bonds. The chemical formula describes this association, e.g. methane, CH₄, has four Hydrogen atoms bonded to one Carbon atom.

* Electrons occupy ‘orbital shells’ around the nucleus of an atom. These are where covalent bonds happen through the ‘sharing’ of electrons in partially filled outer (valence, don’t worry) shells.
The methane example:

1 carbon atom

4 hydrogen atoms

1 methane molecule \((CH_4)\)

\(\text{CH}_4\)

\(\text{H—C—H} \)

\(\text{H} \)

\(\text{H} \)

\(\text{H} \)

\(\text{H} \)

\(\text{H} \)

\(\text{H} \)

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\(\text{H} \)

\(\text{H} \)
Covalent bonds can be... 

- Single, double, triple... depending on the number of shared electron pairs; for example:

  All flammable substances made up of just carbon and hydrogen, but with very different properties depending on the bonding arrangement.
And polarity, huh?

* The ‘balance’ of a bond is it’s polarity.

* A bond can be nonpolar, like those on the previous slide, where there is no ‘offsidedness’ of electronegativity;

* Or they can be polar, like water, where there are negatively and positively charged ends to the molecule.

* Think of a magnet as a metaphor.
An extreme case of polarity is seen in ionic bonds . . .

* They result from an electrical attraction between two ions with opposite charges;
* In general, these form between an atom with a valence shell almost empty and an atom with a valence shell almost full;
* In the NaCl (normal table salt) example these bonds are so strong it forms a crystal:
Here's a nice review.

http://www.youtube.com/watch?v=oNBzyM6TcK8
Hydrogen bonds are special. They happen when . . .

* Opposite partial charges on adjacent molecules, or within the same large molecule, attract each other.
* Hydrogen is usually the partially positive member.
* As we saw with the water example:
  * Two polar covalent bonds per molecule;
  * Oxygen is more electronegative and pulls electrons away from hydrogens; Therefore . . .
  * The partial positive charge on the hydrogens is attracted to the slight negative charge on the oxygen atom of another molecule.
Here's the water model.

The hydrogen bond is vitally important to many biological molecules, including DNA.
Here's an overview of those chemical bonds:

**Table 2.4 Chemical Bonds**

<table>
<thead>
<tr>
<th>Type</th>
<th>Chemical Basis</th>
<th>Strength</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covalent bond</td>
<td>Atoms share electron pairs</td>
<td>Strong</td>
<td>O—H bond within water molecule</td>
</tr>
<tr>
<td>Ionic bond</td>
<td>One atom donates one or more electrons to another atom, forming oppositely charged ions that attract each other</td>
<td>Strong, but break easily in water</td>
<td>Sodium chloride (NaCl)</td>
</tr>
<tr>
<td>Hydrogen bond</td>
<td>Atom with partial negative charge attracts atom with partial positive charge; form between adjacent molecules or between different parts of a large molecule</td>
<td>Weak</td>
<td>Attracts adjacent water molecules to each other</td>
</tr>
</tbody>
</table>
Water! All life needs it; it’s where it all started.

- It’s got a slew of special physical properties that make it so very special. Like . . .
- **Cohesion** — the tendency of water molecules to stick together (to each other). This is . . .
- Based on hydrogen bonding. And creates . . .
- A high surface tension that forms a “skin” strong enough to support small insects and even some lizards.
And adhesion...

* **Adhesion** — the tendency to form hydrogen bonds between water and other substances.

* Cohesion and adhesion work together to create capillary action (like dye in celery stalk experiments).
More about water . . .

* And . . .

* Water is a **solvent** — that is, a chemical in which other substances, called **solute**, dissolve.

* **Solution** — One or more **solute** dissolved in one or more liquid **solvent**.

* **Aqueous solution** — **solvent** is **water**.

* All liquid components of life are aqueous solutions.
Other molecules pretty much either love water . . .

* **Hydrophilic** molecules are polar or ionic.

* Remember, like a magnet. These . . .

* Substances readily dissolve in water; i.e. it is water-loving. An example is sugar or salt in water.

HYPHOPHILIC MOLECULES

Substances that dissolve readily in water are termed **hydrophilic**. They are composed of ions or polar molecules that attract water molecules through electrical charge effects. Water molecules surround each ion or polar molecule on the surface of a solid substance and carry it into solution.

Ionic substances such as sodium chloride dissolve because water molecules are attracted to the positive ($\text{Na}^+$) or negative ($\text{Cl}^-$) charge of each ion.

Polar substances such as urea dissolve because their molecules form hydrogen bonds with the surrounding water molecules.
... Or hate water.

* Hydrophobic molecules are nonpolar.
* Substance does not dissolve in water; i.e. it is water-fearing. An example is oil on water.
Water is also vital to most chemical reactions in life.

* As the medium in which the reaction occurs and/or as a participant in the reaction.

* pH is critical to all this. It measures how acidic or basic a solution is, i.e. how many $\text{H}^+$ ions are floating about, the more $\text{H}^+$, the more acidic and the lower the pH.
Here's a nice review about the pH scale.

Acids, Bases, and pH

- In summary, we use the pH scale to describe the [H+] of a solution by taking the negative logarithm of the actual [H^+]
- pH 7 is arbitrarily described as neutral
- Solutions with pH below 7 have a higher [H+] and are therefore acidic
- Solutions with pH above 7 have a lower [H+] and are therefore basic

http://www.youtube.com/watch?v=gwFR_lph5R0
Next time we’ll extend chemistry to . . .

* Organic compounds. That is, compounds containing Carbon and at least Hydrogen.

* And we’ll see how they make up the biochemicals of life.