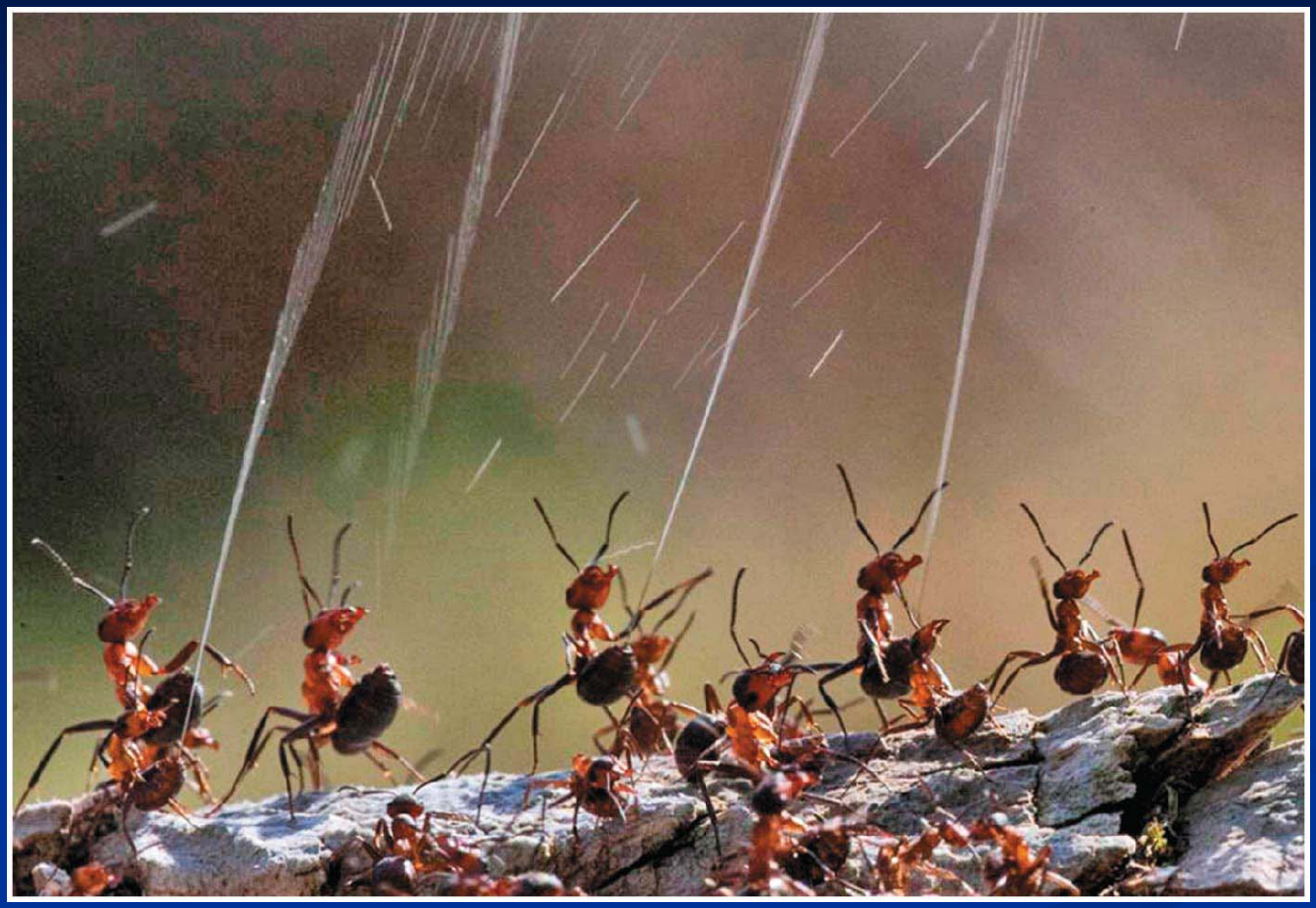
Chapter 2

The Chemical Context of Life

Wood Ants & Acid



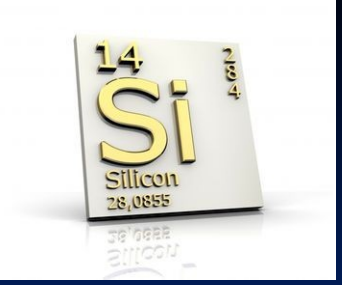
Ants shoot formic acid to defend themselves from attacks from predators (birds).

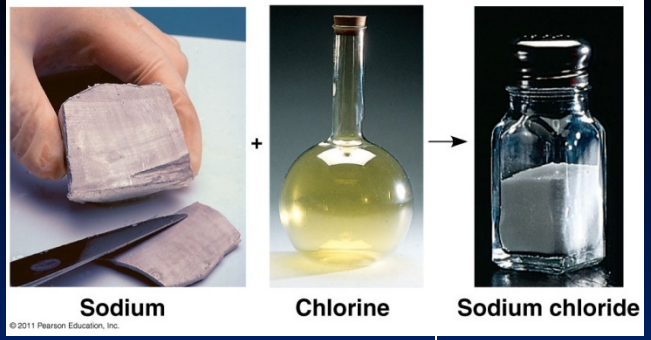
You Must Know

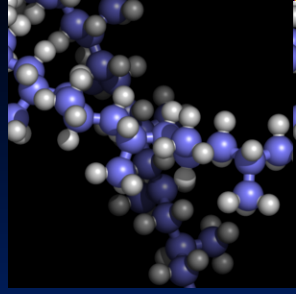
- The three subatomic particles and their significance.
- The types of bonds and how they form.

I. Matter vs. Energy

Matter	Energy
▪ Has mass & takes up space ▪ Affected by gravity ▪ Consists of elements and compounds	▪ Moves matter ▪ Potential, kinetic ▪ Ability to do work ▪ Conversions ▪ Sound, light, heat





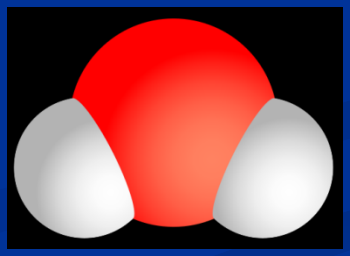


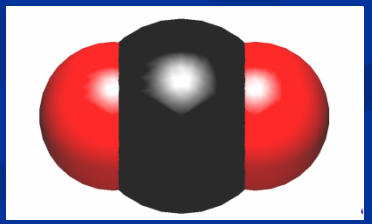
Element

- "pure" substance
- Can't be broken down by "ordinary" means to another substance
- Ex. hydrogen (H), nitrogen (N)

Compound

- 2 or more different elements combined in a fixed ratio
- Ex. H_2O, CO_2





Elements of Life

- 25 elements
  - 96% : O, C, H, N
  - ~ 4% : P, S, Ca, K & trace elements (ex: Fe, I)

Hint: Remember **CHNOPS**

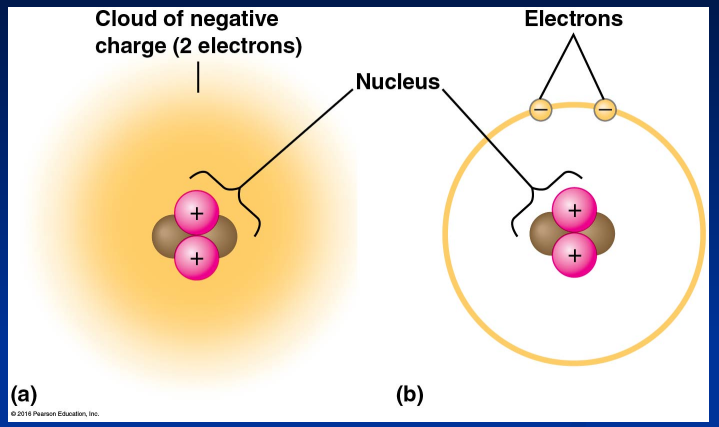
Table 2.1 Elements in the Human Body

Element	Symbol	Percentage of Body Mass (including water)	
Oxygen	O	65.0%	96.3%
Carbon	C	18.5%	
Hydrogen	H	9.5%	
Nitrogen	N	3.3%	
Calcium	Ca	1.5%	3.7%
Phosphorus	P	1.0%	
Potassium	K	0.4%	
Sulfur	S	0.3%	
Sodium	Na	0.2%	
Chlorine	Cl	0.2%	
Magnesium	Mg	0.1%	

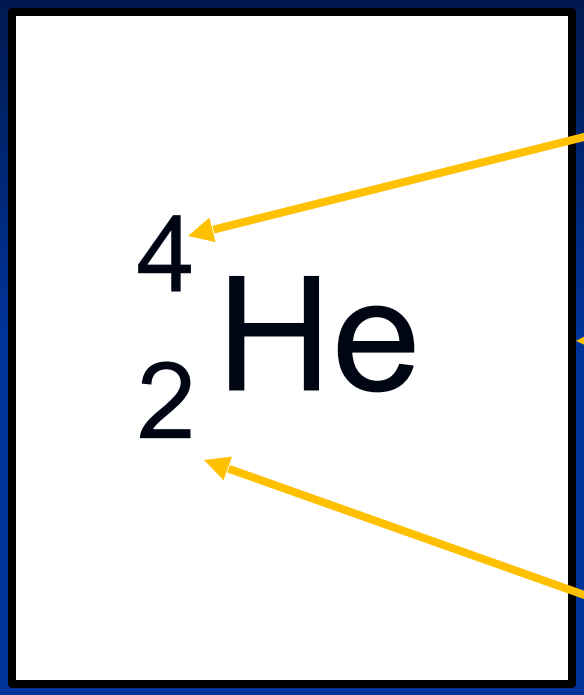
Trace elements (less than 0.01% of mass): Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)

II. Atomic Structure

- Atom = smallest unit of matter that retains properties of an element
- Subatomic particles:



	Mass (dalton or AMU)	Location	Charge
neutron	1	nucleus	0
proton	1	nucleus	+1
electron	negligible	shell	-1



Mass # (protons + neutrons)

symbol

Atomic # (protons or electrons)

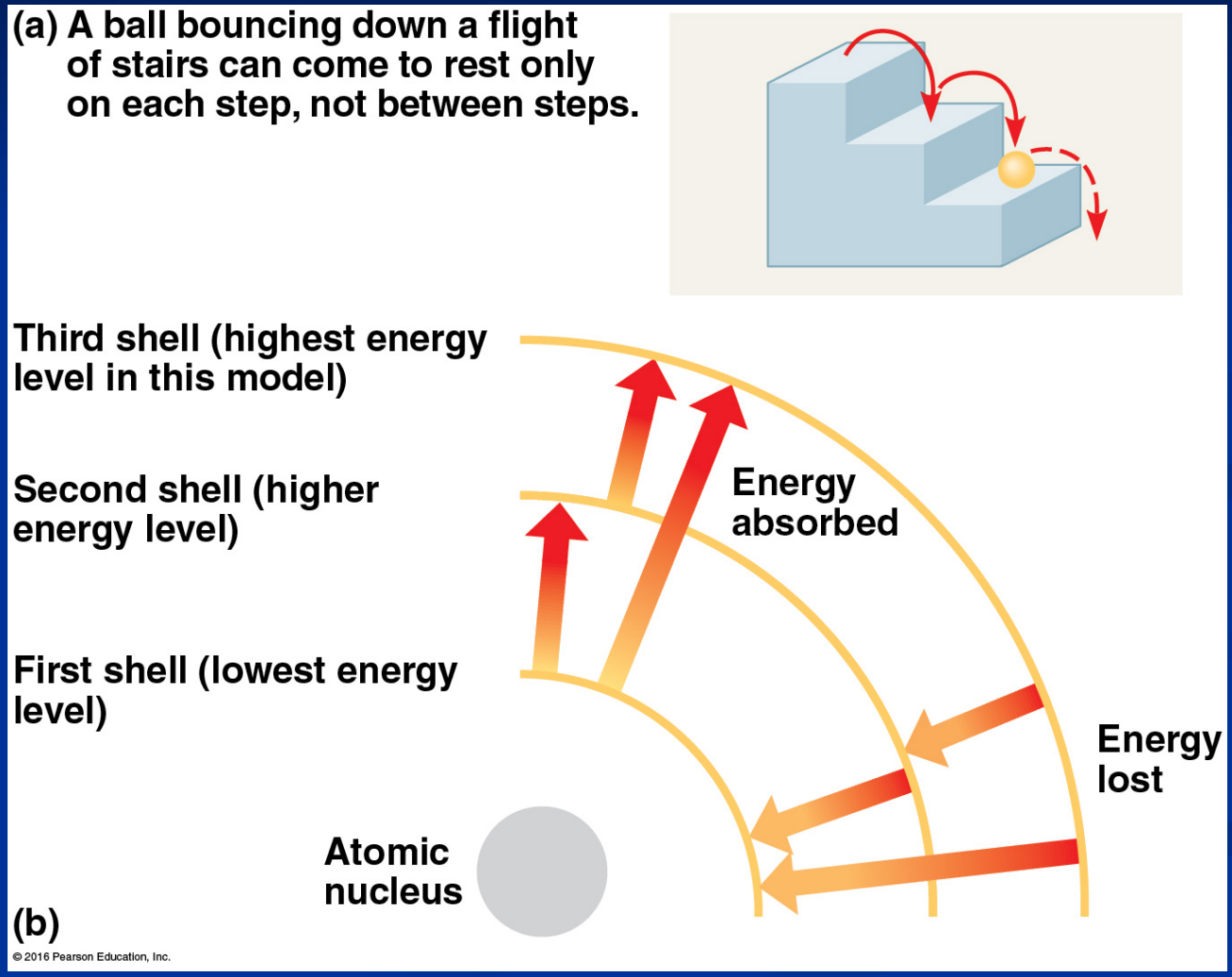
Isotopes

- # neutrons varies, but same # of protons
- Radioactive isotopes used as tracers (follow molecules, medical diagnosis)
- Uncontrolled exposure causes harm

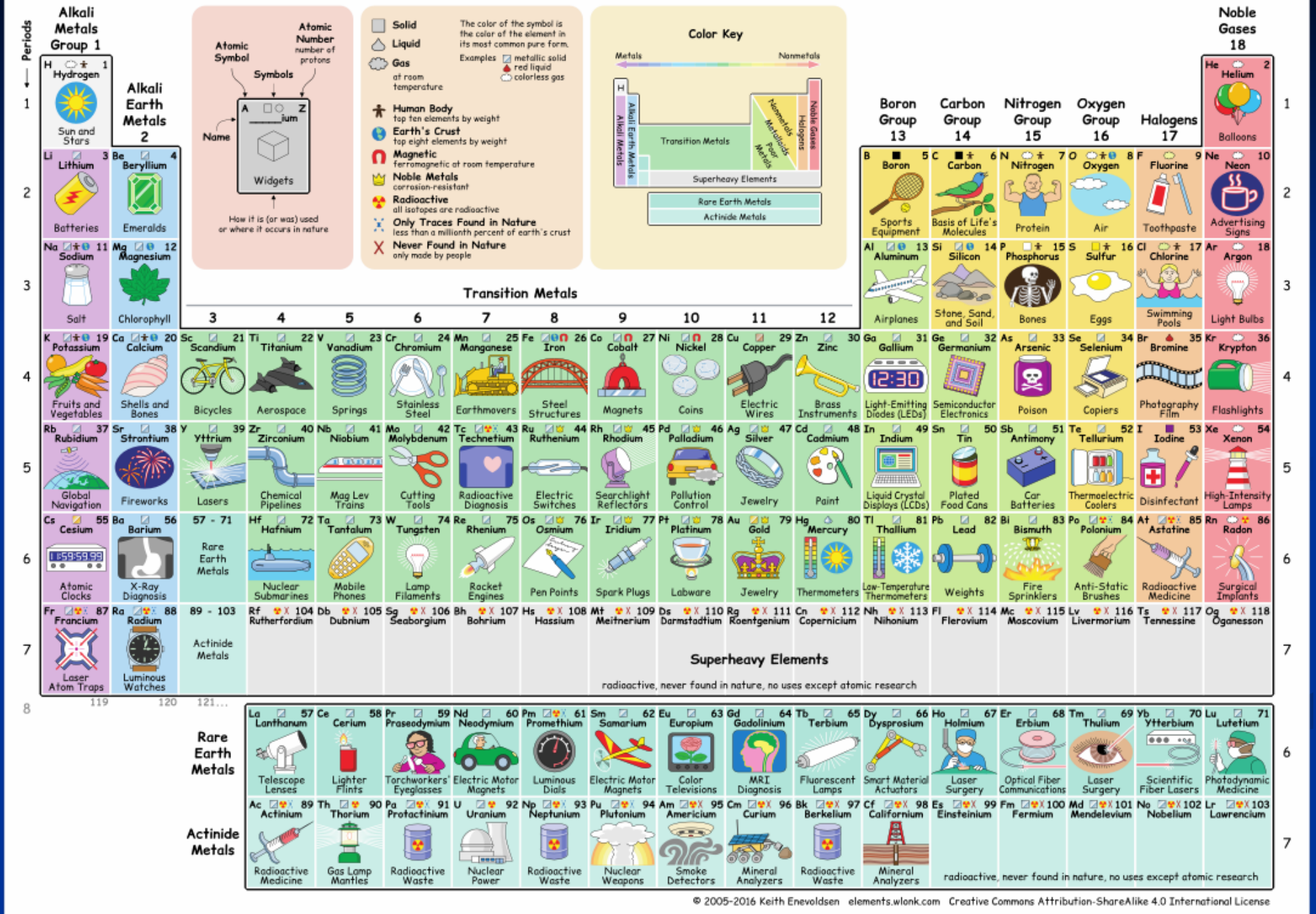
TABLE 2.4 ISOTOPES OF CARBON

	Carbon-12	Carbon-13	Carbon-14
Protons	6	6	6
Neutrons	6	7	8
Electrons	6	6	6

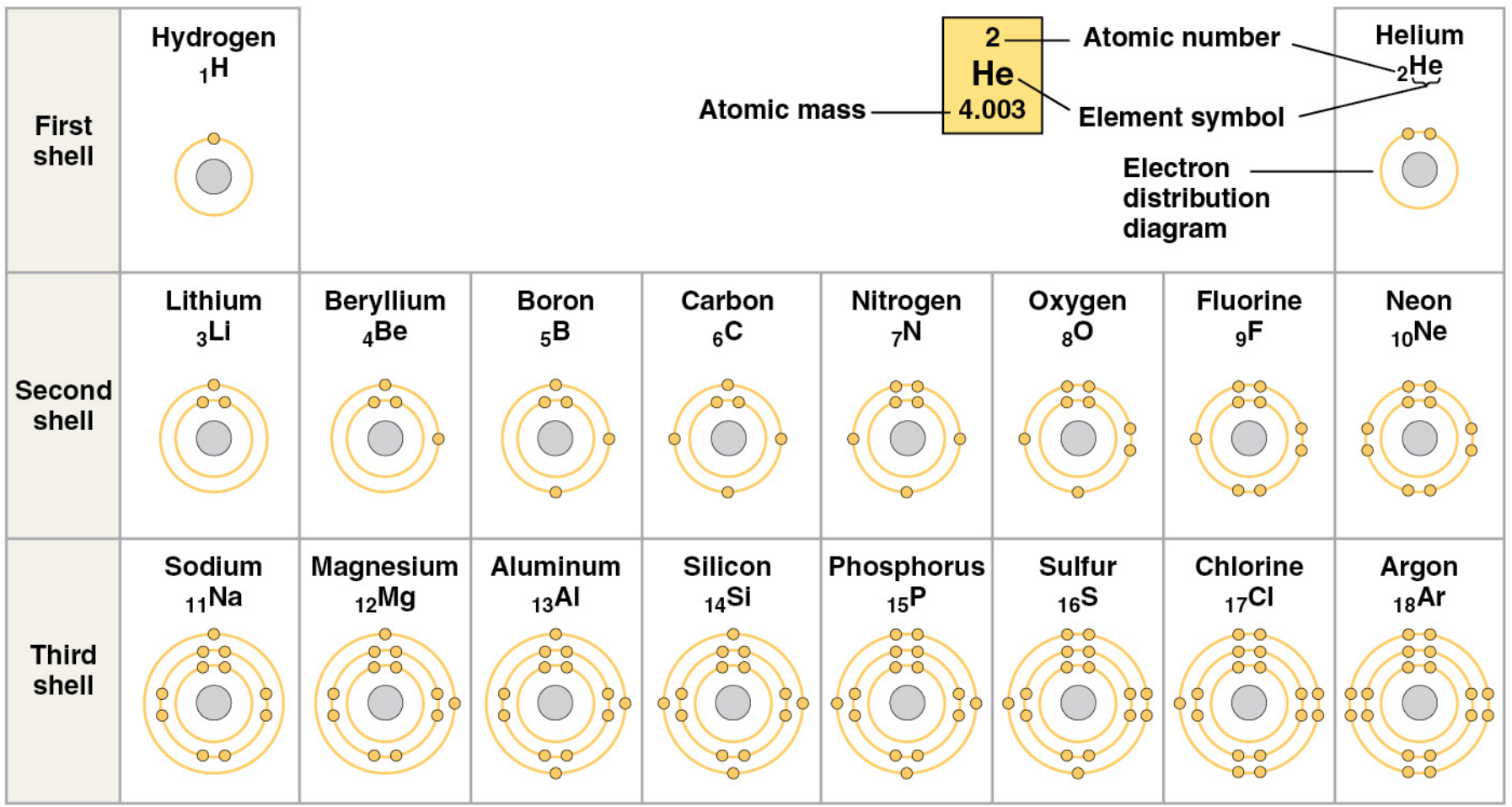
Electrons exist only at fixed levels of potential energy called electron shells



The Periodic Table of the Elements, in Pictures



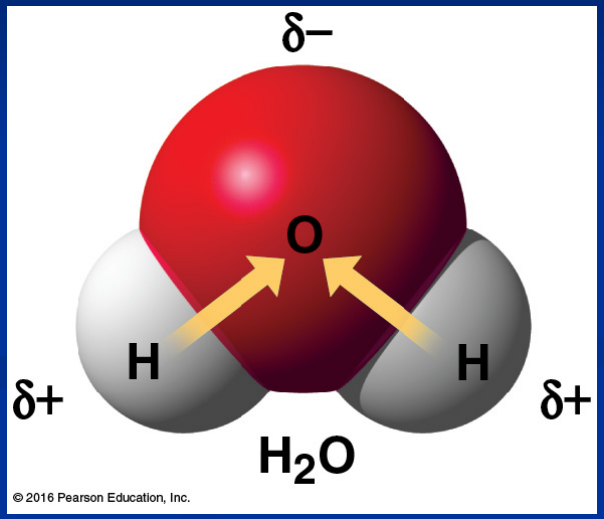
Valence Electrons



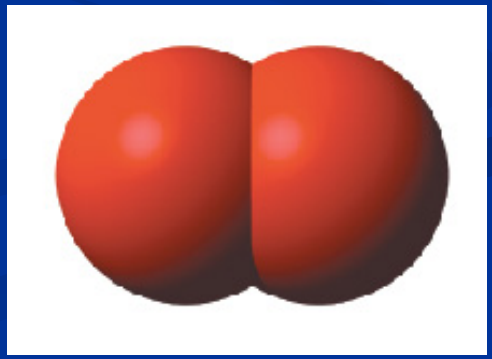
III. Chemical Bonds

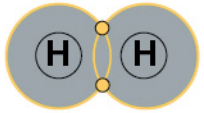
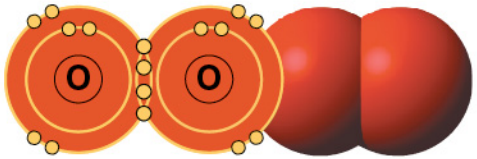
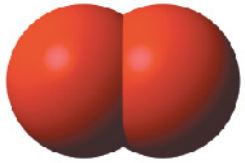
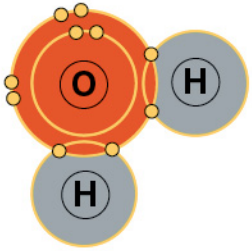
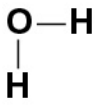
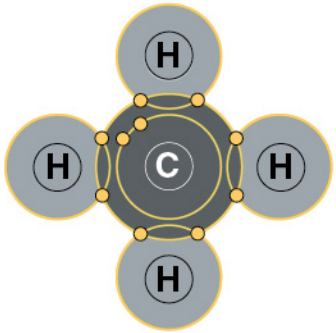
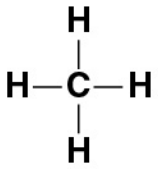
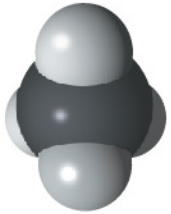
Strongest Bonds:

1. **Covalent**: sharing of e-
   - **Polar**: covalent bond between atoms that differ in *electronegativity*
     - Eg. H_20



   - **Nonpolar**: e- shared equally;
     - Eg. O_2 or H_2

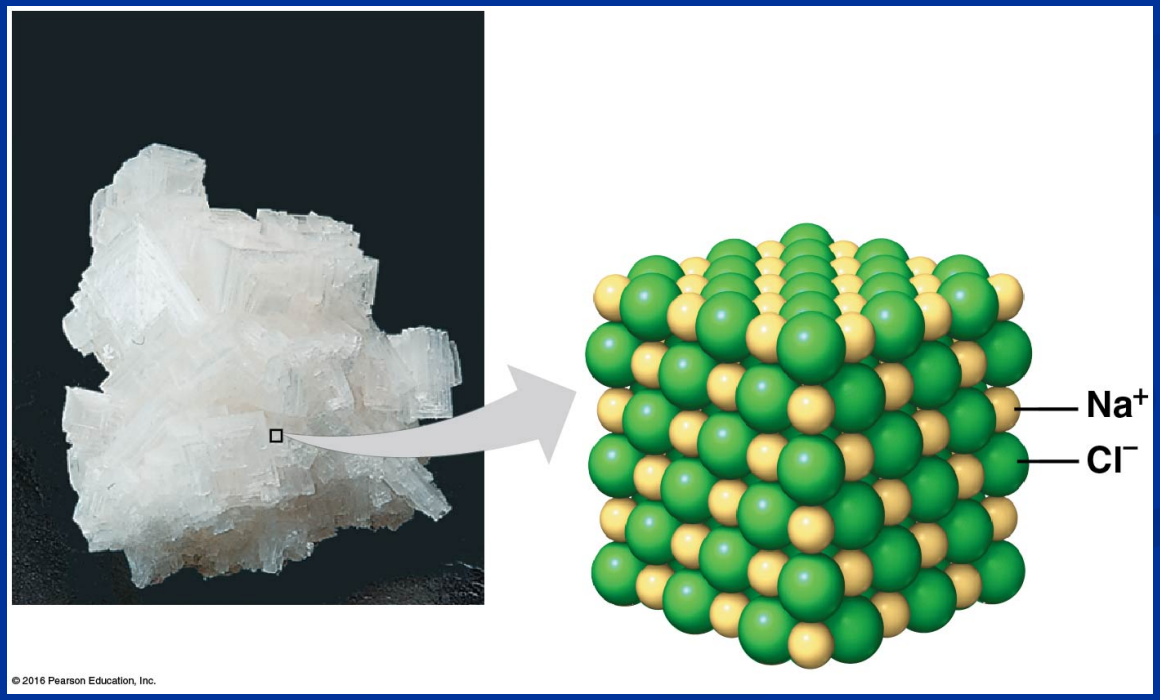


Name and Molecular Formula	Electron Distribution Diagram	Structural Formula	Space-Filling Model
(a) Hydrogen (H_2)		H—H	
(b) Oxygen (O_2)		O=O	
(c) Water (H_2O)			
(d) Methane (CH_4)			

III. Chemical Bonds

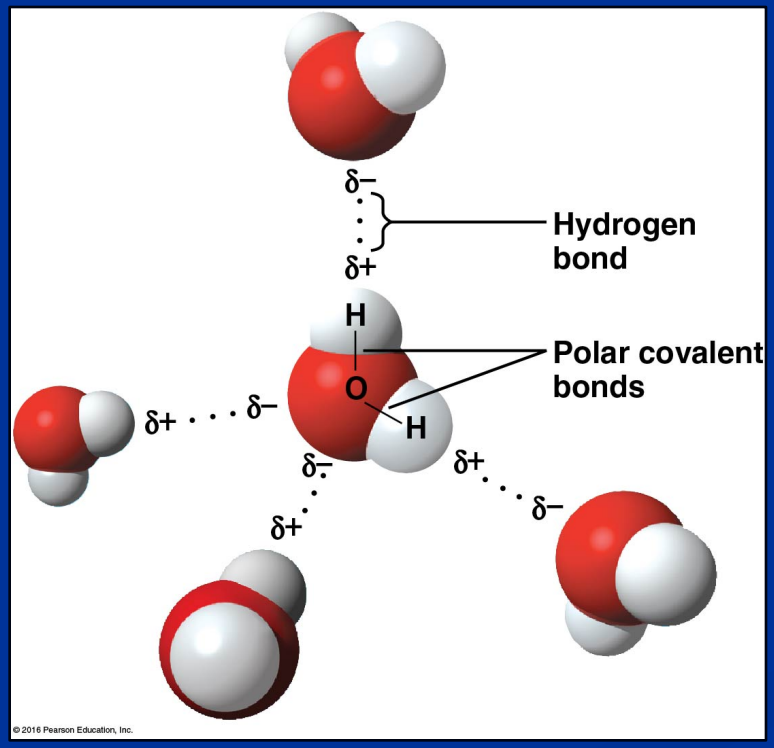
Strongest Bonds:

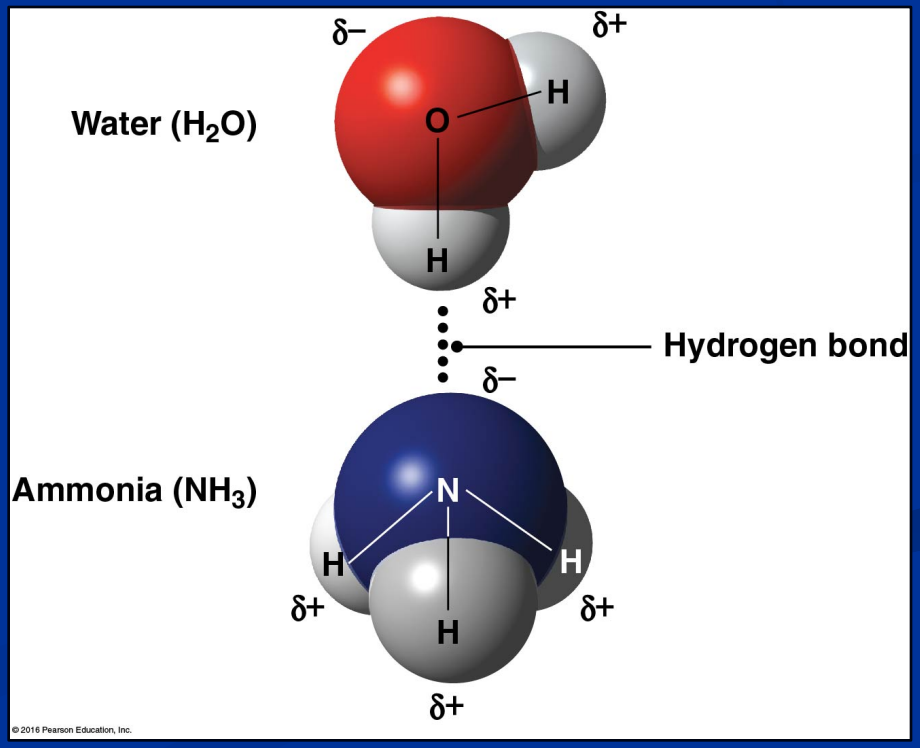
2. Ionic: 2 ions (+/-) bond (givers/takers)
   - Na^+Cl^-
   - Affected by environment (eg. water)



Weaker Bonds:

3. Hydrogen: H of *polar covalent* molecule bonds to electronegative atom of *other polar covalent* molecules





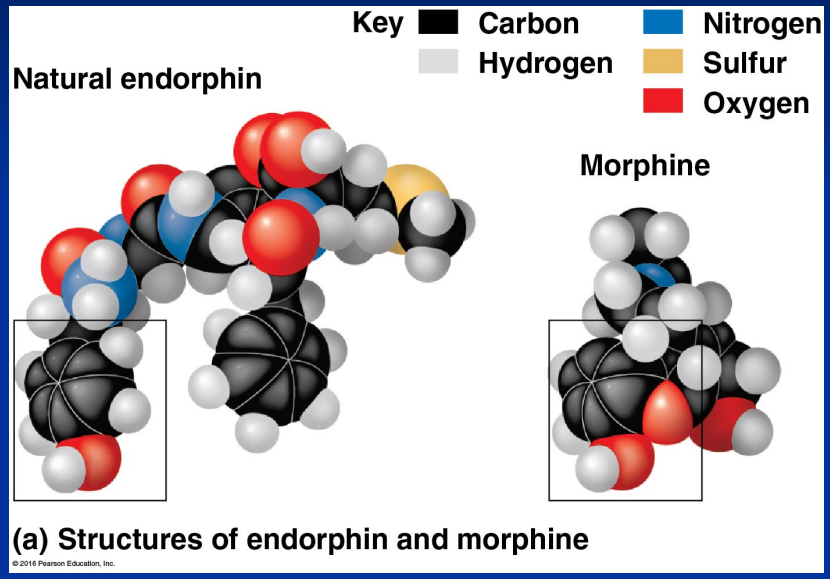
Weaker Bonds:

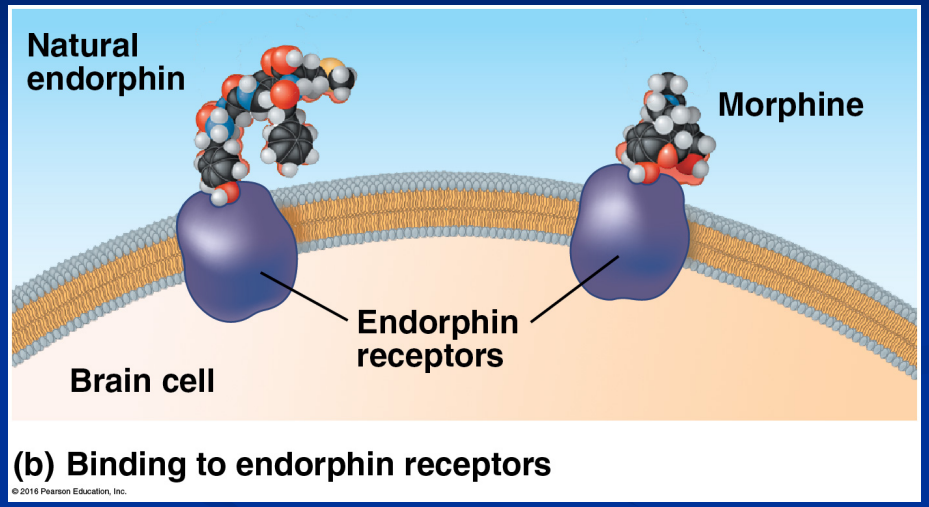
4. Van der Waals Interactions: slight, fleeting attractions between atoms and molecules close together
   - Weakest bond
   - Eg. gecko toe hairs + wall surface

Bonds

Covalent	Ionic	Hydrogen
All important to life		
Form cell's molecules	Quick reactions/ responses	H bonds to other electronegative atoms
Strong bond	Weaker bond (esp. in H_2O)	Even weaker
Made and broken by chemical reactions		

A molecule's STRUCTURE (SHAPE) affects a molecule's FUNCTION





- Similar shapes = mimic
  - morphine, heroin, opiates mimic endorphin (euphoria, relieve pain)

Chemical Reactions

- **Reactants → Products**
  - Eg. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + O_2$
- Some reactions are reversible:
  - Eg. $3H_2 + N_2 \rightleftharpoons 2NH_3$
- **Chemical equilibrium**: point at which forward and reverse reactions offset one another exactly
  - Reactions still occurring, but **no net change** in concentrations of reactants/products