

# Why Study Biology?



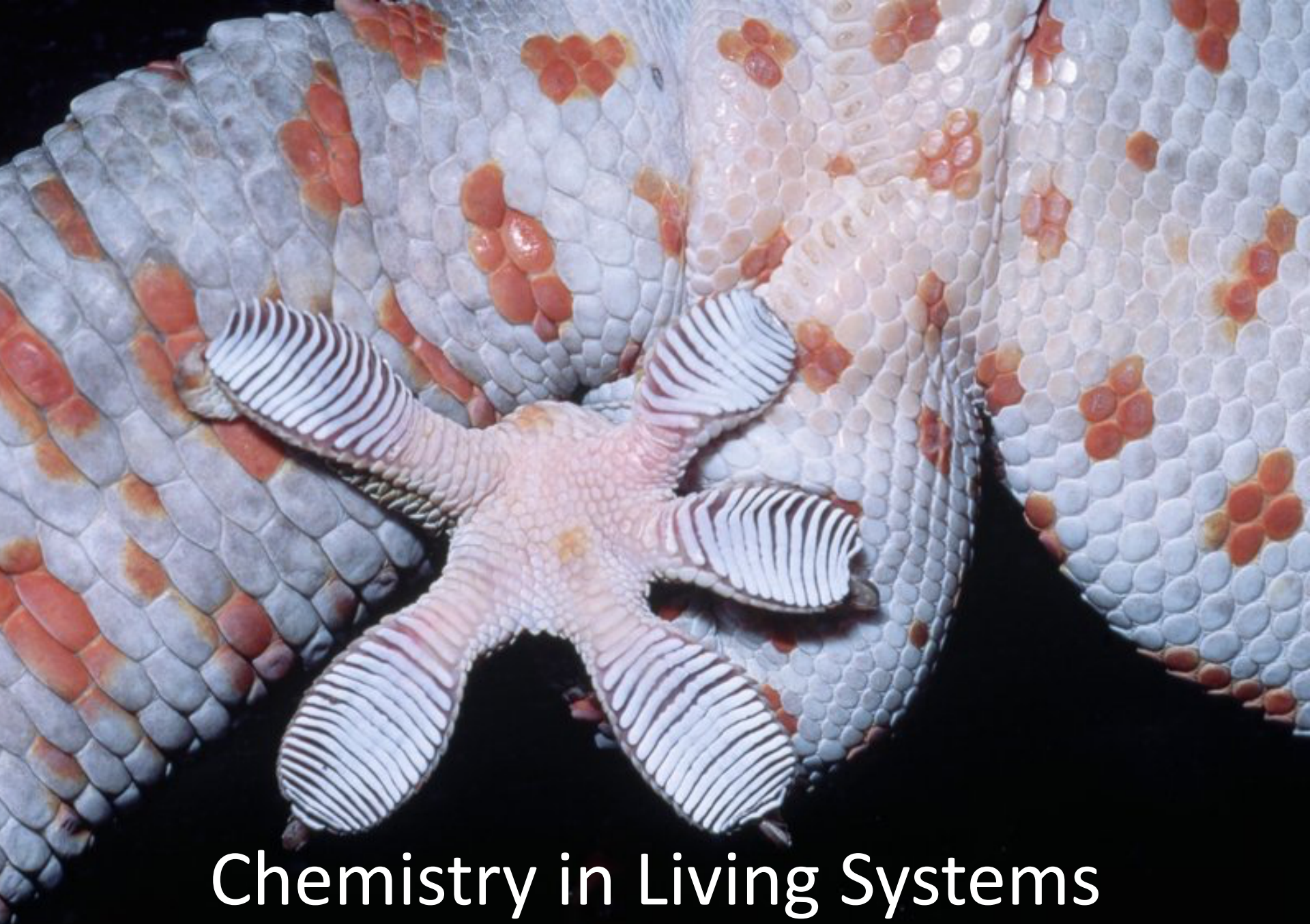
Individually, write **two** questions that would allow you to understand geckos and their feet.



In science, we gain knowledge through asking questions. It is important to consider how we *use* the knowledge, and its effects. Science, technology, society and the environment are inseparably linked.

# Why Study Biology?

- Watch [Gecko Feet Teach NASA How To Stick To Space Objects | Video](#)
- *Things to consider....*
  - Who is responsible for how developed knowledge is used?



Chemistry in Living Systems



# Elements & Compounds

- All matter is composed of **elements** – which cannot be broken down into simpler substances.
- Elements can be chemically combined to form **compounds**.
- There are approximately 92 naturally occurring elements.
- 6 of these – C, H, N, O, P and S are key in biological molecules.

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# Periodic Table of the Elements

Group

1A

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

11

Atomic number

Na

Element symbol

Sodium

Element name

22.990

Atomic weight

Alkali metals

Alkaline earth metals

Lanthanides

Actinides

Transition metals

Unknown properties

Post-transition metals

Metalloids

Other nonmetals

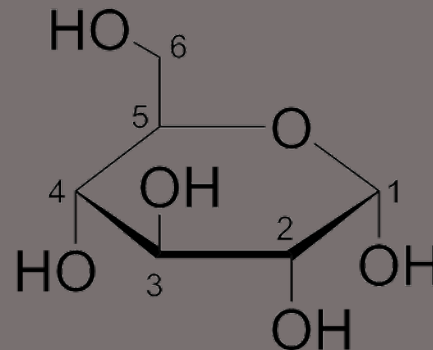
Halogens

Noble gases

1	2																	18					
1 H Hydrogen 1.0079																		2 He Helium 4.0026					
3 Li Lithium 6.941	4 Be Beryllium 9.0122																	5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305																	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798						
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.906	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.91	54 Xe Xenon 131.29						
55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium 144.91	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97							
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)							

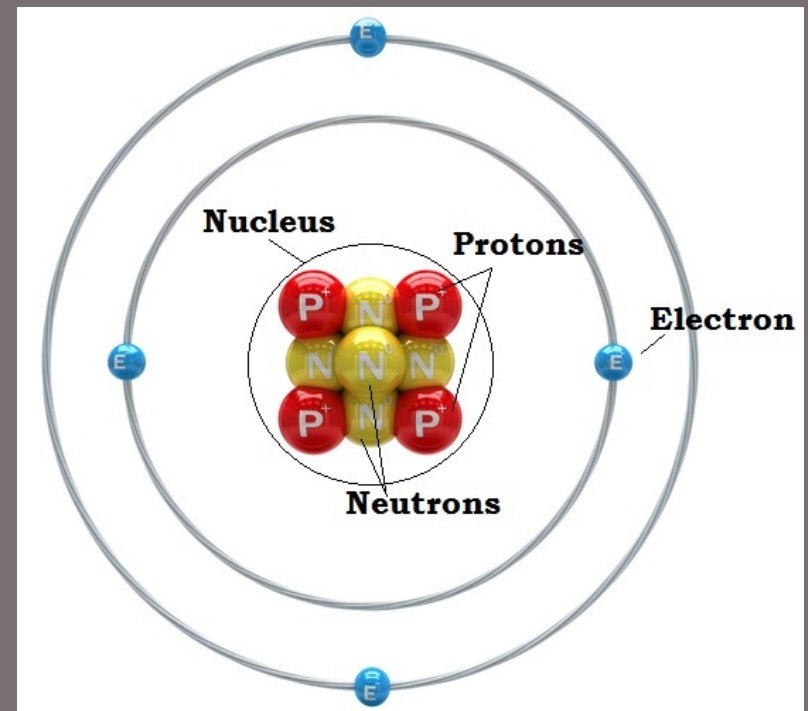
SOURCE: National Institute of Standards and Technology; International Union of Pure and Applied Chemistry

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# The Atom

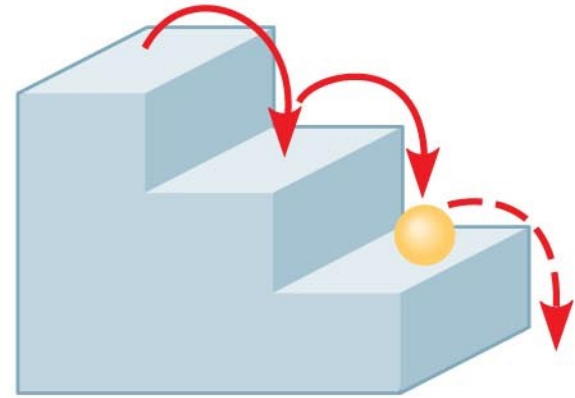
- The **atom** is the smallest particle of an element that keeps the properties of that element.
  - The *atomic mass* represents the sum of the **protons** and **neutrons** found in the nucleus
  - The *atomic number* represents the number of **protons**



# Energy & Electrons

- **Energy** is the capacity to cause change
- **Potential energy** is the energy that matter has because of its location or structure
- The electrons of an atom differ in their amounts of potential energy they possess
- An electron's state of potential energy is called its *energy level*, or electron shell
- An **orbital** is the three-dimensional space where an electron is found 90% of the time
- Each electron shell consists of a specific number of orbitals

**(a) A ball bouncing down a flight of stairs provides an analogy for energy levels of electrons**



**Third shell (highest energy level)**

**Second shell (higher energy level)**

**First shell (lowest energy level)**

**Atomic nucleus**



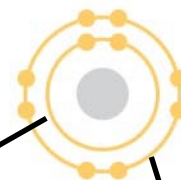
**Energy absorbed**

**Energy lost**

**(b)**

# Neon, with two filled shells (10 electrons)

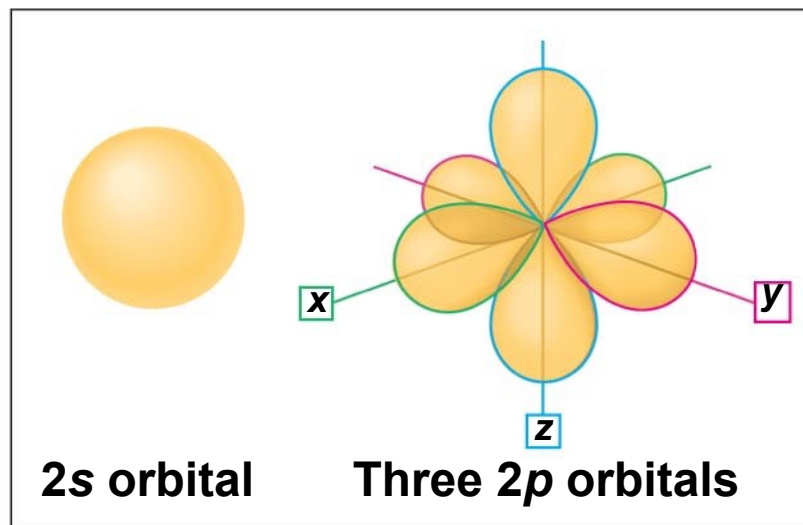
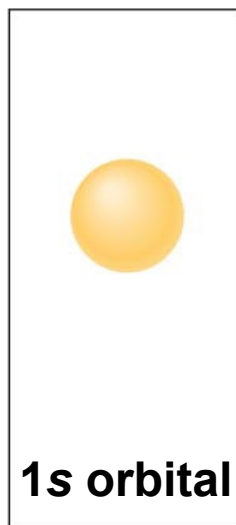
(a) Electron-distribution diagram



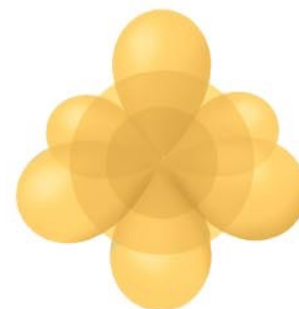
First shell

Second shell

(b) Separate electron orbitals



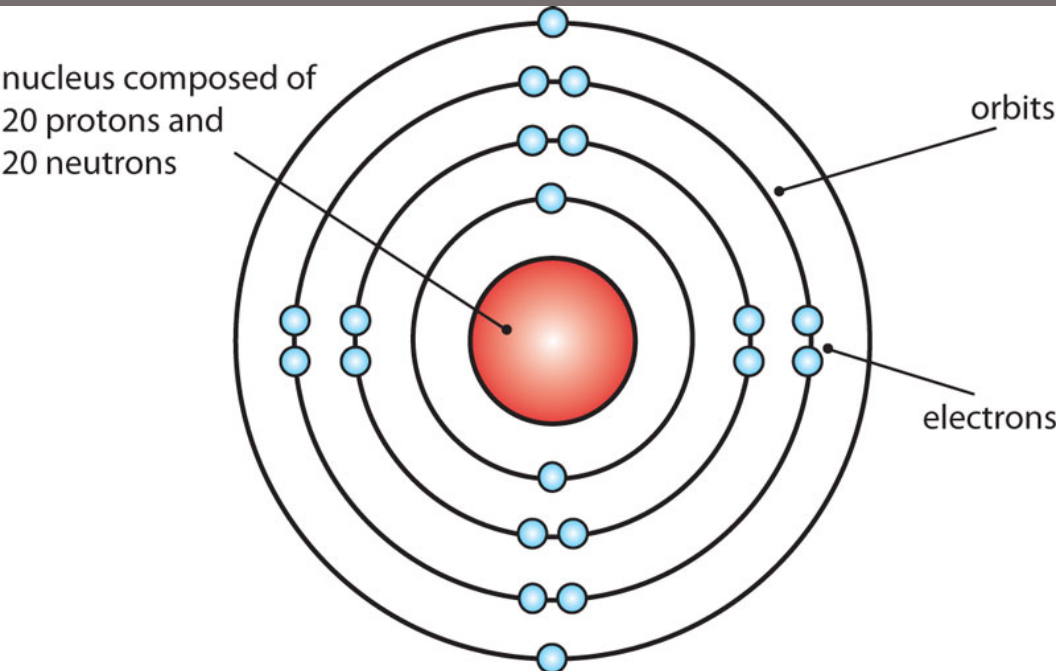
(c) Superimposed electron orbitals



1s, 2s, and 2p orbitals



# The Atom



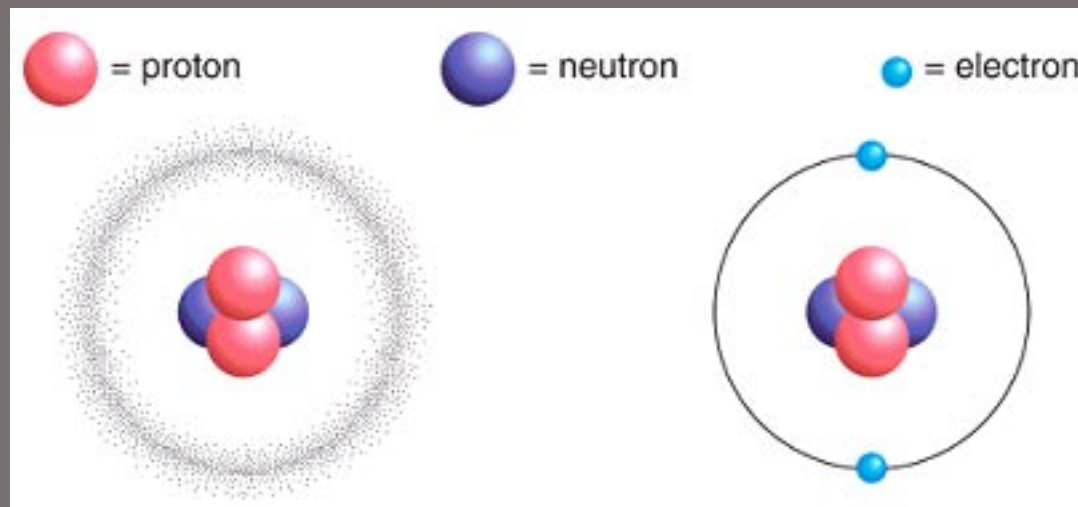
Electron Configuration: 2, 8, 8, 2

- The first energy level (orbit) can hold a maximum of 2 electrons
- The following orbits can hold a maximum of 8 electrons

# The Atom

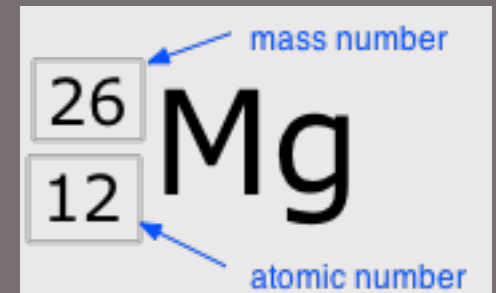
- Summary of Subatomic Particles:

Particle	Location	Charge	Mass
proton	in the nucleus	positive	$1.67 \times 10^{-24}\text{g}$
neutron	in the nucleus	neutral	$1.67 \times 10^{-24}\text{g}$
electron	orbiting the nucleus	negative	1/1836 of the proton



# Representing Atoms

- Atoms can be represented using:
  - Standard (nuclide) notation
  - Bohr-Rutherford Diagram

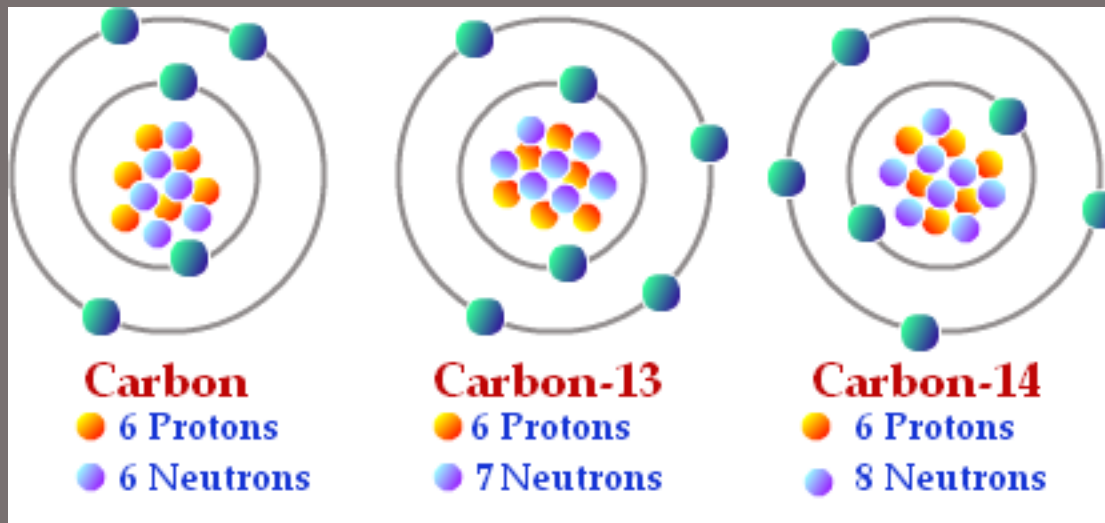


- Lewis Diagrams



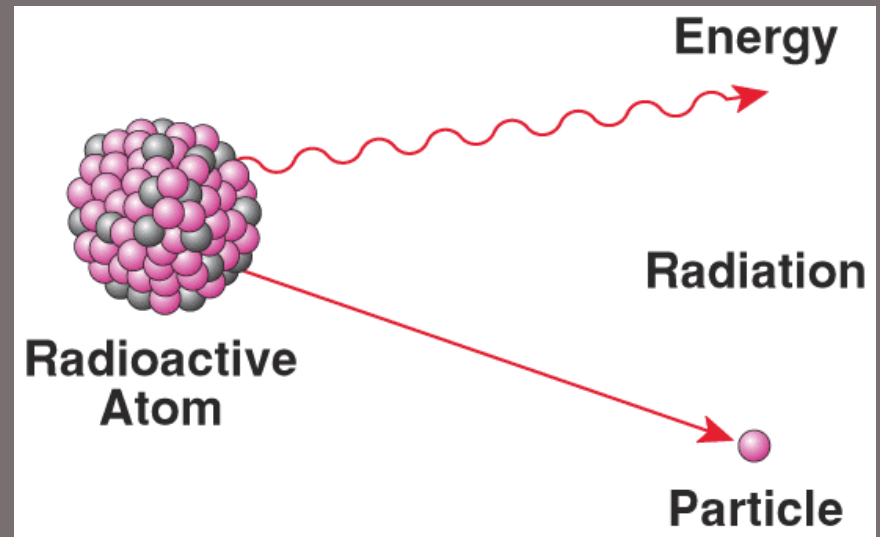
# Isotopes

- **Isotopes** are atoms with the same number of protons, but a different number of neutrons, thereby affecting their mass



# Radioisotopes

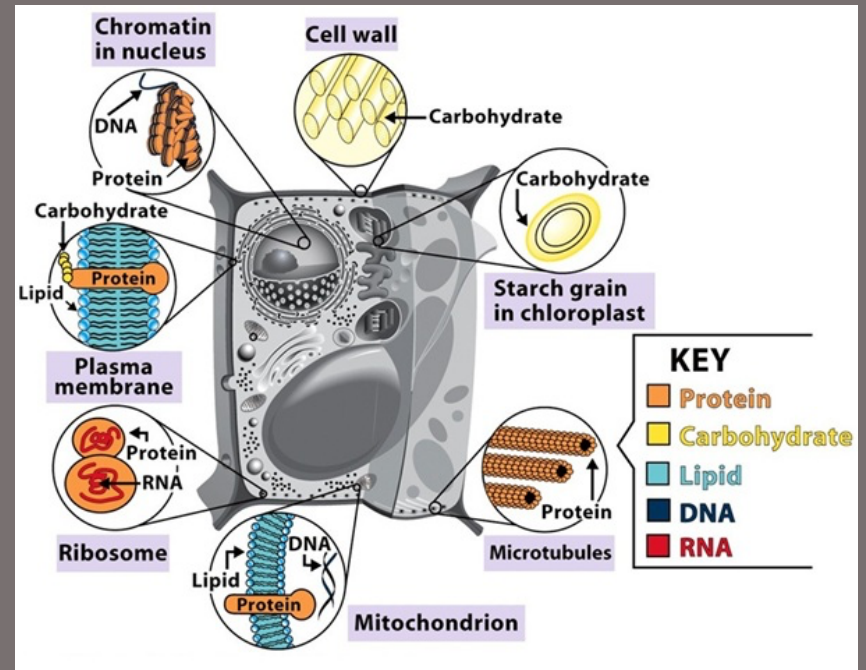
- Isotopes that are unstable experience *nuclear decay*.
- The nucleus breaks down by emitting radiation in the form of subatomic particles
- These **radioisotopes** are used in radioisotope tracing for diagnosing diseases such as cancer.





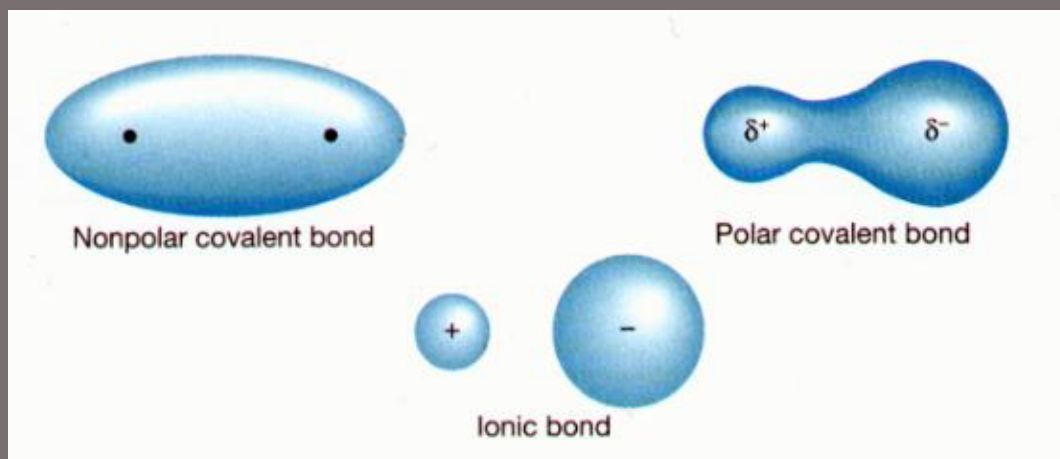
# Biological Molecules

- **Molecules** are composed of two or more atoms.
- Many molecules involved in living systems are carbon-based **organic molecules**.
- In order to understand how biological molecules function in the cell, it is necessary to understand their properties.



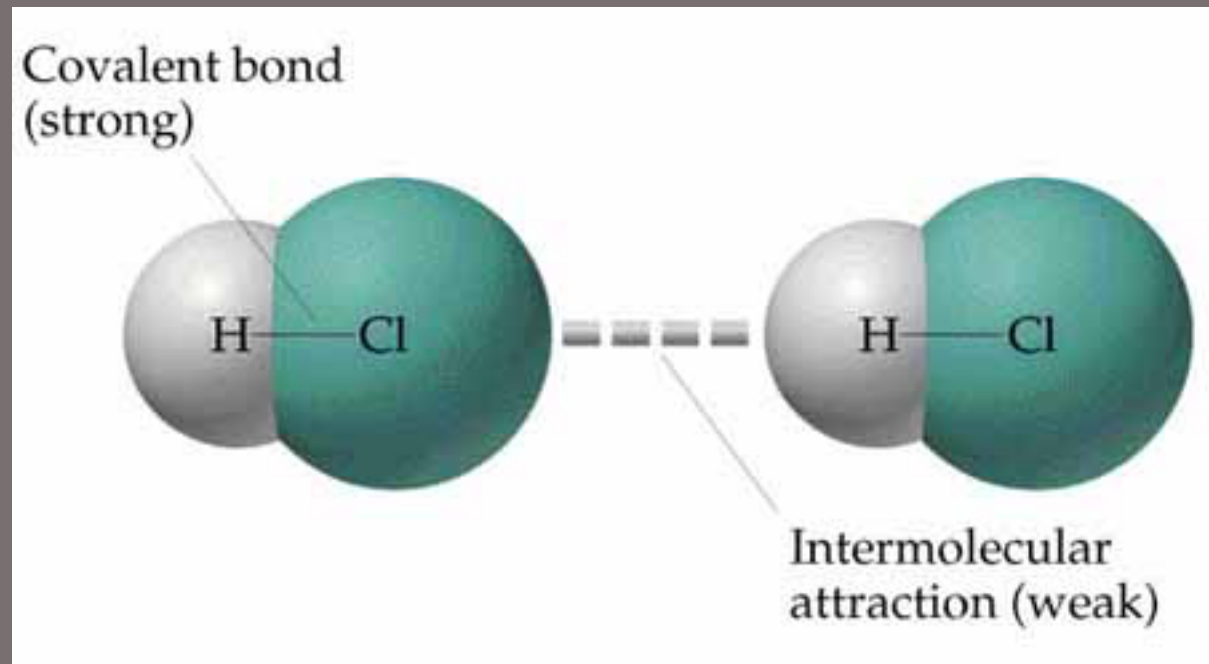
# Interactions Within Molecules

- **Intramolecular forces** hold the atoms *within* a molecule together.
  1. *Pure Covalent Bond* – 2 atoms share electrons (nearly) equally
  2. *Polar Covalent Bond* – 2 atoms share electrons, however the atom with greater electronegativity attracts electrons more, forming a dipole
  3. *Ionic bonds* – force of attraction due to oppositely charged ions



# Interactions Between Molecules

- **Intermolecular forces** are forces of attraction that exist between molecules.
- They are much weaker than intramolecular forces.



# Water

- Due to the polar-covalent O-H bonds in water, an unequal distribution of charge in the molecule causes one end to be slightly negative and the other to be slightly positive
- This **polarity** of the *molecule* gives water many unique properties.

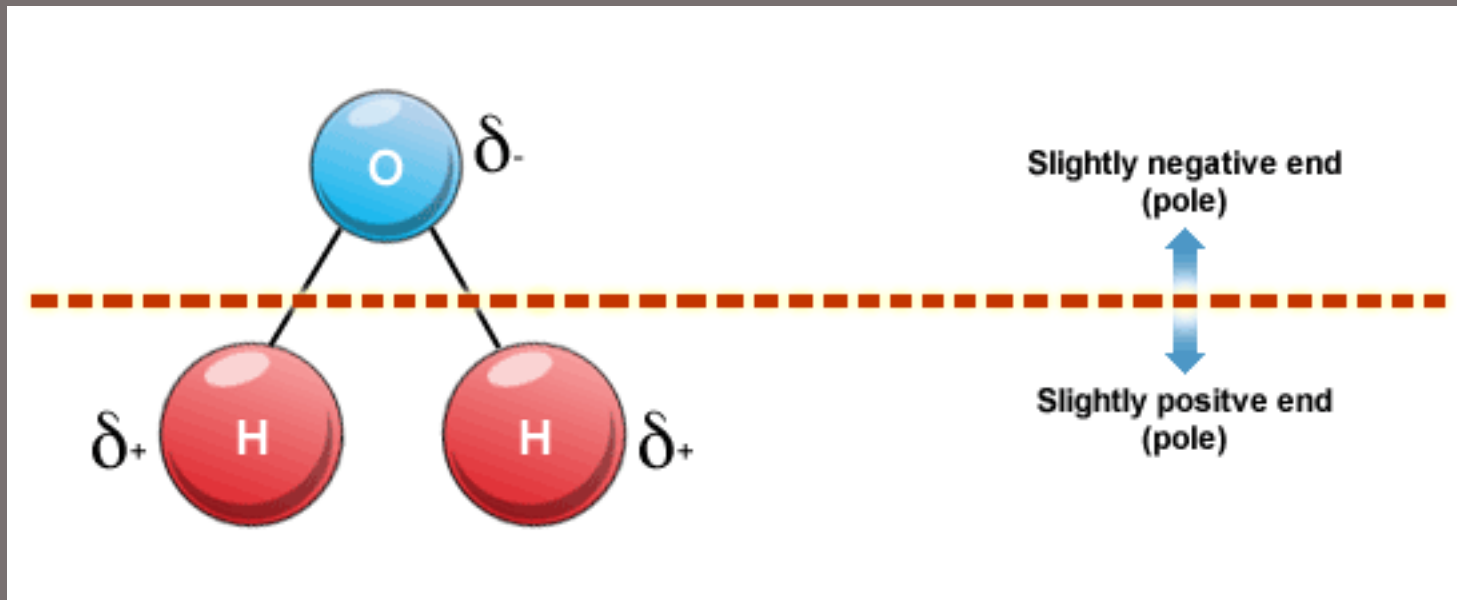
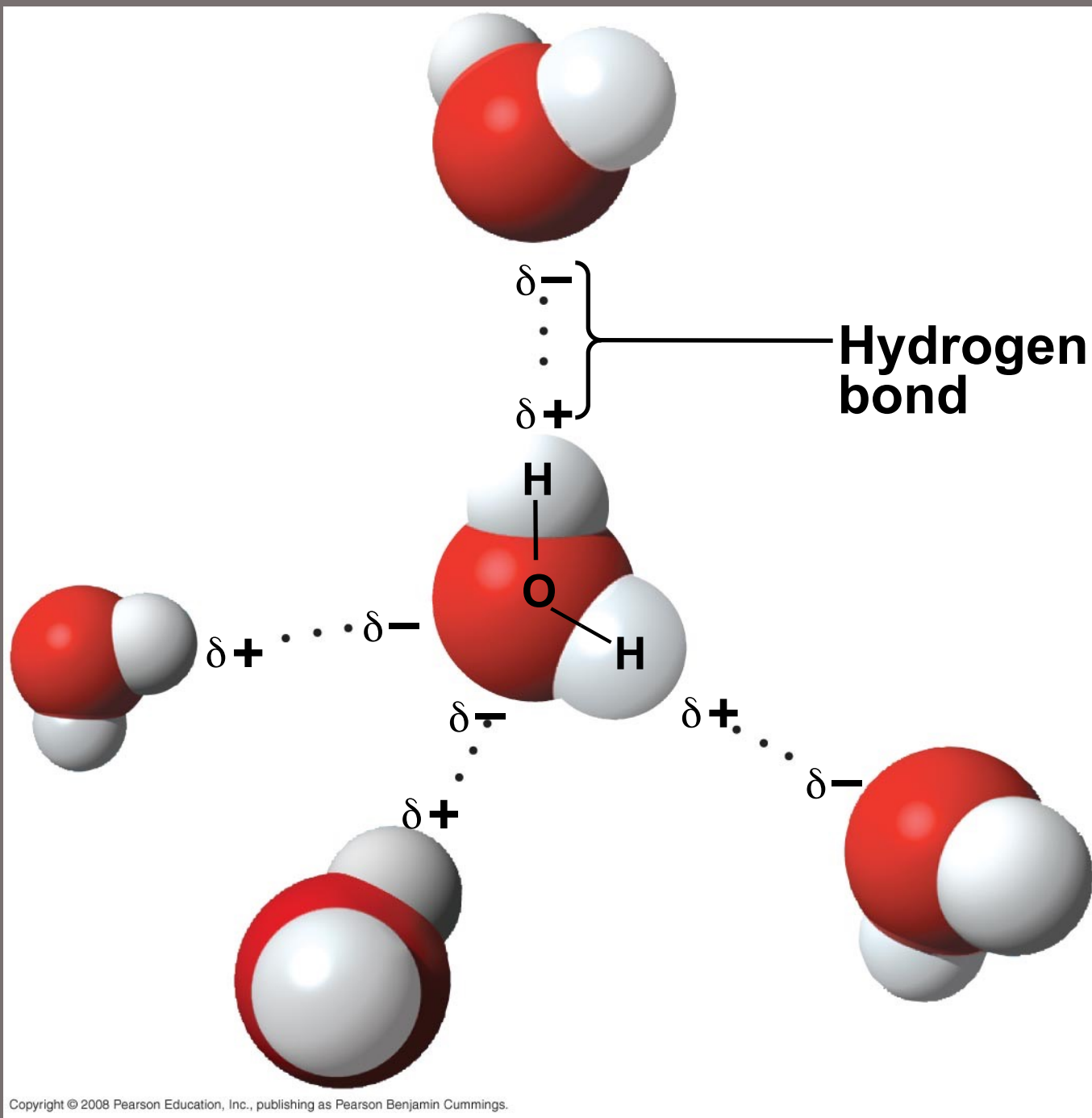


Fig. 3-2

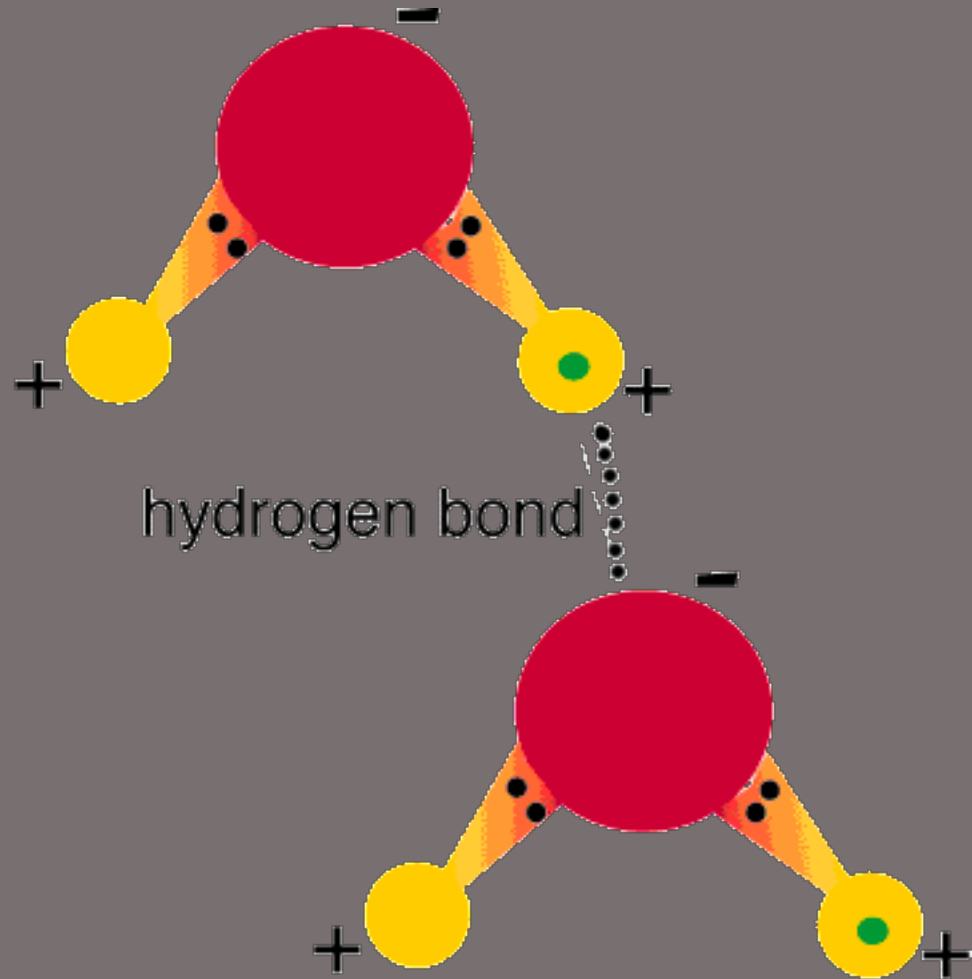




# Intermolecular Forces

## 1. *Hydrogen Bonding:*

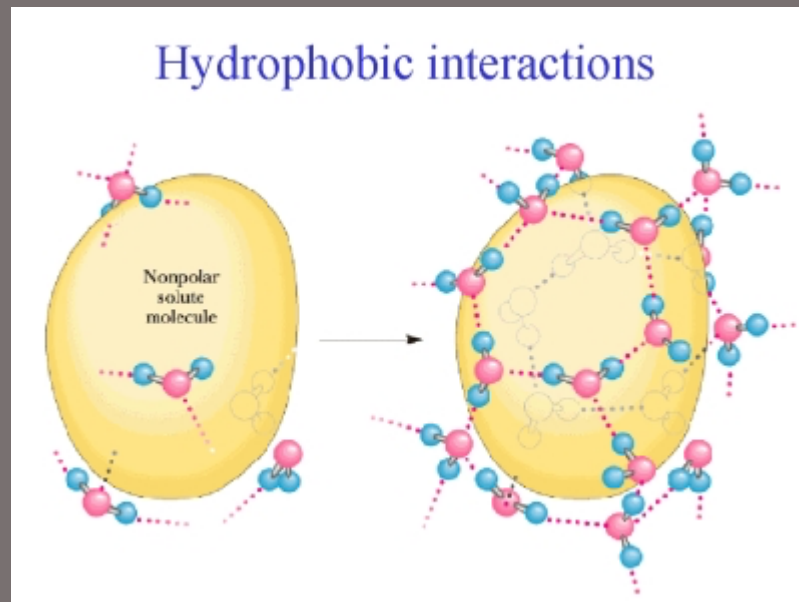
- The slightly positive hydrogen end of a water molecule can attract to the negative end of another molecule
- Can form between hydrogen atoms and N, O, F atoms
- The strongest of intermolecular forces



# Intermolecular Forces

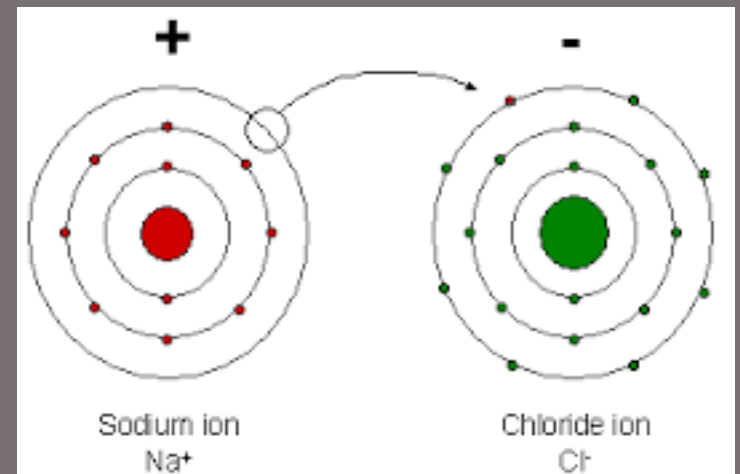
## 2. Hydrophobic Interactions:

- Non-polar (*hydrophobic*) molecules have a tendency to clump together when mixed with polar (*hydrophilic*) molecules



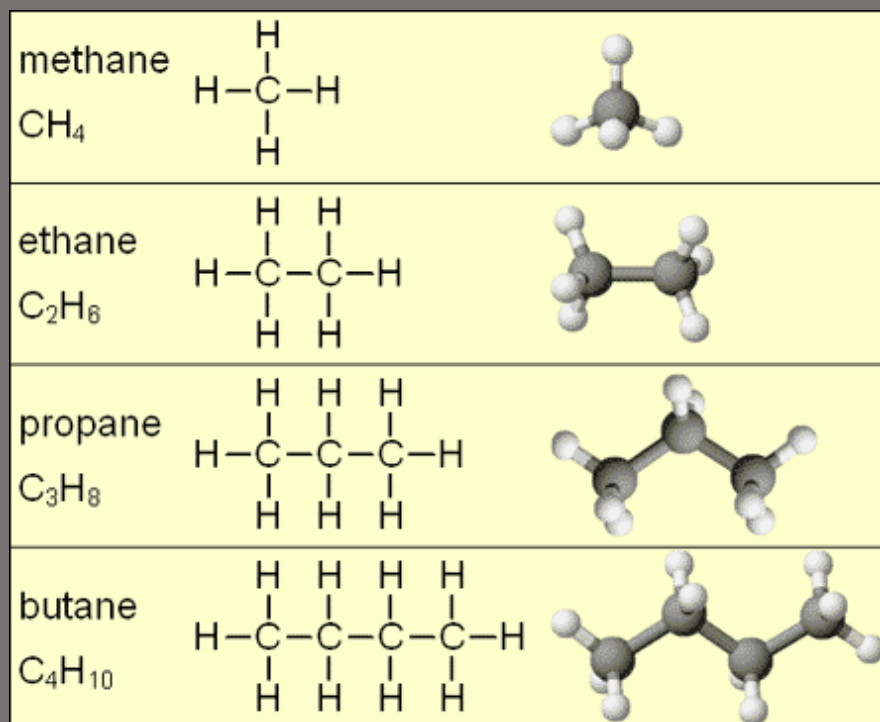
# Ions in Biological Systems

- **Ions** are atoms that have obtained a stable valence shell by losing or gaining electrons.
- **Anions** are atoms that *gain* electrons to become *negative*.
- **Cations** are atoms that *lose* electrons to become *positive*.



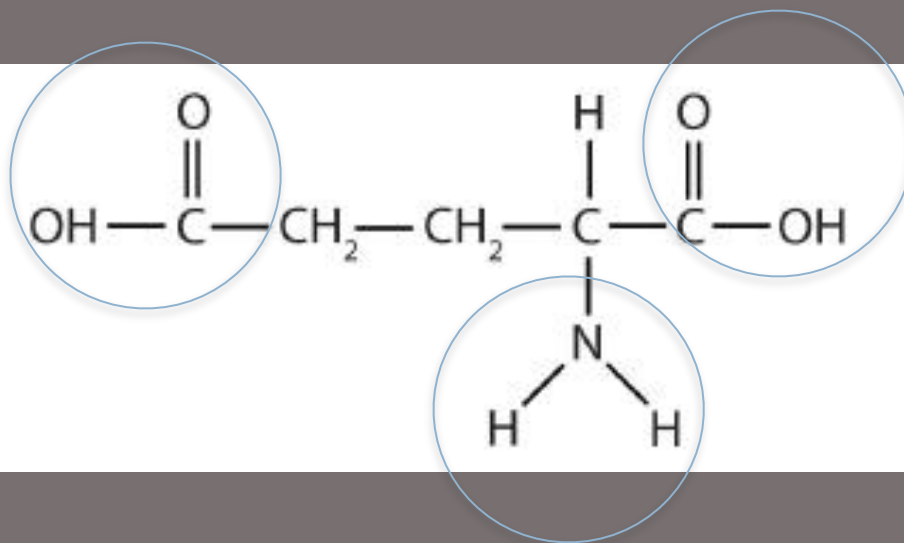
# Hydrocarbons

- **Hydrocarbons** are organic molecules composed only of carbon and hydrogen atoms
- Properties:
  - Non-polar (don't dissolve in water)
  - Low boiling points
  - Flammable
  - Often used as fuels




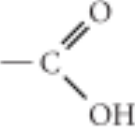
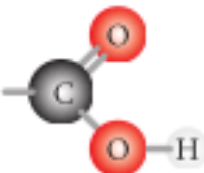
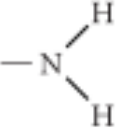


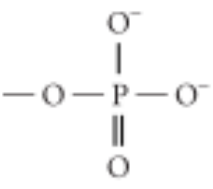

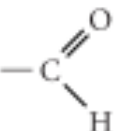
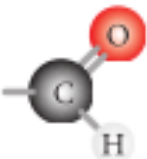
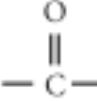
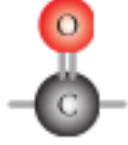
# Functional Groups

- A **functional group** is an atom/group of atoms attached to a hydrocarbon that gives the molecule particular properties





**Table 1** Functional Groups in Biomolecules

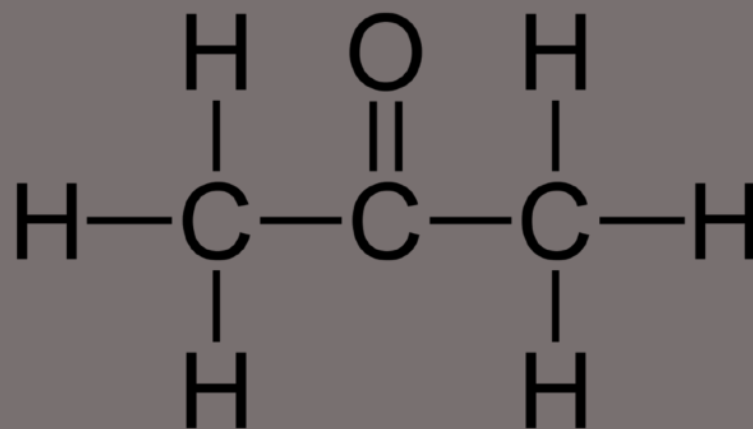
Group	Chemical formula	Structural formula	Ball-and-stick model	Found in
hydroxyl	—OH	—OH		alcohols (e.g., ethanol)
carboxyl	—COOH			acids (e.g., vinegar)
amino	—NH <sub>2</sub>			bases (e.g., ammonia)
sulfhydryl	—SH	—S—H		rubber
phosphate	—PO <sub>4</sub>			ATP
carbonyl	—COH			aldehydes (e.g., formaldehyde)
	—CO—			ketones (e.g., acetone)

# Representing Molecules

- The *molecular formula* shows the number of each atom in an element or a compound.

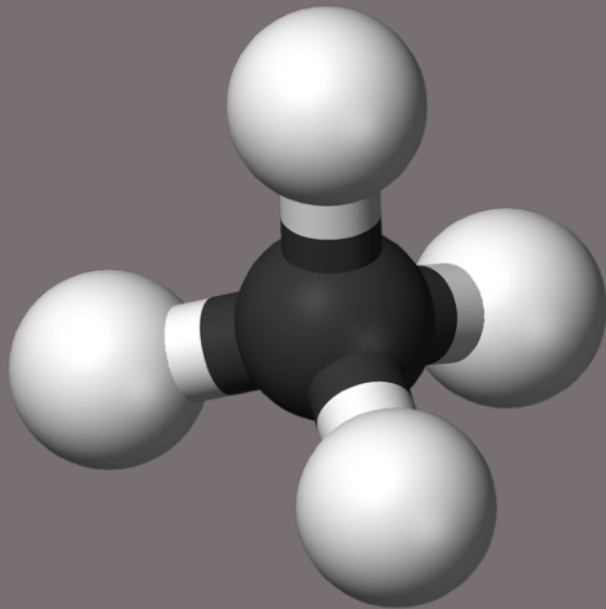


- The *structural formula* shows how the different atoms are bonded together

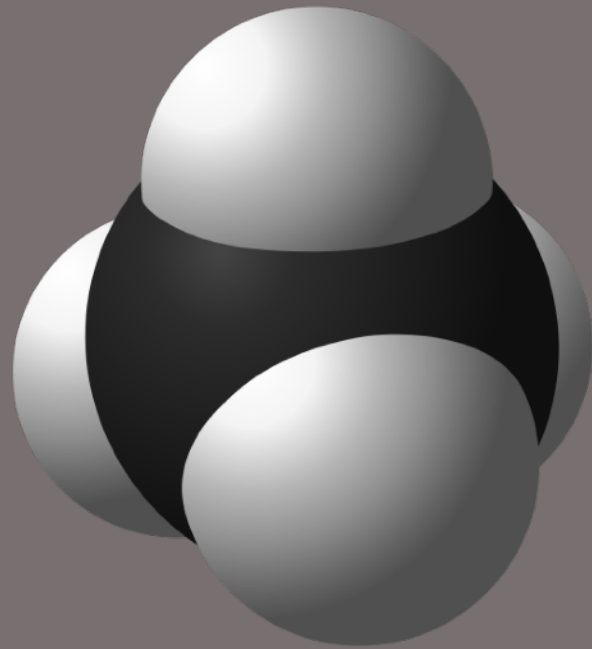


# 3D Models

- A molecule's 3D shape influences its behaviour and function

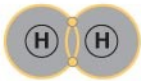

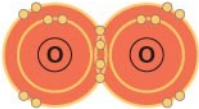

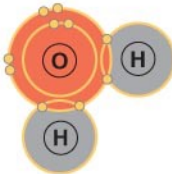

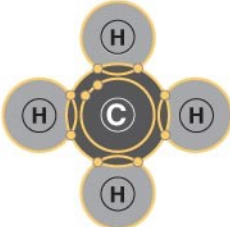


*Ball & Stick Model*



*Space-Filling Model*

Fig. 2-12

Name and Molecular Formula	Electron-distribution Diagram	Lewis Dot Structure and Structural Formula	Space-filling Model
(a) Hydrogen ( $\text{H}_2$ )		$\text{H}:\text{H}$ $\text{H}-\text{H}$	
(b) Oxygen ( $\text{O}_2$ )		$\ddot{\text{O}}::\ddot{\text{O}}$ $\text{O}=\text{O}$	
(c) Water ( $\text{H}_2\text{O}$ )		$\begin{array}{c} \ddot{\text{O}}:\text{H} \\ :\text{H} \end{array}$ $\begin{array}{c} \text{O}-\text{H} \\   \\ \text{H} \end{array}$	
(d) Methane ( $\text{CH}_4$ )		$\begin{array}{c} \text{H} \\ \text{H}:\ddot{\text{C}}:\text{H} \\ \text{H} \\ \text{H}-\text{C}-\text{H} \\   \\ \text{H} \end{array}$	