Biological Building Blocks I

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9/12/11

What are we made of?

- Chemical Bonds
  - Covalent and Ionic
- Important Biological Molecules
  - Carbohydrates
  - Fats and Membranes
    - Energy storage and compartmentalization
  - Amino Acids
    - Building blocks of proteins/enzymes
  - Nucleic Acids
    - Building blocks of DNA and RNA

Observation

Solid to Solution

- Both sugar and salt "go into solution"
  - Solvent being water
  - Solute being sugar or salt

- But what really happens to them then?

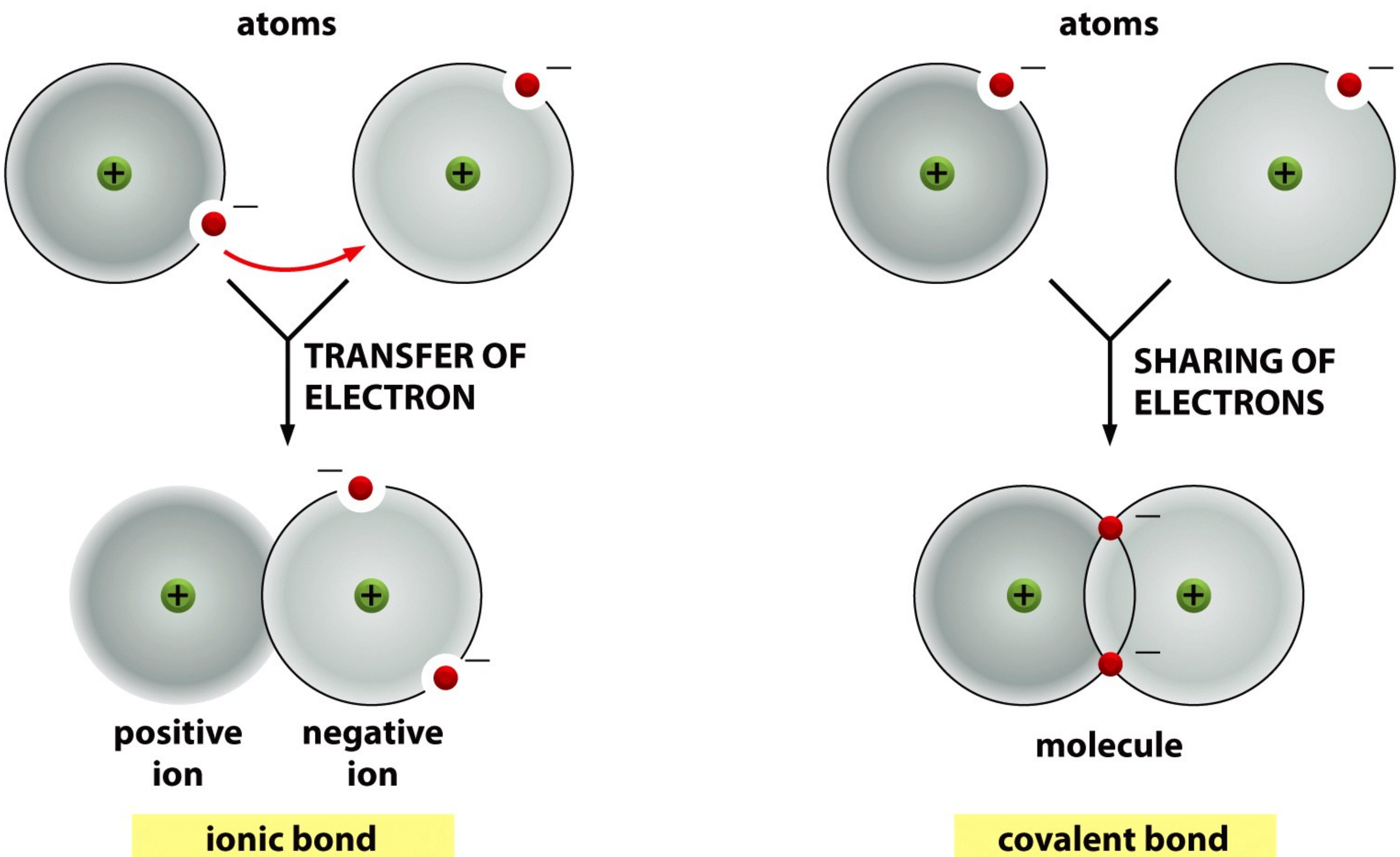
- If you could observe with your eyes:
  - Na**+** and Cl**-** molecules surrounded by water
  - $C_{12}H_{22}O_{11}$ surrounded by water

Why does salt “dissociate” and sugar stay together?

- All about the types of bonds molecules form
  - Ionic Bonds: Very strong electrostatic attraction
    - Although very strong, water can break them apart
  - Covalent Bonds: Sharing of electrons between atoms
    - weaker than ionic, but can not be broken by water (example sugar)
    - only outermost electrons (valence) interact
    - Single bonds: weaker bonds, longer, and atoms can rotate
    - Double bonds and Triple bonds: stronger, shorter bonds: atoms can not rotate (bond is more rigid)

Why does salt "dissociate" and sugar stay together?

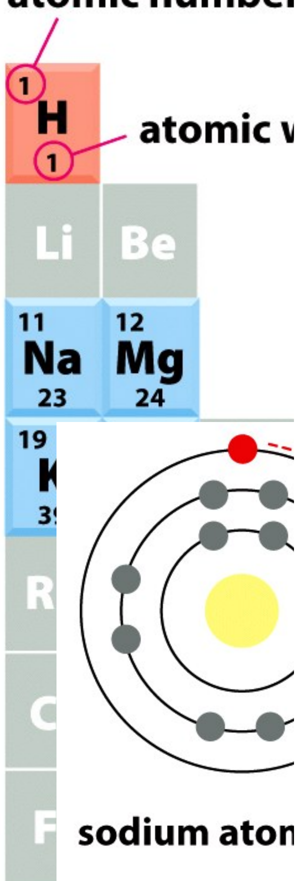
- All about the types of bonds molecules form



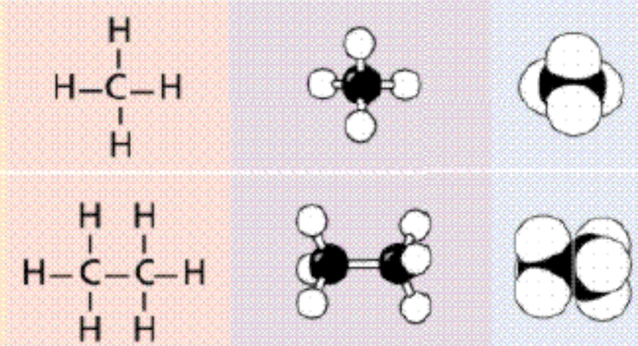
It all comes back to the periodic table

Rows go hori … e; 3rd row..

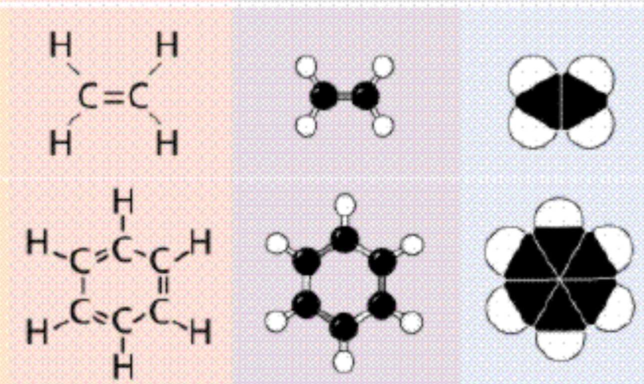
Columns go vertically and have same number of electrons in their valence shells

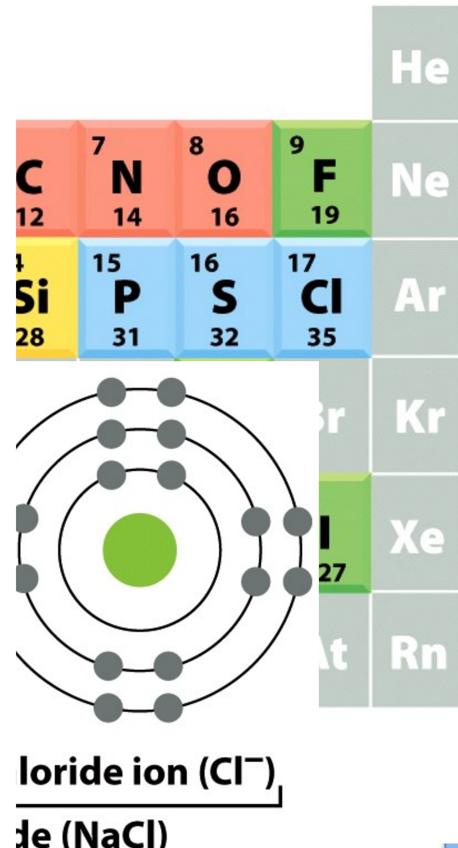


Compound (molecular formula)	Structural formula	Ball-and-stick model	Space-filling model
Methane CH_4			
Ethane C_2H_6			



Compound (molecular formula)	Structural formula	Ball-and-stick model	Space-filling model
Ethylene (Ethene) C_2H_4			
Benzene C_6H_6			





Images from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com)

Figure 2-8a *Essential Cell Biology*

Figure 2-7

Covalent bonds and number of electrons

Valence Number:

1. Valence number of an element is the typical number of bonds it makes with other atoms.
2. Each element is different in the number of bonds it prefers to make. Why?
3. Each single bond is made of two shared electrons.

Valence Electrons:

1. How do you determine the number of valence electrons owned by each element?
2. When bonds are made, each atom tries to fill up its outer shell.
3. The number of electrons needed to fill up the outer shell is two (1^{st} Row), eight (2^{nd} Row), or sixteen (3^{rd} row)

Atom	C	H	O	S	N	P	Cl
Valence (# bonds)	4	1	2	2*	3	5	1*
# Lone pairs	0	0	2	2	1	0	3
Total val electrons	8	2	8	8	8	10	8

S and Cl can have more than eight electrons in their valence shells.

To understand Biological Molecules, we need to understand bonding

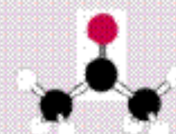
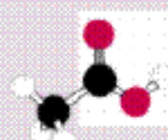
- To understand bonding, we need to understand electrons:

1. For a neutral atom, the number of electrons equals the number of protons
2. For a neutral atom, the total number of electrons is the same as the atomic number
3. Inner shell electrons are buried and don't interact with the environment
4. Outershell (valence) electrons can be shared in bonds or unshared in lone pairs
5. The number of outershell electrons is the same for each of the elements in a column in the periodic table

How is Bonding related to Valence?

Example Molecules

Look for number of bonds:
- Hydrogen
- Oxygen
- Carbon
- Nitrogen

Functional group	Class of compounds	Structural formula	Example	Ball-and-stick model
Hydroxyl —OH	Alcohols	R—OH	Ethanol	
Carbonyl —CHO	Aldehydes	R—C(=O)—H	Acetaldehyde	
Carbonyl >CO	Ketones	R—C(=O)—R	Acetone	
Carboxyl —COOH	Carboxylic acids	R—C(=O)—OH	Acetic acid	
Amino —NH_2	Amines	R—N(—H)—H	Methylamine	

Sugars we know

- Table sugar (cane or beet sugar)
  - Crystallin Sucrose, a disaccharide of glucose and fructose
- High Fructose Corn Syrup
  - Mostly a mix of fructose and glucose in water

Some sweet basics

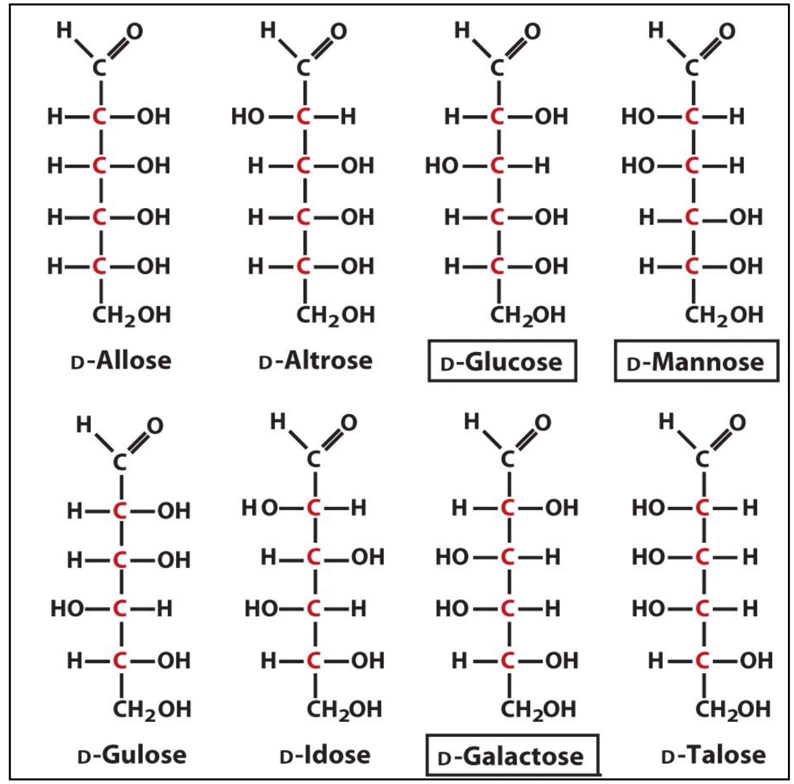
- All sugars have the suffix: -ose
- Are carbohydrates (means carbon plus water)
- Two classes of simple sugars

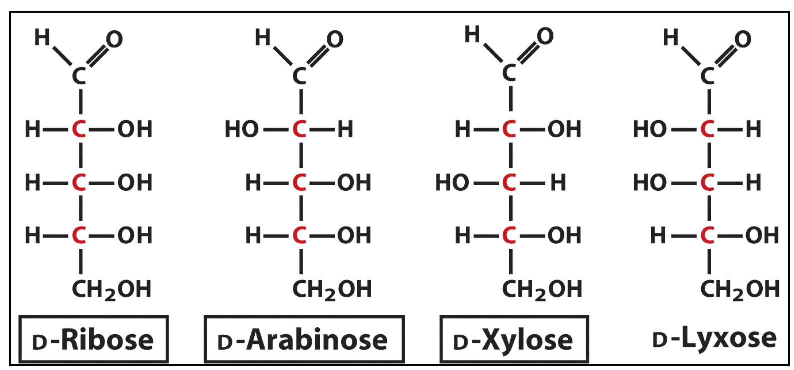
  Keto Aldo

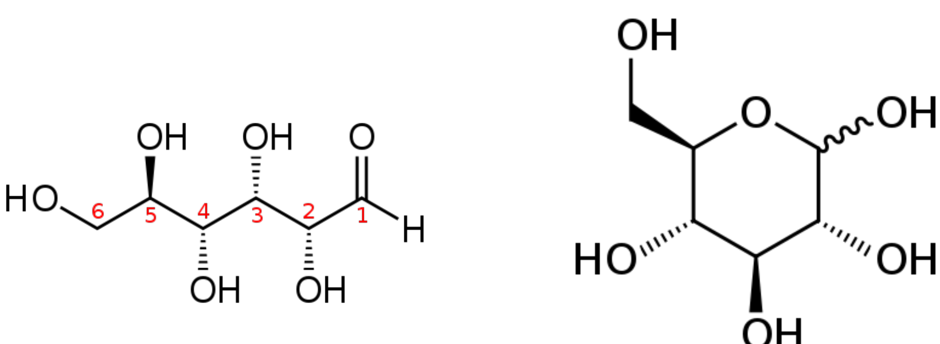
- Simple sugars can contain 5 or 6 carbons
  - Hexose or pentose

Some Hexose and Pentose sugars

- Carbohydrates
  - CH_2O
- Sugars like to cyclize
  - Straight Chain
  - Ring form



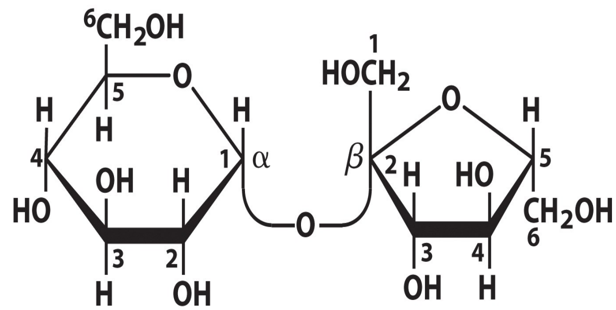




Glucose

Sugars get complex

- “Complex Carbohydrates”
  - Disaccharides and Oligosaccarides



Sucrose

Biology can link different simple sugars together to make new molecules for different tasks.

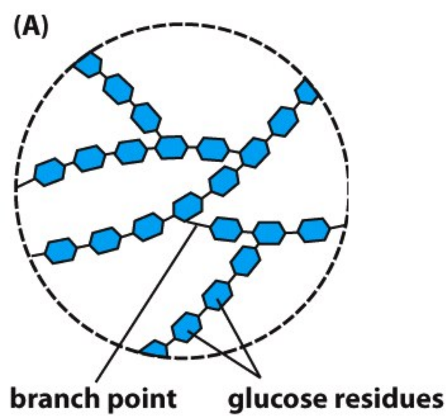
Two Complex Uses of Sugars

- Glycogen
  - Easily accessed source of glucose
  - Controlled storage and release
    - Amount of glucose in blood
    - Insulin, used to trigger glucose storage
- Blood Type

Glycogen

- Primary polysaccharide used to store energy
  - Primarily stored in the liver and muscles
  - Polymer of thousands of glucose molecules

- Reservoir of stored energy
  - About enough to last one day



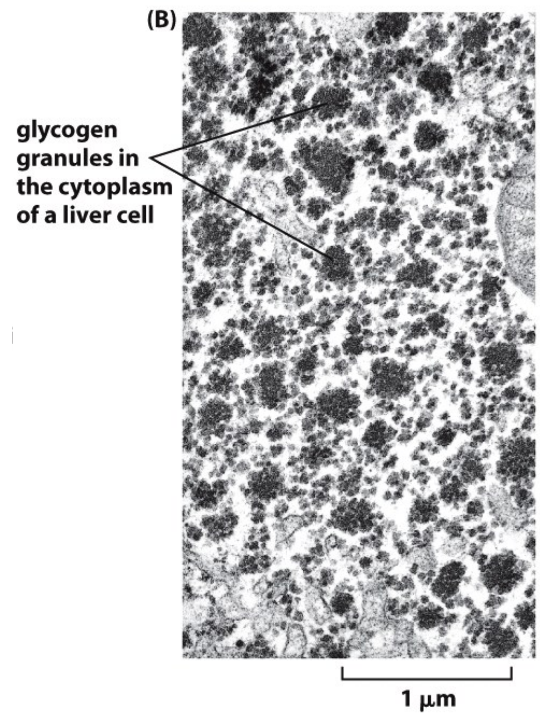
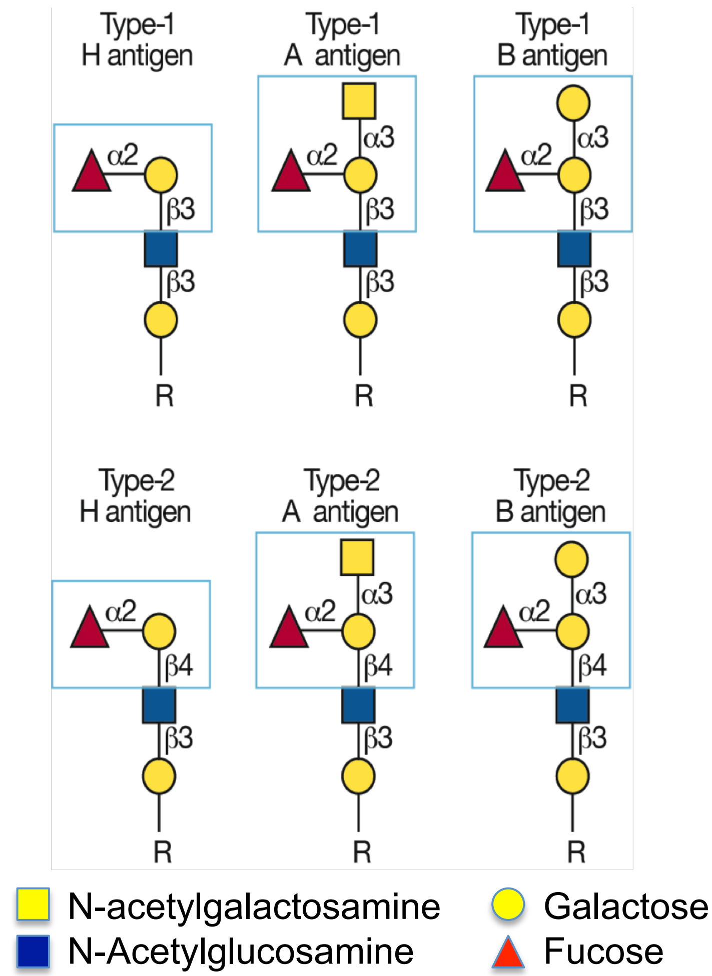


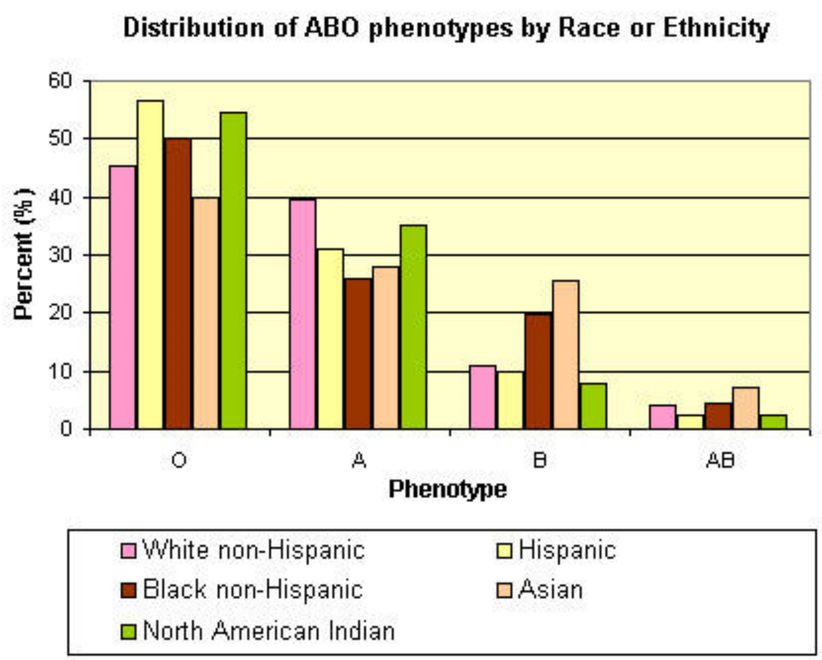
Figure 13-21 *Essential Cell Biology*

ABO Blood types defined by sugars

- Blood sugar groups are assembled by enzymes that catalyze specific reactions
- Sugar groups are transferred to outer membrane of RBC
- Our DNA determines which enzymes we have, therefore what sugars get added.
- Sugars recognized by antibodies



The ABO blood group differ in the kind of sugars on the red blood cell



- The functions of many of the blood group antigens are not known, and if they are missing from the red blood cell membrane, there is no ill effect.
- This suggests that if the blood group antigens used to have a function, e.g., one particular blood group antigen made red blood cells more resistant to invasion from a parasite, it is no longer relevant today.