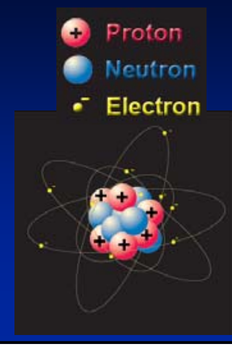
I will post my lectures on the course website in pdf format (no point in wasting paper ☺).

# Atomic Structure

**atom**

1. Smallest particles that retain properties of an element.
2. Contains a nucleus made of protons (+) and neutrons (uncharged), surrounded by clouds of electrons (–)
3. If the number of protons equals the number of electrons there is no net charge.




# Electron orbits

1. The electrons of atoms are contained in orbits with ever increasing energy levels.
2. Each orbit has a maximum number of electrons that it can maintain.
3. Once an inner orbit reaches its maximum number of electrons additional electrons must be housed in the next orbit.
4. The number of electrons in a particular orbit influence an atoms interactions with other atoms.

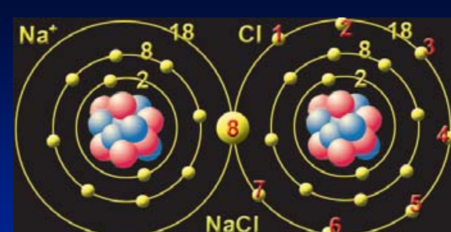

# Electron orbits – example (Na)

1. in a nuetral state, the sodium atom (Na) has 11 protons and 11 electrons.
2. The first two orbits are filled by the first 10 electrons so the 11th electron must occupy the 3rd orbit all by itself. This results in an unstable state for Na.
3. This unstable state often reslts in the loss of the electron in the 3rd orbit. This loss results in an atom with 11 protons and 10 electrons and thus a net positive charge ($Na^+$ - an **"ion"**).
4. When a positively charged atom comes into contact with a negatively charged atom (an atom with an extra electron) they can share that extra electron and form a bond with one another.


# Electron orbits – example (Cl)

1. in a nuetral state, the chloride atom (Cl) has 17 protons and 17 electrons.
2. The first two orbits are filled by the first 10 electrons. The remaining 7 electrons occupy the 3rd orbit. This results in an unstable state for Cl.
3. This unstable state results in the Cl atom grabbing an extra electron and thus resulting in a net negative charge ($Cl^-$ - an **"ion"**).
4. When a positively charged atom comes into contact with a negatively charged atom (an atom with an extra electron) they can share that extra electron and form a bond with one another.


# Electron orbits – example (NaCl)




When the positively charged Na ion atom (missing an electron) comes into contact with a negatively charged Cl ion atom (extra electron) they join and thus match the number of protons for each atom (11 & 17) and form an **"ionic bond"**.

## Isotope

**isotope** – a variant of an atom with a different number of neutrons

- Example: carbon $^{12}C$ vs. $^{14}C$
- Isotopes interacts with other atoms in the same way.
- Uniqueness lets us follow isotopes in the environment, in plants, people, etc.

## Using Isotopes

**Radiocarbon dating**

Archeologist use the proportions of $^{12}C$ and $^{14}C$ in dead organic matter to estimate how long it has been dead.

Plants incorporate $^{12}C$ and $^{14}C$ in the production of molecules from the atmosphere. Therefore the proportion of $^{12}C$ and $^{14}C$ in plants is similar to that found in the atmosphere. When consumers eat plants they too incorporate the same $^{12}C$ and $^{14}C$ proportions into their molecules.

$^{14}C$ slowly decays into $^{14}N$. When an organism dies it no longer adds $^{14}C$ to its tissue – Therefore, as $^{14}C$ decays over time the ratio of $^{14}C$ to $^{12}C$ decreases. The rate of decay for $^{14}C$ 5,730 years for half of the atoms present to be converted to $^{14}N$ (half-life of 5,730 years) that is, if you had one million $^{14}C$ atoms there would be ½ million 5,730 years later.

## Molecules

**molecule** – 2 or more atoms bound together.

- example: NaCl, $H_2O$, $O_2$

**ions** – atoms or molecules that are charged (i.e., + or –) due to the loss or gain of an electron or electrons

- example: $Na^+$ and $Cl^-$

## Molecular Bonds

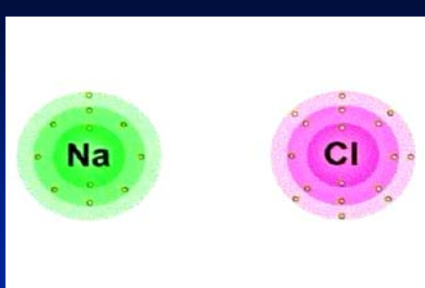
**ionic bond** – two ions that are held together by opposite charges

- **+ and** – attract
- example: $Na^+ + Cl^- \rightarrow NaCl$

**covalent bond** – electrons are shared between atoms.These bonds are the result of atoms that each contribute an electron to the other. Very strong bonds.

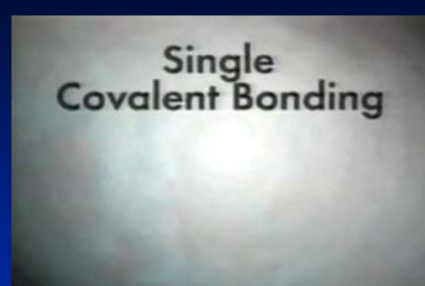
- example: Single covalent bond involves 2 shared electrons (1 from each atom) $H_2$ **=** **(**H-H)
- example: Double covalent bonds - each atom donates 2 electrons for a total of 4 shared electrons $O_2$= (O=O)

## Molecular Bonds




ionic bond

## Molecular Bonds




covalent bond

## Molecular Bonds

nonpolar covalent bond – two identical atoms share electrons equally, and the molecule shows no difference in charge between its two ends. They are symmetrical.

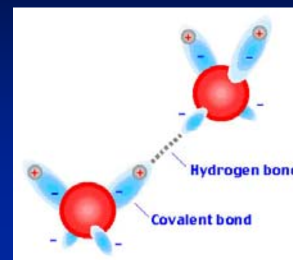
Eg. H–H, O=O and N≡N

polar covalent bond – bonds formed between atoms of different elements. One of the atoms pulls the shared electron a little more than the other. This results in a slightly negative charge on that end of the bond.

- Example: $H_2O$ – has two polar covalent bonds; the oxygen is negatively charged and the hydrogen's are positive.

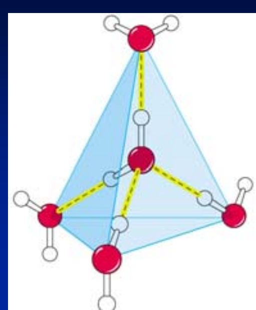

## Molecular Bonds

**hydrogen bond** – weak attraction between an electronegative atom and a hydrogen atom



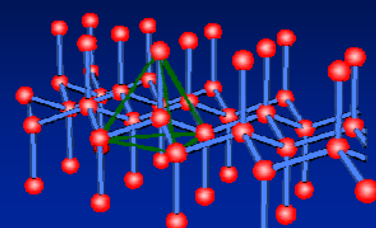

## Molecular Bonds

Hydrogen bonds are weak but can stabilize a structure.



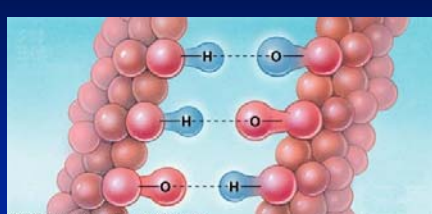
## Molecular Bonds

Below 0°C, each water molecule hydrogen bonds to four others in a three dimensional lattice and forms ice.



## Molecular Bonds

Hydrogen bonds can link chains.




## Molecular Bonds

Hydrogen bonds can cause a molecule to twist back on itself.

## Properties of Water

1. Water is slightly polar and can hydrogen bond to itself or many other polar molecules.
2. Water repels nonpolar molecules such as oils. This property is employed in cell walls to protect inner chemistry.
3. Water stabilizes temperatures. Hydrogen bonds buffer changes in temperature.
4. Water is cohesive.
   Water stands on a surface.
   Water can be pulled up pipelines in plants.
5. Water is a great solvent.
6. Water is used in many metabolic reactions.

## Organic Macromolecules

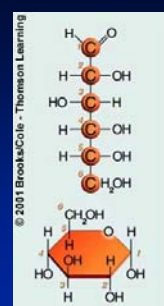
"Molecules of Life"

- Carbohydrates – made of simple sugars
- Lipids – made of fatty acids
- Proteins – made of amino acids
- nucleic acids – made of nucleotides
- made up primarily from Carbon, Hydrogen, Oxygen, and Nitrogen (C, H, O, N)

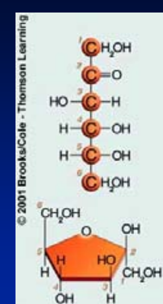
## Carbohydrates

1. Make up structural materials in cells
2. Are storage forms of energy
3. Most have a chemical formula of $(CH_2O)n$
4. Monosaccharides are single sugar molecules with 5 or 6 carbon atoms
   Examples: ribose ($C_5H_{10}O_5$) and glucose ($C_6H_{12}O_6$)
5. Disaccharides are made of two sugars
   Example: sucrose ($C_{12}H_{22}O_{11}$)

## Carbohydrates

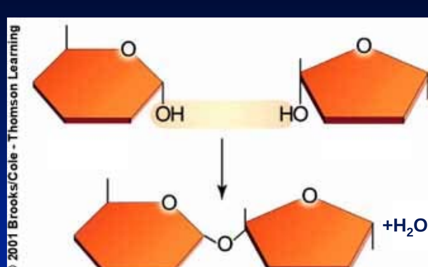



Glucose



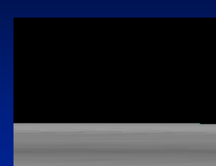

Fructose

## Sucrose




Glucose (top left) combines with Fructose (top right) to produce Sucrose (below) and one molecule of water.

## Condensation and Hydrolysis



## Polysaccharides

Polysaccharides are complex carbohydrates of straight or branched chains of many sugars

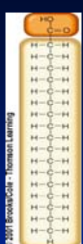
Examples: cellulose, starch, glycogen.

## Lipids

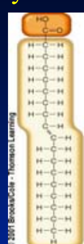
Lipids – fats, oils, waxes

1. Are structural elements (cell membranes and surface coatings)
2. Are energy reserves
3. Are signaling molecules
4. Are nonpolar hydrocarbons with a chemical formula of $(CH_2)n$
5. Don't dissolve in water

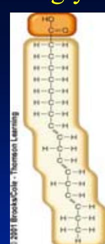
## Fats have 1, 2, or 3 fatty acids attached to a glycerol



Stearic Acid
saturated fatty acid
single bonds on tail



Oleic Acid
monounsaturated fatty acid
one double bond on tail

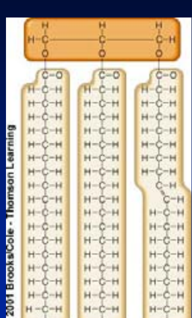


Linolenic Acid
polyunsaturated fatty acid
>one double bond on tail

## Fats

1. Most <u>animal fats</u> have <u>saturated fatty acids</u> and are usually solid at room temp.
2. Most <u>plant fats</u> (vegetable oils) have <u>unsaturated fatty acids</u> and are usually liquid at room temp.

## Triglyceride

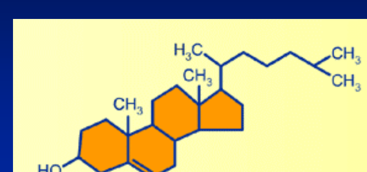


1. Triglyceride=3 fatty acids attached to a glycerol (at top)
2. Triglycerides are the body's richest energy source. Insulate animal bodies.
3. Examples: butter, lard, vegetable oils, and natural fats

## Sterols

Sterols – lipids with no fatty acids

Example: cholesterol, estrogen, testosterone

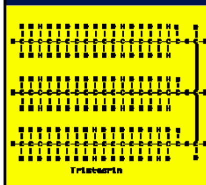
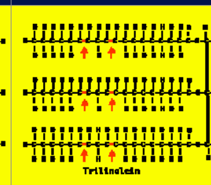
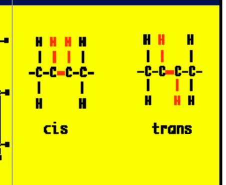


# Waxes

Waxes – lipids that are rigid, yet flexible and repel water.

- Example: Covering (cuticle) of plants, skin, hair, beeswax.

# Fats

| Saturated Fat | Unsaturated Fat | "Trans-Fat" |
|---|---|---|
|   |   |   |
| Hard at room temperature | Liquid at room temperature | Hard at room temperature |
| Mostly animal fats | Mostly vegetable oils | Hydrogenated vegetable oils |

## Limit ALL Fat Intake

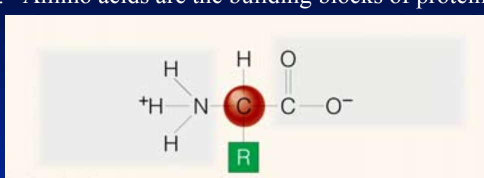
| Saturated Fat | Unsaturated Fat | "Trans-Fat" |
|---|---|---|
| "Bad Fat" | "Good Fat" | "VERY Bad Fat" |
| ↑ Bad cholesterol | ↓ Bad cholesterol, maintains good cholesterol | ↑ Bad cholesterol, ↓ good cholesterol |
| Butter, lard, fatty red meat, full-fat dairy | Olive, peanut, & canola oil; avocados, seeds, fish | Processed foods, fast foods, margarine, cookies, cakes, doughnuts, potato chips, French fries |

# Proteins

1. Most diverse of the large biological molecules
2. Enzymes are proteins that make reactions go faster
3. Found in structural elements such as feathers, bones, cartilage, muscles, hair, spider webs, etc.
4. Move molecules across membranes and through fluids
5. Are nutritious and found in eggs and seeds
6. Hormones are proteins that signal changes in cell activities

# Amino Acids

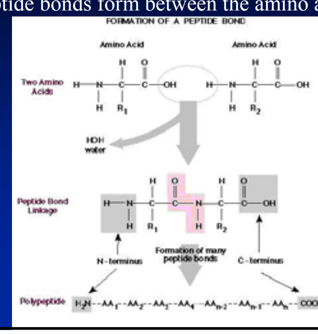
1. Only 20 amino acids produce <u>all</u> proteins!
2. Amino acids are the building blocks of proteins




A generalized structural formula for amino acids. The "R" group differs for each amino acid.

# Peptide Bonds

When amino acids bond together to form proteins, it is a dehydration process. Peptide bonds form between the amino acids.



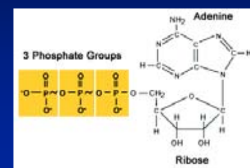
## Proteins

1. Proteins can have many different structures – chains, coiled, pleated sheets, or folded into a 3-D shape.
2. Proteins can attach to each other.

## Nucleic Acid

1. A nucleotide is a sugar, carbon ring with nitrogen (nitrogenous base), and ≥1 phosphate groups
2. Cells have free nucleotides floating around inside.

   Examples: cytosine, ATP (adenosine triphosphate)




3. ATP drives most energy-requiring metabolic reactions.

## Nucleic Acid

1. A nucleic acid consists of nucleotides in single or double-stranded chains.

   Example: DNA and RNA.
2. DNA (deoxyribonucleic acid) contains genetic information. DNA codes for proteins.
3. DNA has two helically-coiled strands of nucleotides with hydrogen bonds between the strands of nucleotides.
4. 4 nucleotide building blocks are involved: adenine, cytosine, guanine, thymine

## RNA

1. RNA (ribonucleic acid) takes DNA code and makes proteins
2. There are three classes of single-stranded RNAs:

   mRNA (messenger)

   rRNA (ribosomal)

   tRNA (transfer)
3. 4 nucleotide building blocks are involved: adenine, cytosine, guanine, uracil