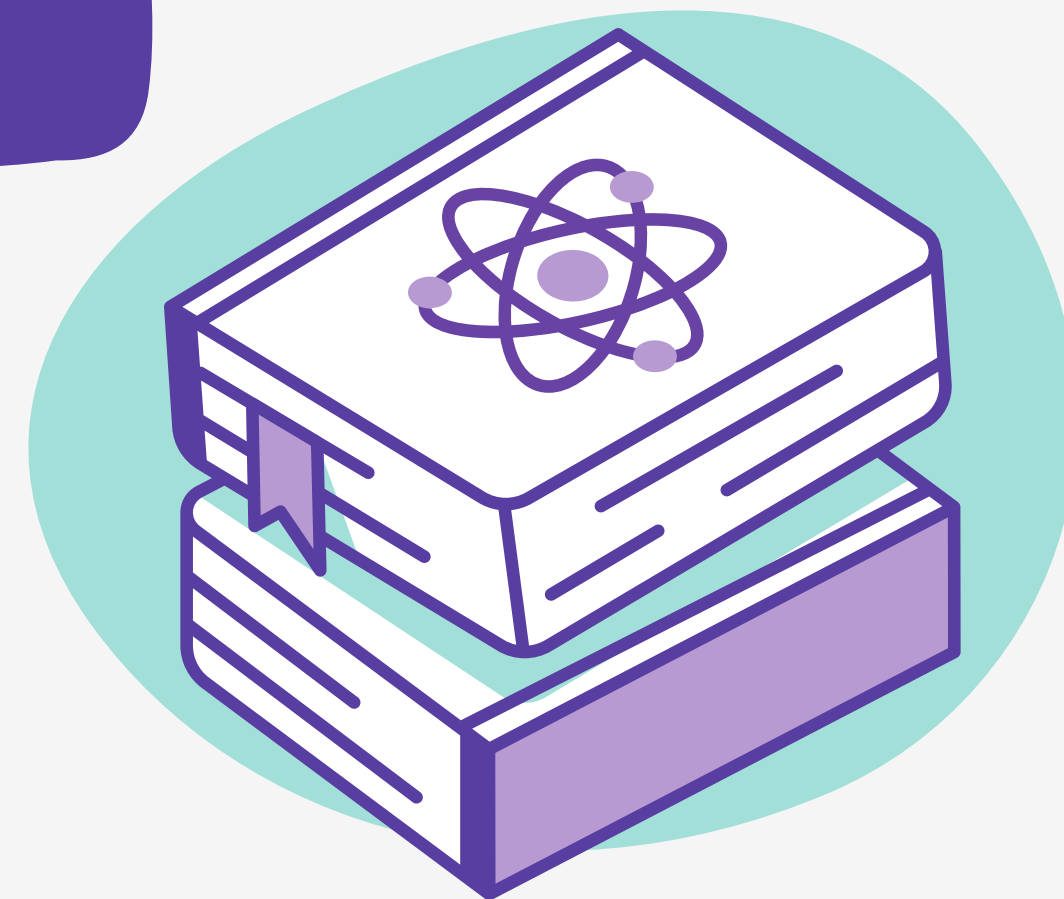


# Unit 1

Scientific Method and  
Chemistry of Life



# review vocab

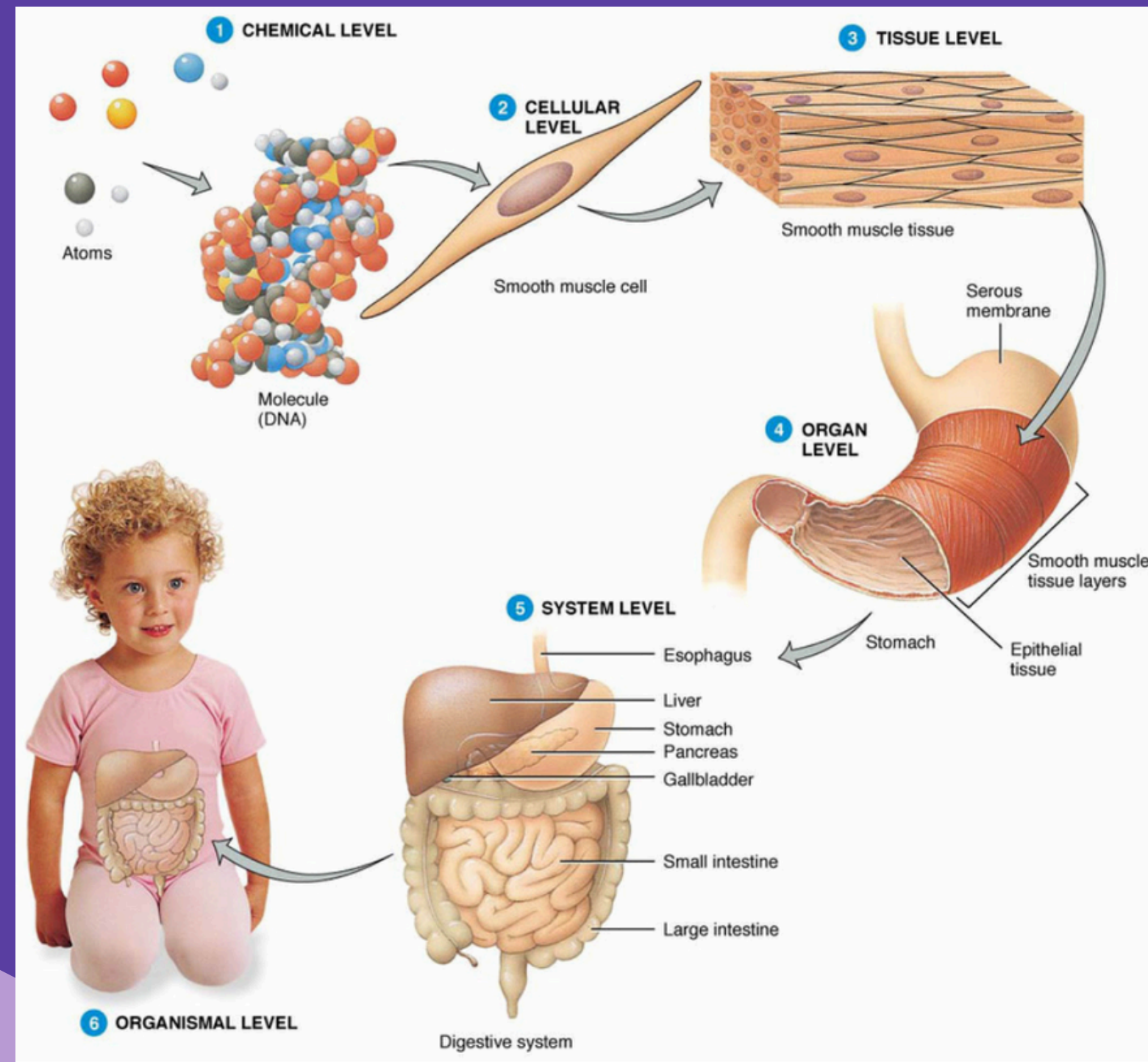
1. **Biology**: The study of living things and their interactions with their environments
2. **Cell**: The smallest unit of **LIFE** that can perform all processes of life.
3. **Organism**: Any individual living thing
4. **Species**: A group of organisms that are closely related and can produce fertile offspring

# All living things have these 7 characteristics

1. All organisms are made of one or more **cells**.
2. All organisms need a **source of energy** to carry out life processes.
3. All organisms must be able to **react** to **stimuli** or changes within their **environment**.
4. All organisms must have the ability to **reproduce**.
5. All organisms have **systems of related parts**.
6. All organisms must maintain **homeostasis**.
7. All organisms **evolve** over generations.

# #1

All organisms are made of one or more cells



Organisms can be unicellular (bacteria) or multicellular (plants, animals)



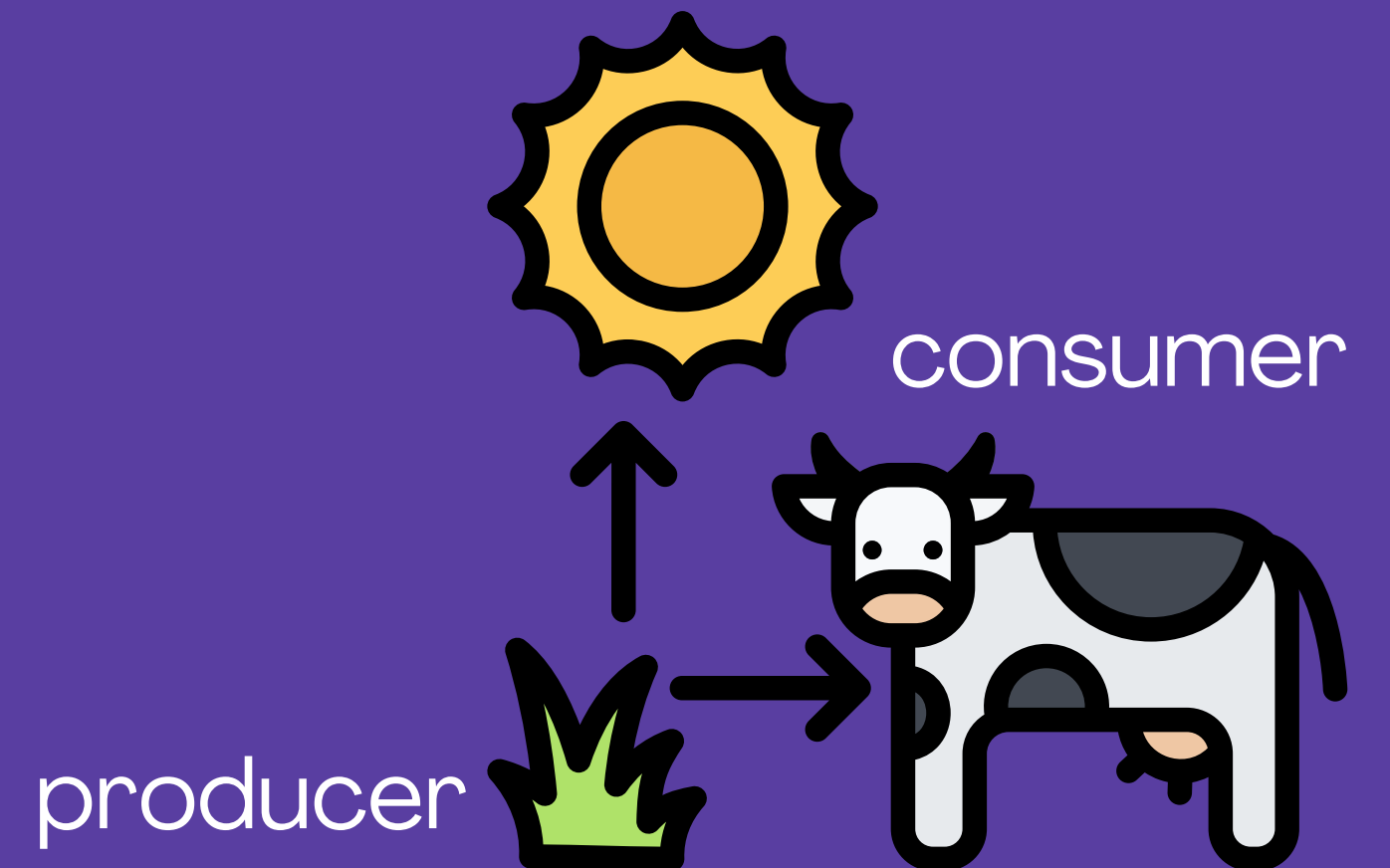


# #2

All organisms need a source of energy to carry out the processes of life



Metabolism is the sum of all chemical processes that build or break down materials for energy



# #3

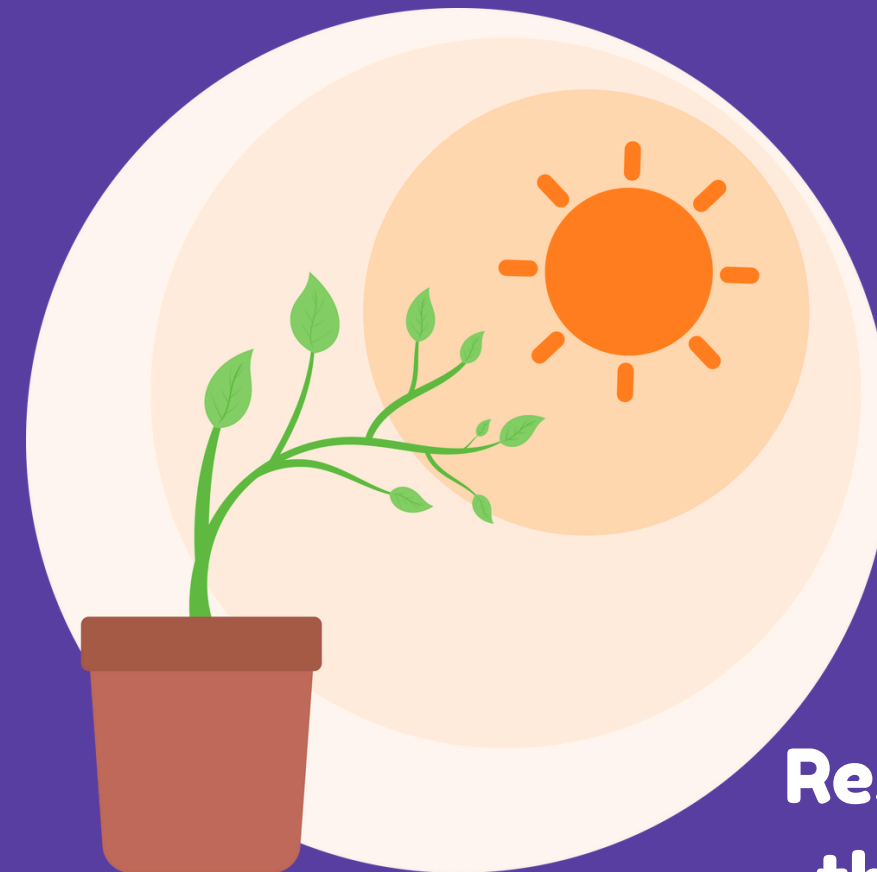
**All organisms must be able to react to stimuli or changes within their environment.**

**Stimulus** a thing or event that evokes a specific functional reaction in an organ or tissue.

Ex: light or touch



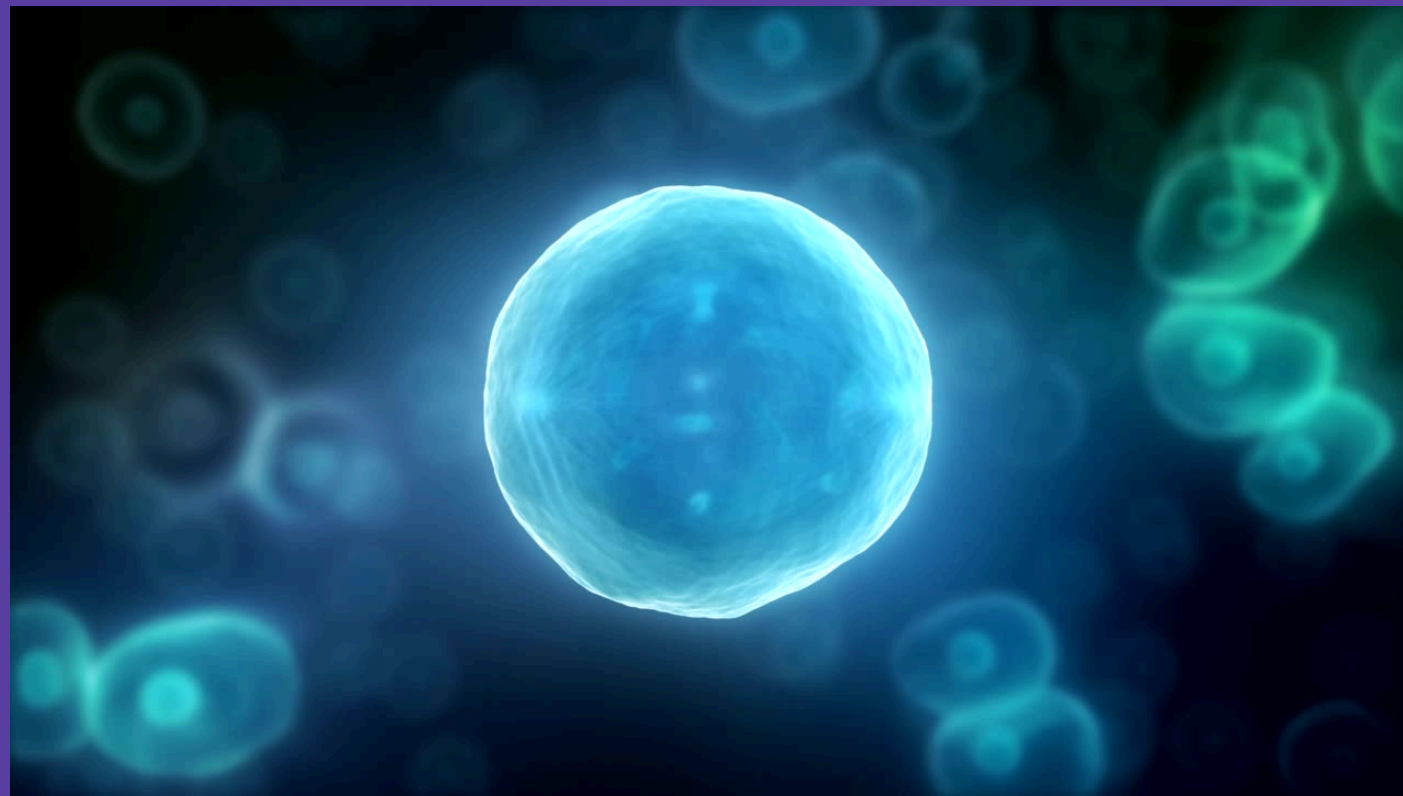
**Response to a hot environment**



**Response to light in the environment**

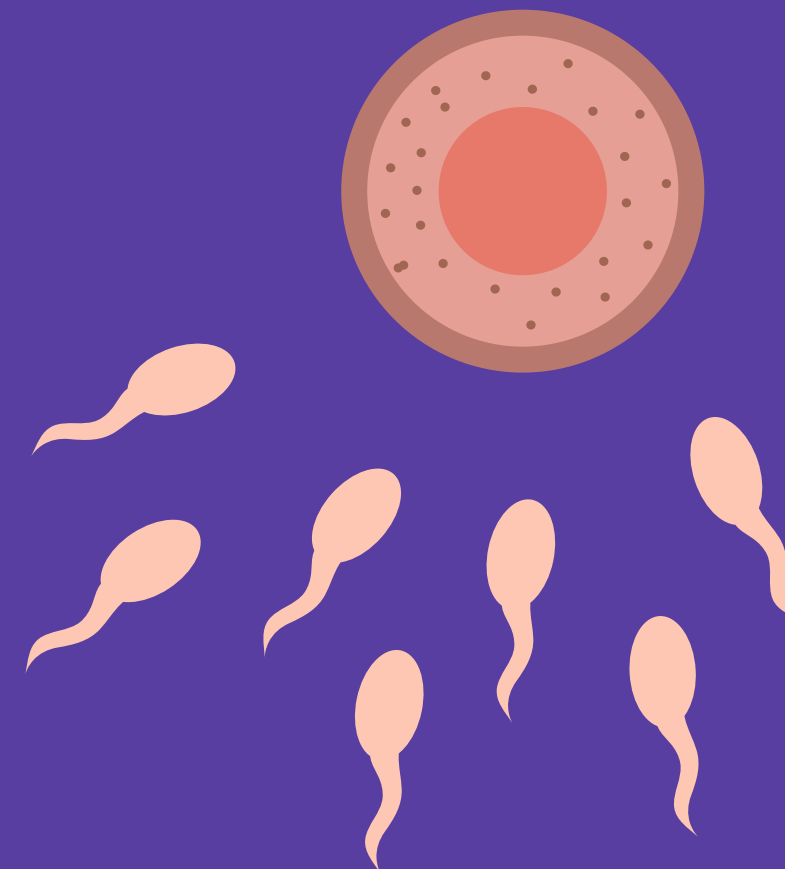
# #4

**All organisms must have the ability to reproduce.**



**Asexual reproduction**

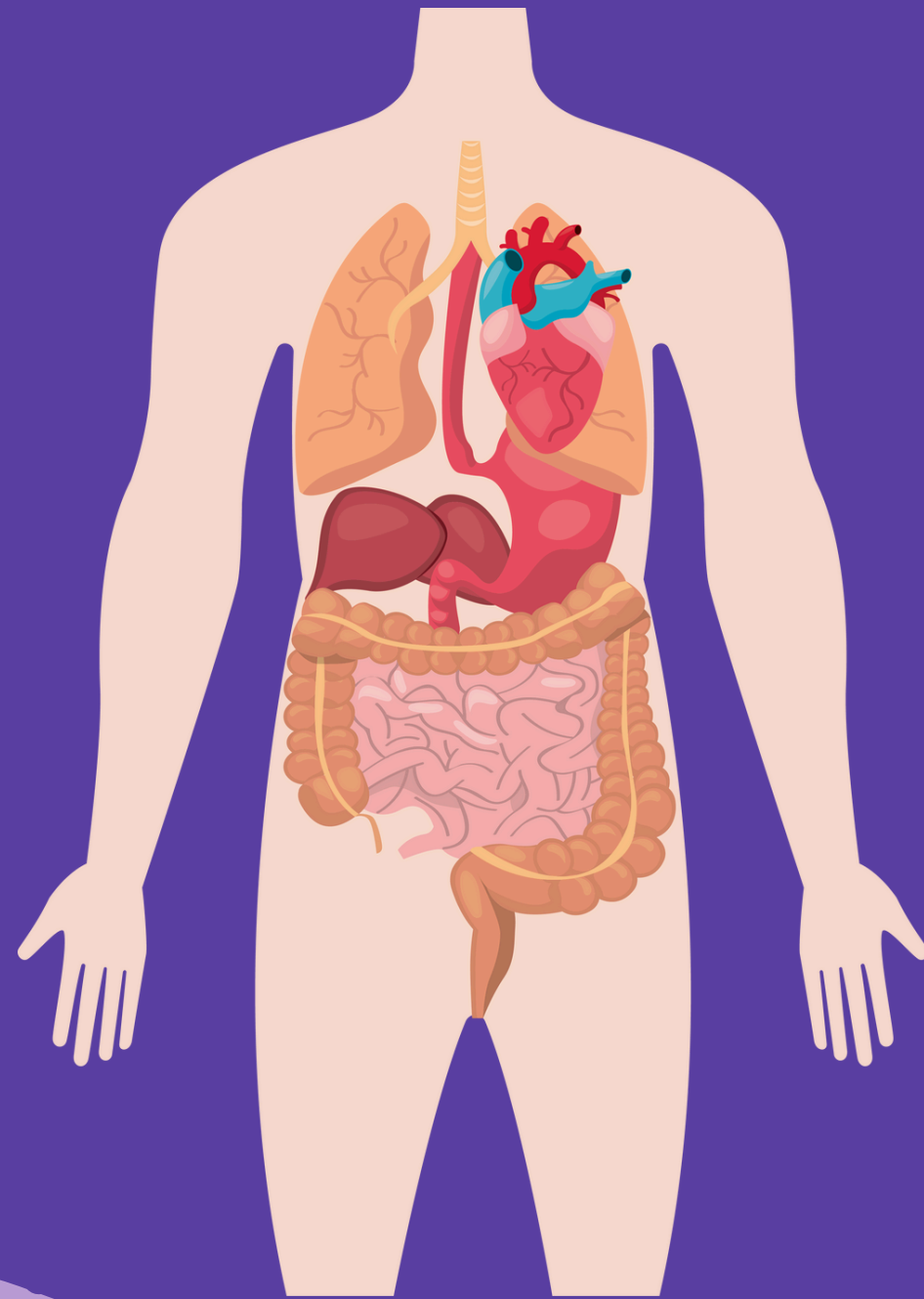
Organisms can reproduce asexually or sexually.  
In both cases, DNA gets passed to offspring.  
Organisms grow and develop after reproduction



**Sexual reproduction  
with a sperm and an  
egg cell**

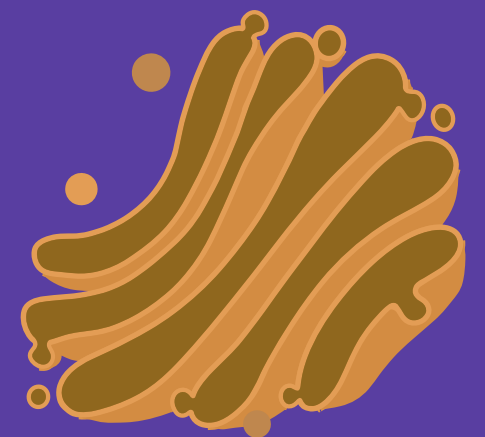
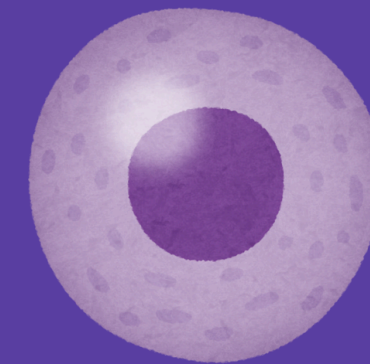
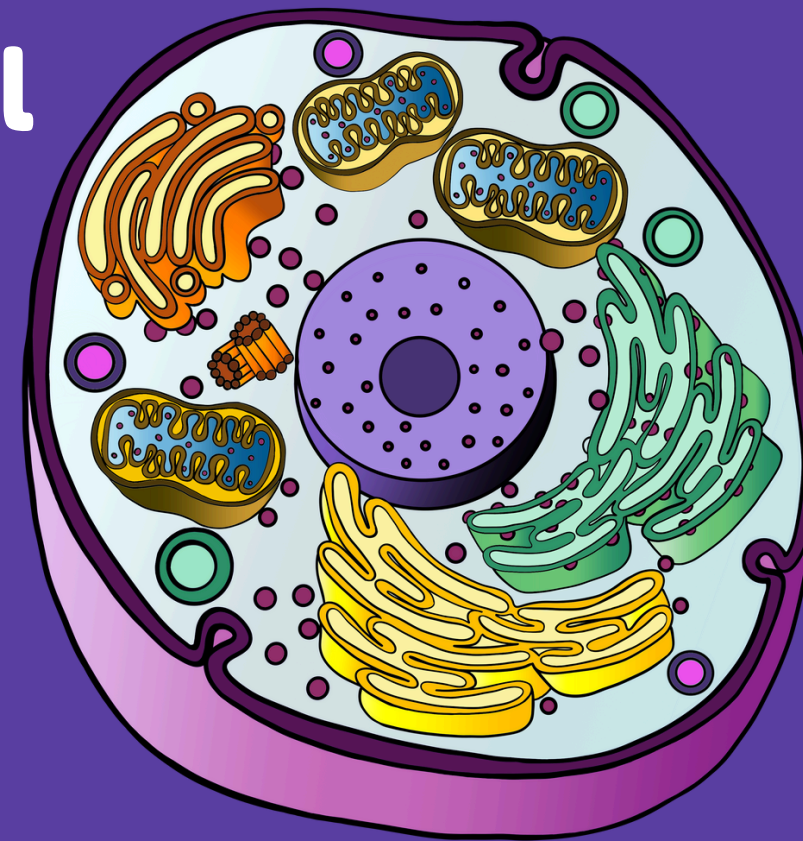
# #5

All organisms have a system of related parts



Bodies have body systems  
(ex: circulatory system)  
Cells have organelles (mini organs)

The cell



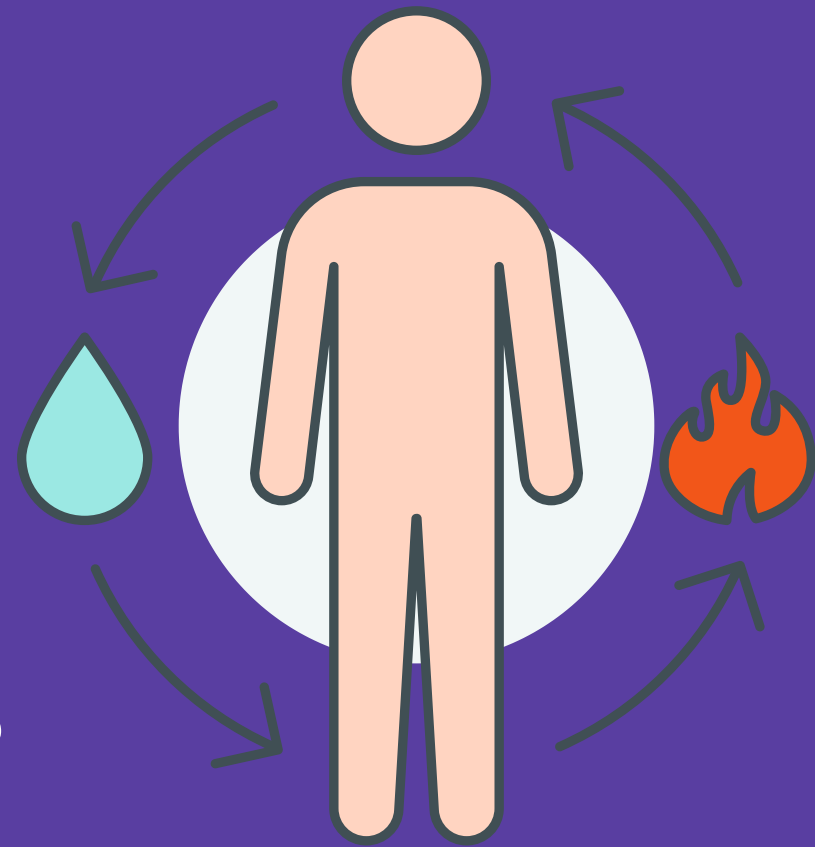
The  
organelles

# #6

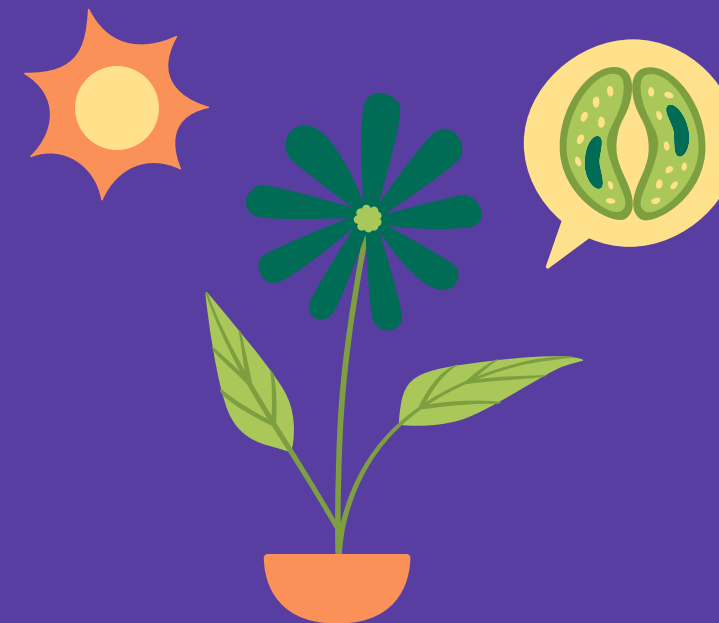
All organisms must maintain homeostasis.

**Homeostasis** is the process of maintaining a stable balanced internal environment despite changes to the external environment.

Regulating  
your body  
temperature



Light



No Light





# #7

**All organisms evolve using adaptations.**

## Antibiotic Resistance



A bunch of bacteria, a few of them are resistant to antibiotics

How does it occur?



Bacteria transfers resistance to other bacteria



Antibiotic kills the germs, pathogens or not



Remaining are the resistant pathogens, they can develop freely

**Evolution** is the change in living things over time.

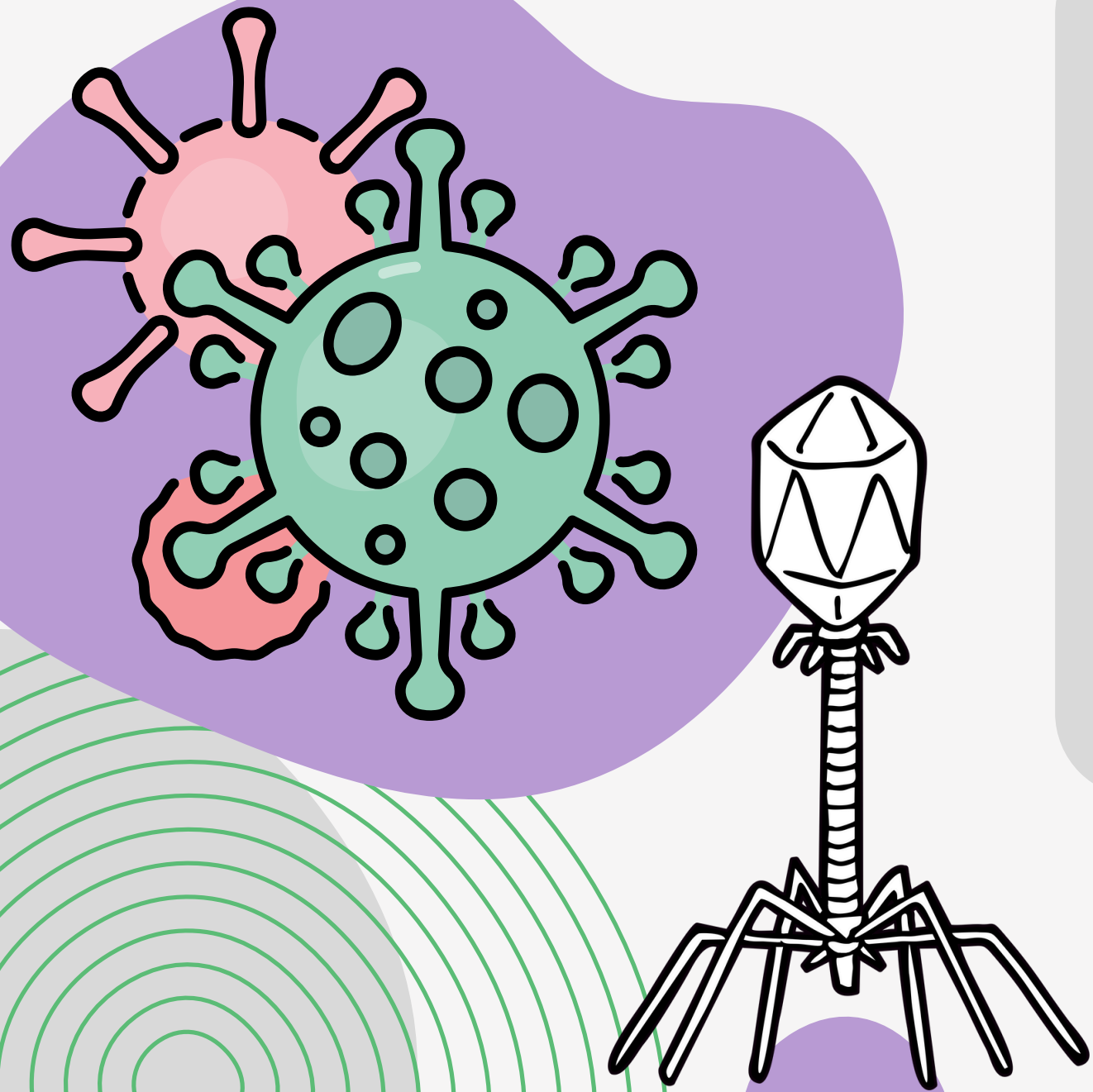
**Adaptations** are inherited traits that give an advantage to individual organisms and are passed onto future generations



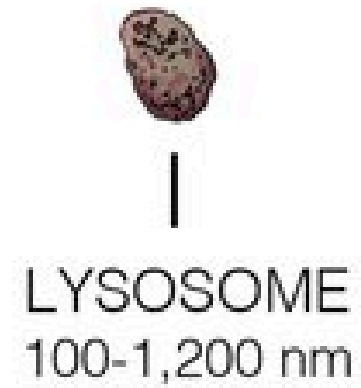
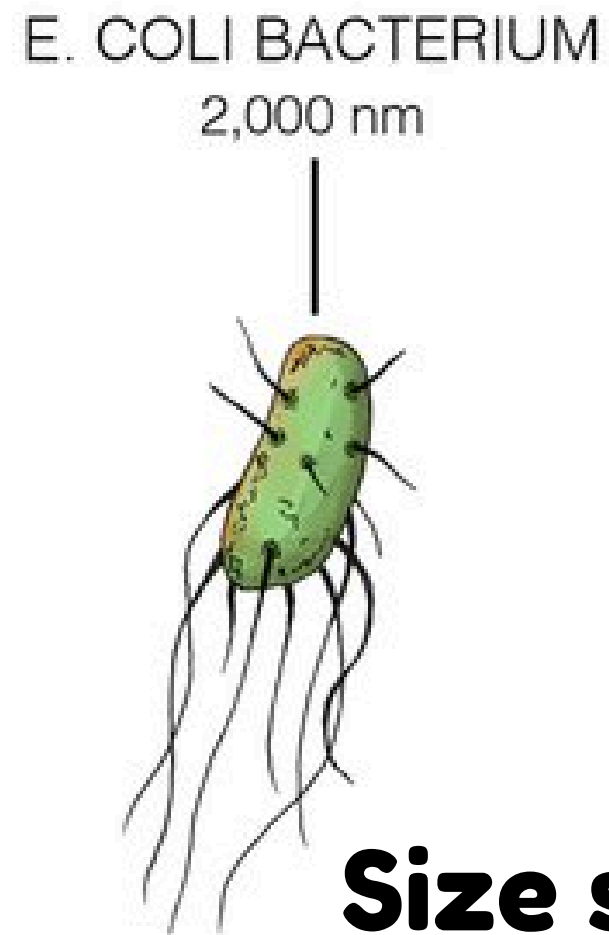
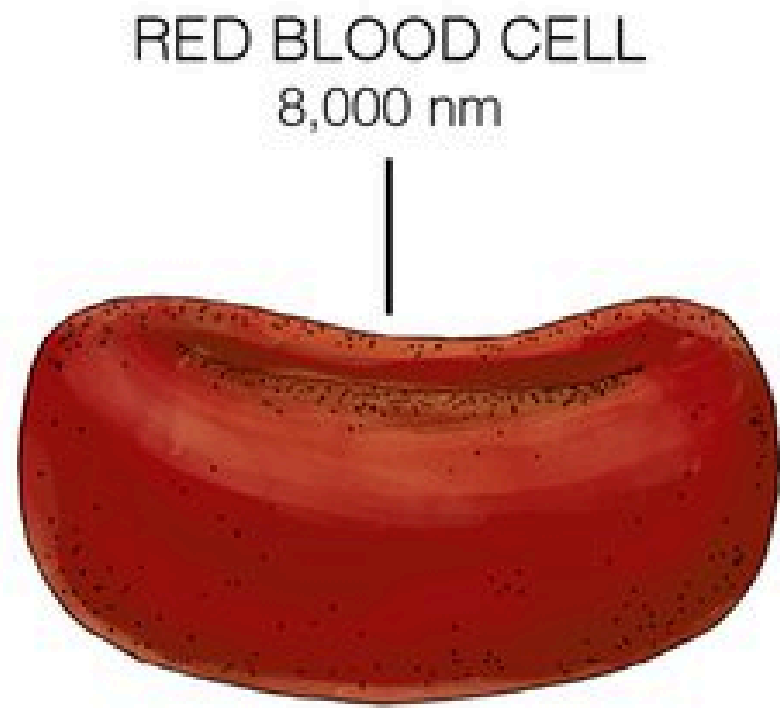
**What do you think about  
viruses?**

**Are they living?**

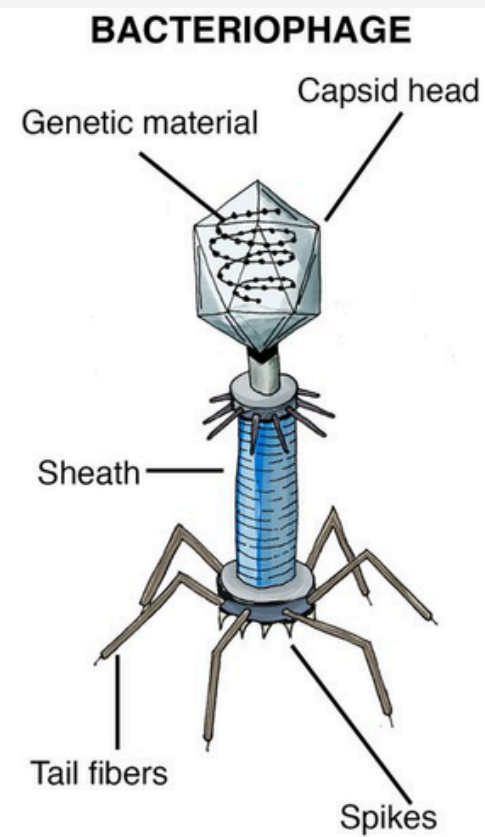
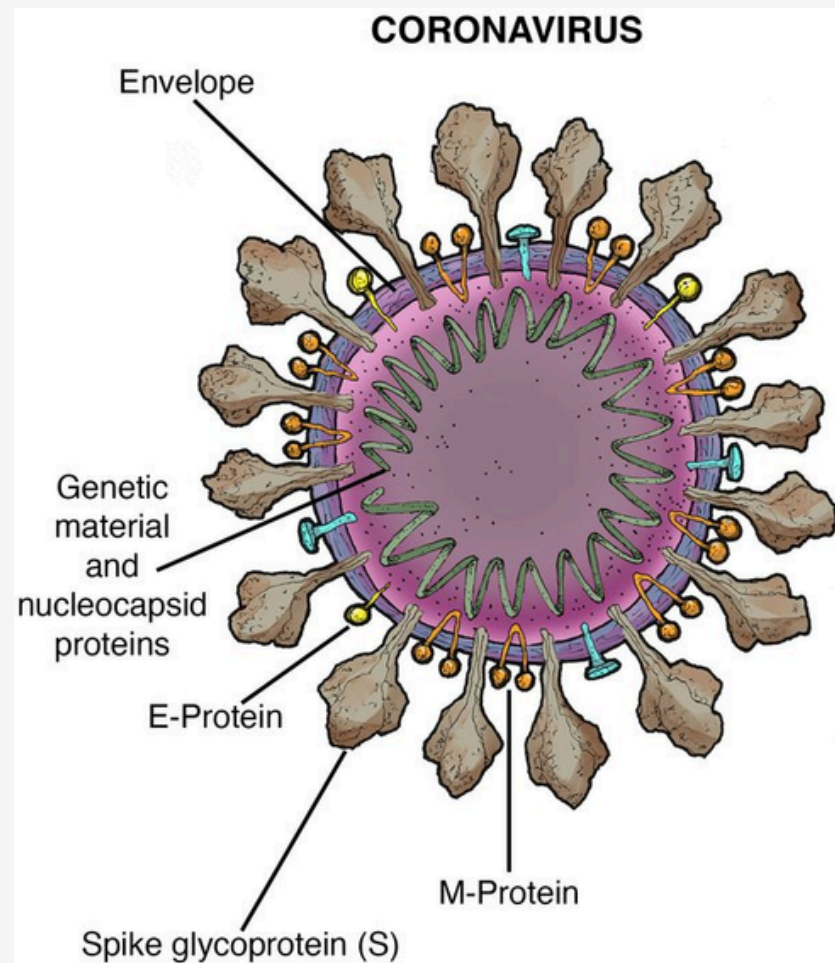
# What is a Virus?



- composed of a core of **DNA or RNA** surrounded by a protein coat called a **capsid**
- reproduce only by infecting a living cell (**host cell**)
- all viruses enter living cells and, once inside, use the host's machinery to produce more viruses
- They differ in size and structure, depending on what they infect and the illness it causes.




## Size scaling of a virus



**Coronavirus infects humans, the bacteriophage infects bacteria cells**

Characteristics	Virus	Cell
Structure	DNA or RNA, Surrounded by a capsid	Cell Membrane and organelles
Reproduction	Only within a host cell	Independent (asexual and sexual)
Genetic Code	DNA or RNA	DNA
Growth/Development	No	Yes
Uses energy	no	yes
Responds to Environment	no	yes
Evolves	yes	yes
Metabolism	no	yes
Maintains Homeostasis	no	yes





# Experimental Design

What is it and how is it useful?





Scientists make careful and systematic **observations** and record observations as data

- form a hypothesis as a possible answer to a question
- test the hypothesis and analyze the data
- evaluate results and possibly begin the cycle again

# Scientific Thinking



# Hypothesis

a proposed answer for a scientific question

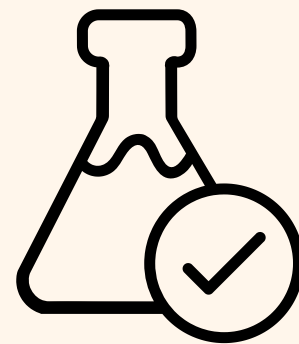
- must be specific and testable
- experiments test hypotheses



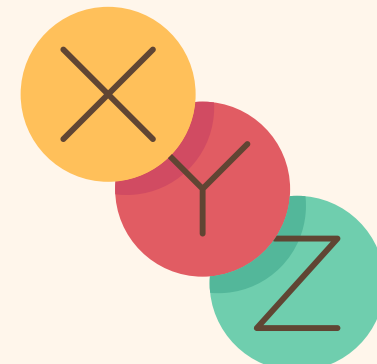
Question



Research



Testable



Variables



# Scientific Theory

explains a wide range of observations and experimental results

- supported by a wide range of scientific evidence
- theories can change based on new evidence



# Scientific Law

a statement of fact that defines relationships that are valid everywhere in the universe

- generally accepted to be true and universal
- examples: law of gravity, law of conservation of mass



true and  
universal



# Types of Investigations

## Descriptive

describes or quantifies a natural system

- has a question, procedures and a conclusion
- used when little is known about the topic
- no hypothesis

**Key Words:** observe, describe, list, and identify

## Example

observing cells under a microscope and diagramming what is seen



# Types of Investigations

## Comparative

collects data over different objects, organisms or conditions (ex: time of year)

- has a question, hypothesis, procedures and a conclusion
- can have variables
- no control

**Key Words:** compare/contrast, similarity/difference, categorize

## Example

Comparing bear diets and eating frequencies during different seasons



# Types of Investigations

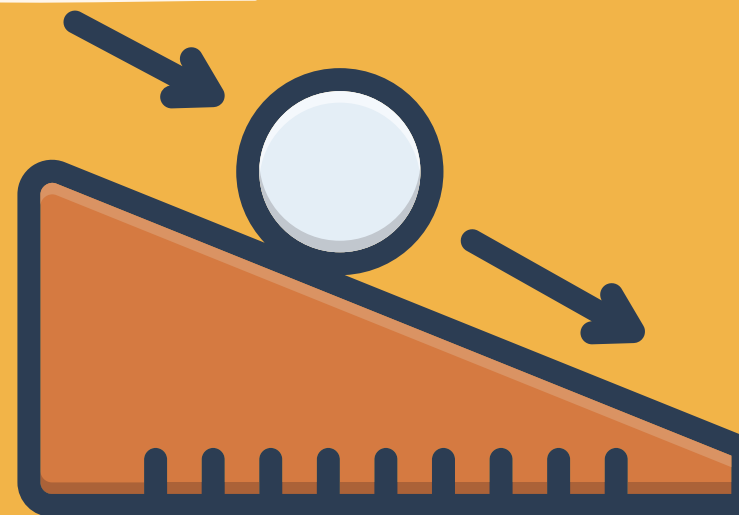
## Experimental

“fair test”, variables are manipulated, controlled and measured to gather evidence to support/refute a relationship

- has a question, hypothesis, procedures, control and a conclusion
- variables identified
- all factors are held **constant** except the manipulated variable

## Example

testing the height of a ramp to determine how far a marble will roll



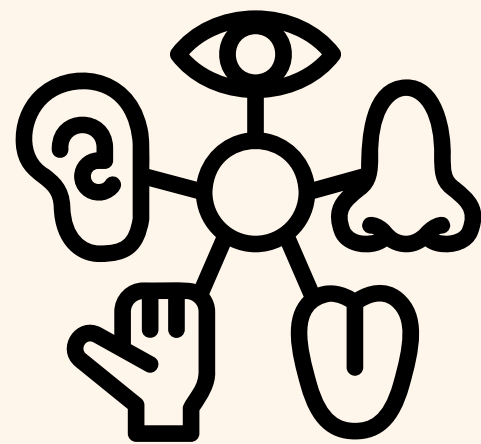
# Two Types of Data

1

## Qualitative

descriptions in words of what is being observed

Think of your 5 senses



2

## Quantitative

analyzes results using numerical values

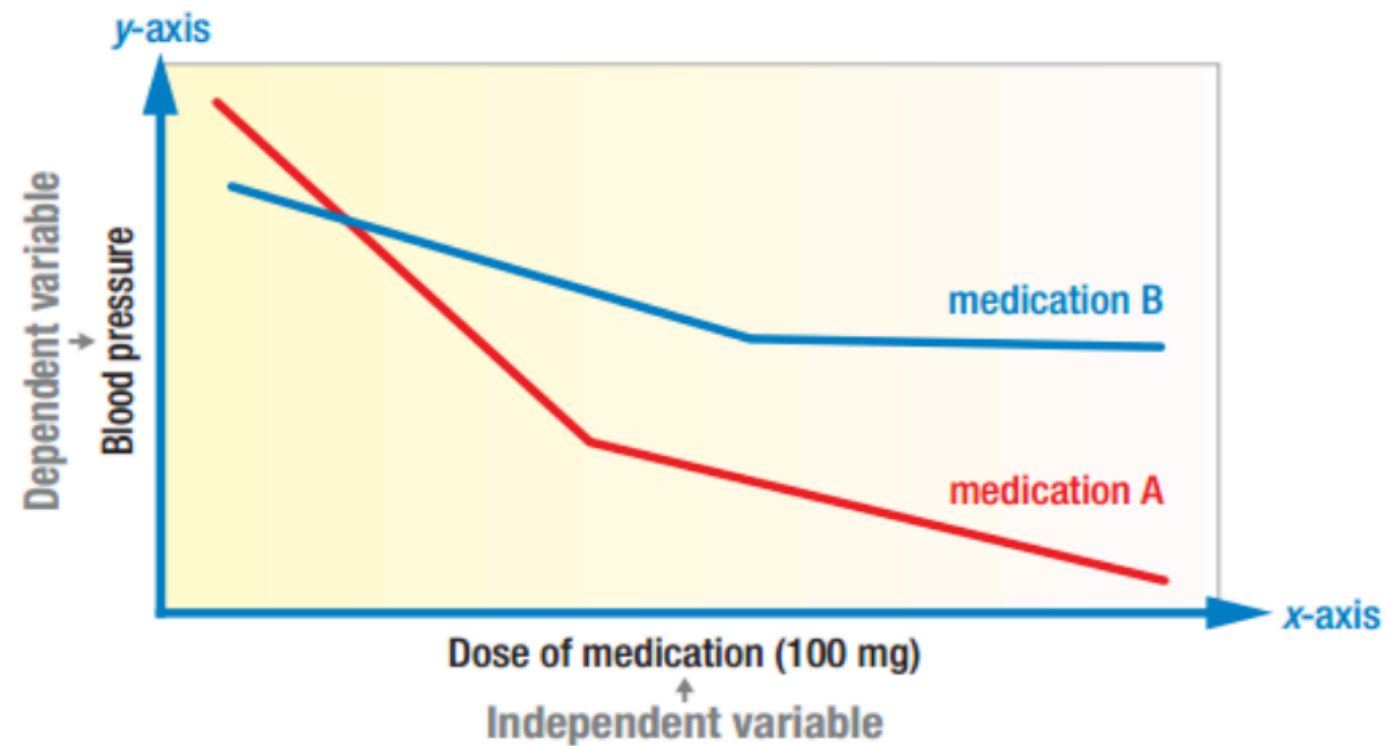
Height,  
weight,  
age



# Experimental Setup

- **independent variables** are manipulated/changed (X-axis)
- **dependent variables** are observed and measured (Y-axis)
- **constants** are conditions that are kept the same
- the **control** is not changed but used for comparison

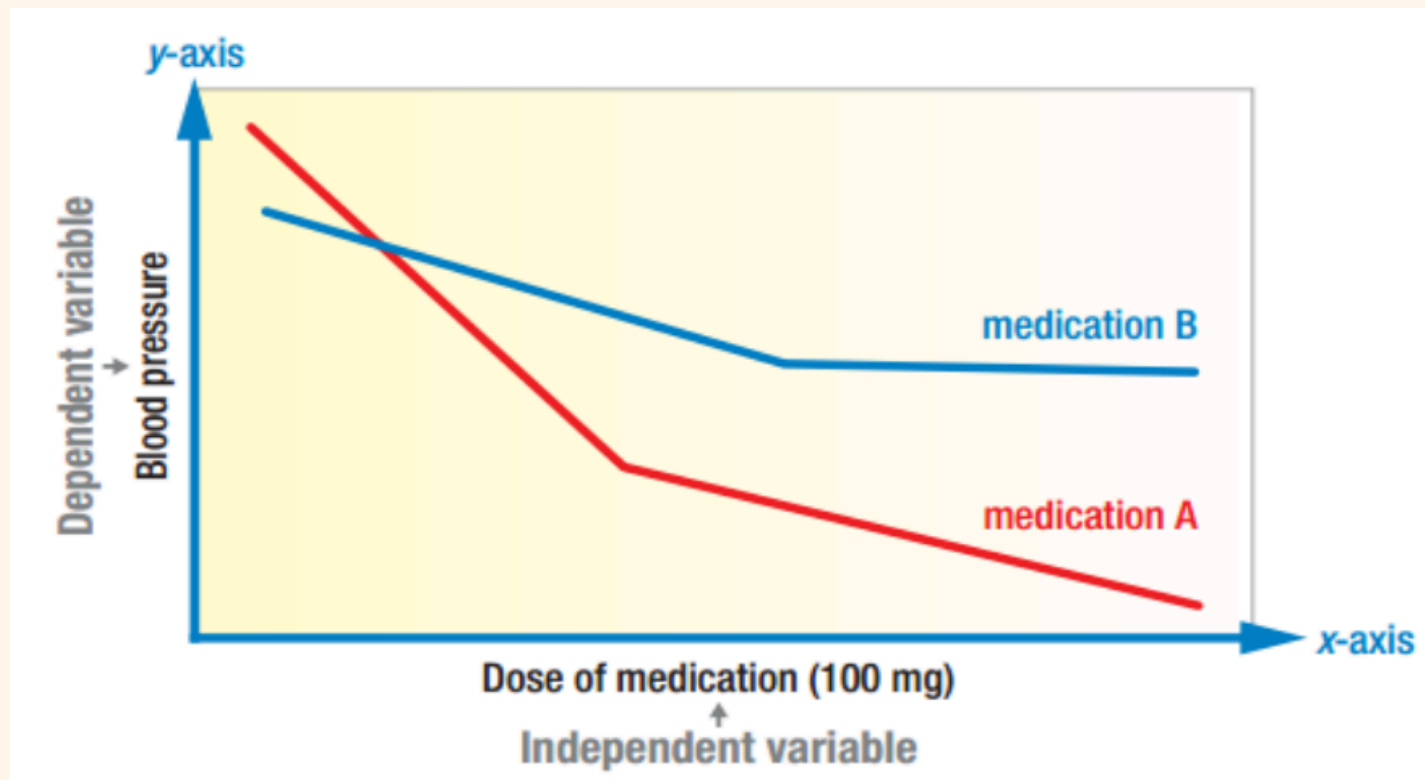
This graph compares the effects of the same dosage of two different medications on blood pressure. The independent variable (dosage) stayed the same for each type of medication tested.





# Experimental Setup

- independent variable
- dependent variable
- constants
- control group



This graph compares the effects of the same dosage of two different medications on blood pressure. The independent variable (dosage) stayed the same for each type of medication tested.

# Are student test scores impacted by the amount of noise in the room?

independent variable

**noise**

dependent variable

**test scores**

control

**classroom with no noise**

constant

**same room, same test, same temp, same age**

what type of data is collected?

**quantitative**

# Will different solutions (penny, aspirin, bleach) keep flowers in a vase alive longer?

independent variable

**type of solution**

dependent variable

**days alive**

control

**plain water**

constant

**sunlight, temp, type of flower, water amount**

what type of data is collected?

**quantitative**

# Graphing Checklist



Title



Axis



Labels



Key



Scale/Spacing

THE TITLE SHOULD TELL THE VIEWER  
WHAT THE GRAPH/DATA IS ACTUALLY  
SHOWING.

IT SHOULD **NOT** SAY LAB, GRAPH, OR  
EXPERIMENT

EX:

“THE EFFECT OF \_\_\_\_\_ ON \_\_\_\_\_”

“THE CHANGE IN \_\_\_\_\_ OVER TIME”

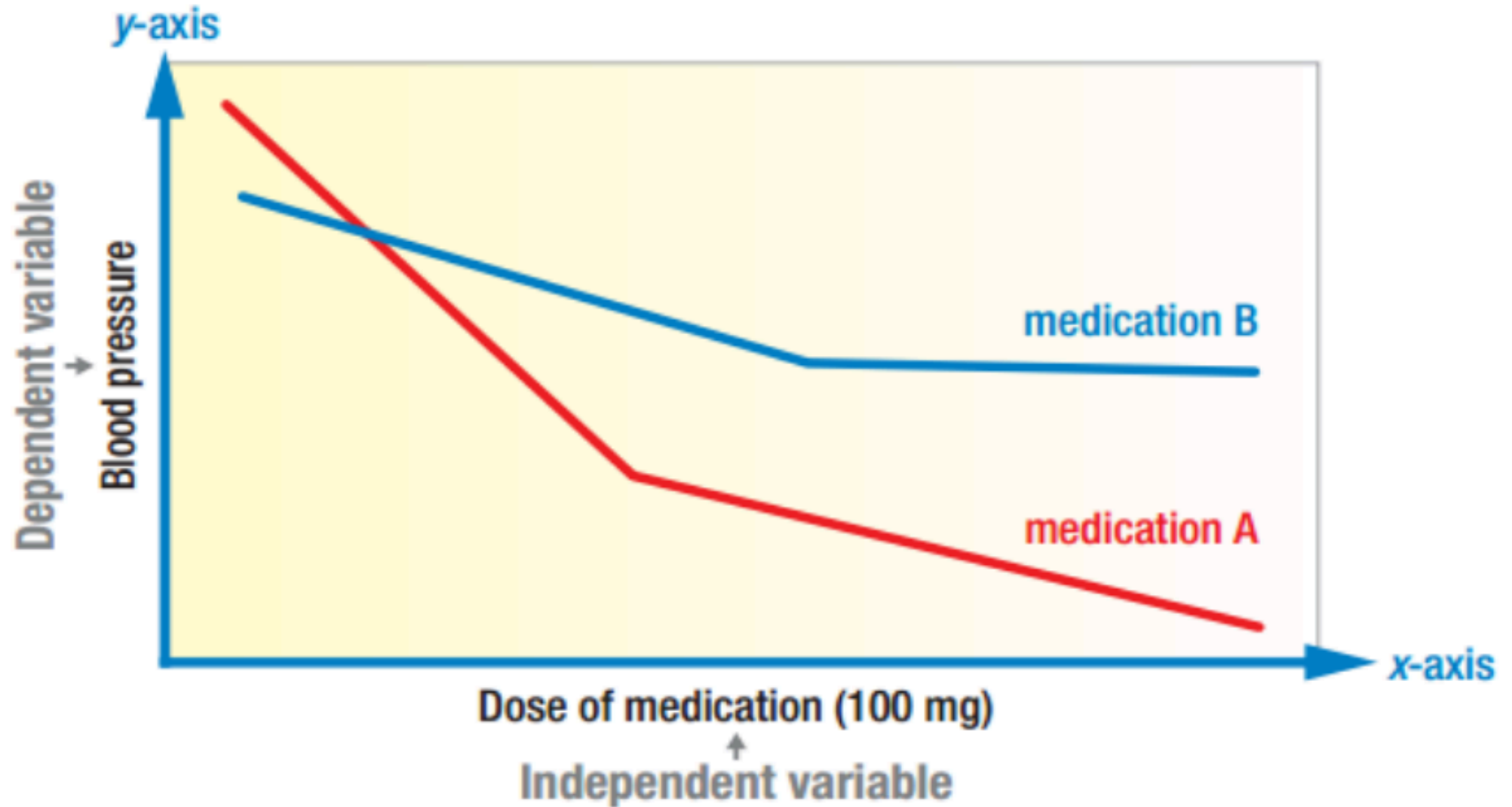


# Title



# WHAT WOULD YOU CALL THIS GRAPH?

This graph compares the effects of the same dosage of two different medications on blood pressure. The independent variable (dosage) stayed the same for each type of medication tested.





THE INDEPENDENT VARIABLE GOES ON  
THE X-AXIS

THE DEPENDENT VARIABLE GOES ON  
THE Y-AXIS

# A Axis



**D** = dependent

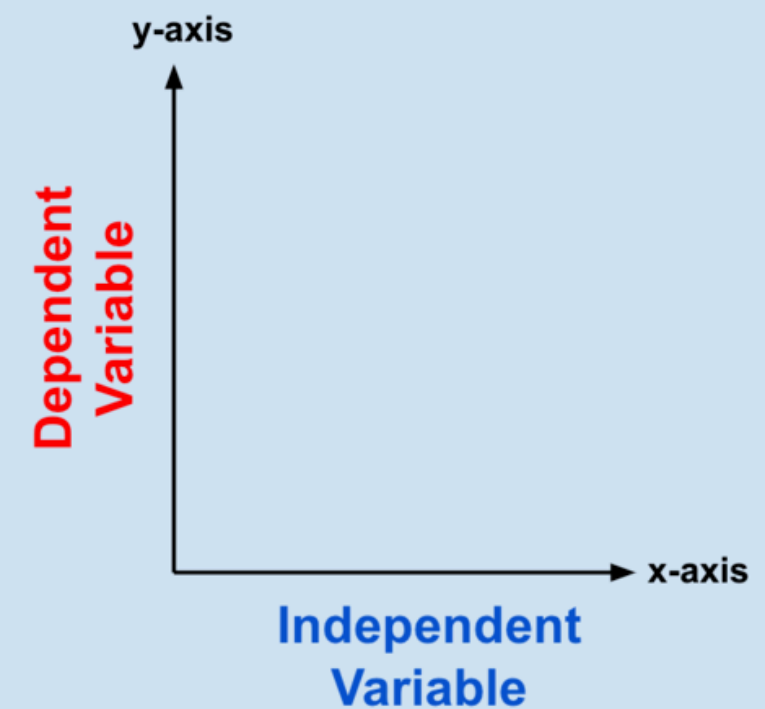
**R** = responding

**Y** = y-axis

**M** = manipulated

**I** = independent

**X** = x-axis



# L Labels



LABEL ALL AXES WITH THE  
VARIABLE THAT GOES WITH IT

INCLUDE UNITS!

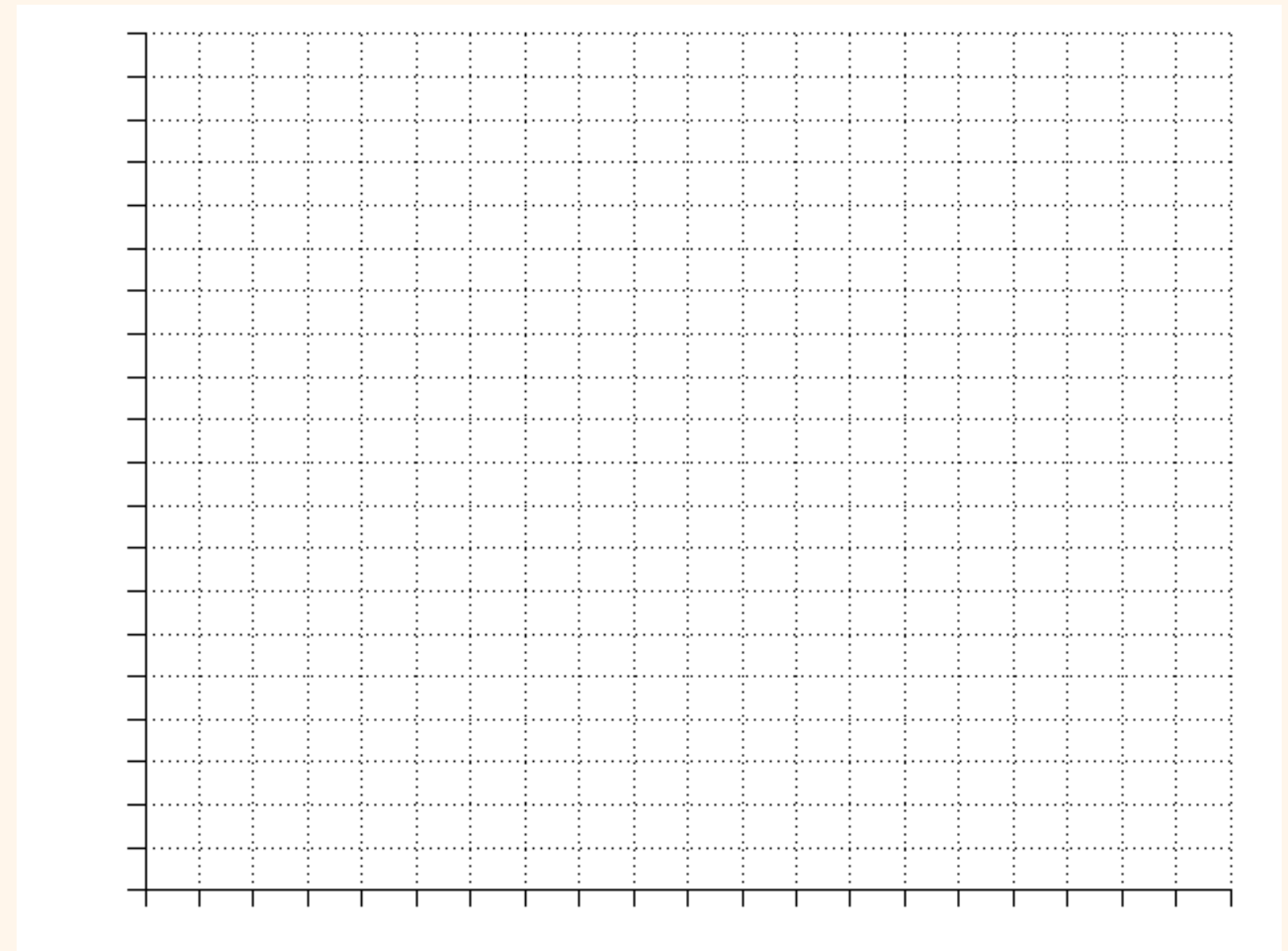
**ALWAYS** LABEL ZERO, EVEN IF  
YOU DON'T GRAPH ZERO

# GROUP PRACTICE

WHAT IS ON THE X-AXIS AND Y-AXIS?

**Experiment:** What is the effect of different fertilizers on plant height?

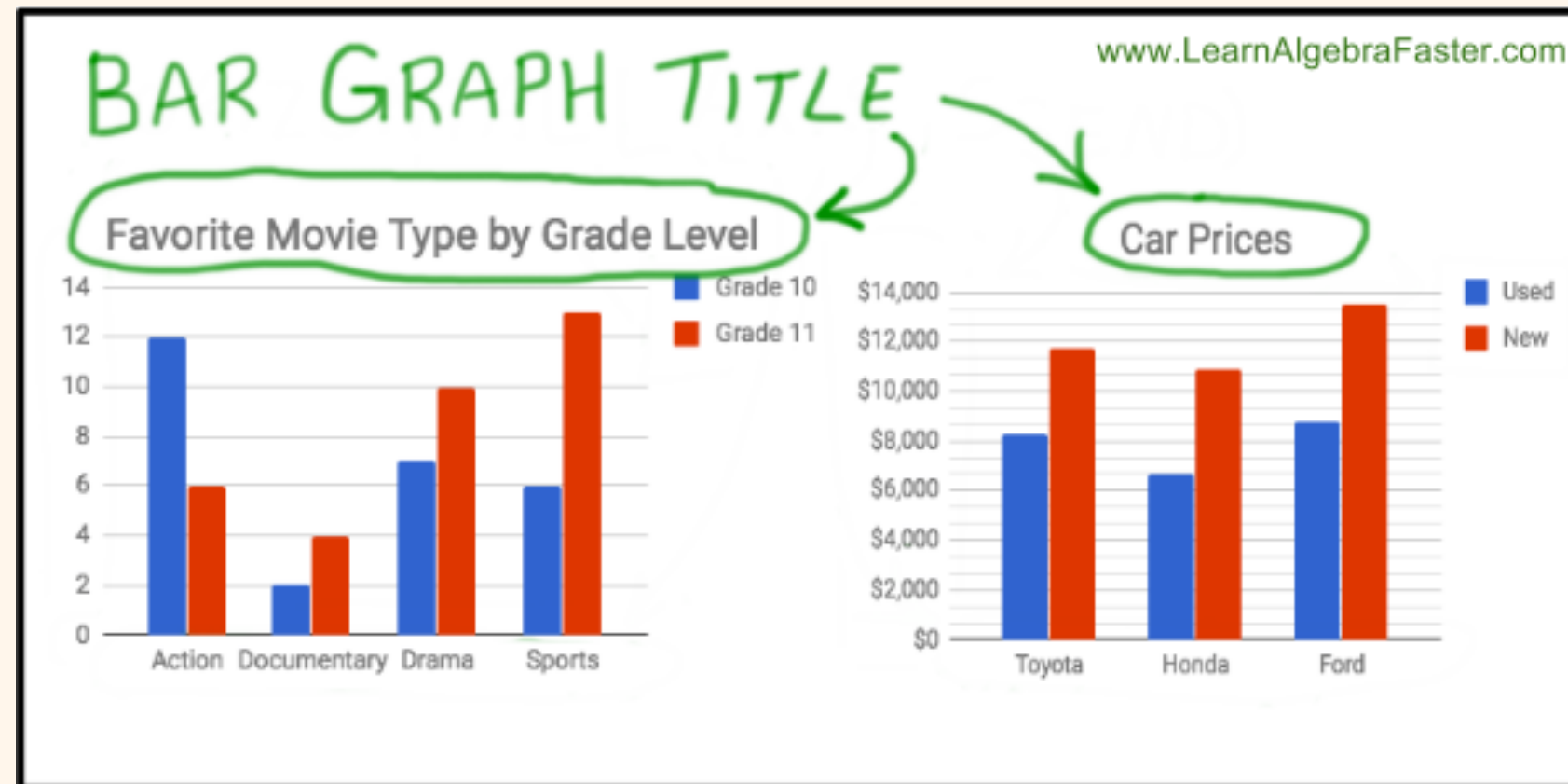
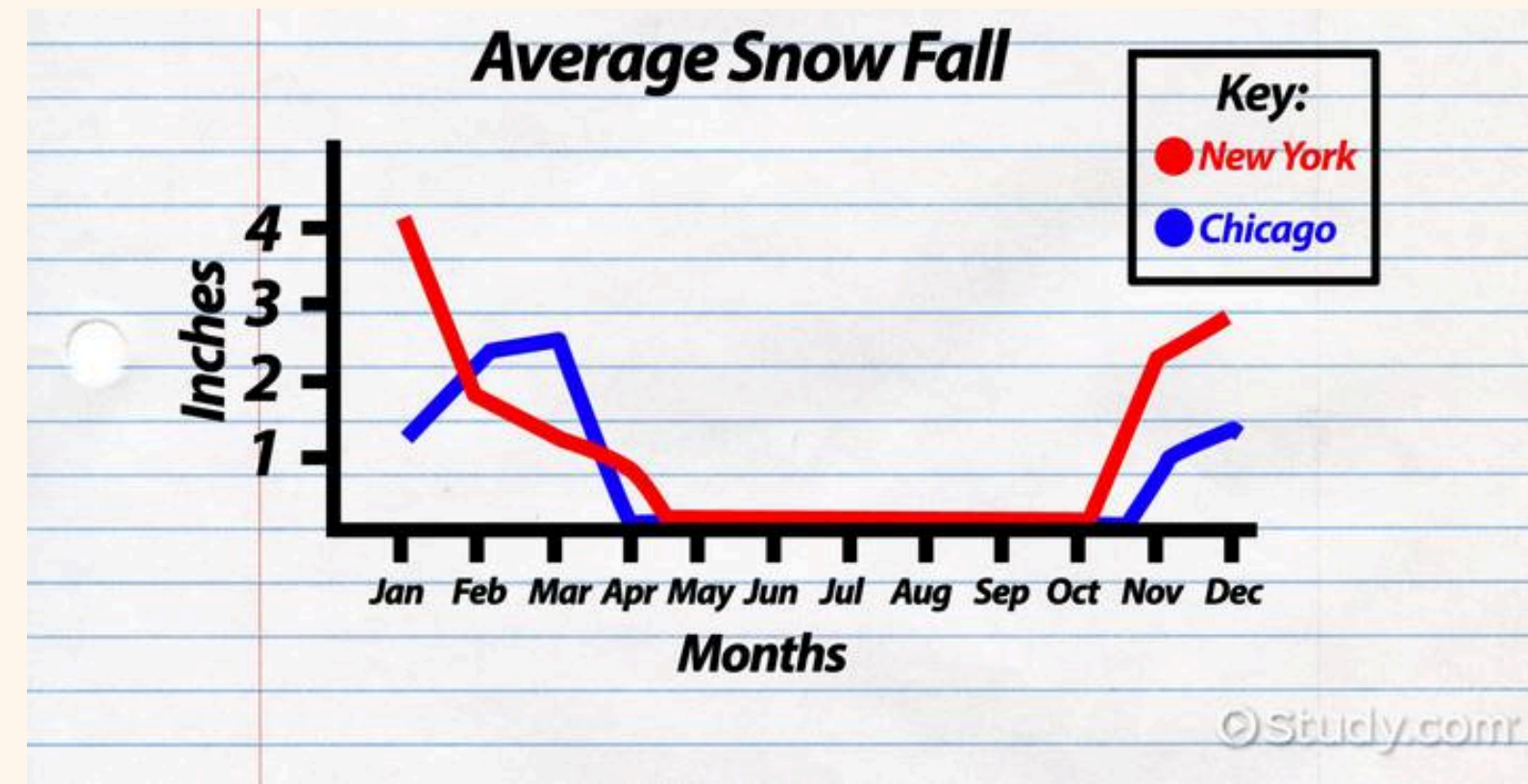
Fertilizer	Height after 3 weeks
Miracle Gro	17 cm
Germination Giant	9 cm
GroPro	13 cm
Feed Me, Seymour	4 cm



# FOR LINE GRAPHS WITH MULTIPLE LINES OR BAR GRAPHS



# Key

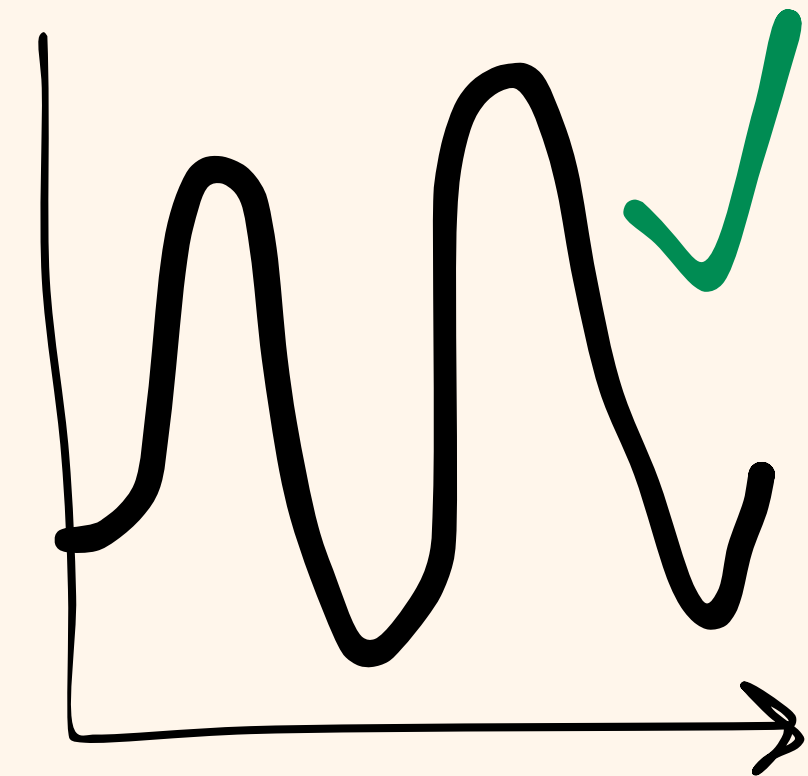


PLAN AHEAD!

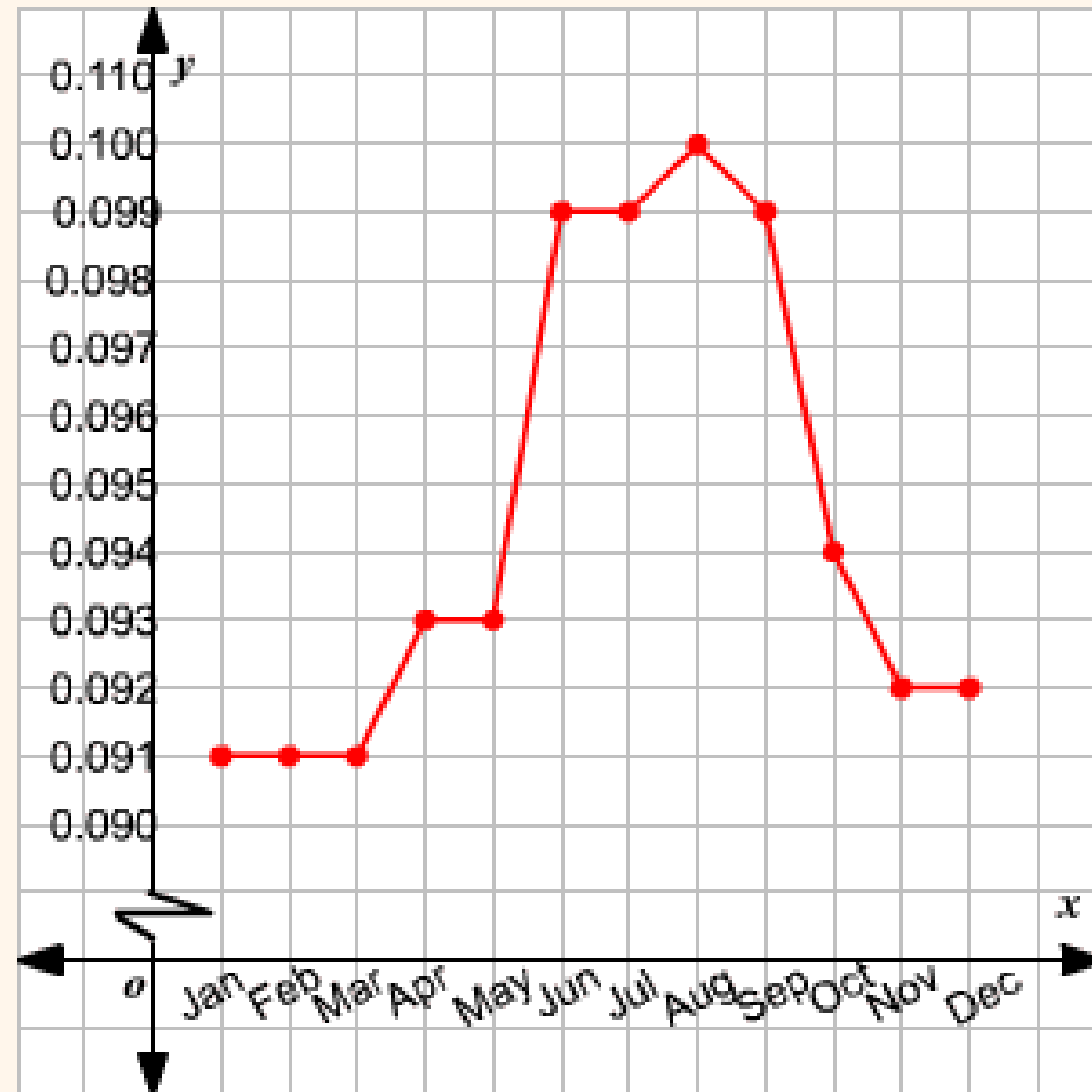
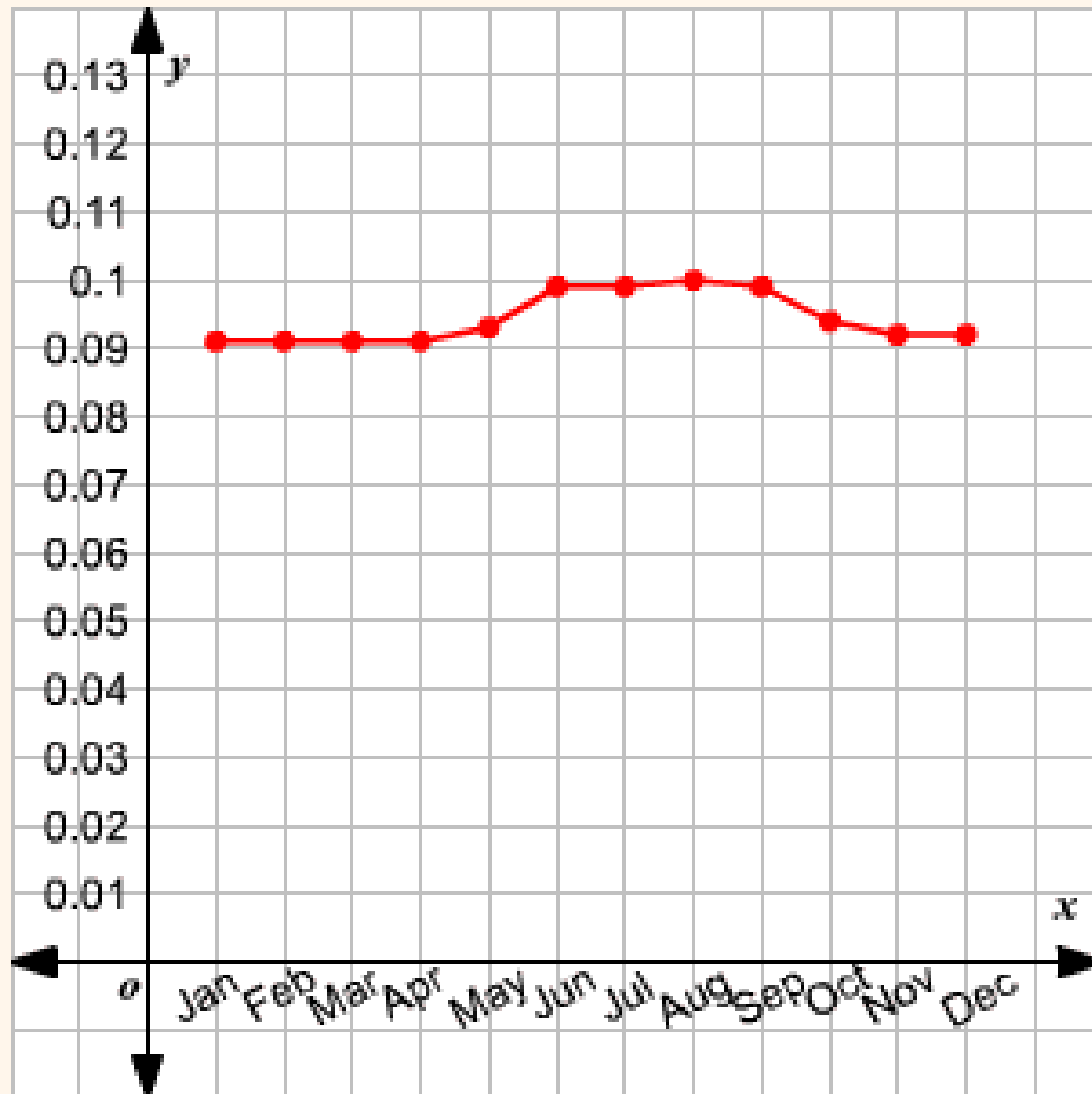
THE GRAPH SHOULD TAKE UP AT LEAST 50% OF THE PROVIDED GRID.

S Scale/Spacing

THE GRAPH SHOULD NOT GO OUTSIDE OF THE GRID SPACE.

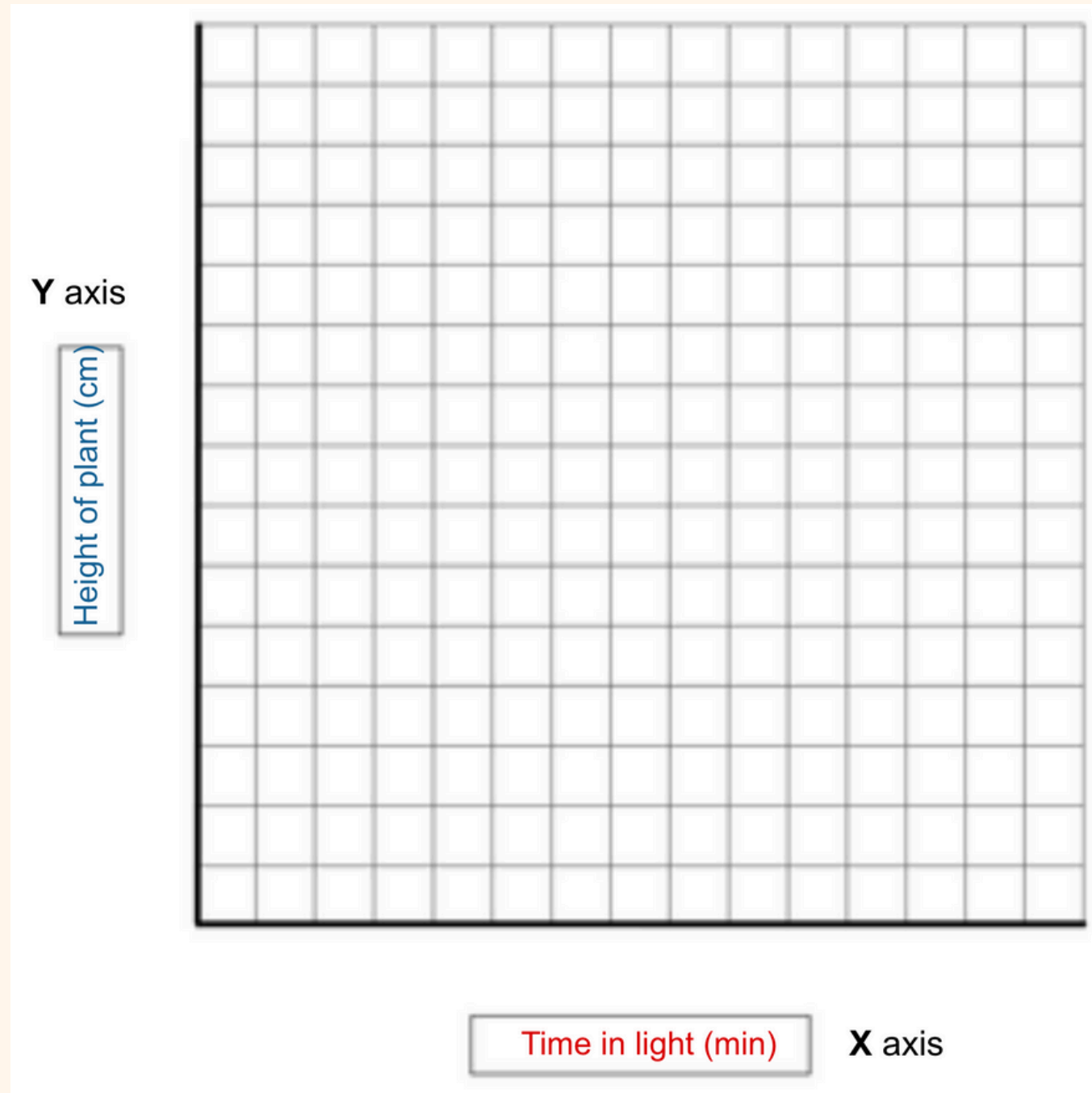


HINT: IF YOU NEED TO SKIP A LARGE SET OF NUMBERS, DRAW A ZIGZAG ABOVE ZERO ON THE AXIS TO SHOW YOU SKIPPED NUMBERS, THEN BEGIN YOUR SCALE.





# Make a line graph

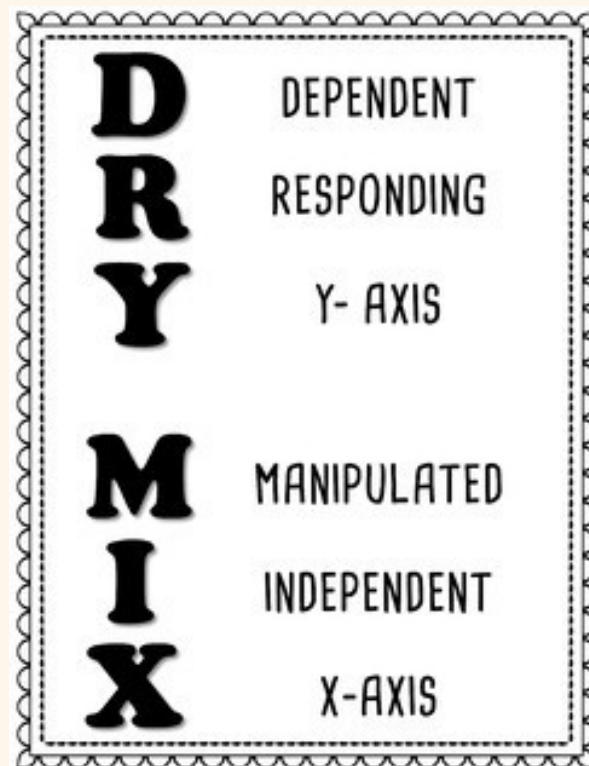


Should you graph (0,0)?

Time in Sunlight (min)	Height of the plant (cm)
5	2
10	4
15	7
20	8
25	10
30	12
35	15

# Try it on your own!

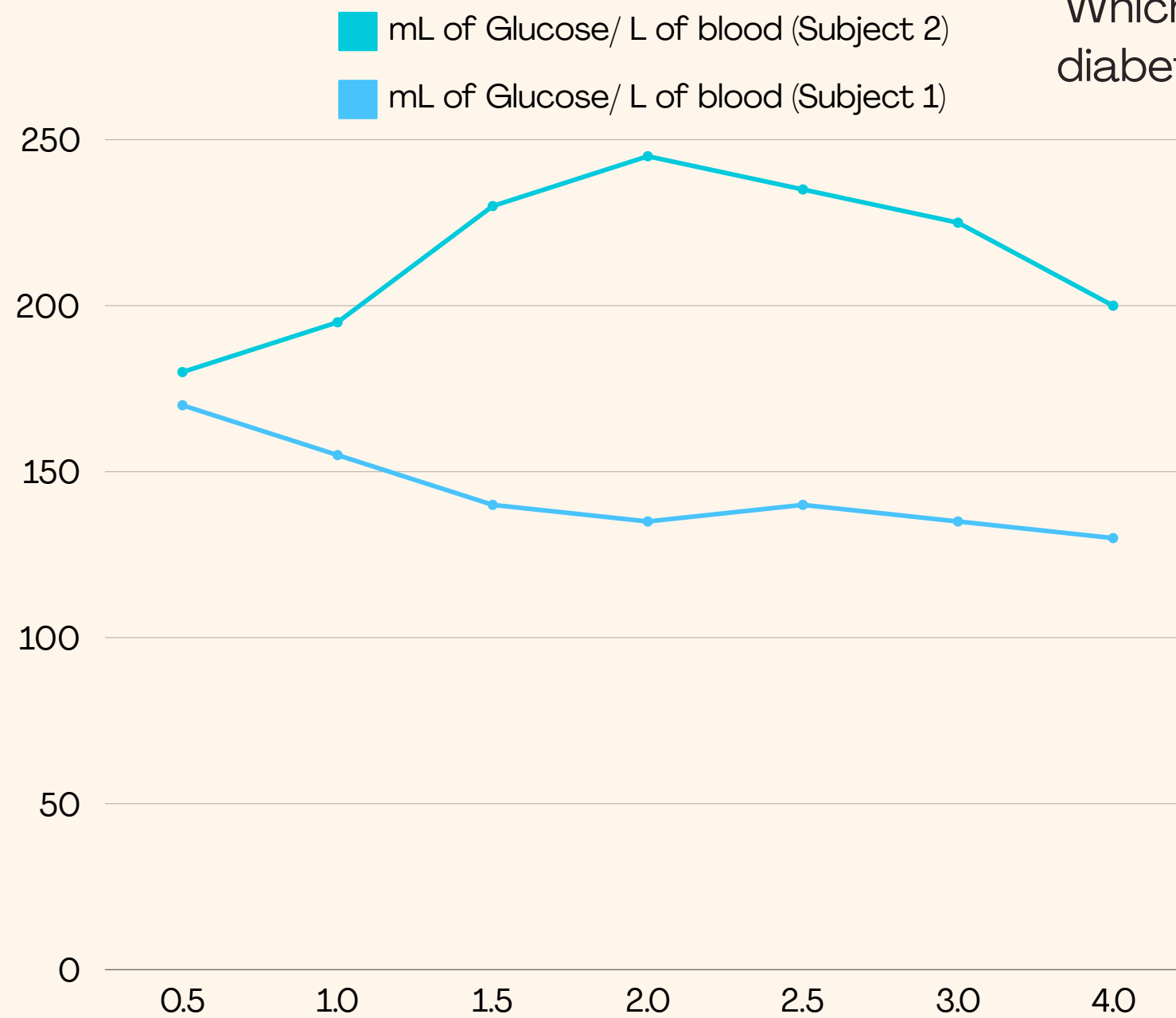
Diabetes is a disease affecting the insulin producing glands of the pancreas. If there is not enough insulin being produced by these cells, the amount of glucose in the blood will remain high. A blood glucose level above 140 for an extended period of time is not considered normal. This disease, if not brought under control, can lead to severe complications.



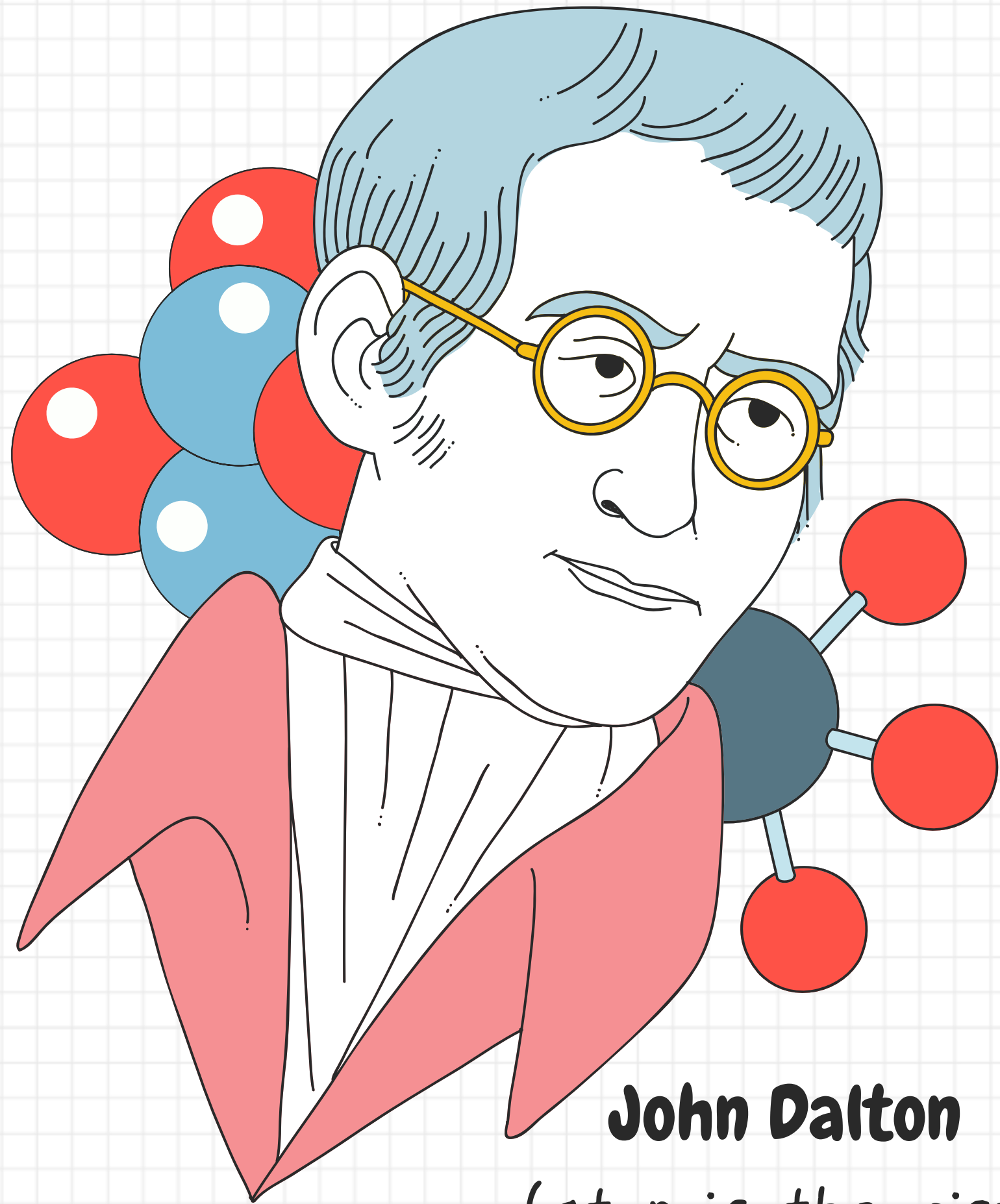
Time after eating (Hrs)	mL of Glucose / L of blood Subject A	mL of Glucose / L of blood Subject B
0.5	170	180
1	155	195
1.5	140	230
2.0	135	245
2.5	140	235
3	135	225
4	130	200

# Make a line graph

What should the title of the graph be?  
Independent Variables?  
Dependent Variables?  
Which subject has diabetes and why?



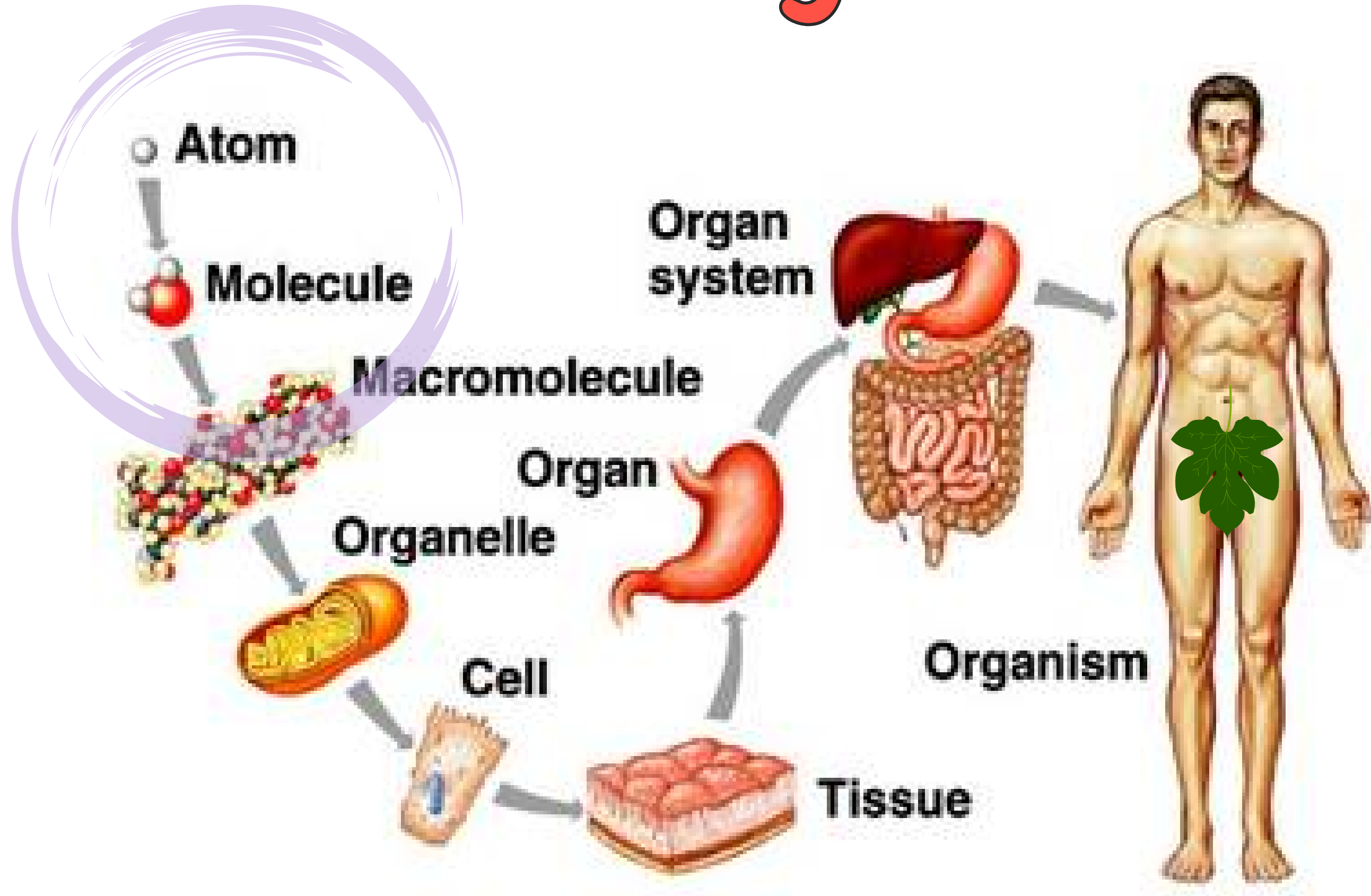
Time after eating (Hrs)	mL of Glucose / L of blood Subject A	mL of Glucose / L of blood Subject B
0.5	170	180
1	155	195
1.5	140	230
2.0	135	245
2.5	140	235
3	135	225
4	130	200



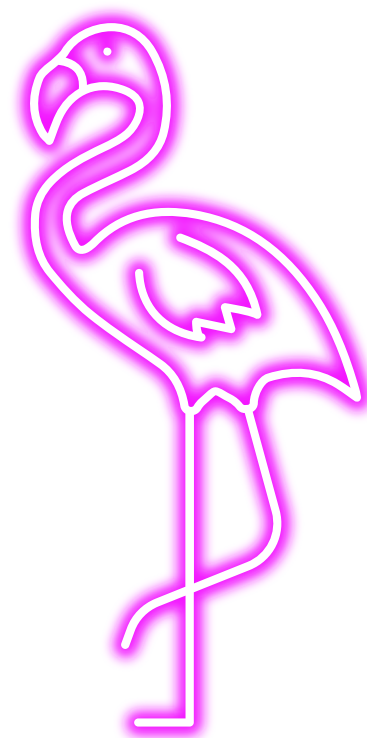
**John Dalton**  
(atomic theorist)

# Atoms & Molecules

# Levels of Organization



# Do you know these Elements?

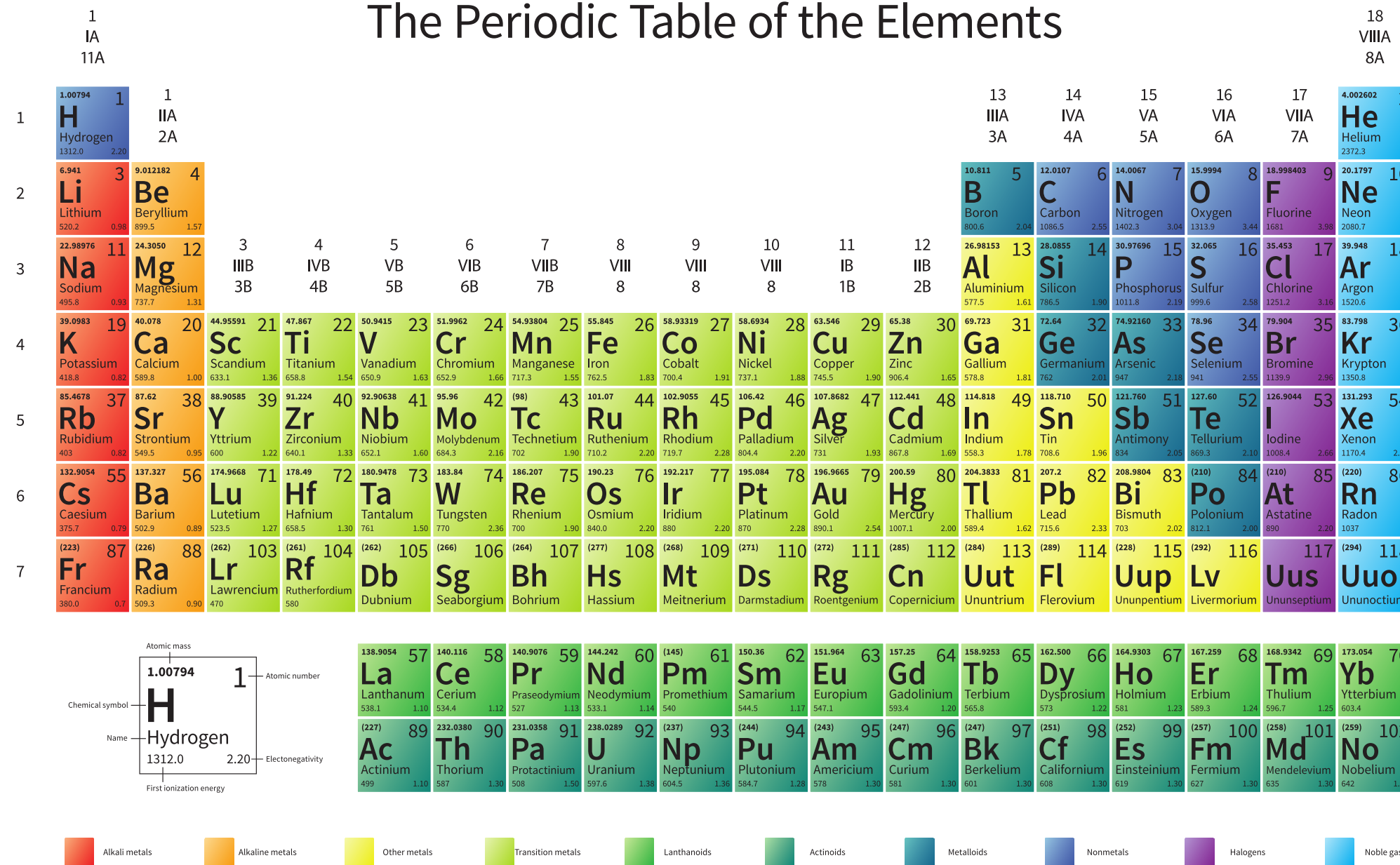




# What are Elements?

An element is a pure substance that cannot be broken down into simpler chemical substances

The Periodic Table of the Elements



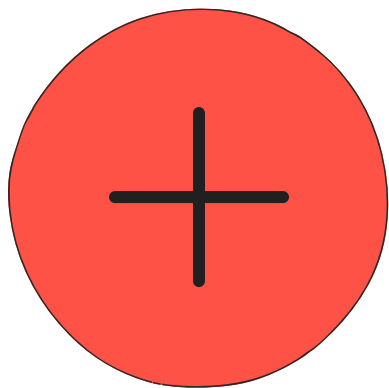
## Major elements in the Human Body

Element	symbol	% of human body
oxygen	O	65%
carbon	C	18.5%
hydrogen	H	9.5%
nitrogen	N	3.2%

# Atom and its Structure

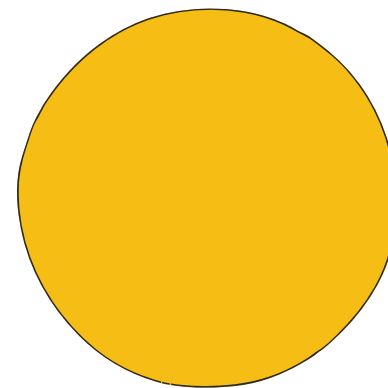
An atom is the basic unit of matter and the smallest particle of an element that retains its properties. Atoms are made up of three types of subatomic particles: protons, neutrons, and electrons.

## Proton



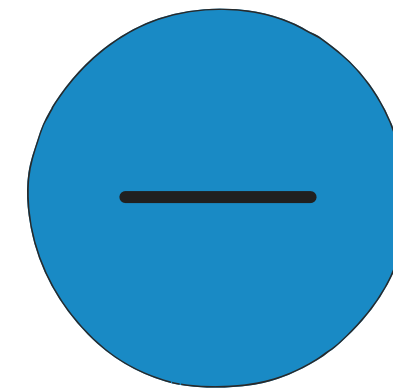
Protons are positively charged particles located in the nucleus (center) of the atom

## Neutron



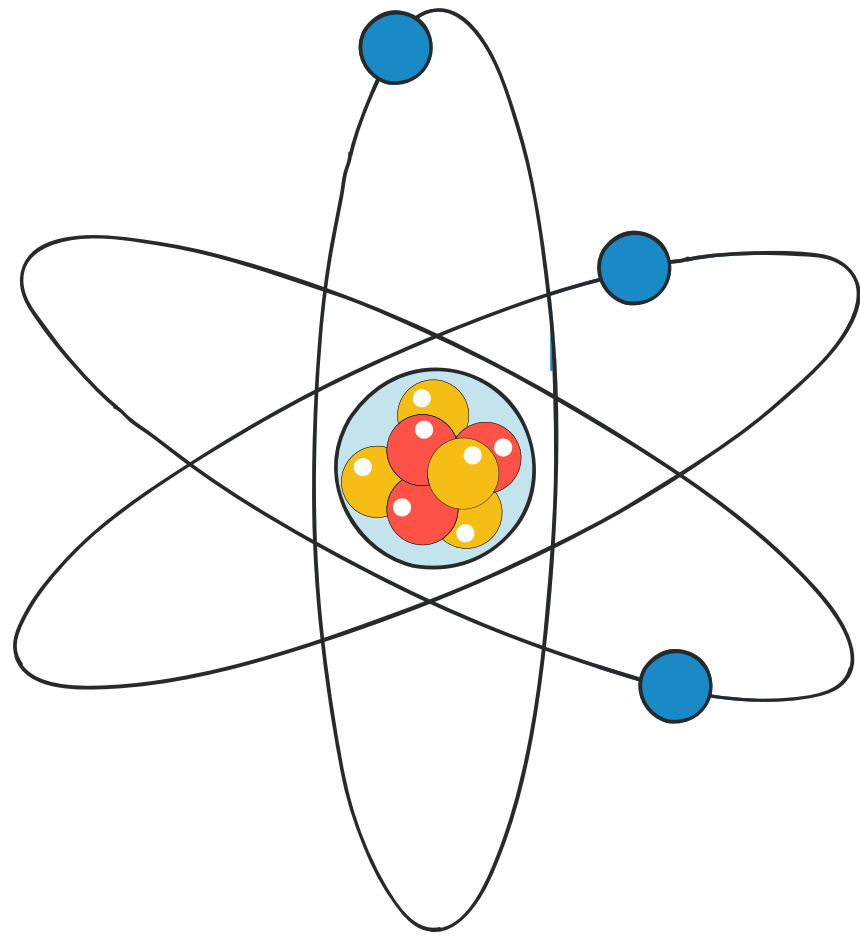
Neutrons are neutrally charged particles also located in the nucleus.

## Electron

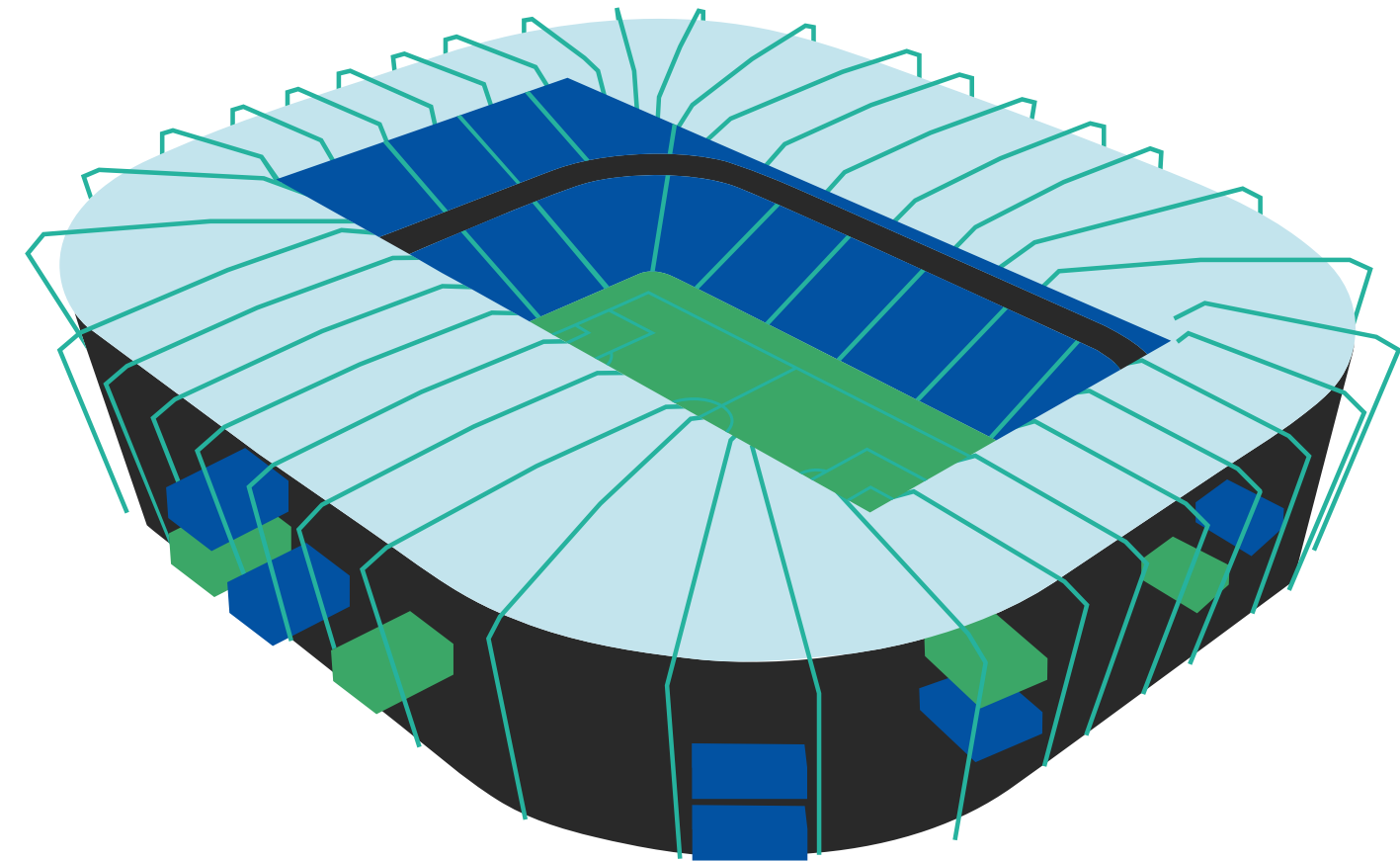


Electrons are negatively charged particles that orbit around the nucleus in energy levels.

# Atom facts

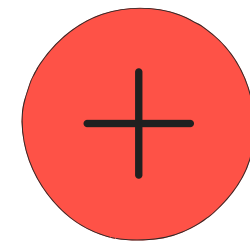
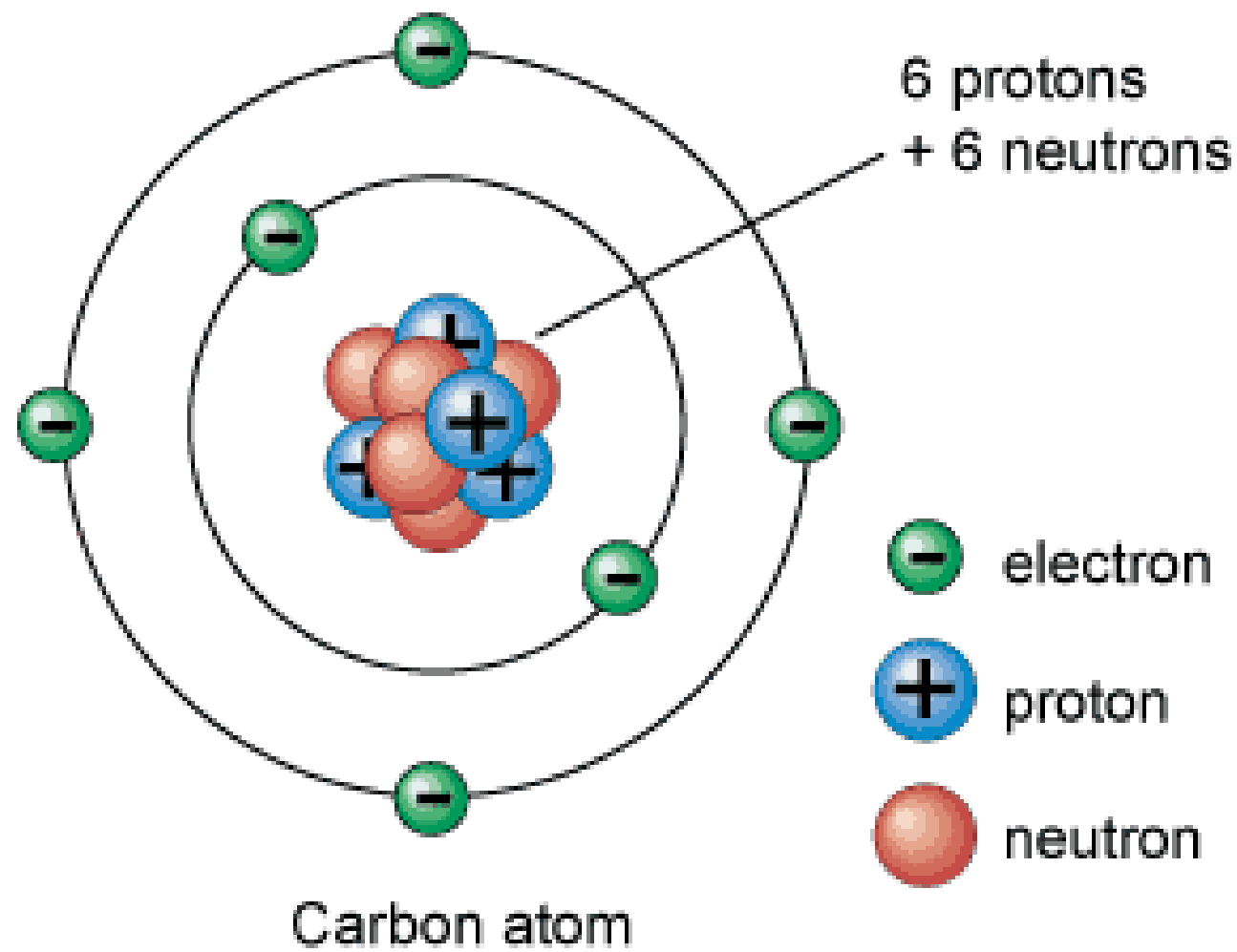


The nucleus of an atom is actually about 100,000 times smaller than the overall size of the atom.

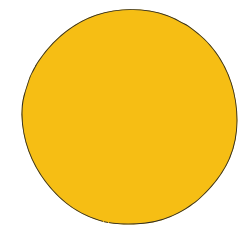


In perspective, if we imagine an atom were the size of a stadium, the nucleus would be smaller than a grain of sand.

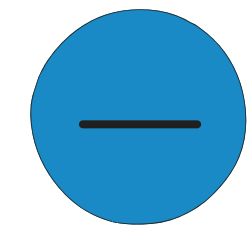
# What is the overall charge of this atom?



How many protons? **6**



How many neutrons? **6**



How many electrons? **6**

**Zero!**  $(+6) + (-6) = 0$



# Reading the

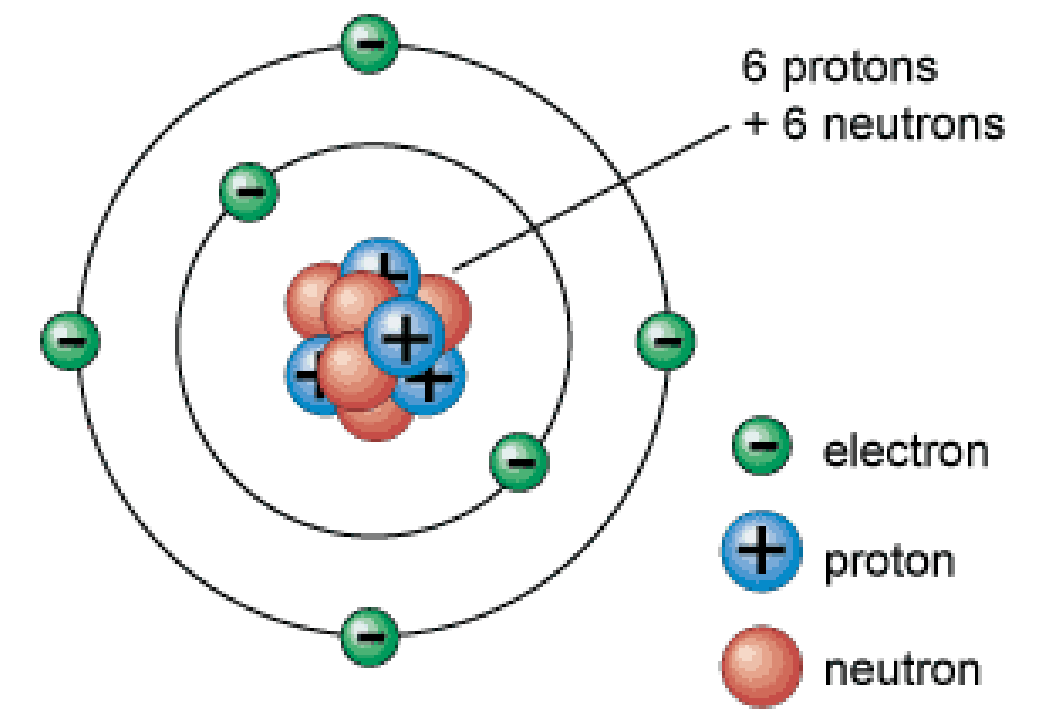
# periodic table of elements

## Periodic Table of the Elements

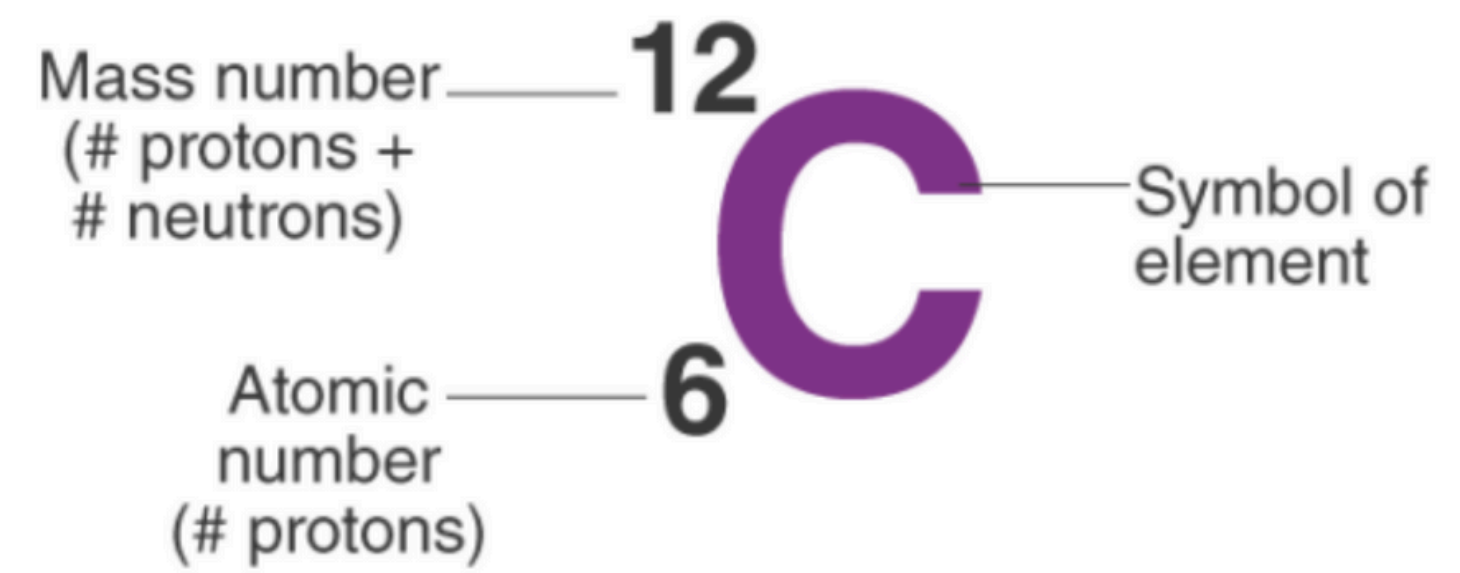
Group	1	2											13	14	15	16	17	18																												
	1A	2A											3A	4A	5A	6A	7A	8A																												
1	1 H Hydrogen 1.0078																	2 He Helium 4.0026																												
2	3 Li Lithium 6.938	4 Be Beryllium 9.0122											5 B Boron 10.806	6 C Carbon 12.009	7 N Nitrogen 14.006	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180																												
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305	3 Sc Scandium 44.956	4 Ti Titanium 47.867	5 V Vanadium 50.942	6 Cr Chromium 51.996	7 Mn Manganese 54.938	8 Fe Iron 55.845	9 Co Cobalt 58.933	10 Ni Nickel 58.693	11 Cu Copper 63.546	12 Zn Zinc 65.38	13 Al Aluminum 26.982	14 Si Silicon 28.084	15 P Phosphorus 30.974	16 S Sulfur 32.059	17 Cl Chlorine 35.446	18 Ar Argon 39.948																												
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	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 72.63	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798																												
5	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 95.96	43 Tc Technetium 98.9062	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 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29																												
6	55 Cs Cesium 132.91	56 Ba Barium 137.33	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)																													
7	87 Fr Francium (223)	88 Ra Radium (226)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (268)	111 Rg Roentgenium (268)	112 Cn Copernicium (268)	113 Uut Ununtrium (268)	114 Fl Flerovium (268)	115 Uup Ununpentium (268)	116 Lv Livermorium (268)	117 Uus Ununseptium (268)	118 Uuo Ununoctium (268)																													
			<table border="1"> <tr> <td>57 La Lanthanum 138.91</td> <td>58 Ce Cerium 140.12</td> <td>59 Pr Praseodymium 140.91</td> <td>60 Nd Neodymium 144.24</td> <td>61 Pm Promethium (145)</td> <td>62 Sm Samarium 150.36</td> <td>63 Eu Europium 151.96</td> <td>64 Gd Gadolinium 157.25</td> <td>65 Tb Terbium 158.93</td> <td>66 Dy Dysprosium 162.50</td> <td>67 Ho Holmium 164.93</td> <td>68 Er Erbium 167.26</td> <td>69 Tm Thulium 168.93</td> <td>70 Yb Ytterbium 173.04</td> <td>71 Lu Lutetium 174.97</td> </tr> <tr> <td>89 Ac Actinium (227)</td> <td>90 Th Thorium 232.04</td> <td>91 Pa Protactinium 231.04</td> <td>92 U Uranium 238.03</td> <td>93 Np Neptunium (237)</td> <td>94 Pu Plutonium (244)</td> <td>95 Am Americium (243)</td> <td>96 Cm Curium (247)</td> <td>97 Bk Berkelium (247)</td> <td>98 Cf Californium (251)</td> <td>99 Es Einsteinium (252)</td> <td>100 Fm Fermium (257)</td> <td>101 Md Mendelevium (258)</td> <td>102 No Nobelium (259)</td> <td>103 Lr Lawrencium (262)</td> </tr> </table>														57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	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 173.04	71 Lu Lutetium 174.97	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)
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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



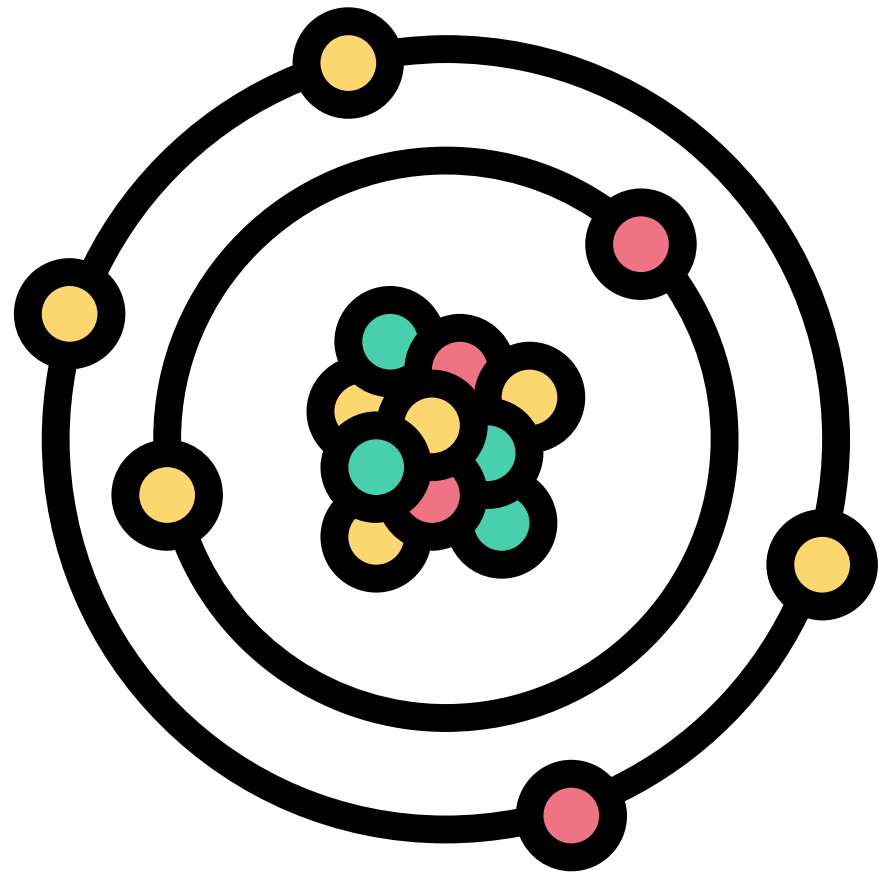
Carbon atom



SOURCES: National Institute of Standards and Technology, International Union of Pure and Applied Chemistry

KARL TATE / © LiveScience.com

# What are valence electrons?



The number of electrons in the outermost energy level/orbital

These electrons form bonds with other atoms to form molecules

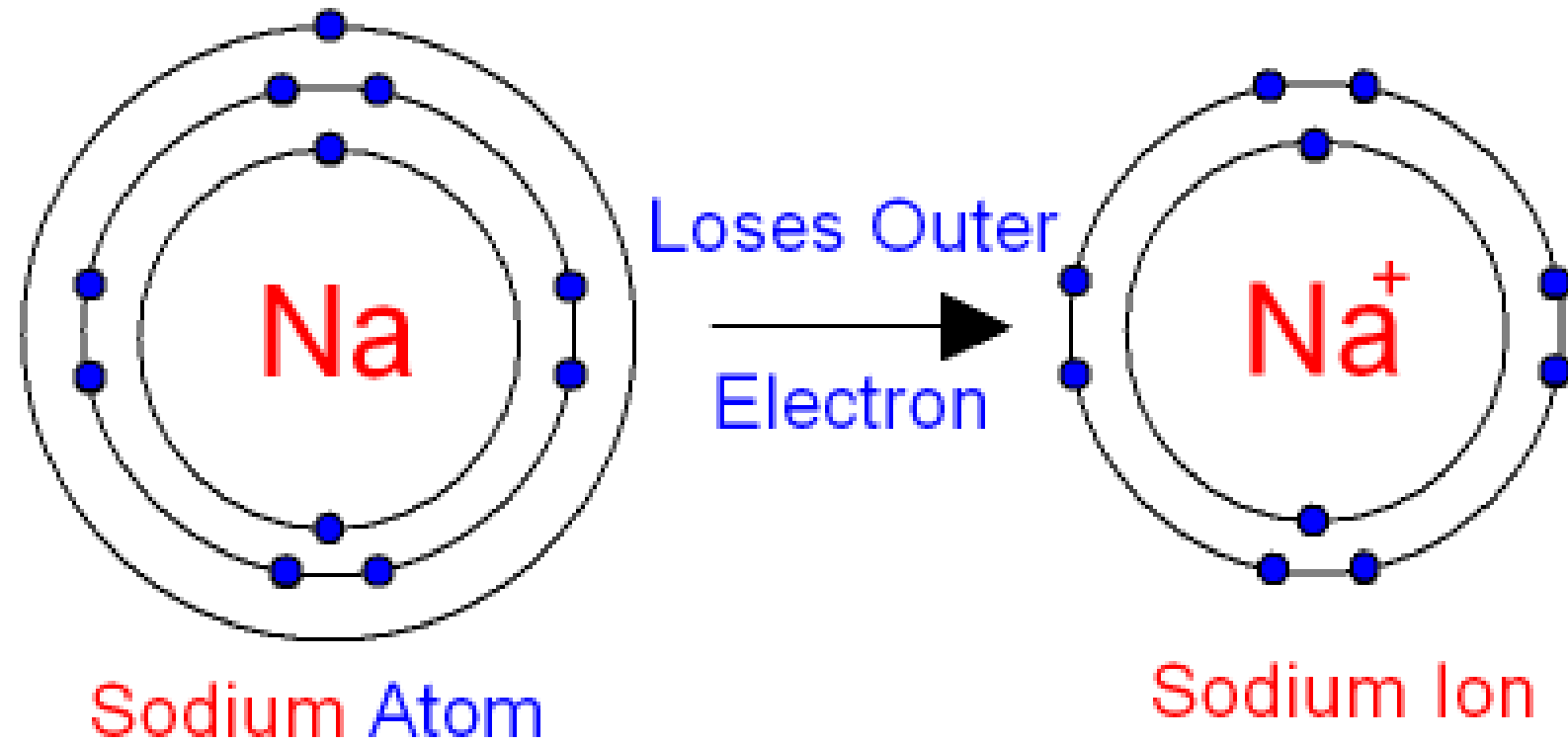
How many valence electrons are in this atom?

**4**

8 electrons in the outer orbital is the happy, balanced number

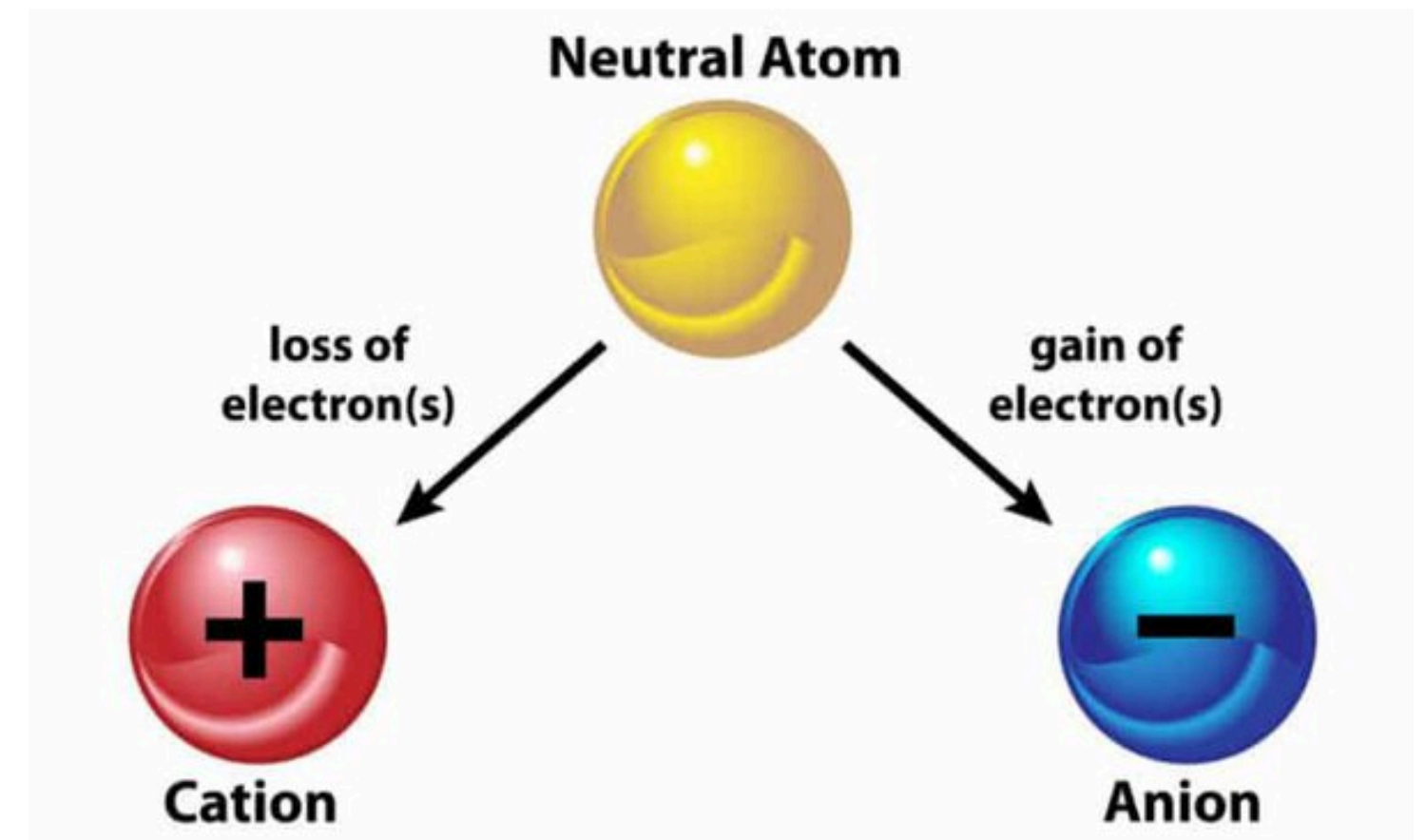


# ions



an atom that has gained or lost one or more valence electrons and now carries a "charge"

positive ion lost electron  
negative ion gained electron



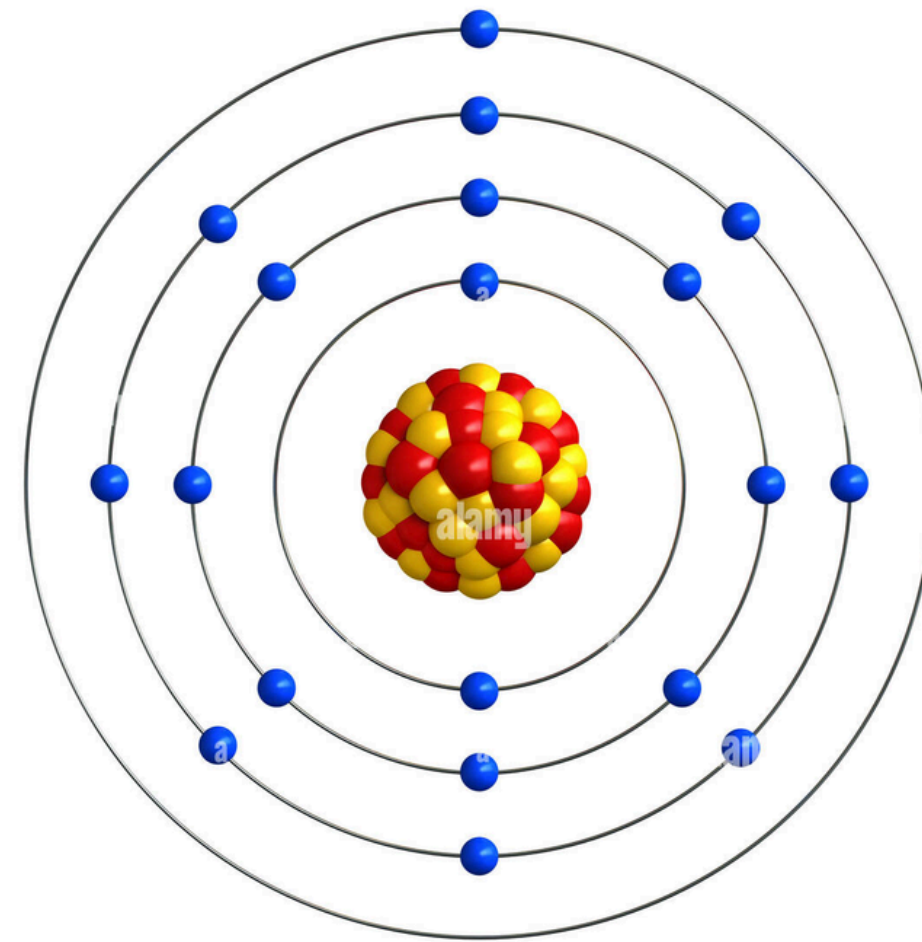
# try it

Q: Potassium (K) is element 19 on the periodic table. When K forms an ion, it becomes  $K^+$ . How is  $K^+$  different from K?

A: K carries no charge and is neutral (equal protons+ and electrons-)

$K^+$  carries a charge of +1 meaning that it lost one electron.

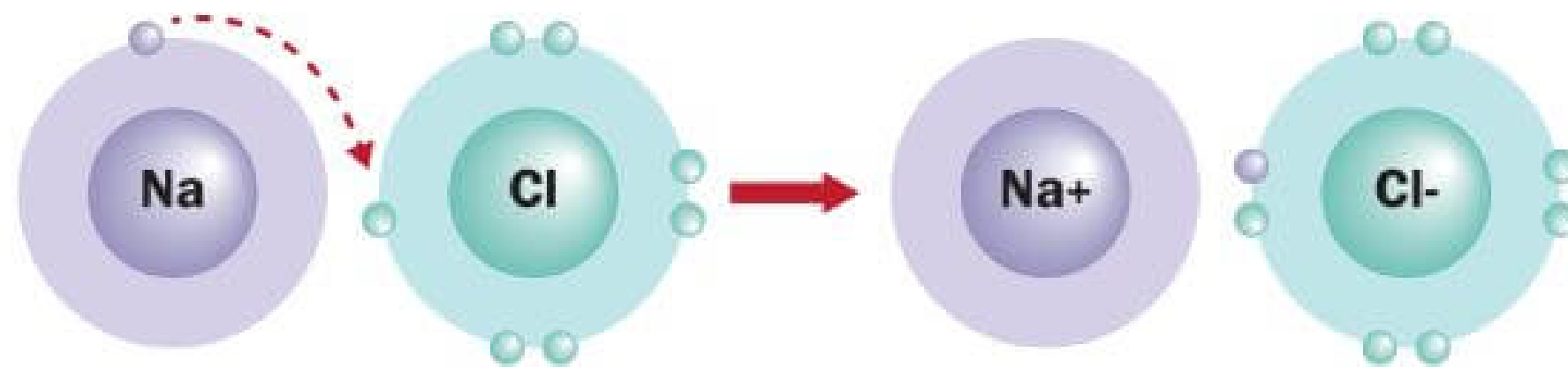
$$(+19 + -18 = +1)$$



# Ionic Bonds

form when one atom TAKES an electron away from another atom

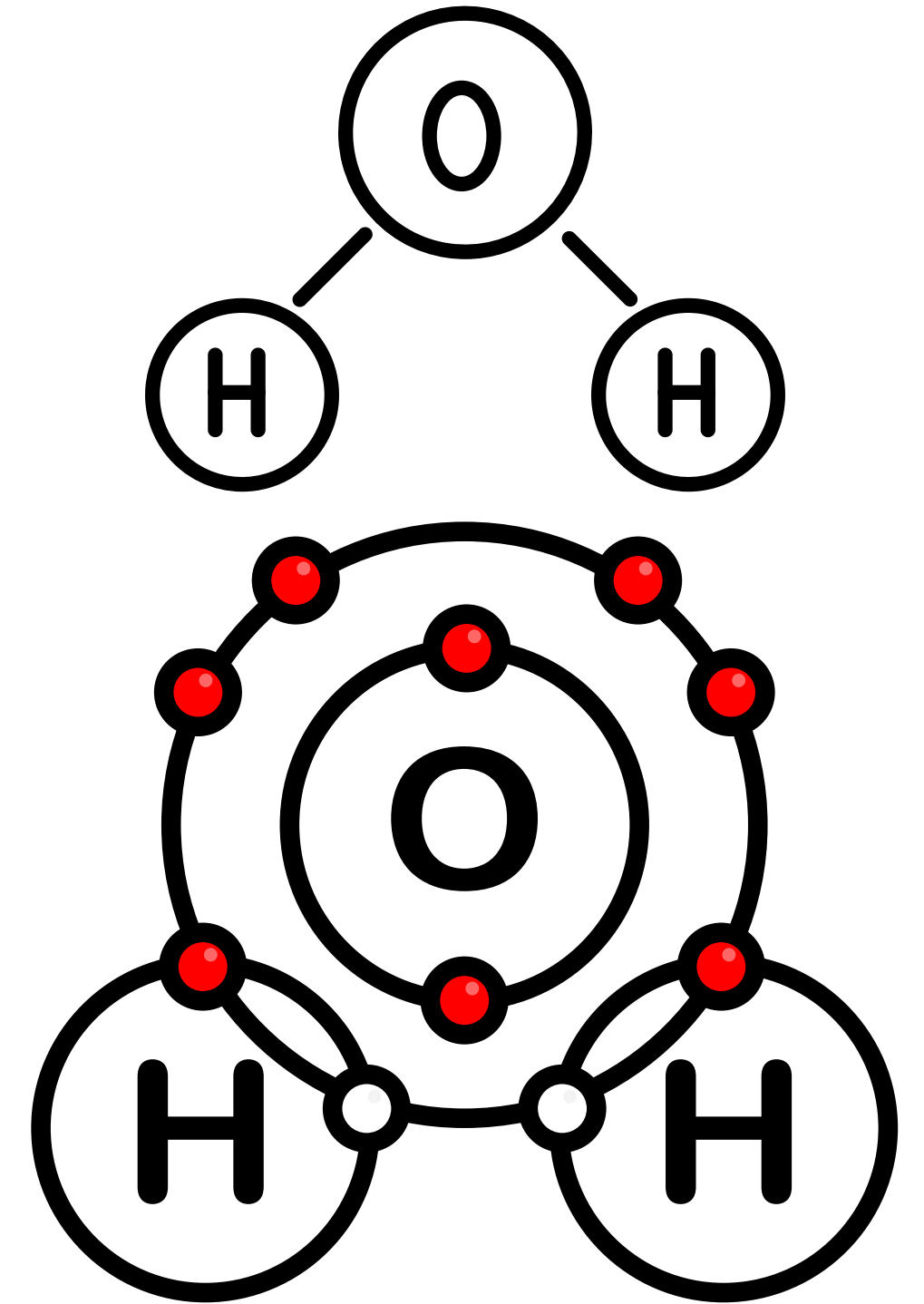
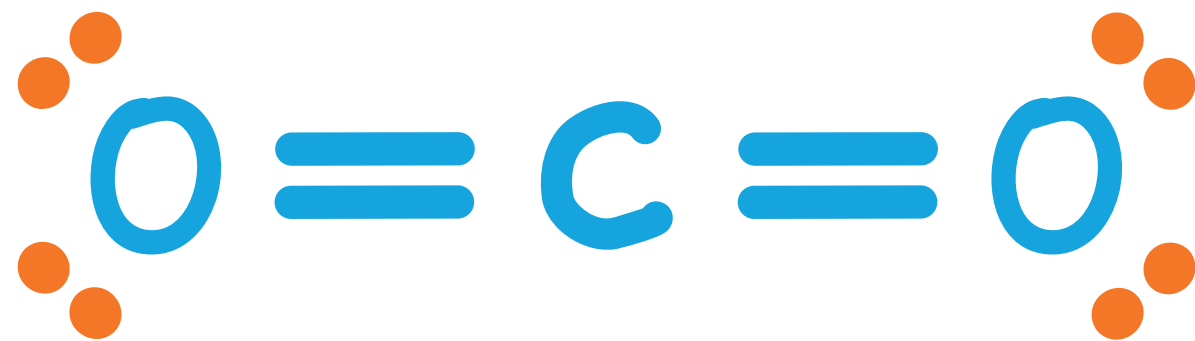
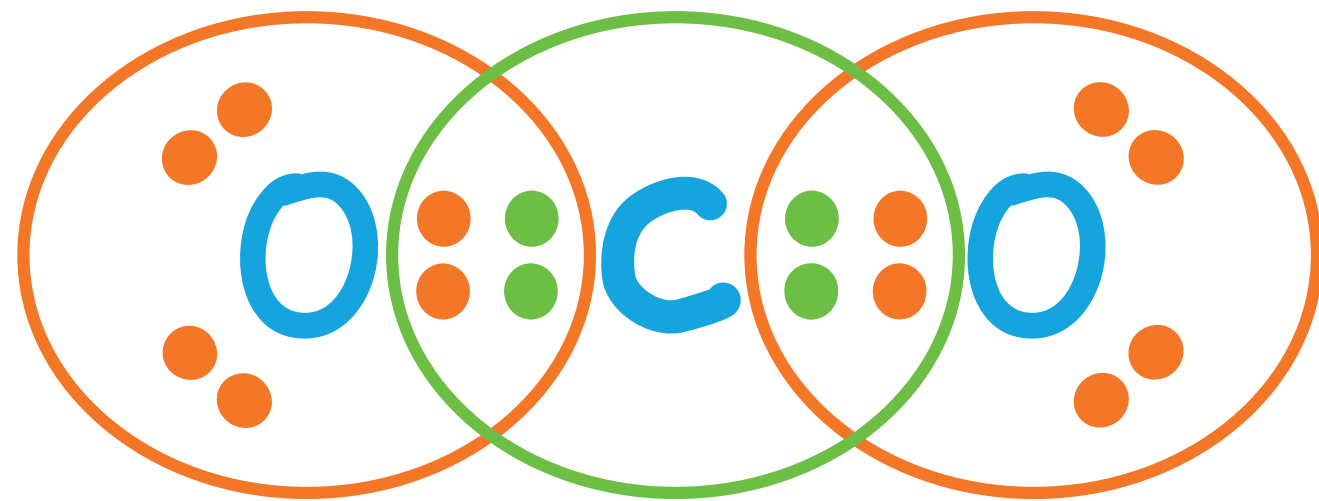
- created by oppositely charged ions
- easily broken apart by water
- ex: table salt (NaCl)



# Covalent Bonds

form when atoms SHARE a pair of electrons

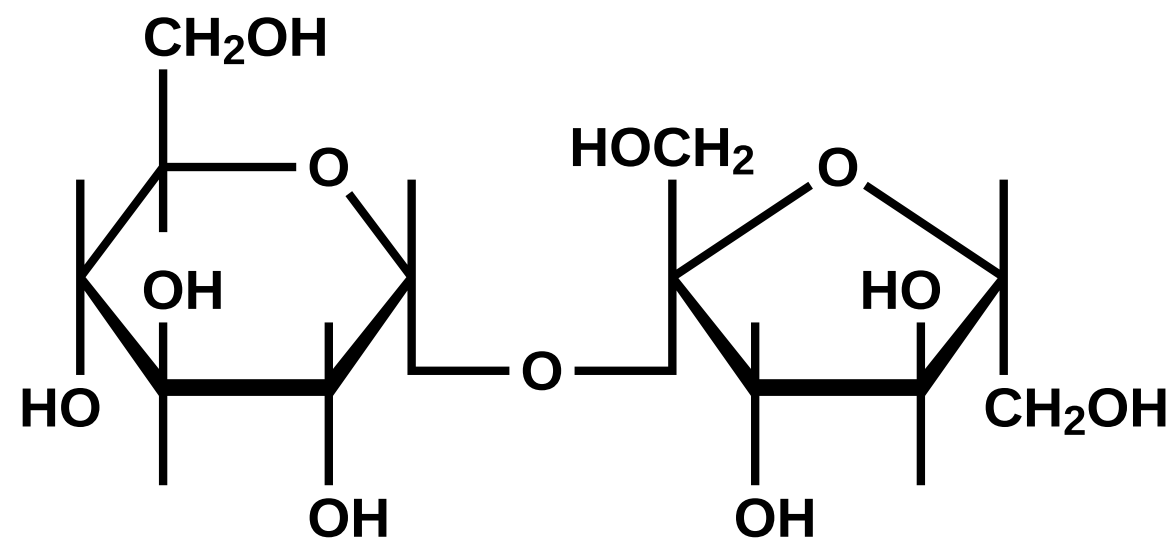
- strong 💪
- NOT easily broken apart by water
- ex: water ( $H_2O$ ) carbon dioxide ( $CO_2$ )



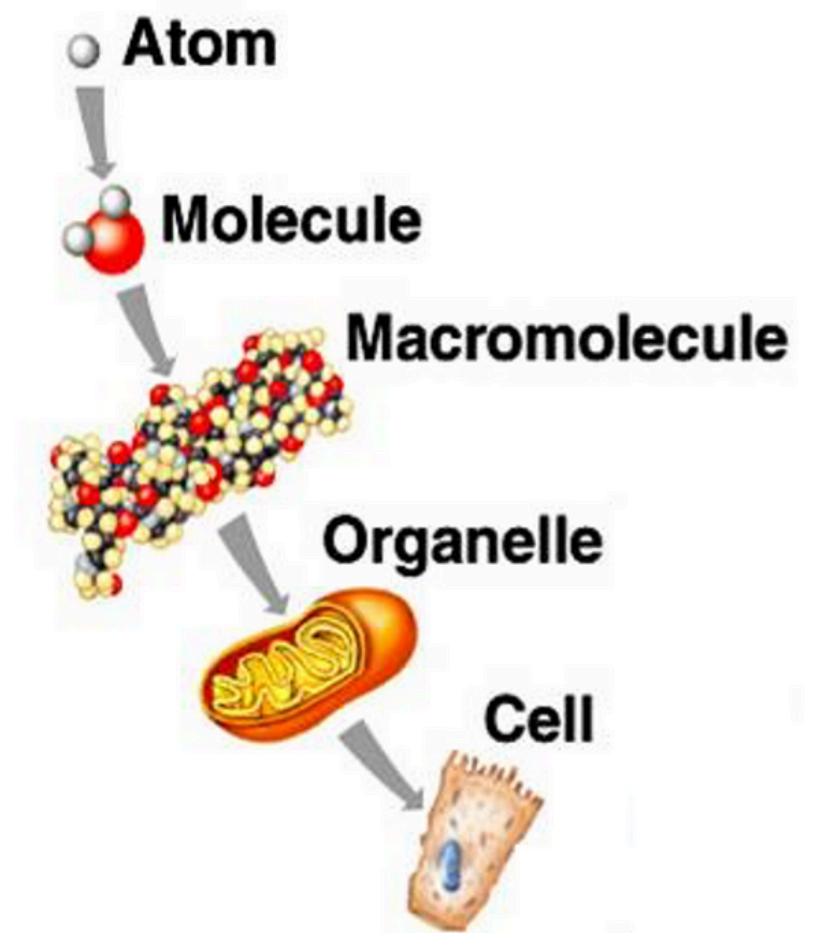
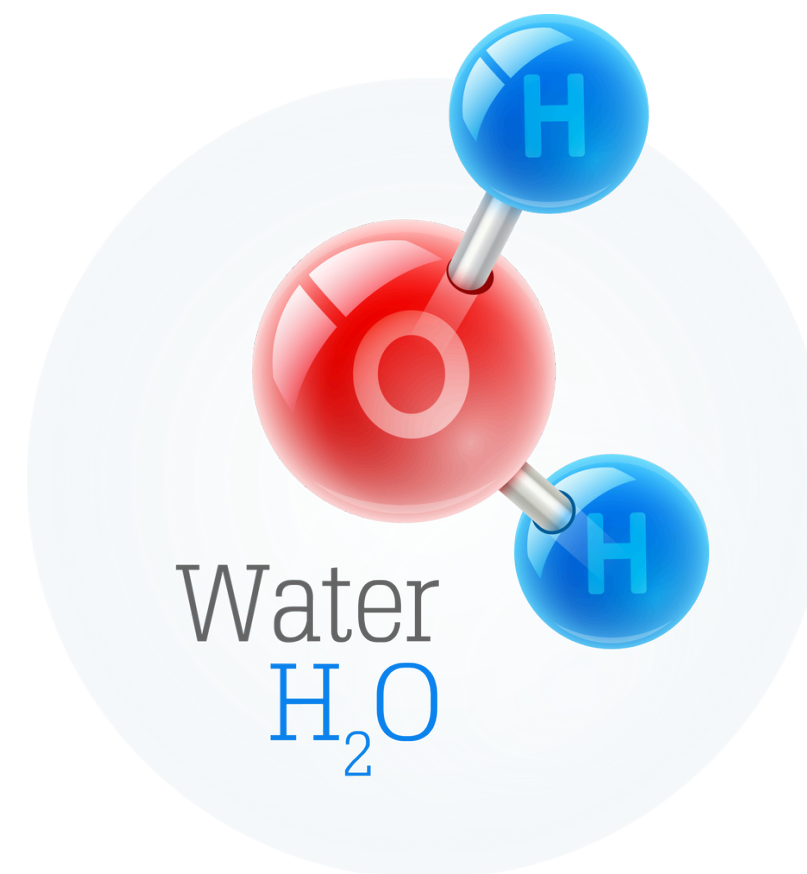
# Molecule (molecular compound)

two or more atoms held together by covalent bonds

- stable
- does not dissociate (break apart) in water
- ex:  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ , DNA, proteins, lipids (biomolecules)



sucrose (table sugar)



# molecules

share electrons

held together with covalent bonds

strong bond

do not dissociate in water

# ionic compounds

do not share electrons

held together with ionic bonds

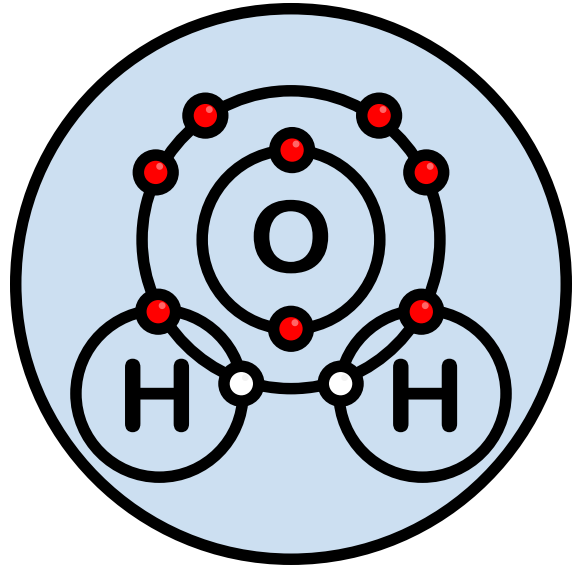
strong bond

dissociate in water

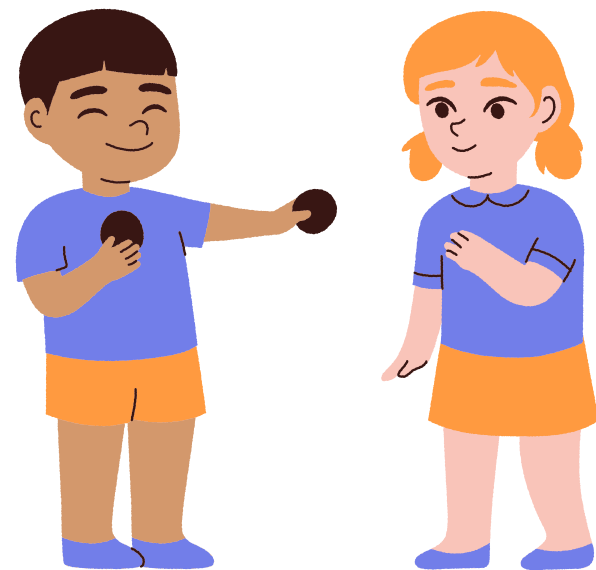
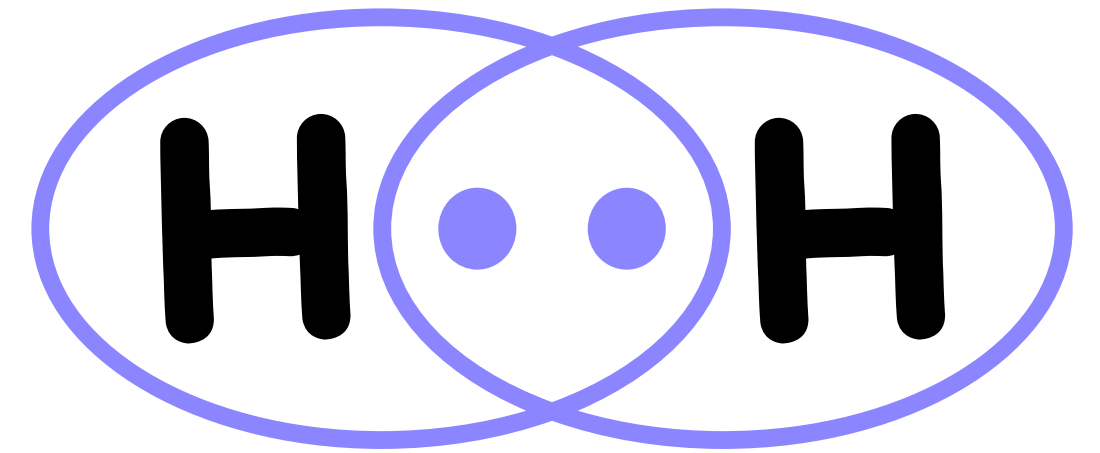


## Biological significance of

# Covalent Bonds



nearly all substance that make up living things use covalent bonds, because they do NOT break apart in water

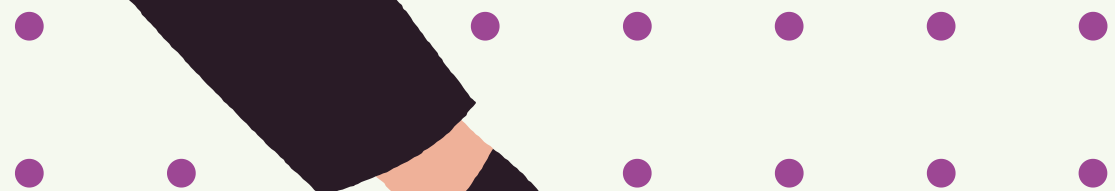
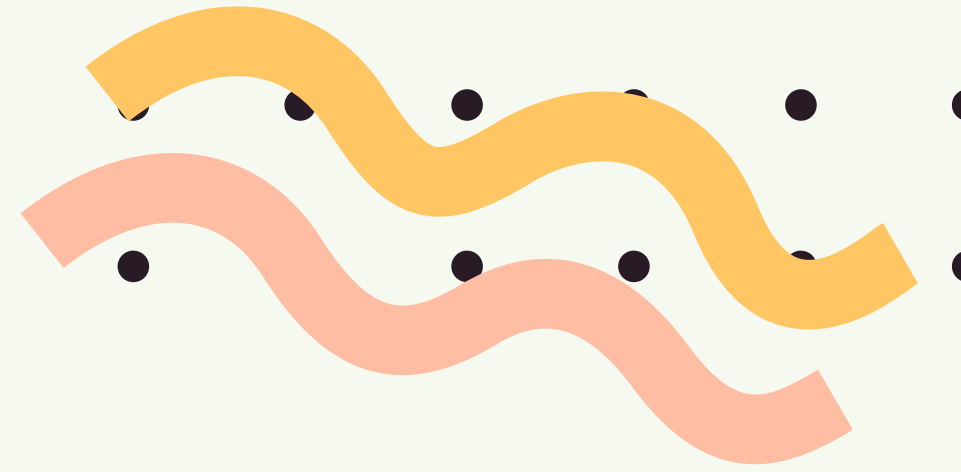


- carbohydrates (sugars)
- lipids (fats)
- proteins
- nucleic acids (DNA)





# PROPERTIES OF WATER



# Polar vs. Nonpolar Molecules

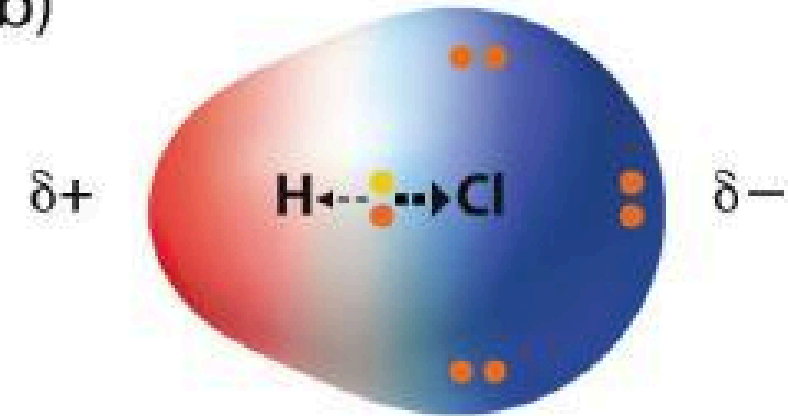
## **Polar:**

has a positive and a negative end, like a magnet

## **Nonpolar:**

a molecule that is electrically neutral (not positively or negatively charged)

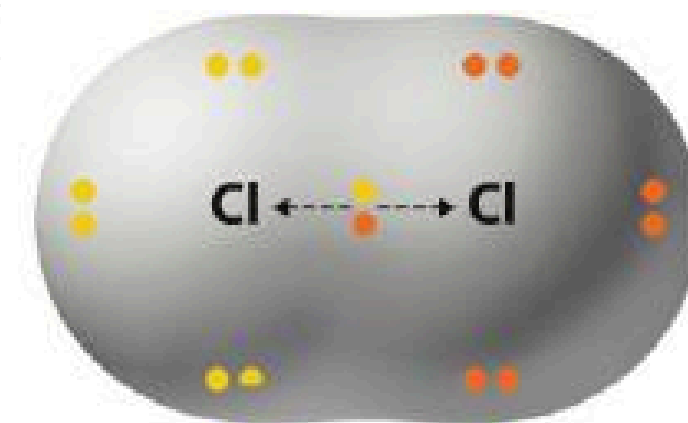
(b)



### **Polar covalent bond**

Bonding electrons shared unequally between two atoms. Partial charges on atoms.

(a)

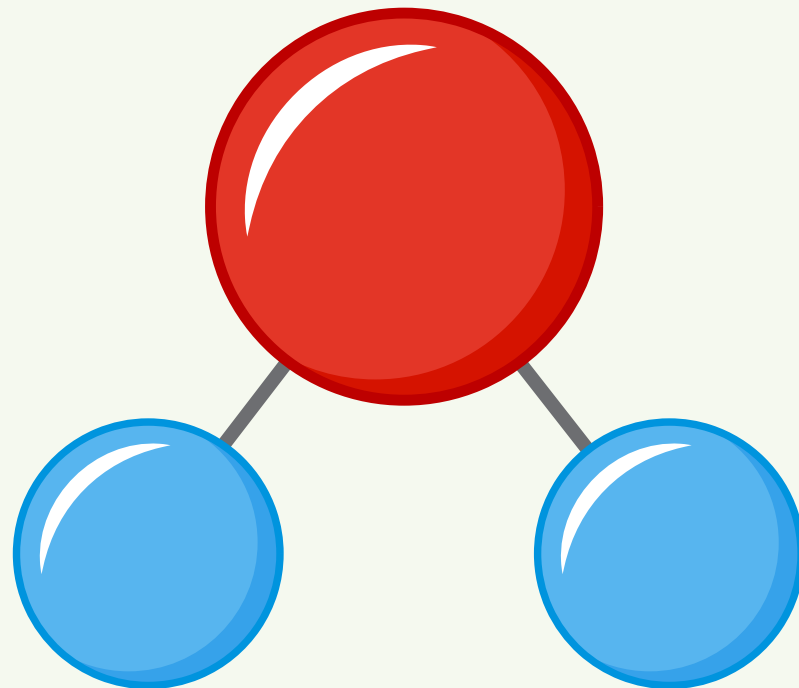
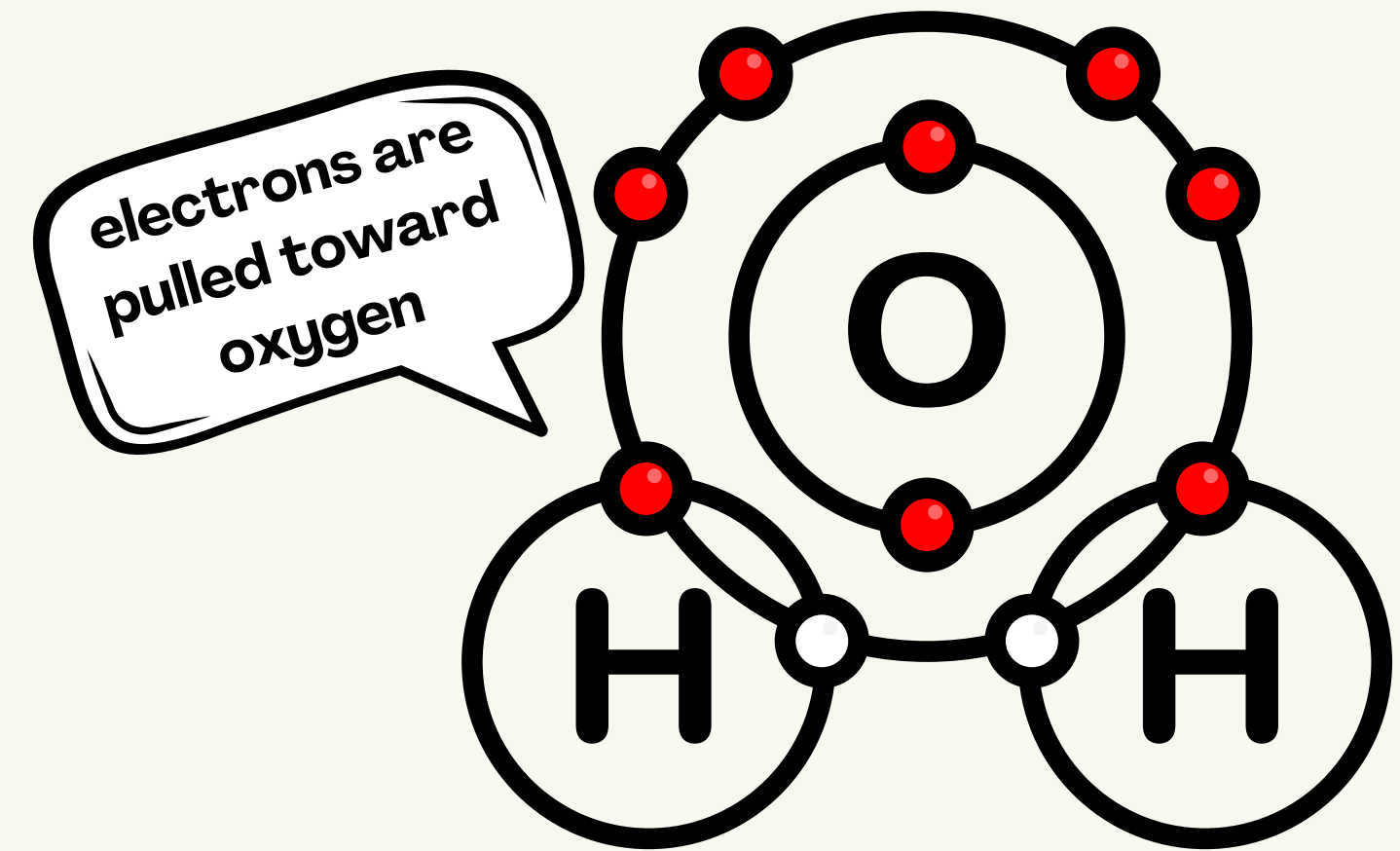


### **Nonpolar covalent bond**

Bonding electrons shared equally between two atoms. No charges on atoms.

# Water is a POLAR MOLECULE

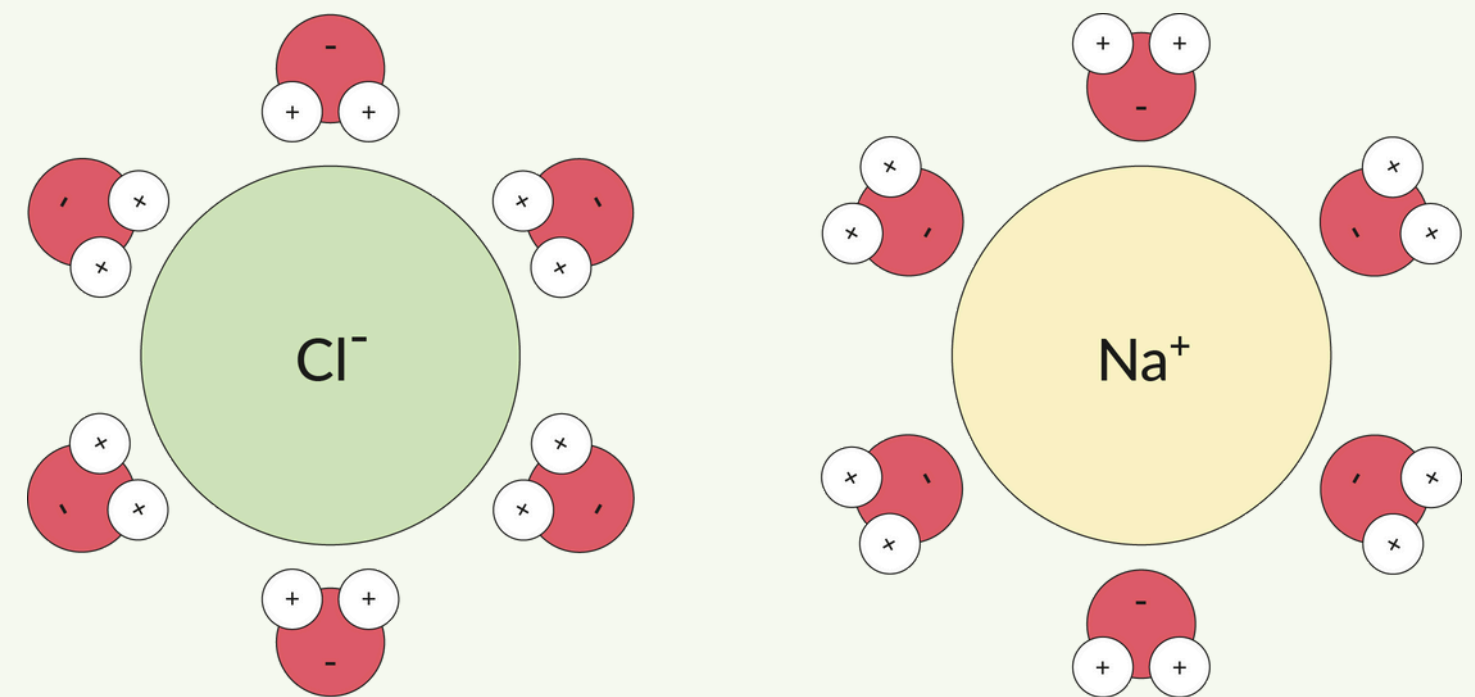
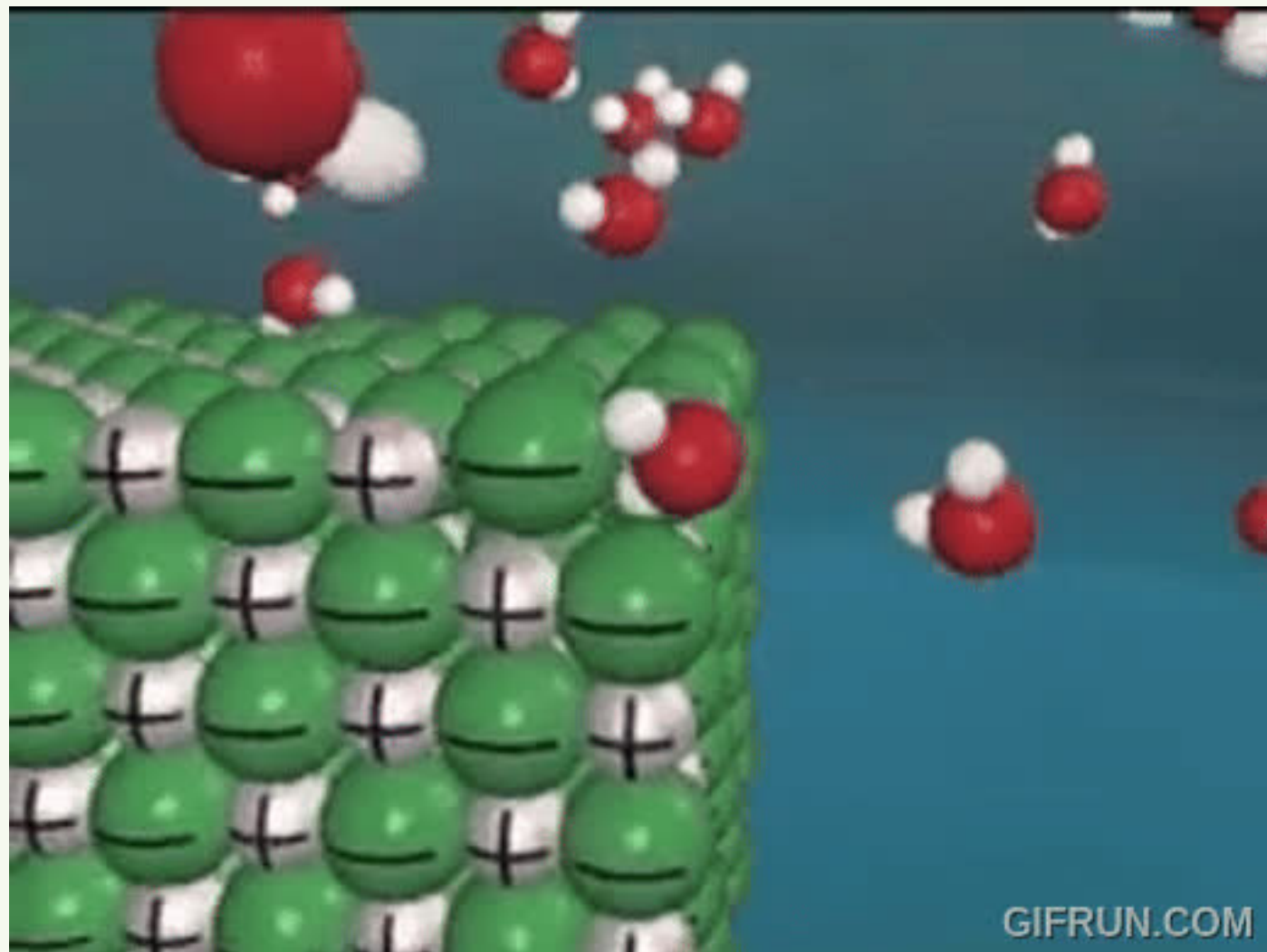
the oxygen atom exerts a greater pull on the electrons, making oxygen slightly negative and the hydrogen atoms slightly positive



# Water as a solvent

water causes ionic compounds to dissociate, or break apart

- the negative oxygen atoms are attracted to the  $\text{Na}^+$
- the positive hydrogen atoms are attracted to the  $\text{Cl}^-$

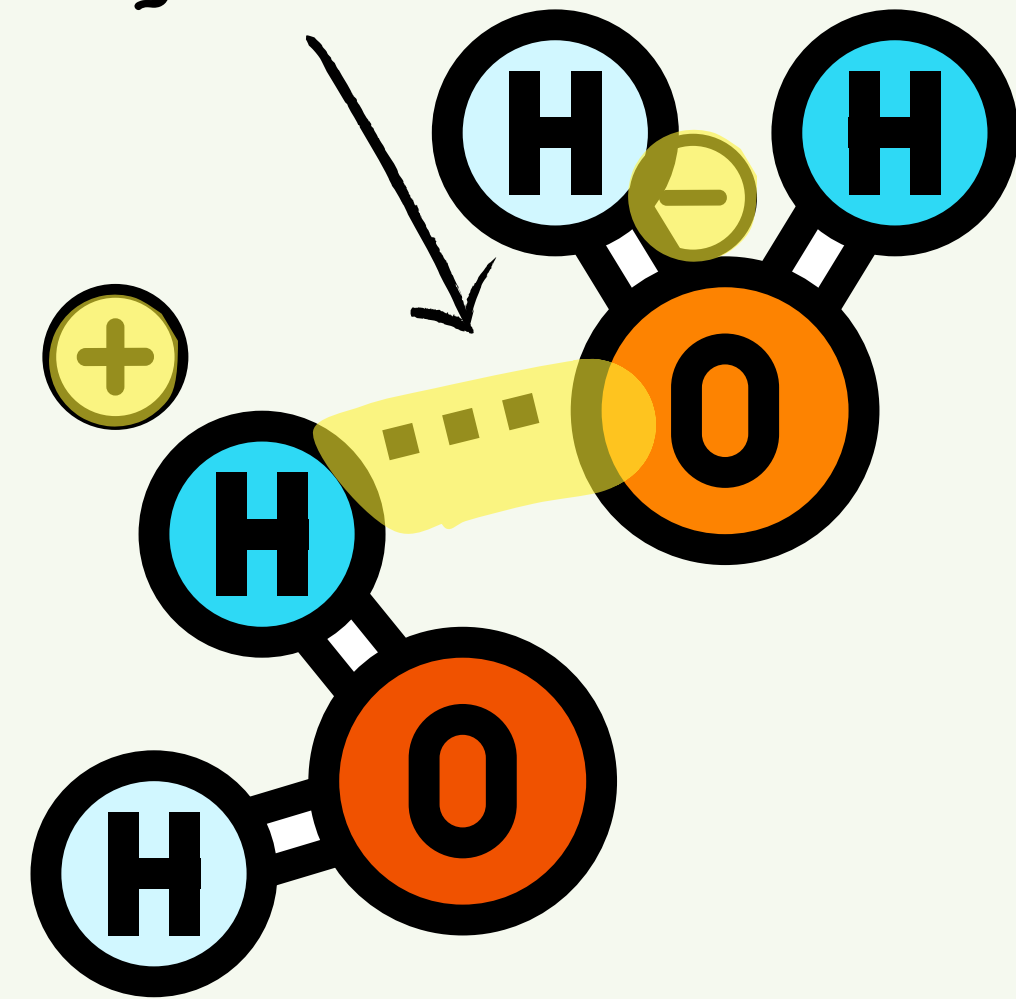


# What is Hydrogen bonding?

an attraction between a slightly positive hydrogen atom and a slightly negative atom

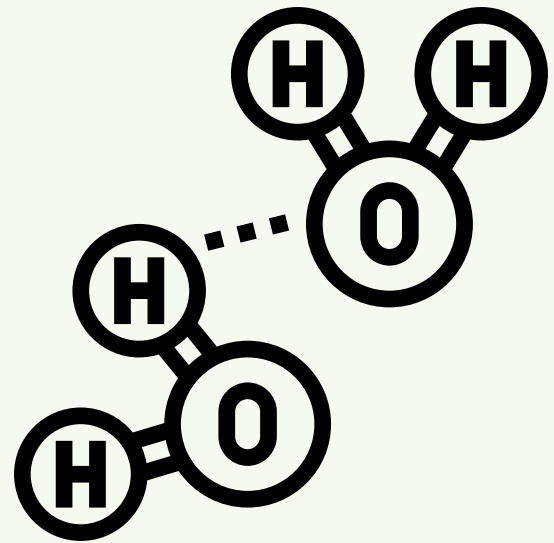
- hydrogen bonds are NOT true bonds
- there is no taking or sharing of electrons (not forming something new)
- like two magnets attracted to each other
- are weak and easily broken

Hydrogen bond

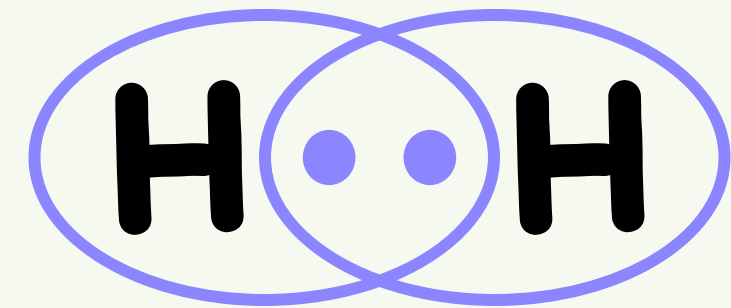




# Hydrogen vs Covalent Bonds

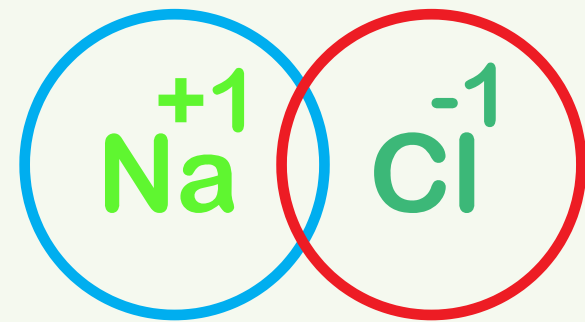


Hydrogen	Covalent
not real bonds	real bonds
<b>attraction</b> between charged molecules	atoms <b>share</b> electrons
easily broken	strong



# Type of Bonds

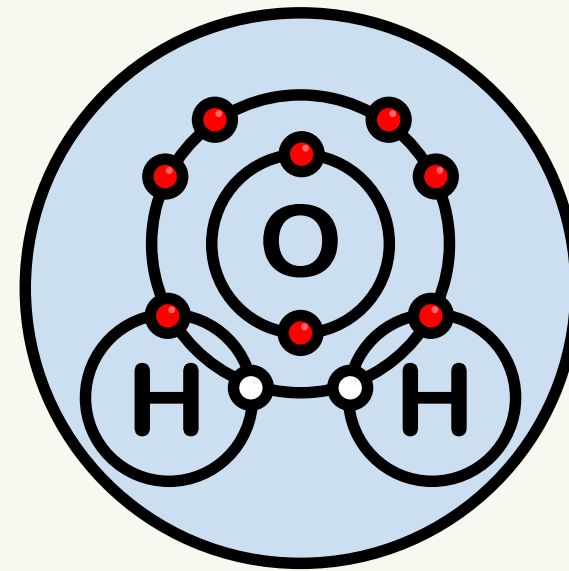
Ionic



\*An **ion** is an **atom** that has **gained** or **lost** one or more **electrons**. It is now **charged**

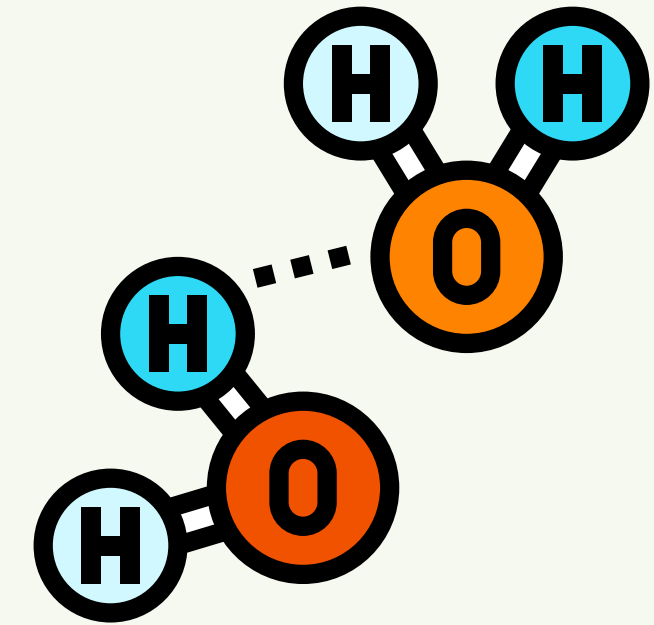
Forms when one atom **TAKES** an electron away from another

Covalent



forms when atoms **SHARE** electrons

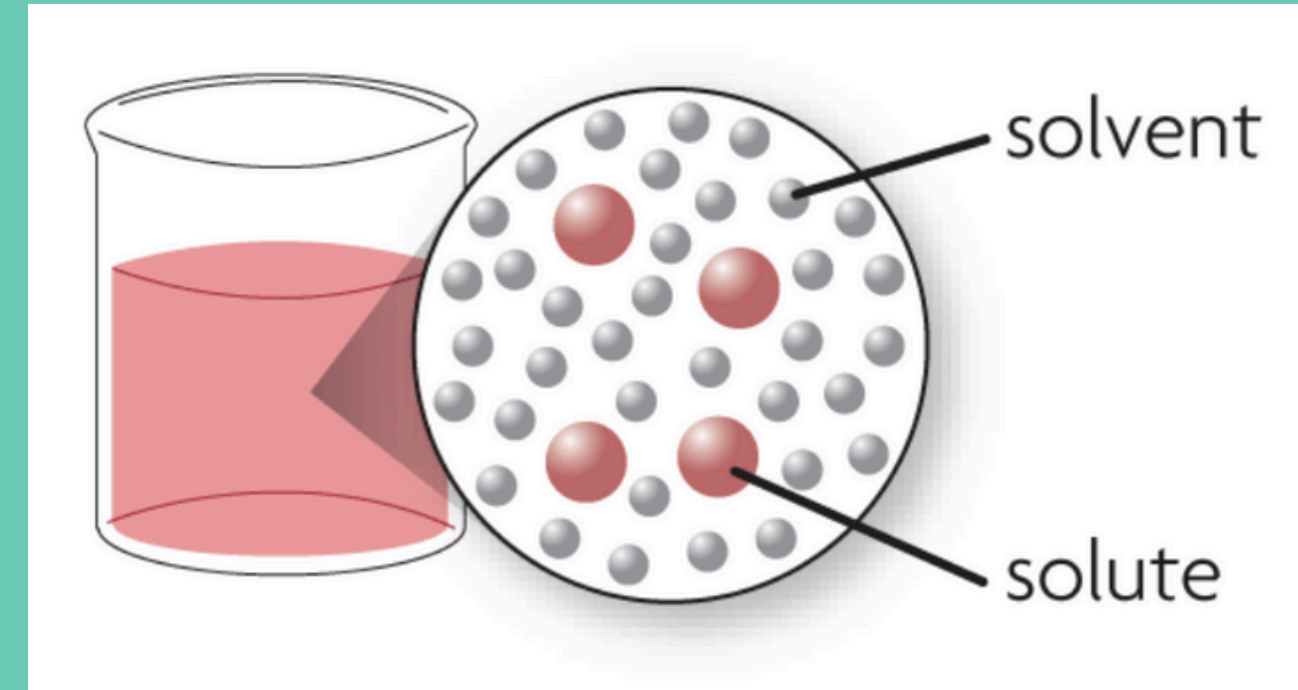
Hydrogen



**ATTRACTION** between molecules; not a real bond

# Solution

formed when one substance dissolves in another

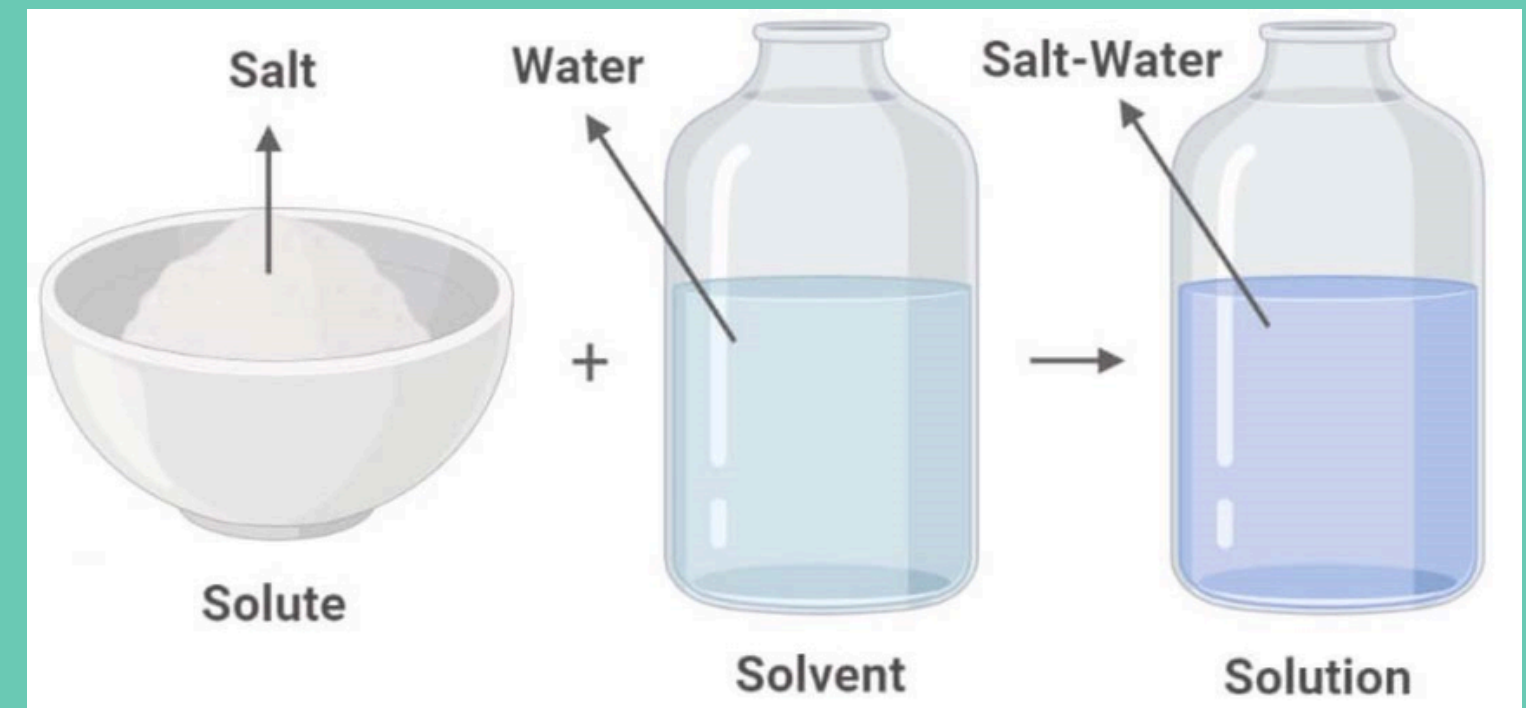


# Solvent

dissolves other substances present in greater amounts (ex: water)

# Solute

dissolves in a solvent present in smaller amounts (ex: kool-aid)

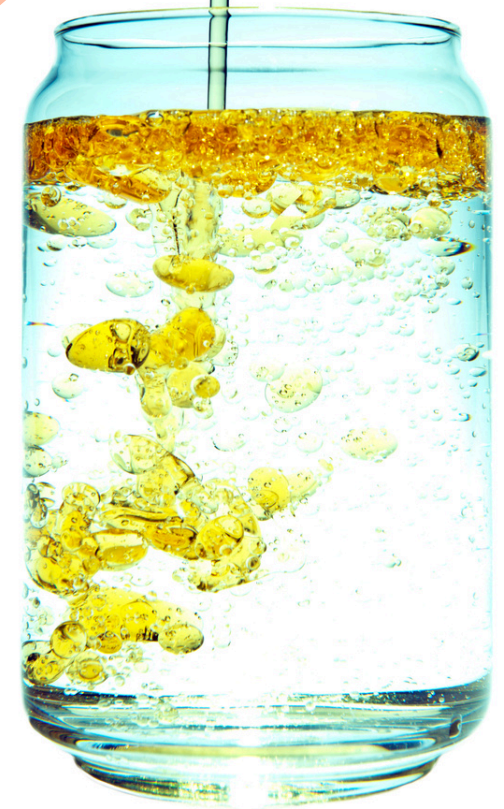


# Like Dissolves Like

**POLAR SOLVENTS  
DISSOLVE POLAR SOLUTES**

**NONPOLAR SOLVENTS  
DISSOLVE NONPOLAR SOLUTES**

do water  
and oil  
mix?



# THE SIX PROPERTIES OF WATER





# 1. HIGH SPECIFIC HEAT

- it takes a lot of energy (heat) to increase temp.
- water resists changes in temp.

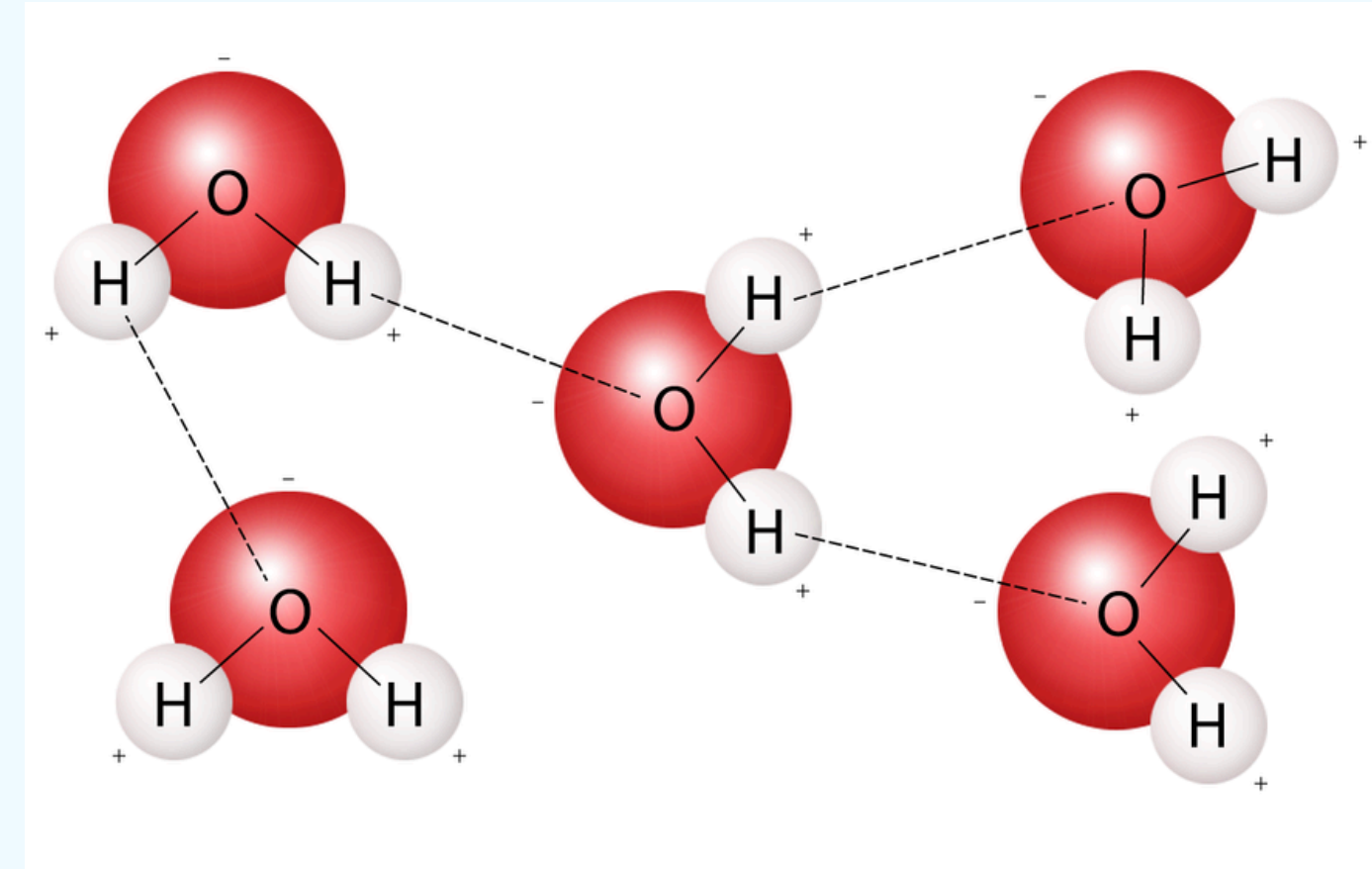


MATERIAL	SPECIFIC HEAT (Joules/gram • °C)
Liquid water	4.18
Solid water (ice)	2.11
Water vapor	2.00
Dry air	1.01
Basalt	0.84
Granite	0.79
Iron	0.45
Copper	0.38
Lead	0.13



# 2. COHESION

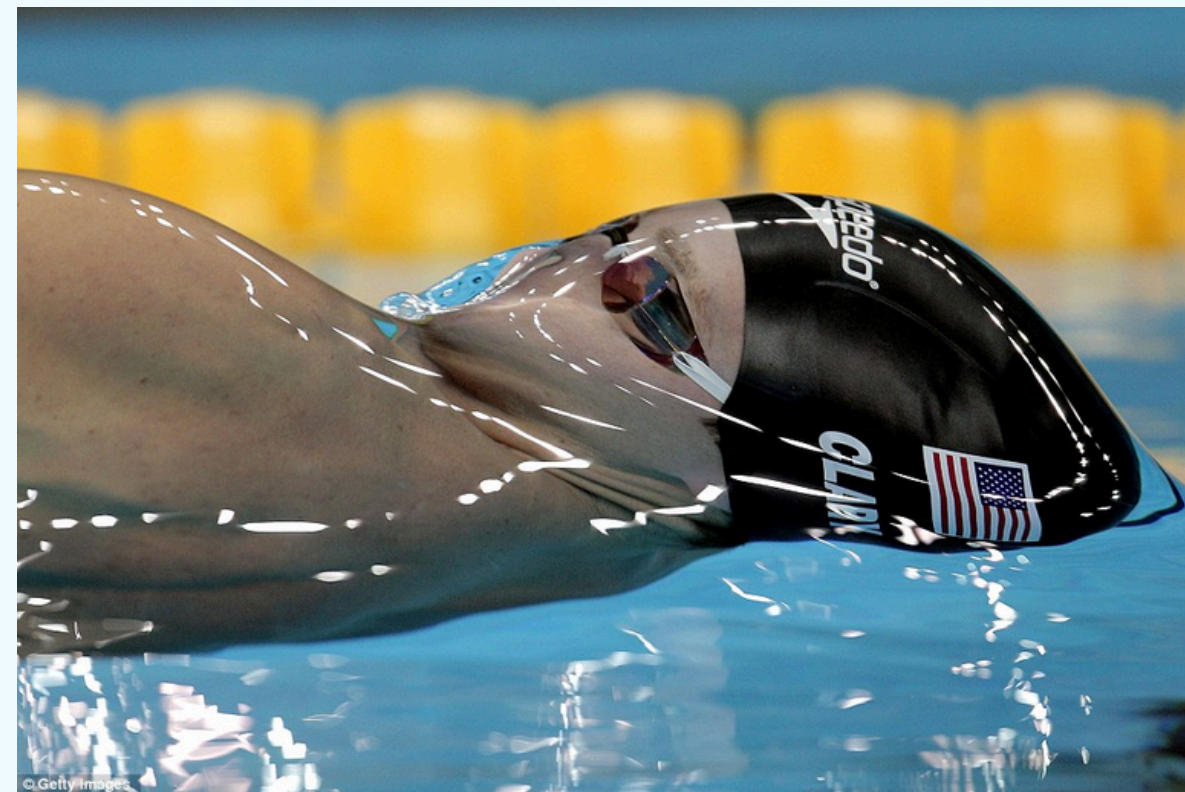
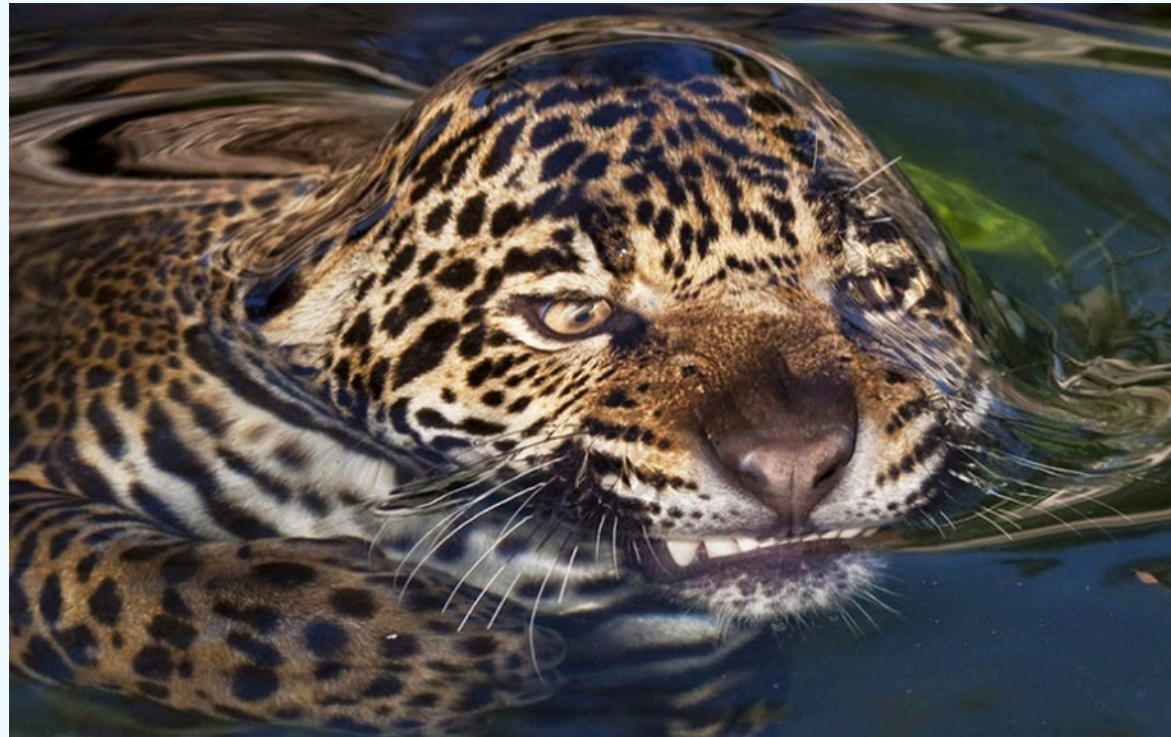
- water is attracted to water
- forms droplets





# 3. SURFACE TENSION

- water sticks to itself (cohesion) and will bend before breaking





# 4. ADHESION

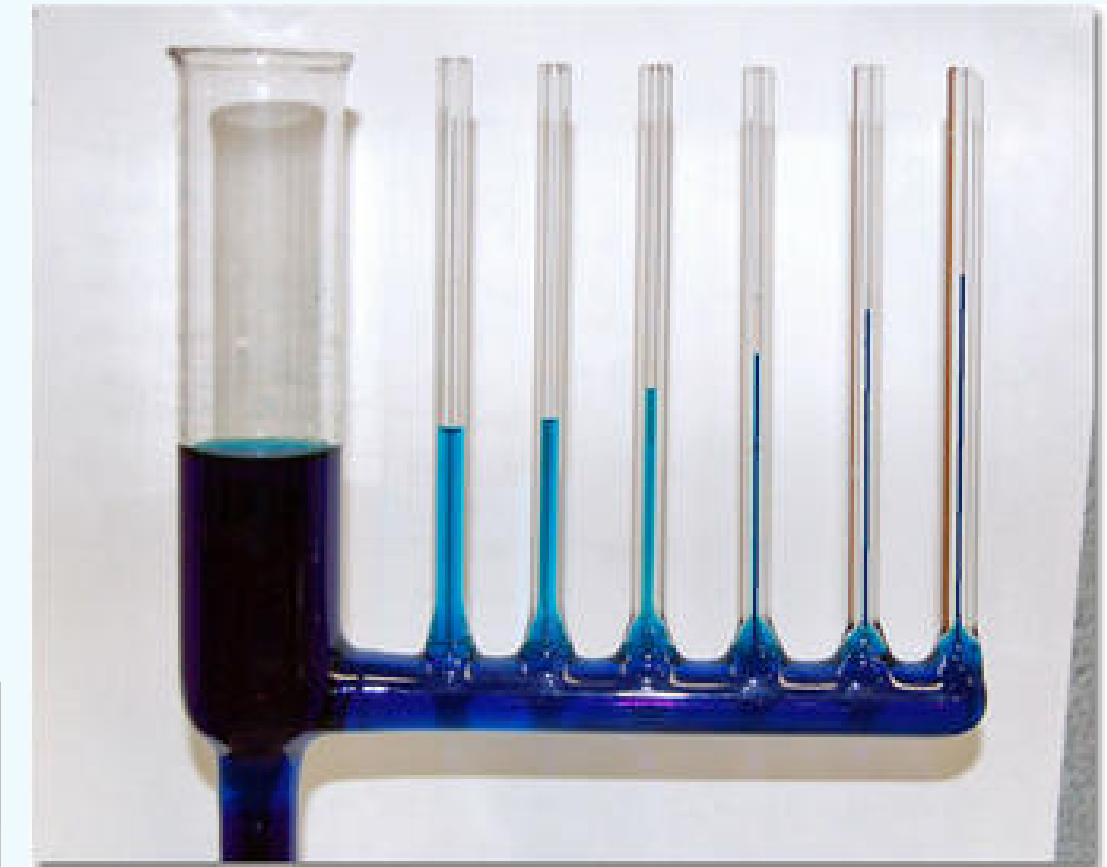
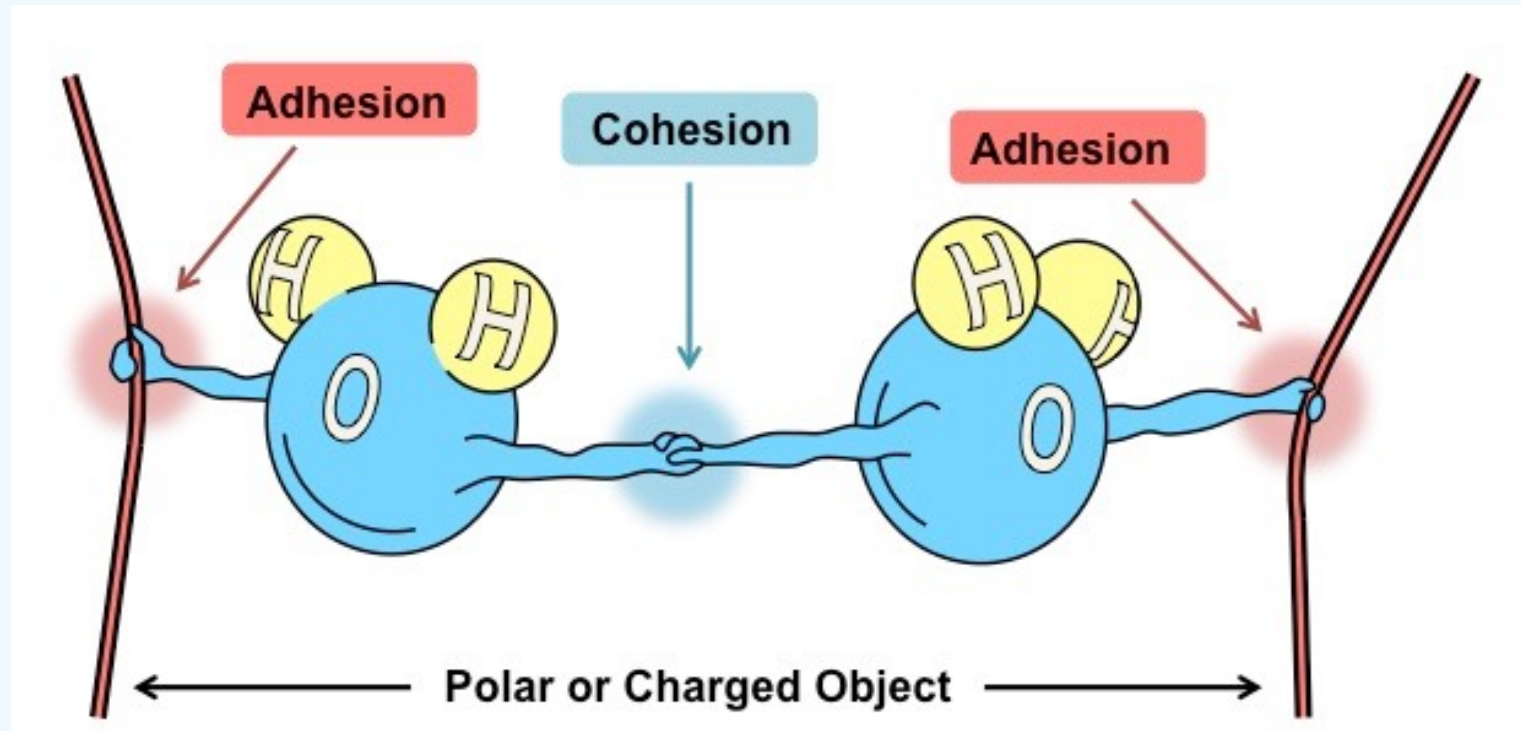
- water sticks to other objects





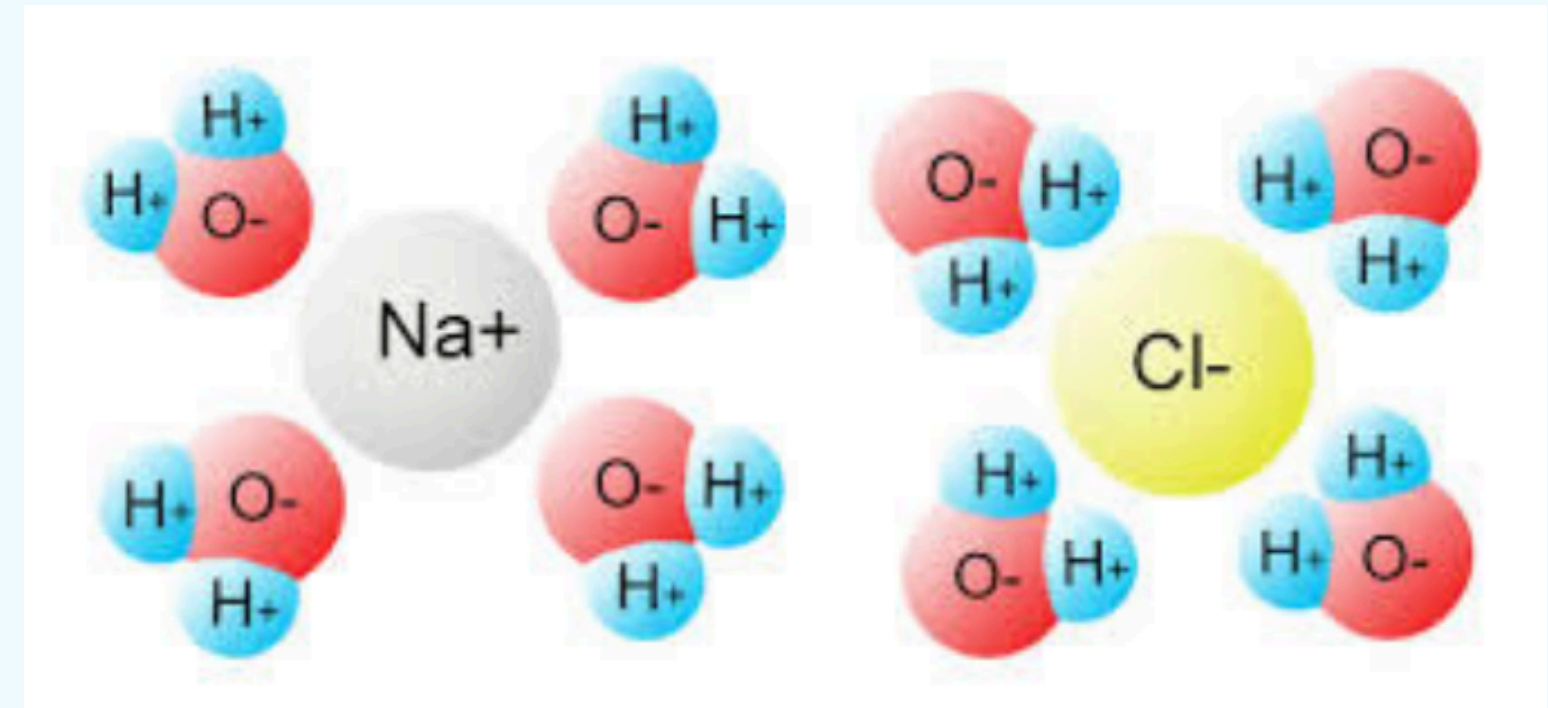
# 5. CAPILLARY ACTION

- tendency for water to climb up a thin tube
- thinner tube, higher water rises
- caused by cohesion and adhesion



# 6. UNIVERSAL SOLVENT

- water dissolves more substances than any other liquid
- many chemical reactions take place in the watery environment in our cells

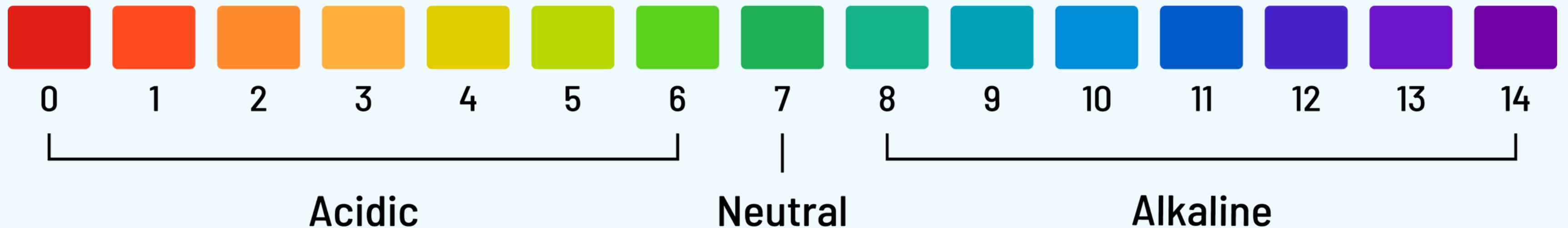


remember: water causes ionic compounds to dissociate, or break apart

# THE pH SCALE

a measure of how acidic/basic a solution is  
(actually a measure of the concentration  
of hydrogen ions ( $H^+$ ) in the solution)

## pH scale



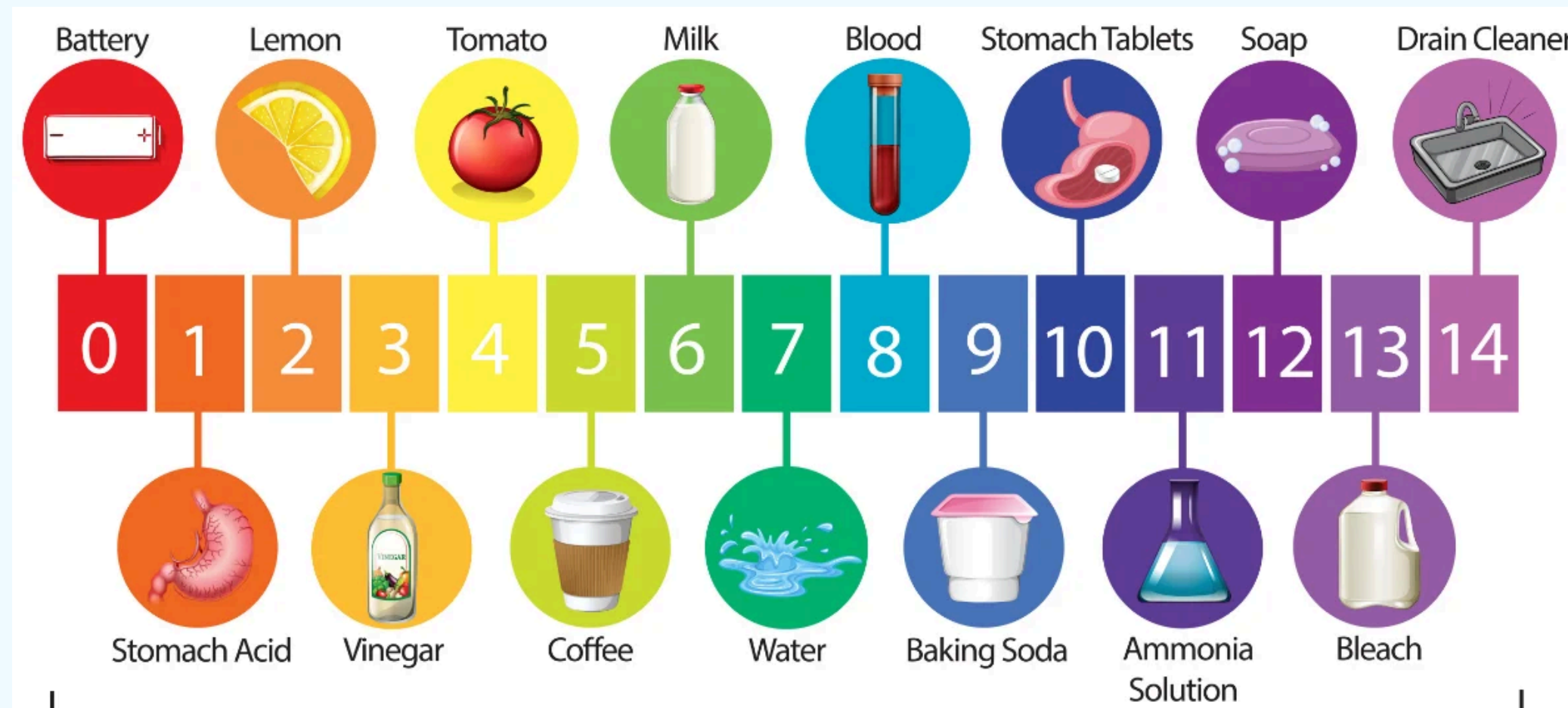


# THE pH SCALE

acidic  
 $\text{pH} < 7$

neutral  
 $\text{pH} = 7$

basic  
 $\text{pH} > 7$



the farther away from neutral, the more extremely acidic/basic a solution is