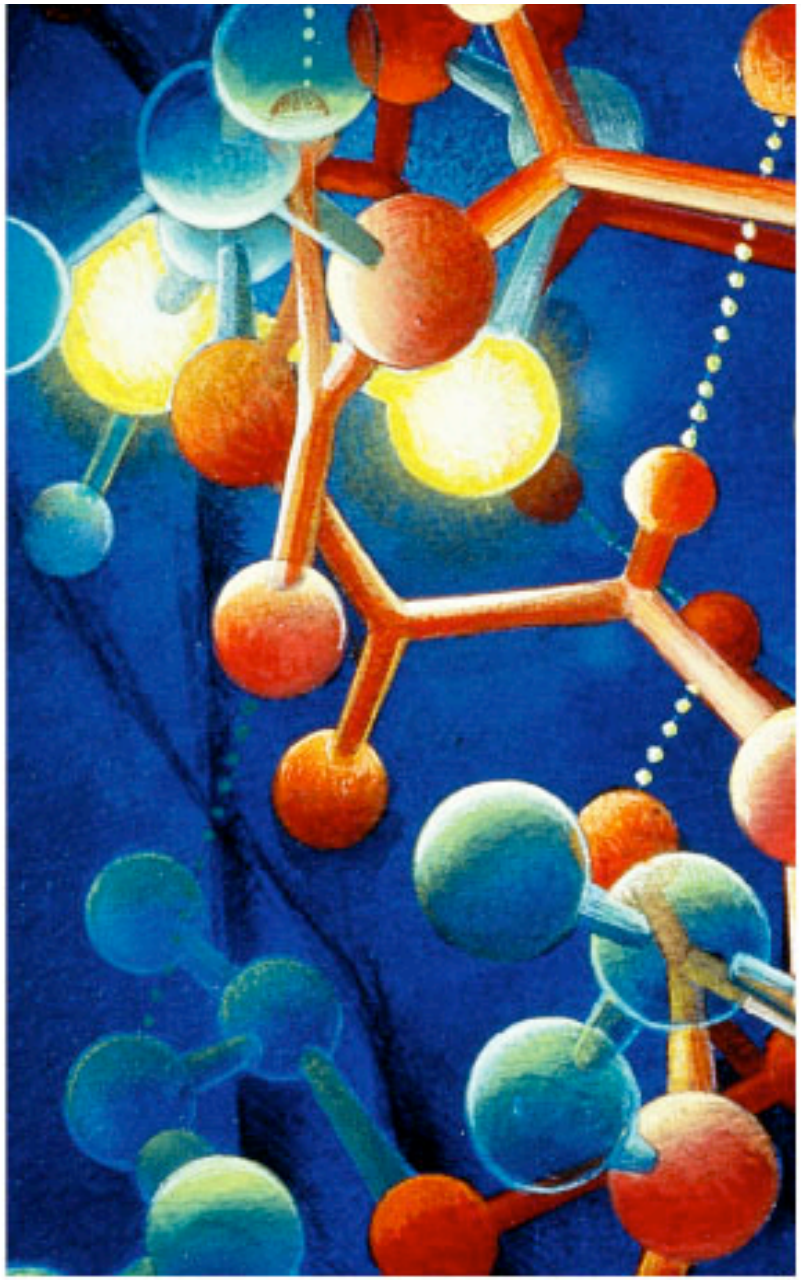
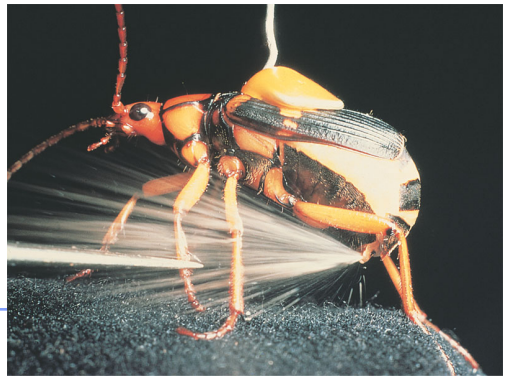
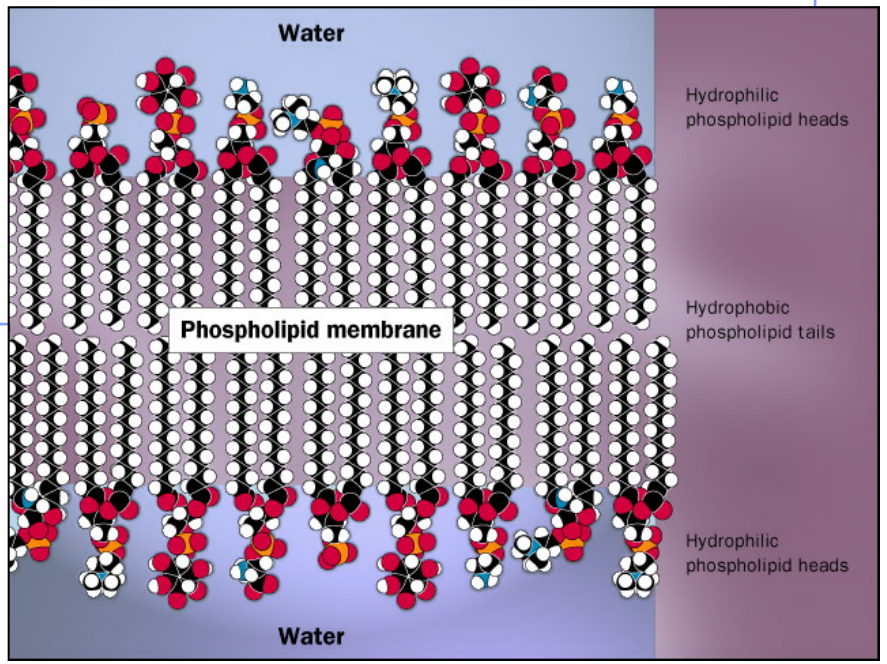


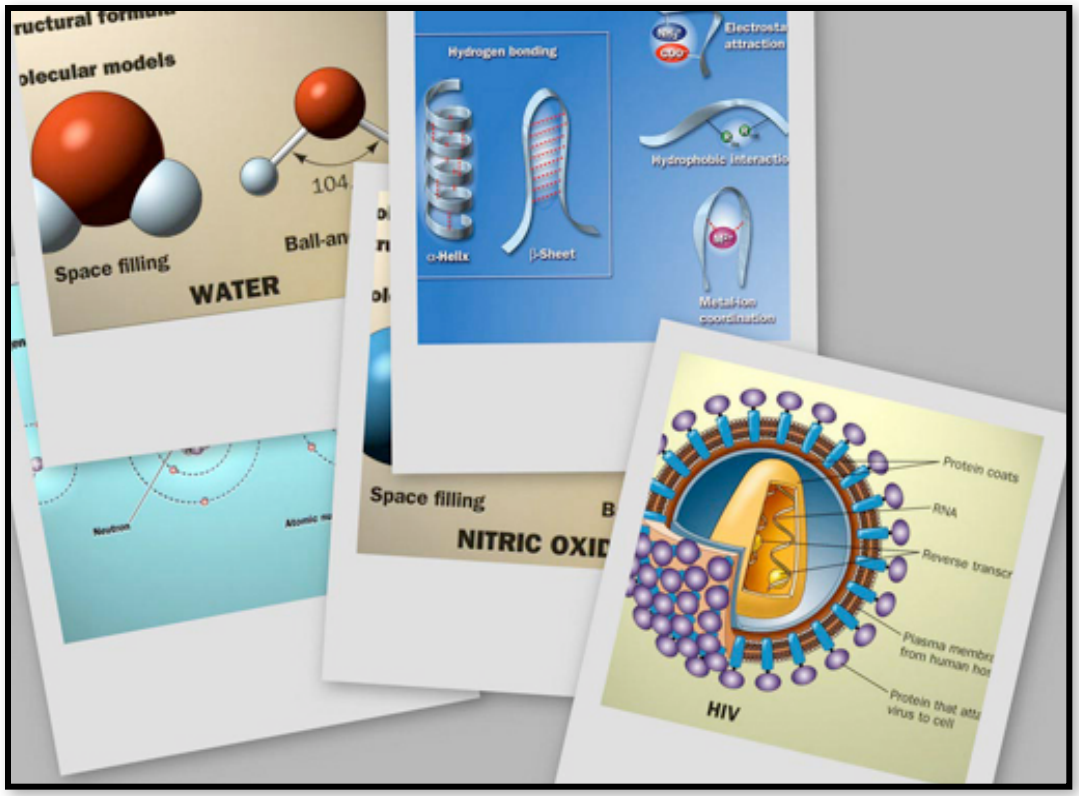


The Chemistry of Life



Why are we studying chemistry?

Chemistry is the foundation of Biology

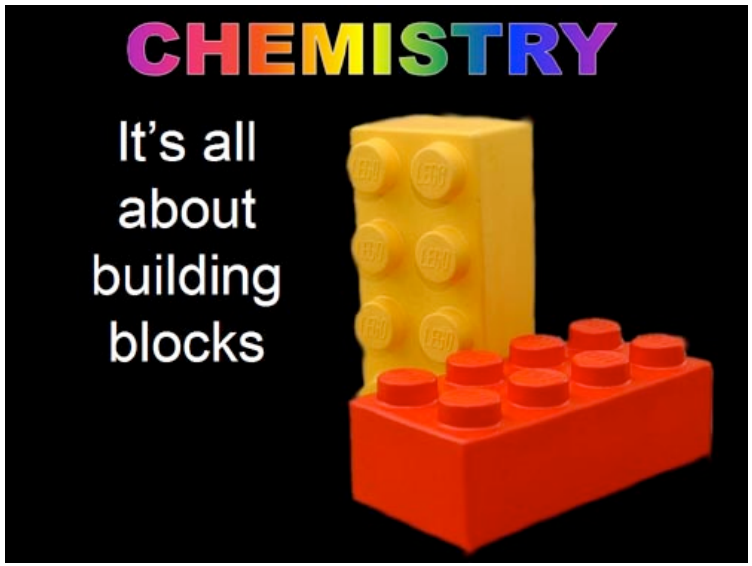


Life only happens because of the millions of chemical reactions taking place inside our bodies every second.

Matter is made of one or more elements

- An ELEMENT is a fundamental substance that cannot be chemically changed or broken down into a simpler substance by ordinary means.

- Example: Table salt is made up of the elements sodium and chlorine.
- Example: Glucose is made up of the elements hydrogen, carbons, and oxygen, and chlorine.



Matter is made of one or more elements

EXERCISE: Scientists attempt to decompose three gases (oxygen, nitrogen, carbon dioxide) into simpler substances using chemical reactions. Oxygen and Nitrogen CANNOT be split into simpler substances. Carbon dioxide DOES decompose and releases Carbon and Oxygen. *Based on these results which gases are elements?*

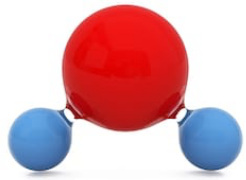
N_2

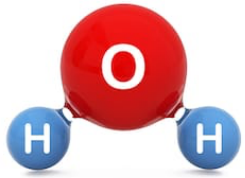
ANSWER: Oxygen and nitrogen are elements. They cannot be broken down into simpler substances.

Carbon dioxide is not one of the simplest building blocks because it can be broken down into 2 components.

Matter is made of one or more elements

EXERCISE: It is possible using an electrical current to decompose a sample of water producing hydrogen gas and oxygen gas. Is water an element? Why?





ANSWER: No, because water is decomposed into two simpler substances in this chemical reaction and elements cannot be broken down into a simpler substance. Therefore, water is not an element.

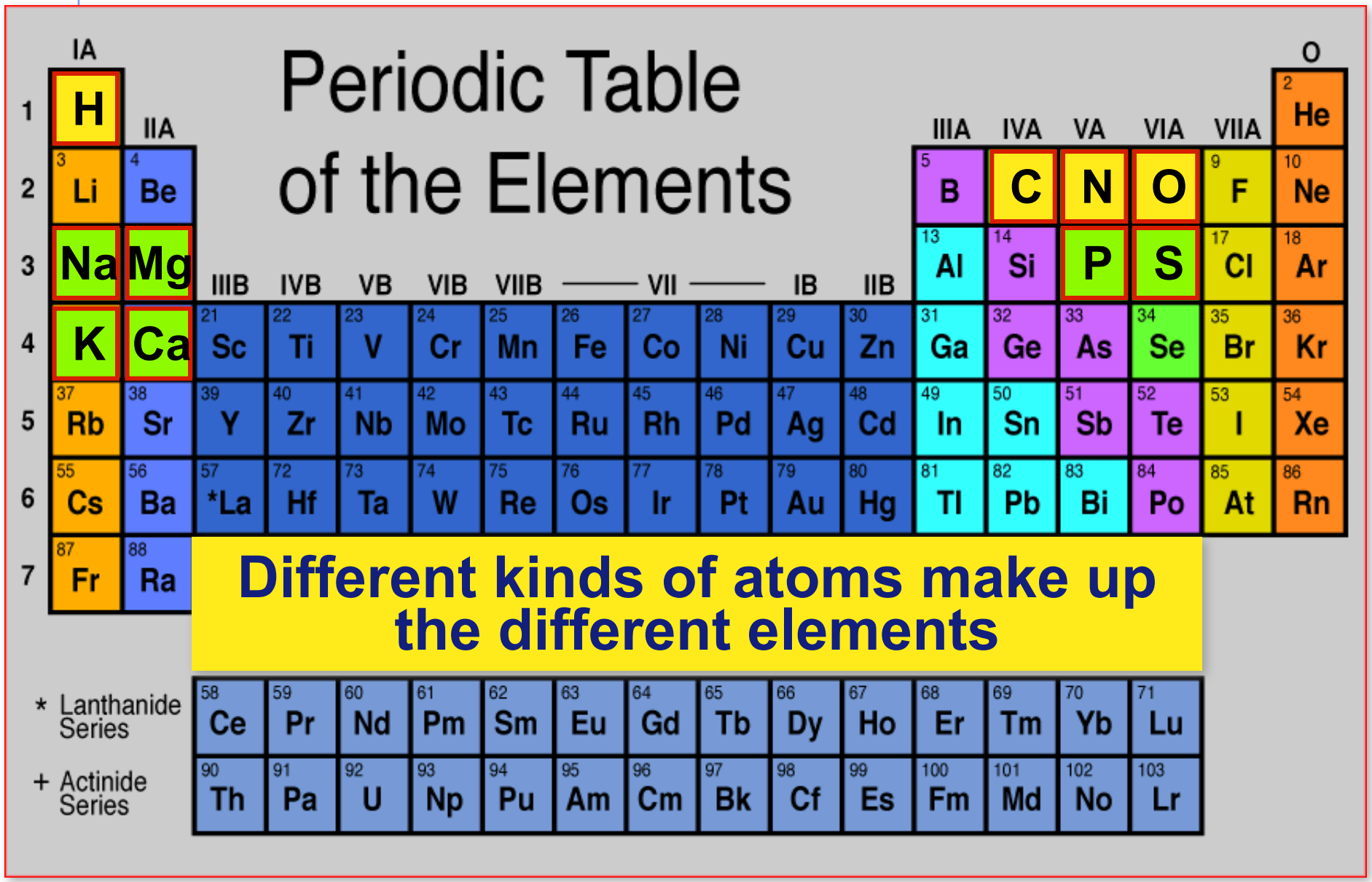
H_2O
Water

Matter is made of one or more elements

- For simplicity, chemists refer to specific elements using one or two letter **CHEMICAL SYMBOLS**.
  - The first letter is capitalized and the second is lower case.
- An **ATOM** is the smallest particle of an element that still retains the properties of that element.
  - 1 to 2 million atoms would fit in a period at the end of this sentence!!!
    - These atoms are the building blocks of the matter of the universe.
      - An element's symbol also refers to an atom of that element

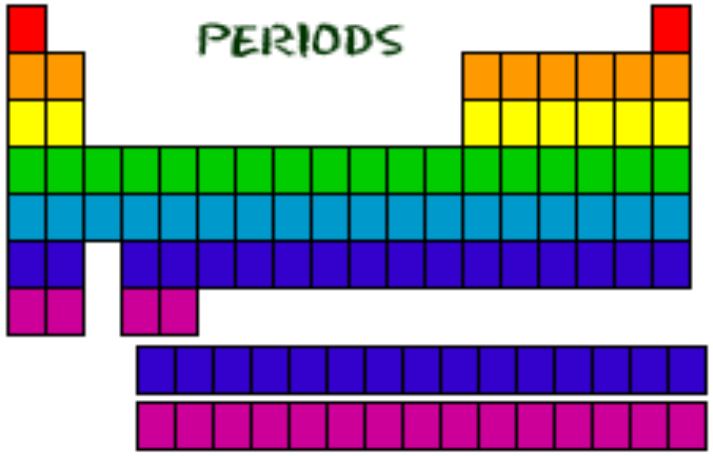
Hydrogen	H
Iodine	I
Lithium	Li
Magnesium	Mg
Manganese	Mn
Nitrogen	N
Oxygen	O
Phosphorus	P
Silicon	Si

Element Symbols are Arranged Into the Periodic Table

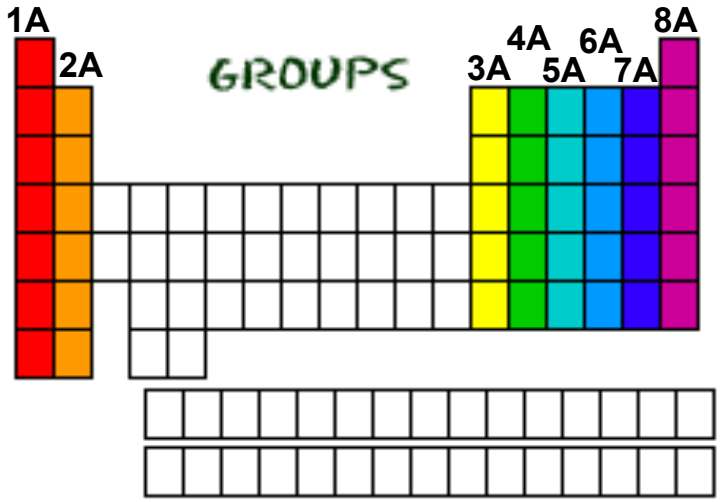


Matter is made of one or more elements

- Elements are placed on a grid with 7 horizontal rows called PERIODS.

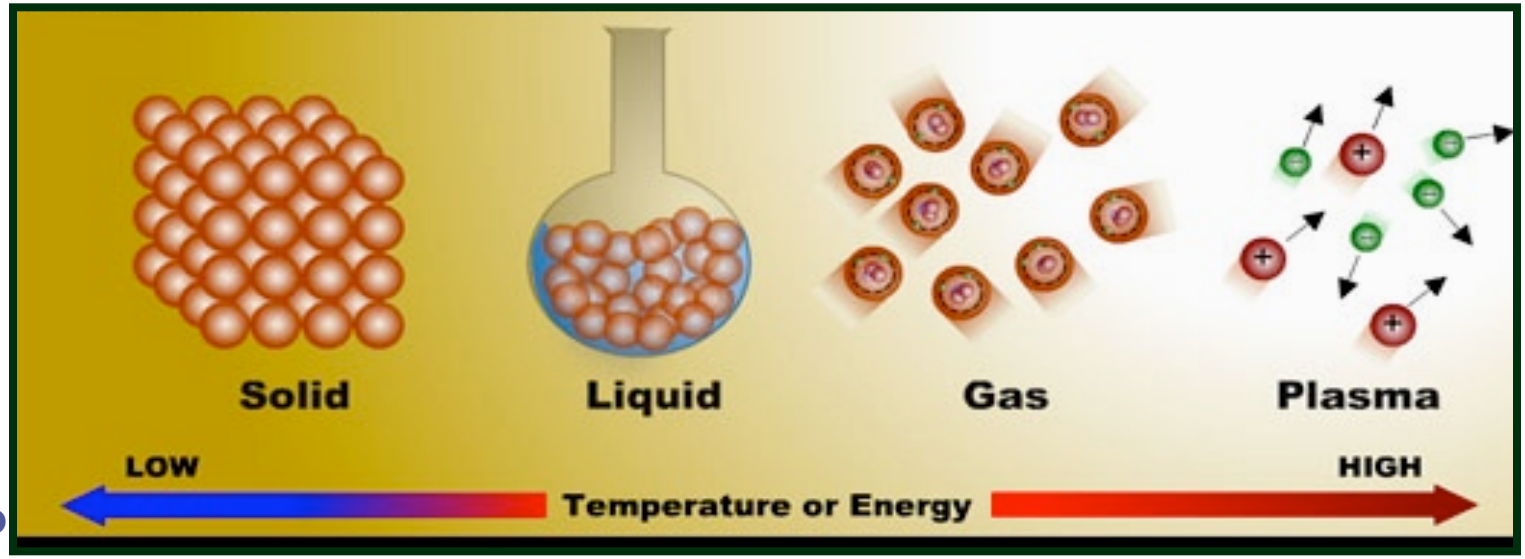


- There are also vertical columns called GROUPS.
  - The colored groups are groups 1A, 2A, 3A, 4A, 5A, 6A, 7A, and 8A and are referred to as the MAIN GROUPS.

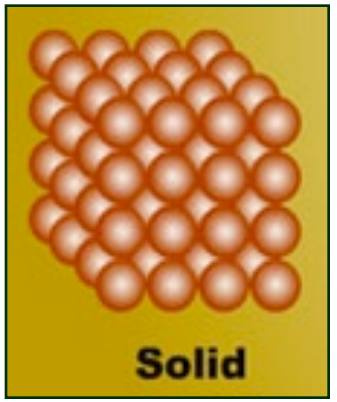


Matter is made of one or more elements

- **MATTER:** Anything that occupies **SPACE** and has **MASS**.
  - Anything with a physical presence and is made up of one or more atoms of one or more elements
- Matter can exist in different states or phases, the first three are of particular importance in biology



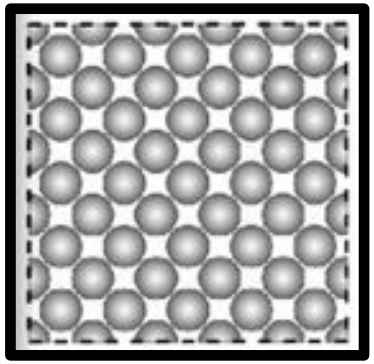
The Solid Phase



1. High density
2. Hard to expand or compress
3. Rigid shape
4. Fixed volume
5. Particles that make up a solid are tightly packed, usually in a regular pattern
6. Particles are held strongly in place, unable to move past each other, but can vibrate within a limited area

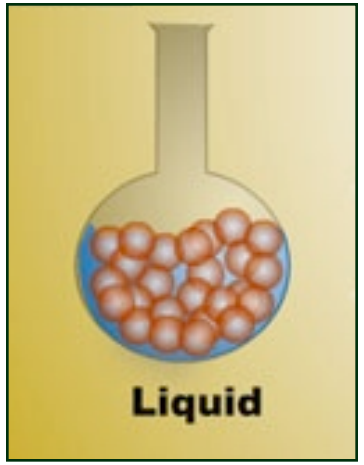
EXAMPLE: ICE (H20)

The Solid Phase



- **Particles (and the atoms that make them up) in a solid substance vibrate in place *(because there is always some thermal energy in the system)*, but these particles do not slides past each other, moving in location within the rigid block of solid substance.**
  - **Particles in a solid sit closer together because they are either:**
    1. **under extreme positive pressure or...**
    2. **because there is not enough thermal energy (and thus not enough particular motion) in the system for the particles to overcome the intermolecular forces that attract these particles to each other.**
  - **The weak intermolecular attractions between particles are long-lasting and permanent, preventing the particles from sliding past each other (as in liquids) or from moving very far apart from each other (as in gases)**

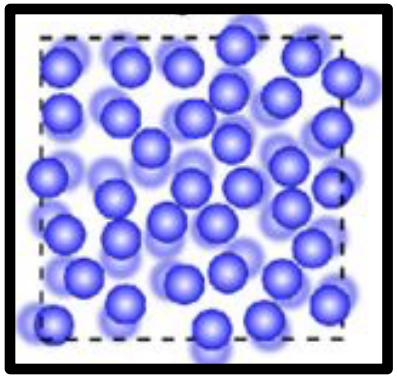
The Liquid Phase



1. High density
2. Fixed volume
3. Hard to expand and compress
4. Particles are held close together by attractive forces but assume no regular pattern
5. Particles flow and can easily move or slide past one another
6. Liquids assume the shape of their containers

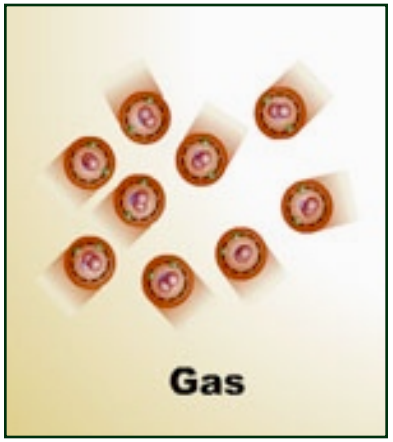
EXAMPLE: LIQUID WATER (H20)

The Liquid Phase



- Particles of a liquid substance are still close together, but they are also able to slide past one another, moving locations due to the random collisions between particles within the liquid.
  - Particles in a liquid move past, yet still within close proximity to, each other because there is enough thermal energy (and thus enough random particular motion and collisions between particles) in the system so that the weak intermolecular attractions between particles are continually breaking, though they also keep continually reforming, allowing the particles to slide past one another, but still preventing them from moving very far apart from each other (as in gases).

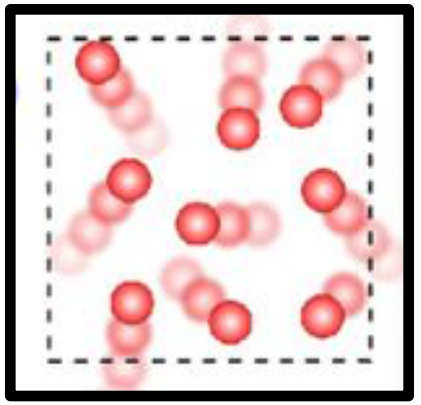
The Gas Phase



1. Low density
2. Easy to expand and compress
3. Assume the shape of the container
4. Assume the shape of the container
5. Fills the container with no regular pattern.
6. Assume the volume of the container
7. Particles vibrate and fly in all directions at great speeds
8. Particles are so far apart that the attractive forces between them are insignificant.

EXAMPLE: STEAM or WATER VAPOR (H20)

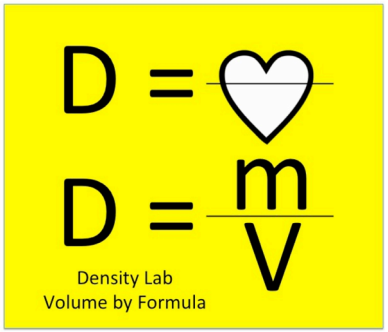
The Gas Phase



- **Particles in a gas move far away from one another since the high amount of thermal energy in the system prevents the weak intermolecular attractions between particles from holding the particles close together.**

1. **Because there is a high amount of thermal energy (compared to the amount in the liquid version of this substance), there exists a lot of vigorous random motion of now fast moving particles in the system, allowing the particles to move far apart and fully overcome the weak intermolecular forces that attract these particles to each other permanently in a solid and temporarily, yet repeatedly, in a liquid, both of which have lower thermal energy that causes less random motion of particles and particles to move at slower speeds.**
2. **Due to the continual random collision between particles moving at much higher speeds, on average, than the particles do in liquid form, particles move far apart, too far for weak intermolecular forces of attraction to have a significant effect.**
3. **Without the intermolecular forces being able to hold particles together in the presence of the high thermal energy, particles spread apart into any empty space, filling the volume of the container they are in.**

Density



- The density of an object equals its total mass divided by its total volume.
  - Generally, solids of a substance are more dense than liquids of that substance and liquids of a substance are more dense than gases of that substance.
    - Units of density relate mass to volume such grams per cubic centimeter (g/cm^3) or grams per cubic milliliter (g/mL).

- If masses are equal, a more dense object (such as iron) will occupy less volume than a less dense substance (such as water).
  - When you mix substances, the most dense substance sinks to the bottom, whilst the least dense substance is more buoyant and floats to the top.

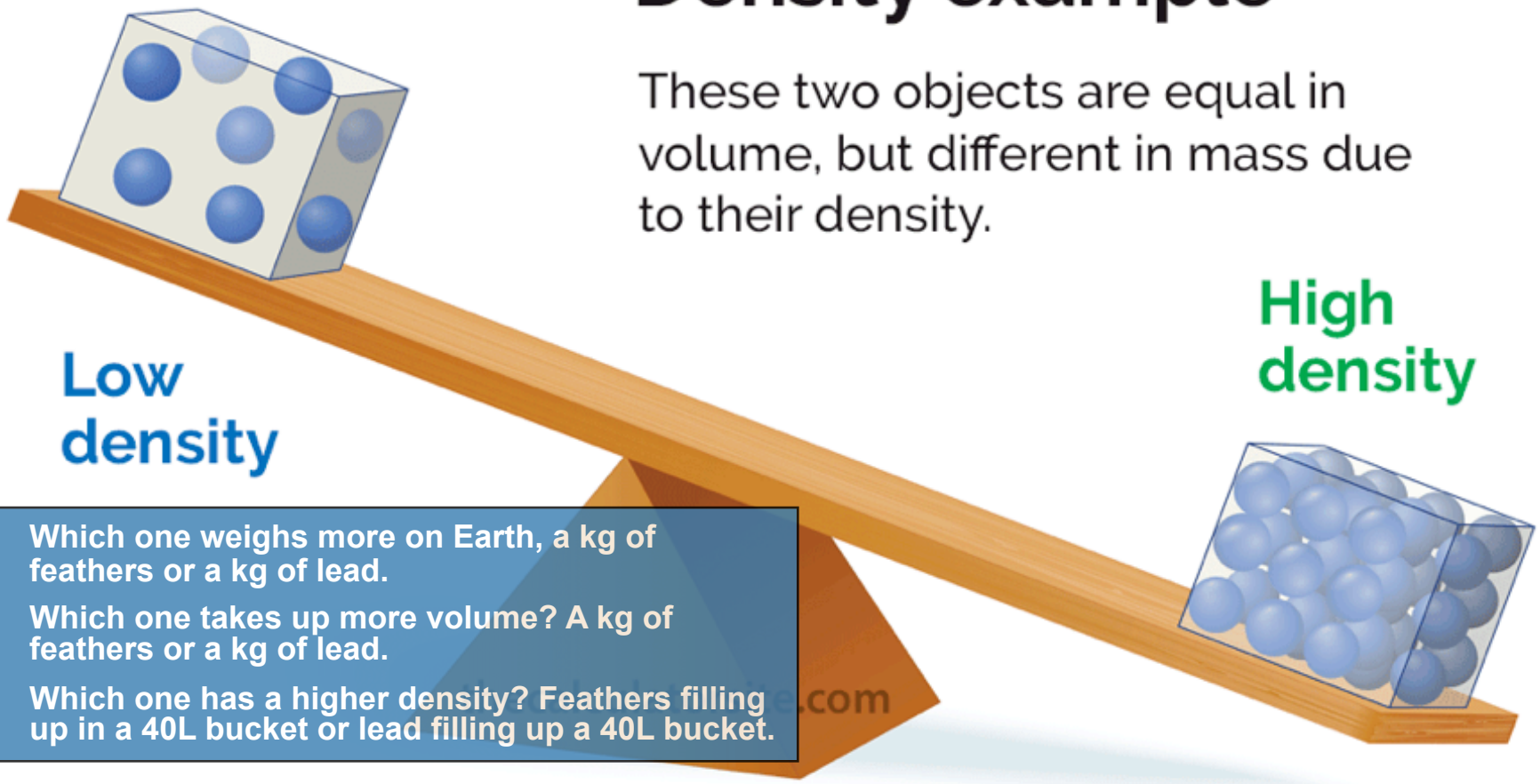
density = mass / volume

$$\rho = \frac{m}{v}$$

If volumes are equal, a more dense object will contain more mass than a less dense substance .

Density example

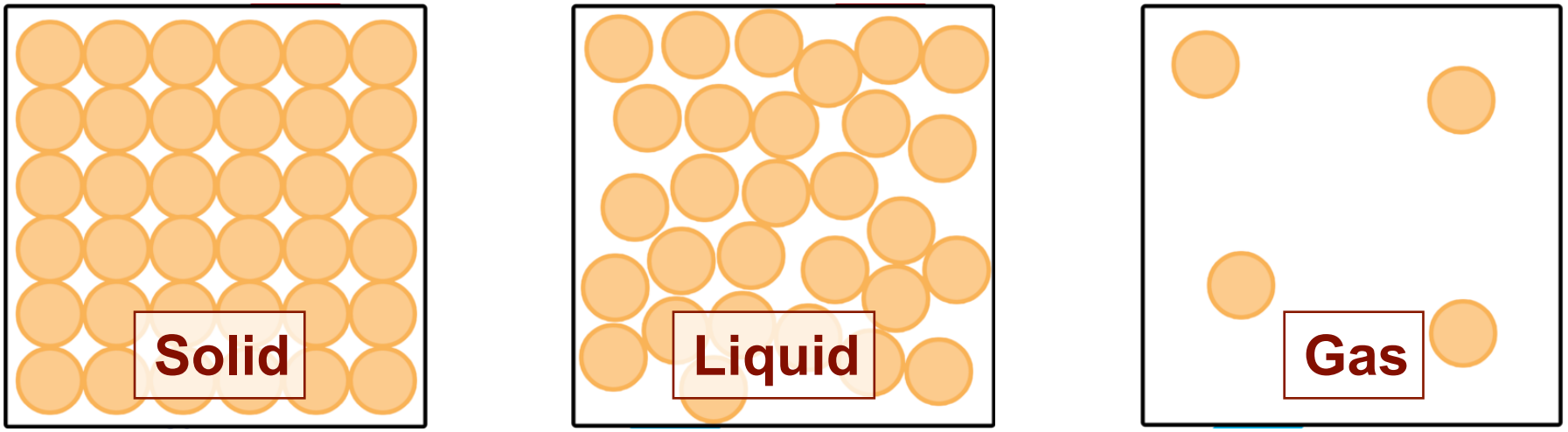
These two objects are equal in volume, but different in mass due to their density.



- Which one weighs more on Earth, a kg of feathers or a kg of lead.
- Which one takes up more volume? A kg of feathers or a kg of lead.
- Which one has a higher density? Feathers filling up in a 40L bucket or lead filling up a 40L bucket.

Changes in the Density of Solids, Liquids, & Gases

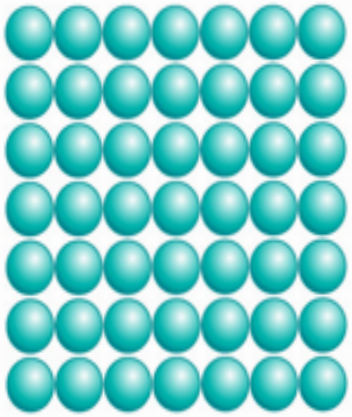
- **Let's say we have three cubes of equal volume filled with the same substance in three different phases of matter: solid, liquid, and gas.**
  - **In general, in solid form, more particles of a certain substance would fit into that cube's volume compared to what would fit if that substance was in liquid form.** ***(We will see how solid vs liquid water is an exception to this general rule in Ch.3)***
  - **In liquid form, many more particles of a certain substance would fit into that cube's volume compared to what would fit if that substance was in a gaseous state.**



Physical states

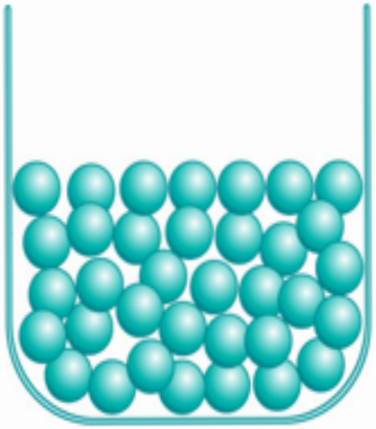
decreasing thermal energy

increasing thermal energy



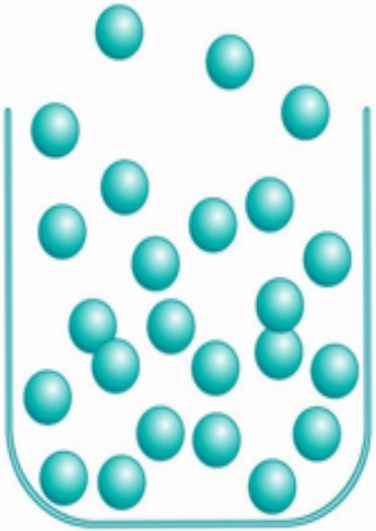
Solid

The molecules that make up a solid are arranged in regular, repeating patterns. They are held firmly in place but can vibrate within a limited area.



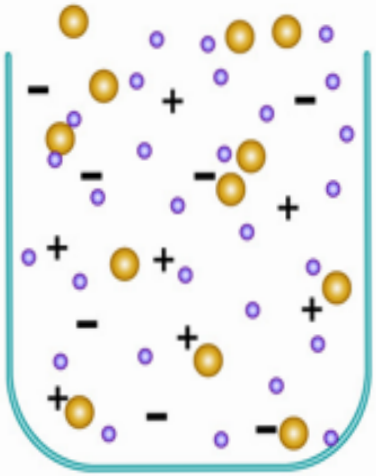
Liquid

The molecules that make up a liquid flow easily around one another. They are kept from flying apart by attractive forces between them. Liquids assume the shape of their containers.



Gas

The molecules that make up a gas fly in all directions at great speeds. They are so far apart that the attractive forces between them are insignificant.



Plasma

At the very high temperatures of stars, atoms lose their electrons. The mixture of electrons and nuclei that results is the plasma state of matter.