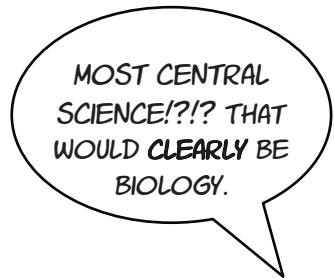


# CHEMISTRY

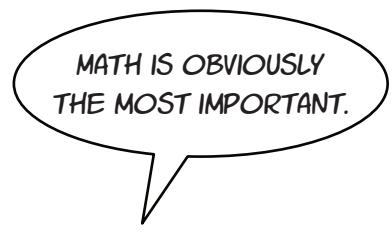
The central and most important branch of science



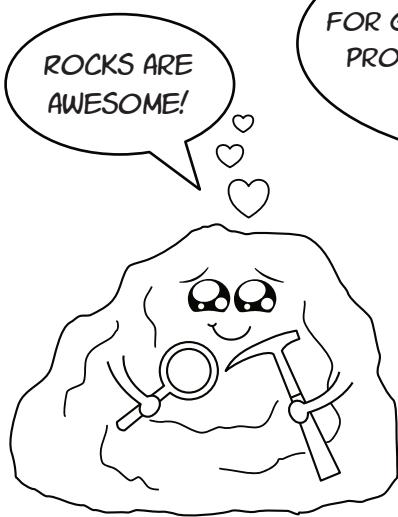
MOST CENTRAL  
SCIENCE!?!? THAT  
WOULD CLEARLY BE  
BIOLOGY.



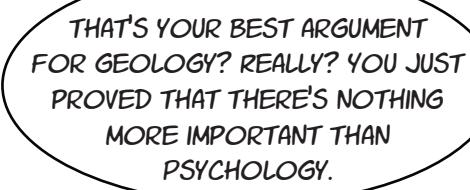
DON'T BE RIDICULOUS.  
WITHOUT PHYSICS YOU  
WOULDN'T EVEN HAVE A  
PLANET TO LIVE ON!



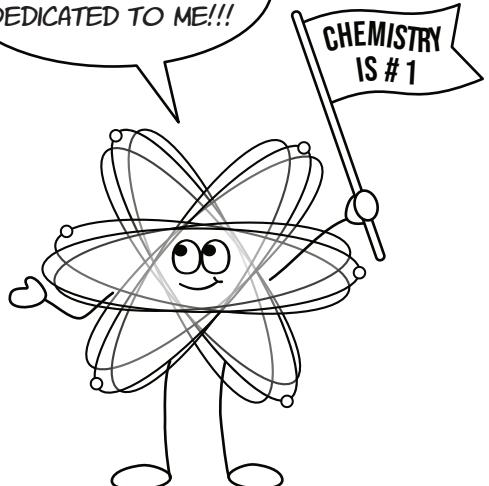
MATH IS OBVIOUSLY  
THE MOST IMPORTANT.



ROCKS ARE  
AWESOME!



THAT'S YOUR BEST ARGUMENT  
FOR GEOLOGY? REALLY? YOU JUST  
PROVED THAT THERE'S NOTHING  
MORE IMPORTANT THAN  
PSYCHOLOGY.



# Chemistry

Lesson	Topic	Pages in the notes
Introduction	Tips for best learning and why chemistry is important!	
1	The story of the atom	1-2
2	Elemental, dear Watson!	3-4
3	Modeling clay orbitals	5-6
4	A noble quest	7-10
5	Why share electrons?	11-14
6	Game show review	
7	Element vs mixture vs compound	15-16
8	What is radioactivity?	17-18
9	Going bananas	
10	Edible experiments	19-20
11	States of matter	21-22
12	Matter batter	
13	Physical reactions	23-24
14	Fizzing experiments	25-26
15	What's a reaction?	
16	Chemical reactions	27-29
17	More chemical reactions	30
18	Lemon battery	31-32
19	Toasters and cooking mysteries	33-34
20	Carbon, the building block of life	35-36
21	Game show review	
22	Where do fossil fuels come from?	37-39
23	What is fire really?	40
24	Why do leaves change color?	
25	The chemistry of lava	43
26	The chemistry of acids and bases	44

Have questions? Contact [jenny@science.mom](mailto:jenny@science.mom)

Lesson	Topic	Pages in the notes
27	Game show review	
28	Chemistry of swimming pools	45
29	Photosynthesis	46
30	Frankenseeds	47-48
31	All about sugars	49
32	Why can't you eat books?	50-51
33	Game show review	
34	Lipids	52
35	Plankton	53
36	Proteins	
37	Why things glow in the dark	56
38	From cells to colonies	57
39	Game show review	
40	Nitrogen cycle	58
41	Water reclamation	59
42	Water chemistry	
43	DIY water filter	60
44	Fireworks and safety	61
45	Final gameshow	

You will see boxes like this throughout the notes. Use them to draw your favorite moment from class, to write down something cool you learned, or for plain old-fashioned doodling.

YOUR DOODLE SPACE

# Supply List for Hands-on Activities:

## **Lesson 3 - Modeling Clay Orbitals**

- Toothpicks
- Modeling clay or dough (7 different colors)

## **Lesson 10 - Edible Experiments**

- Granulated Sugar (at least 7 cups)
- Kool-aid packets
- Cake pop sticks or string
- A ruler
- 2 pint-size mason jars with lids OR cups and rubber bands
- Coffee filters or paper
- 2 Microwavable popcorn packets

## **Lesson 14 - Fizzing Experiments**

- 6 Alka-Seltzer tablets
- 6 bottles of soda in plastic containers with narrow tops. Any size and type will work, but I recommend 16 oz coke bottles (because Coke is slightly more carbonated than other sodas). You'll use the bottles twice in this experiment and reuse two of them again in the Dec 4<sup>th</sup> water filtration experiment.
- Baking soda
- 3 packages of Pop Rocks candy
- 6 Balloons (standard 9 inch size)
- A funnel (to help get baking soda inside the balloon)
- Food Coloring
- Vinegar
- Vegetable oil (a whole bottle)
- Safety glasses

## **Lesson 20 - Lemon or Vinegar Batteries**

- Citrus fruit such as lemons OR a potato OR vinegar and an empty ice cube tray

- An LED diode
- Copper penny, wire, or copper sheets
- Galvanized nail or zinc sheets
- Alligator clips
- Scissors or knife

You can get all of these items  
in a "lemon battery science kit"  
online for about \$9.

### ***Lesson 30 Frankenseeds***

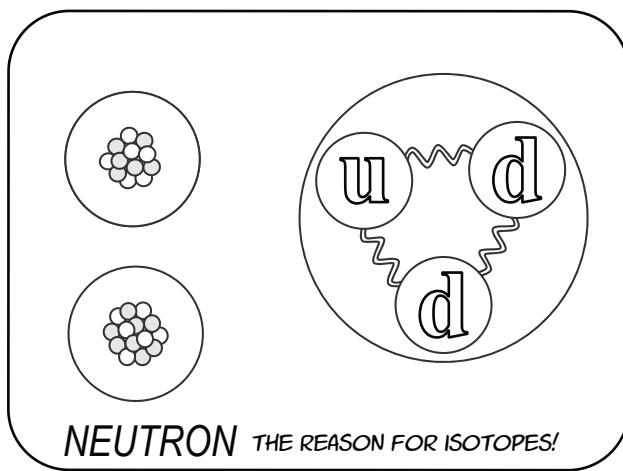
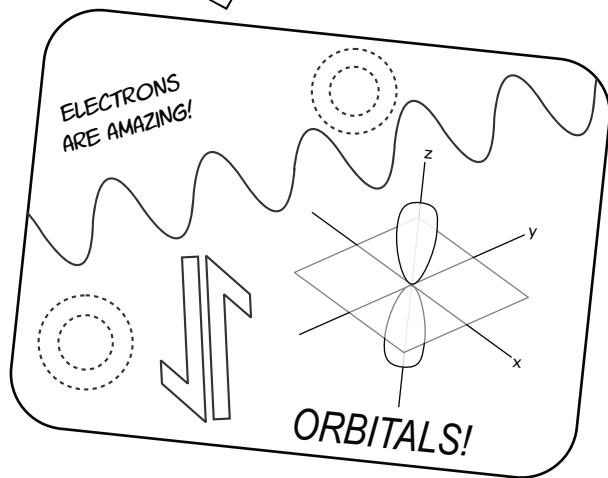
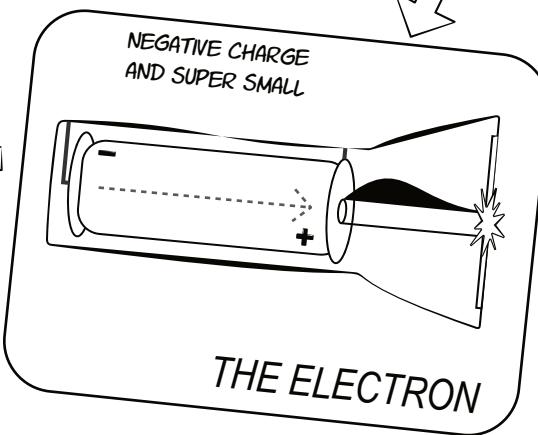
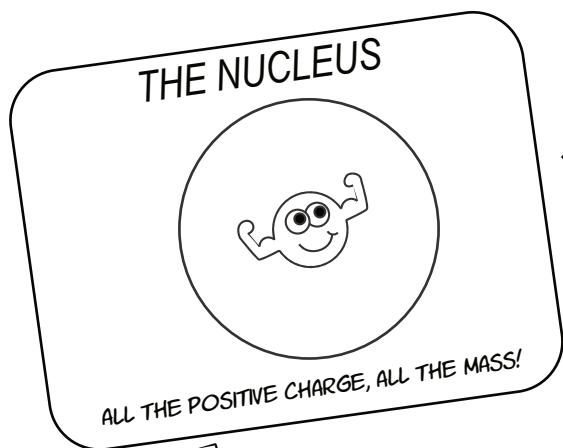
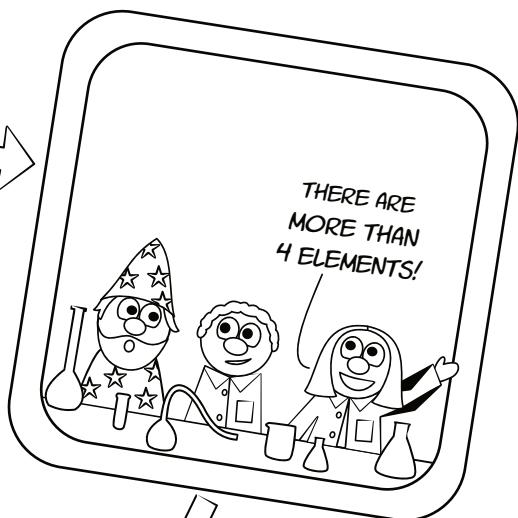
- Cardboard egg carton(s)
- Paper towels
- An empty bread or produce bag
- At least 6 types of seeds from the kitchen (could include rice, beans, lentils, chia seeds, walnuts, sunflower seeds, almonds, peanuts, flax seeds quinoa, or seeds from inside foods like apples, peas, avocados, pears, oranges, kiwis, or cucumbers)

### ***Lesson 43 - DIY Water Filter***

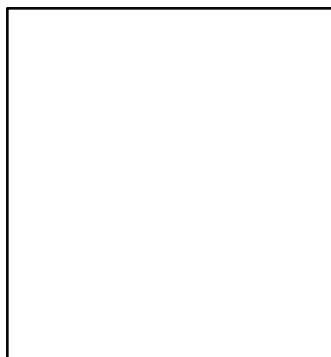
- Two plastic 12 or 16 oz bottles (can reuse the ones from Sept 25)
- Scissors (you might want an adult's help to cut the bottles)
- Sand
- Gravel
- Activated charcoal
- Coffee filters
- A small square of cotton fabric or a couple of cotton balls

# The story of the ATOM

WHAT ARE THINGS REALLY MADE OF?



DRAW THE DIFFERENT MODELS IN THESE BOXES!



### SOLID SPHERE

- 1803 JOHN DALTON  
 ELEMENTS ARE MADE OF DIFFERENT ATOMS  
 THE ATOM ISN'T THE SMALLEST PARTICLE

### PLUM PUDDING

- 1904 J.J. THOMPSON  
 ELECTRONS ARE NEGATIVELY CHARGED  
 HAD NO NUCLEUS

### PLANETARY

- 1911 RUTHERFORD  
 POSITIVE CHARGE IN THE NUCLEUS  
 DIDN'T PREDICT ELECTRON BEHAVIORS

### BOHR

- 1913 NIELS BOHR  
 ELECTRONS HAVE DISTINCT ENERGY LEVELS  
 DID NOT EXPLAIN LARGER ATOMS

YOUR NOTES:

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## Welcome to the Elemental Cafe

### How to order an element:

1. Choose the number of protons\*
2. Make it an isotope!  
Adjust the number of neutrons
3. Make it an ion!\*\*  
Adjust the number of electrons

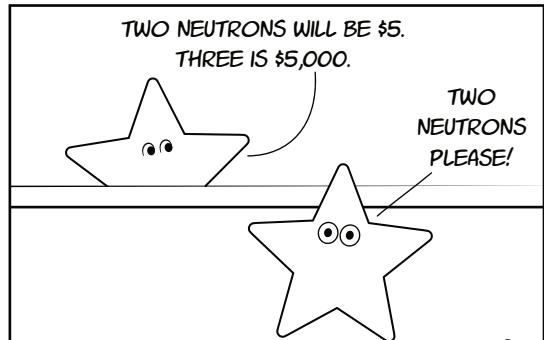
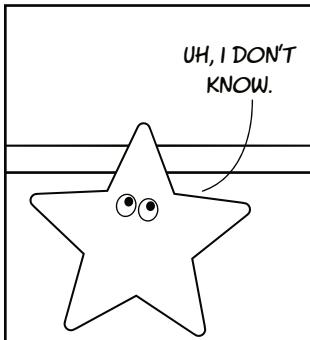
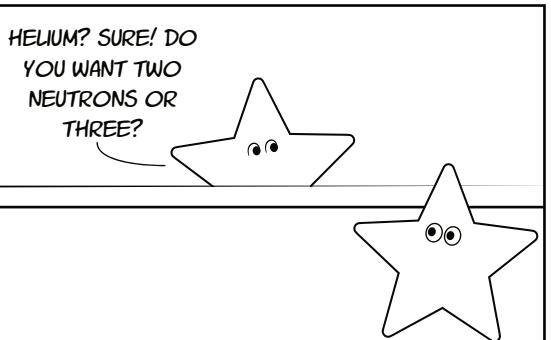
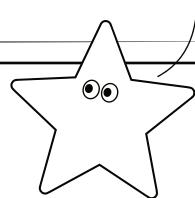
\* NUMBERS ABOVE 90 ARE NOT SERVED.

\*\* LIMITED AVAILABILITY.

Daily Special  
CARBON 14  
6 PROTONS  
8 NEUTRONS  
6 ELECTRONS  
Remarkably stable!

WHAT CAN I GET YOU?

I'LL HAVE A NUMBER TWO.



FILL IN THE BLANKS USING THESE WORDS:

element  
nucleus

positive  
protons

no  
nucleus

nucleus  
118

orbitals  
matter

neutrons  
negative

## ELECTRONS

HAVE A \_\_\_\_\_ CHARGE AND OCCUPY SPACES AROUND THE NUCLEUS KNOWN AS \_\_\_\_\_. THEY DON'T ADD ANY REAL MASS TO THE ATOM.

## PROTONS

HAVE A \_\_\_\_\_ CHARGE AND EXIST IN THE \_\_\_\_\_ OF THE ATOM. THE NUMBER OF PROTONS DETERMINES WHICH ELEMENT THE ATOM IS.

## AN ELEMENT

CANNOT BE BROKEN INTO SIMPLER SUBSTANCES BY CHEMICAL REACTIONS. THERE ARE \_\_\_\_\_ KNOWN ELEMENTS.

ALL \_\_\_\_\_ IS MADE OF ATOMS. ATOMS ARE THE SMALLEST PIECE OF AN \_\_\_\_\_ THAT STILL BEHAVES LIKE THAT ELEMENT.

ATOMS ARE MOSTLY MADE OF EMPTY SPACE. ALL OF THEIR MASS IS IN THE \_\_\_\_\_

## NEUTRONS

HAVE A \_\_\_\_\_ CHARGE AND EXIST IN THE \_\_\_\_\_ OF THE ATOM. THEY ARE ABOUT THE SAME SIZE AS PROTONS.

## ISOTOPES

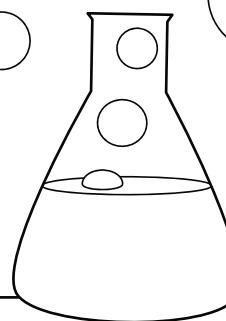
ARE VARIATIONS OF THE SAME ELEMENT WITH A DIFFERENT NUMBER OF NEUTRONS.



HELIUM



ALSO HELIUM

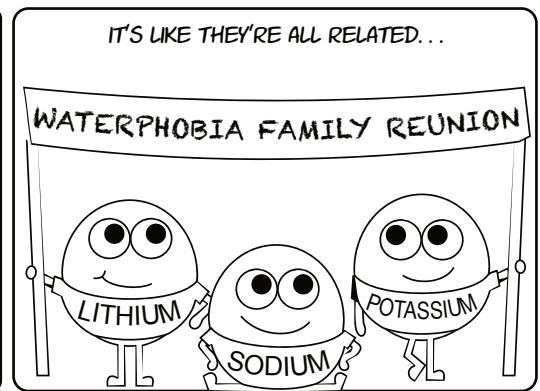
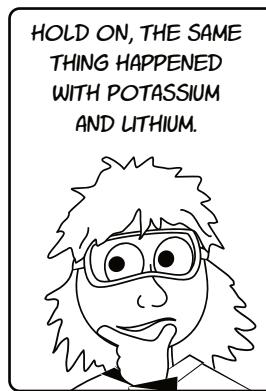
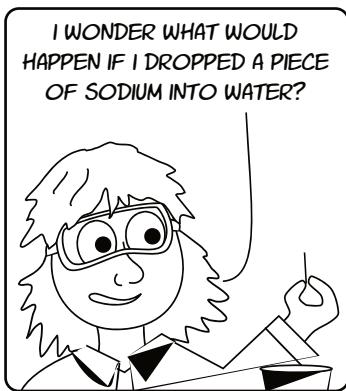


SCIENCE MAM

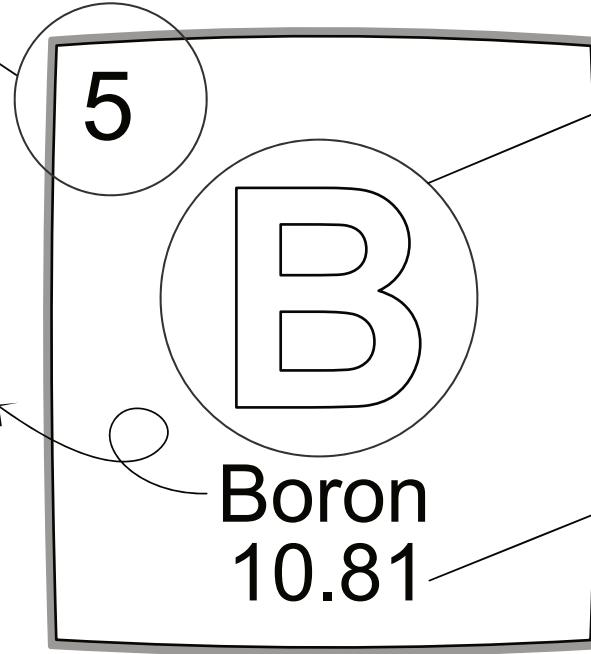
YOUR NOTES:

# The PERIODIC table

PRETTY MUCH THE COOLEST CHART EVER



The ATOMIC NUMBER is the number of \_\_\_\_\_



1	H	Hydrogen
3	Li	Be
	Lithium	Beryllium
11	Na	Mg
	Sodium	Magnesium
19	K	Ca
	Potassium	Calcium
37	Rb	Sr
	Rubidium	Srtrium
55	Cs	Ba
	Ce	Lanthanum
87	Fr	Ac
	Th	Pa

THE PERIODIC TABLE    EVERY SINGLE ELEMENT!

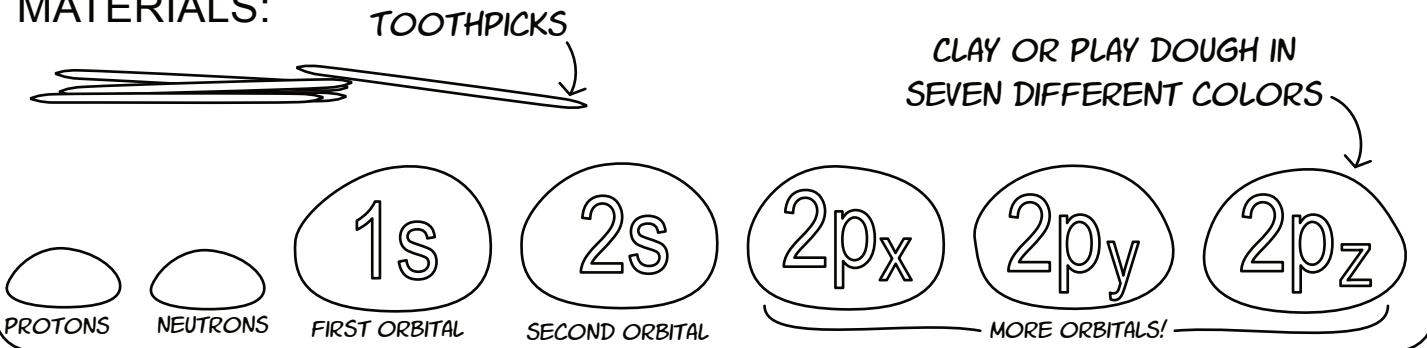
2	He	Helium
5	B	C
	Boron	Carbon
13	Al	N
	Aluminum	Nitrogen
14	Si	O
	Silicon	Oxygen
15	P	F
	Phosphorus	Fluorine
16	S	Ne
	Sulfur	Neon
17	Cl	Ar
	Chlorine	Argon
18	Ar	
	Argon	
5	Ga	Ge
	Gallium	Germanium
14	As	Se
	Arsenic	Selenium
15	Se	Br
	Sulfur	Bromine
16	Br	Kr
	Bromine	Krypton
17	Kr	
	Krypton	
5	Ti	V
	Titanium	Vanadium
23	V	Cr
		Chromium
24	Cr	Mn
		Manganese
25	Mn	Fe
		Iron
26	Fe	Co
		Cobalt
27	Co	Ni
		Nickel
28	Ni	Cu
		Copper
29	Cu	Zn
		Zinc
30	Zn	In
		Indium
31	In	Sn
		Tin
32	Sn	Sb
		Antimony
33	Sb	Te
		Tellurium
34	Te	I
		Iodine
35	I	Xe
		Xenon
36	Xe	
5	Ti	C
	Titanium	Carbon
41	Nb	N
	Zirconium	Nitrogen
42	Mo	O
	Molybdenum	Oxygen
43	Tc	F
	Technetium	Fluorine
44	Ru	P
	Ruthenium	Palladium
45	Rh	Ag
	Rhodium	Silver
46	Pd	Cd
	Palladium	Cadmium
47	Ag	In
	Silver	Indium
48	Cd	Sn
	Cadmium	Tin
49	In	Sb
	Indium	Antimony
50	Sn	Te
	Tin	Tellurium
51	Sb	I
	Antimony	Iodine
52	Te	Xe
	Tellurium	Xenon
53	I	
	Iodine	
54	Xe	
	Xenon	
5	B	C
	Boron	Carbon
14	Si	N
	Silicon	Nitrogen
15	P	O
	Phosphorus	Oxygen
16	S	F
	Sulfur	Fluorine
17	Cl	Ne
	Chlorine	Neon
18	Ar	
	Argon	
5	Ga	Ge
	Gallium	Germanium
14	As	Se
	Arsenic	Selenium
15	Se	Br
	Sulfur	Bromine
16	Br	Kr
	Bromine	Krypton
17	Kr	
	Krypton	
5	Ti	V
	Titanium	Vanadium
23	V	Cr
		Chromium
24	Cr	Mn
		Manganese
25	Mn	Fe
		Iron
26	Fe	Co
		Cobalt
27	Co	Ni
		Nickel
28	Ni	Cu
		Copper
29	Cu	Zn
		Zinc
30	Zn	In
		Indium
31	In	Sn
		Tin
32	Sn	Sb
		Antimony
33	Sb	Te
		Tellurium
34	Te	I
		Iodine
35	I	Xe
		Xenon

ARRANGING ALL OF THE ELEMENTS BY NUMBER CREATES A REALLY WIDE TABLE. SO THIS BLOCK (THE LANTHANIDES AND ACTINIDES) IS USUALLY SHOWN BELOW THE REST OF THE ELEMENTS.

# Hands-on Activity

## MODELING CLAY ORBITALS!

### MATERIALS:



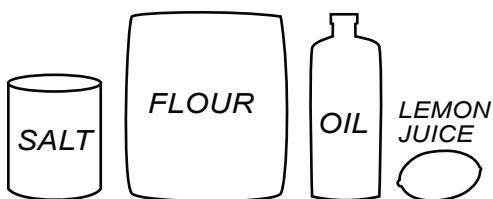
Don't have modeling clay?  
No problem! Make play  
dough using this recipe:

### DOUGH RECIPE

1 cup flour  
1/3 cup salt  
3/4 cup water  
3 Tbsp lemon juice  
1 Tbsp cooking oil  
Food coloring

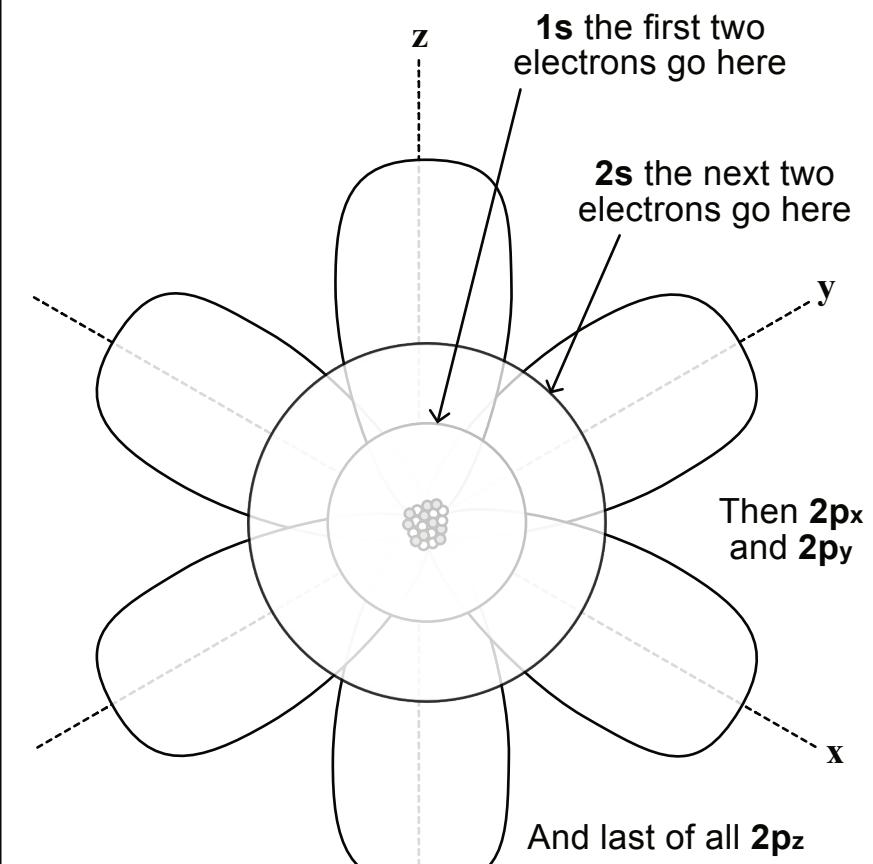
Mix the flour and salt together in a bowl. Heat the water to boiling and add the oil and lemon juice. Then mix all the ingredients together. For best results, mix in a pot over the stovetop until mixture is thick (about 1 minute).

Let sit and cool for a few minutes before kneading. Add another spoonful of flour if the dough is too sticky. Kool-aid drink packets can be used instead of food coloring.



## ORBITALS

WHERE AN ELECTRON IS  
MOST LIKELY TO BE



~ INSTRUCTIONS ON PAGE 6 ~

## MODELING CLAY ORBITALS CONTINUED...

### INSTRUCTIONS:

Shape the colors of clay that represent neutrons and protons into small spheres and put them together to make the nucleus. Then cover the nucleus in layers of clay to represent the orbitals. Use the images below to guide you in making models of a hydrogen, helium, lithium, carbon, fluorine, and neon atom. Partially-filled orbitals can be represented by moulding half of the orbital. Use toothpicks to attach the p-orbitals.

### HYDROGEN

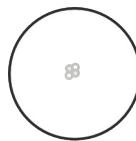
1 PROTON  
0 NEUTRONS  
1 ELECTRON



WARNING! VERY REACTIVE  
ORBITAL INCOMPLETE

### HELIUM

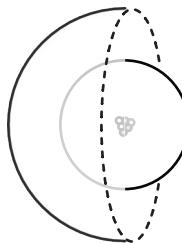
2 PROTON  
2 NEUTRONS  
2 ELECTRON



CONGRATULATIONS!  
YOU ARE REMARKABLY STABLE

### LITHIUM

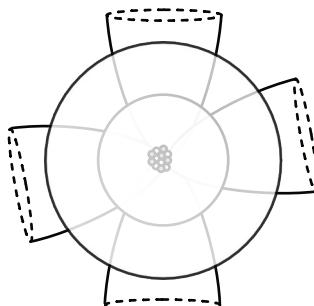
3 PROTON  
3 NEUTRONS  
3 ELECTRON



WARNING! VERY REACTIVE  
ORBITAL INCOMPLETE

### CARBON

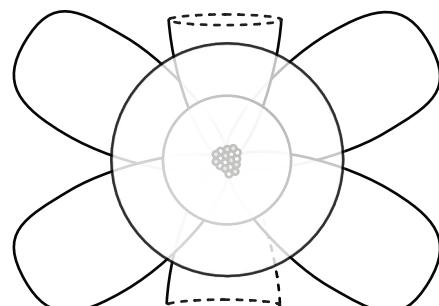
6 PROTON  
6 NEUTRONS  
6 ELECTRON



INCOMPLETE ORBITALS  
VERY REACTIVE!

### FLUORINE

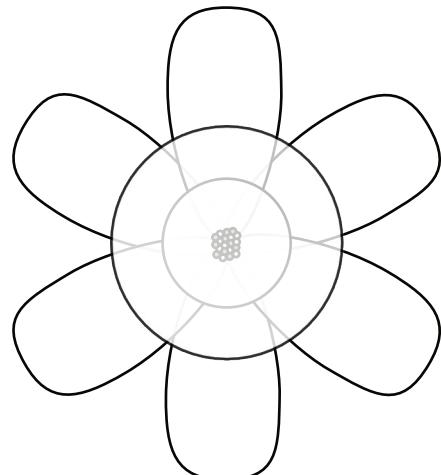
9 PROTON  
9 NEUTRONS  
9 ELECTRON



WARNING! VERY REACTIVE  
ORBITAL INCOMPLETE

### NEON

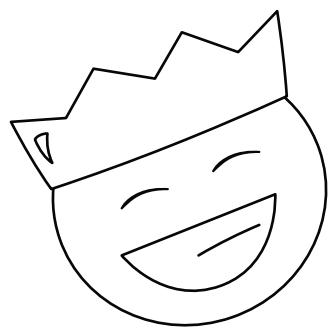
10 PROTON  
10 NEUTRONS  
10 ELECTRON



CONGRATULATIONS!  
YOU ARE REMARKABLY STABLE

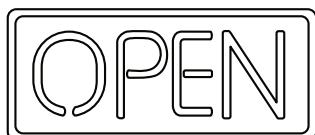
# A NOBLE Quest!

The elements in this family are called the “Noble gases.” At room temperature, they are all colorless, odorless, and tasteless. They hardly ever form bonds or react with anything! Can you draw lines to match each element with its fact box?

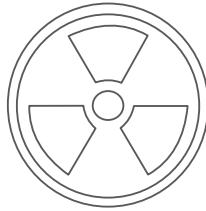


2	He	Helium	4
10	Ne	Neon	20.18
18	Ar	Argon	39.95
36	Kr	Krypton	83.80
54	Xe	Xenon	131.24
86	Rn	Radon	222

When electricity passes through this colorless gas, it can glow a bright red-orange color. It's often used in signs.



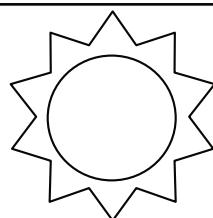
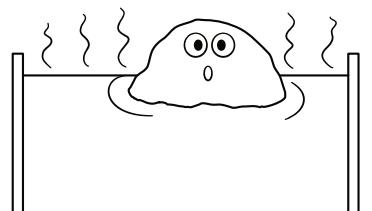
People used to mix this element into paints to make them glow in the dark, but then it was banned from paint because it's radioactive.



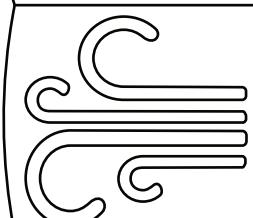
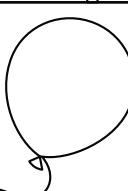
This gas is sometimes used in high-powered lasers.



This gas glows bright white when electricity passes through it. In its (very cold) liquid form, it's so dense that granite would float on it!



Second most abundant element in the universe! Created in our sun and sometimes found in balloons.



This gas, the 3<sup>rd</sup> most abundant in our atmosphere, makes up 1% of the air you breath.

1%

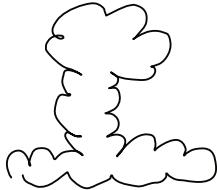
# The Halogens

REACTIVE &  
DANGEROUS

The elements in this family are called the “halogens.” At room temperature, the first two (fluorine and chlorine) are gasses with strong unpleasant smells. Breathing too much of them is toxic and they are all flammable and corrosive (will destroy or damage other substances). Can you draw lines to match each element in this family with its fact box?

9	F	Fluorine	19.0
17	Cl	Chlorine	35.45
35	Br	Bromine	79.80
53	I	Iodine	126.91
85	At	Astatine	210

Rarest of the naturally occurring elements, this radioactive element will only be around for a few hours, but while it is, it can do impressive damage. If you had more than few molecules of this element, they'd immediately be vaporized by the heat of their own radioactivity.



Used to treat water in swimming pools.

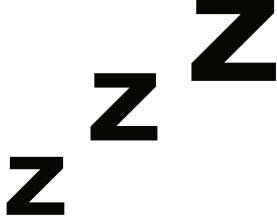


Lack of this element in a person's diet can cause a goiter: a huge overgrown thyroid that sticks out from the neck.

WHAT MADE THAT BIG BUMP ON YOUR NECK?  
I DIDN'T EAT ENOUGH OF A CERTAIN ELEMENT.



Salts of this element were once used as sedatives.



Can strengthen tooth enamel.



# THE PERIODIC TABLE COLORING CHALLENGE

1	<b>H</b> Hydrogen	3	<b>Li</b> Lithium	4	<b>Be</b> Beryllium	11	<b>Na</b> Sodium	12	<b>Mg</b> Magnesium	19	<b>K</b> Potassium	20	<b>Ca</b> Calcium	21	<b>Sc</b> Scandium	22	<b>Ti</b> Titanium	23	<b>V</b> Vanadium	24	<b>Cr</b> Chromium	25	<b>Mn</b> Manganese	26	<b>Fe</b> Iron	27	<b>Co</b> Cobalt	28	<b>Ni</b> Nickel	29	<b>Cu</b> Copper	30	<b>Zn</b> Zinc	31	<b>Ga</b> Gallium	32	<b>Ge</b> Germanium	33	<b>As</b> Arsenic	34	<b>Se</b> Selenium	35	<b>Br</b> Bromine	36	<b>Kr</b> Krypton
37	<b>Rb</b> Rubidium	38	<b>Sr</b> Strontium	40	<b>Y</b> Yttrium	41	<b>Nb</b> Niobium	42	<b>Mo</b> Molybdenum	43	<b>Tc</b> Technetium	44	<b>Ru</b> Ruthenium	45	<b>Rh</b> Rhodium	46	<b>Pd</b> Palladium	47	<b>Ag</b> Silver	48	<b>Cd</b> Cadmium	49	<b>In</b> Indium	50	<b>Sn</b> Tin	51	<b>Sb</b> Antimony	52	<b>Te</b> Tellurium	53	<b>I</b> Iodine	54	<b>Xe</b> Xenon												
55	<b>Cs</b> Caesium	56	<b>Ba</b> Barium	72	<b>Hf</b> Hafnium	73	<b>Ta</b> Tantalum	74	<b>W</b> Tungsten	75	<b>Re</b> Rhenium	76	<b>Os</b> Osmium	77	<b>Ir</b> Iridium	78	<b>Pt</b> Platinum	79	<b>Au</b> Gold	80	<b>Hg</b> Mercury	81	<b>Tl</b> Thallium	82	<b>Pb</b> Lead	83	<b>Bi</b> Bismuth	84	<b>Po</b> Polonium	85	<b>At</b> Astatine	86	<b>Rn</b> Radon												
87	<b>Fr</b> Francium	88	<b>Ra</b> Radium	104	<b>Rf</b> Rutherfordium	105	<b>Db</b> Dubnium	106	<b>Sg</b> Seaborgium	107	<b>Bh</b> Bohrium	108	<b>Hs</b> Hassium	109	<b>Mt</b> Meitnerium	110	<b>Ds</b> Darmstadtium	111	<b>Rg</b> Roentgenium	112	<b>Cn</b> Copernicium	113	<b>Nh</b> Nihonium	114	<b>Fl</b> Flerovium	115	<b>Mc</b> Moscovium	116	<b>Lv</b> Livermorium	117	<b>Ts</b> Tennessee	118	<b>Og</b> Oganesson												

Certain elements are grouped together because they behave in a similar way. For this coloring challenge, choose a color to represent each family of elements. Then use the number key below to find and color your elements!

57	<b>La</b> Lanthanum	58	<b>Ce</b> Cerium	59	<b>Pr</b> Praseodymium	60	<b>Nd</b> Neodymium	61	<b>Pm</b> Promethium	62	<b>Sm</b> Samarium	63	<b>Eu</b> Europium	64	<b>Gd</b> Gadolinium	65	<b>Tb</b> Terbium	66	<b>Dy</b> Dysprosium	67	<b>Ho</b> Holmium	68	<b>Er</b> Erbium	69	<b>Tm</b> Thulium	70	<b>Yb</b> Yterbium	71	<b>Lu</b> Lutetium
89	<b>Ac</b> Actinium	90	<b>Th</b> Thorium	91	<b>Pa</b> Protactinium	92	<b>U</b> Uranium	93	<b>Np</b> Neptunium	94	<b>Pu</b> Plutonium	95	<b>Am</b> Americium	96	<b>Cm</b> Curium	97	<b>Bk</b> Berkelium	98	<b>Fm</b> Fermium	99	<b>Es</b> Einsteinium	100	<b>Md</b> Mendelevium	101	<b>No</b> Nobelium	102	<b>Lu</b> Lawrencium	103	<b>Rf</b> Rutherfordium

**Nonmetals:** These Elements do not conduct electricity. 1,6,7,8,15,16,34

**Alkali Metals:** All of these react explosively with water. 3,11,19,37,55,87

**Alkali Earth metals:** These all also reactive elements and especially like to react with oxygen. 4,12,20,38,56,88

**Transition metals:** These are good conductors of heat and electricity. And there are a lot of them! 21, 22, 23, 24 25, 26, 27, 28, 29, 30, 39, 40,

**Metals:** These are great conductors heating electricity and in their solid form they can are shiny and ductile. 13, 31, 49, 50, 81, 82, 83

**Metaloids:** these elements are semiconductors! 5,14,32,33,51,52,84

**Halogens:** These are very reactive elements. 9,17,35,53,85

**Noble gases:** These elements have a full show of electrons and are not very reactive. 2,10,18,36,54,86

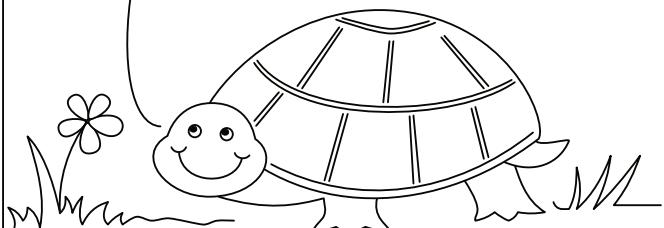
**Transactinides:** Super big elements with more than 104 protons! These have been created artificially in laboratories, but are not found in nature. 104-118

**Lanthanides:** Called the rare earth elements. 57-71

**Actinides:** These are all radioactive. 89-103

A FULL SHELL OF ELECTRONS IS LIKE A HAPPY TURTLE - UNLESS IT GETS TOO BIG.

LIFE WITH A  
FULL SHELL IS  
GREAT!



An \_\_\_\_\_ with a full shell is stable. It is not interested in reacting with other elements. But if it gets too large, then that "turtle" is no longer very happy, even though it has a full shell.

The elements with \_\_\_\_\_ shells of electrons are in the column called the noble gases. Next to the noble gases are the \_\_\_\_\_. If these elements *gain* one more electron, then they have a full shell. If the

\_\_\_\_\_ lose one electron, then they have a full shell. Both groups or families of elements are very \_\_\_\_\_. They want to \_\_\_\_\_ with other elements and fill their shells!

FILL IN THE BLANKS USING THESE WORDS:

reactive	alkali	element	full
metals	halogens	periodic	bond

Your notes: \_\_\_\_\_

\_\_\_\_\_

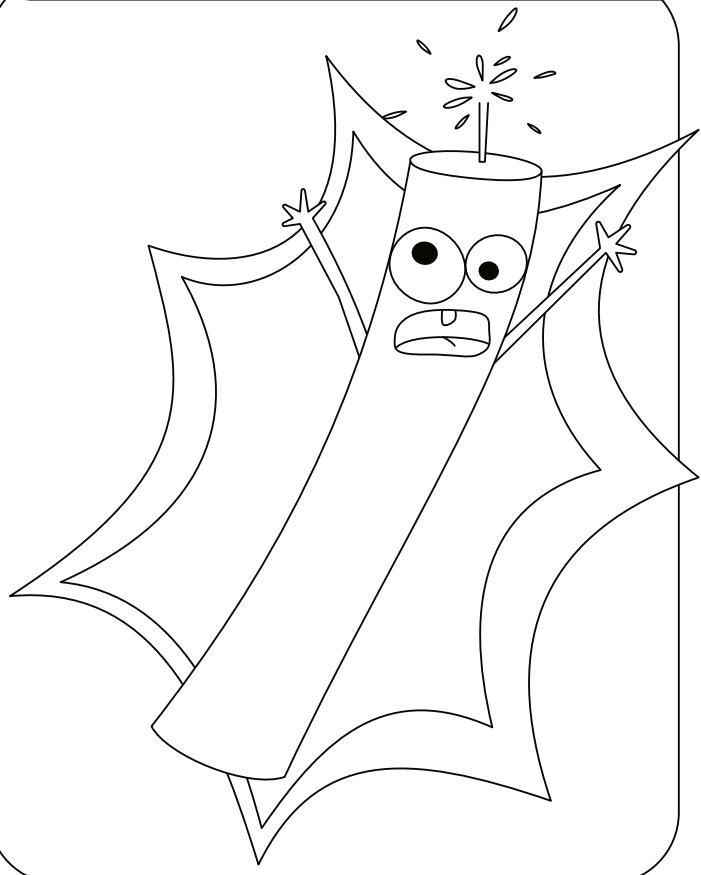
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

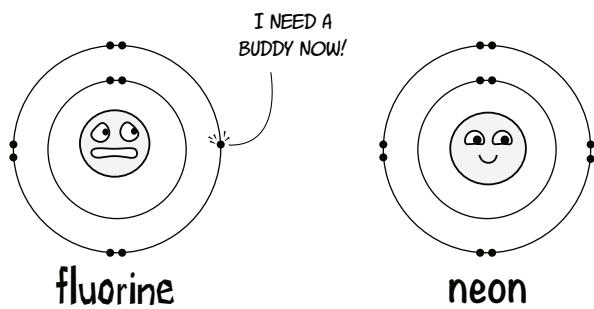
AN ALMOST-FULL SHELL OF ELECTRONS IS LIKE A FIRECRACKER READY TO EXPLODE!



# CHEMICAL BONDS

**SHARING ELECTRONS MAKES ATOMS HAPPY!**

Electrons really like to be in pairs. Fluorine, which is super reactive, has nine electrons, leaving one of them unpaired. Neon, a nonreactive noble gas, has ten electrons, each of them paired in different "shells" or orbitals around the nucleus.



Your notes: \_\_\_\_\_

\_\_\_\_\_

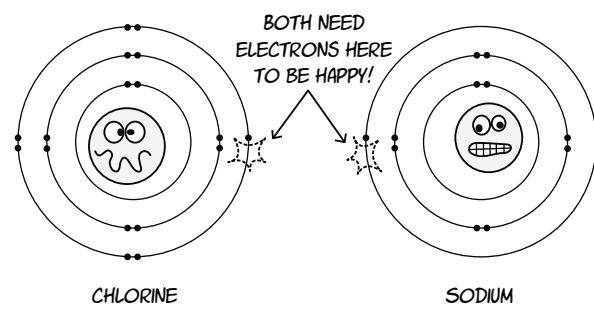
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

By themselves, chlorine and sodium are both "unhappy" because they have unpaired electrons.



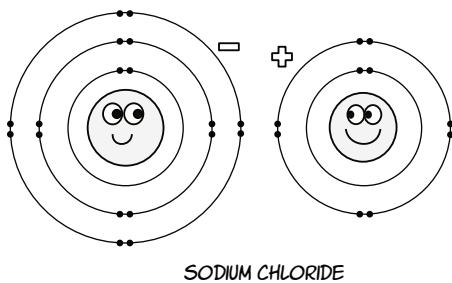
**IONIC BOND:** A CHEMICAL BOND WHERE AN ELECTRON IS TRANSFERRED FROM ONE ATOM TO ANOTHER. THIS CREATES IONS WITH OPPOSITE CHARGES. AND OPPOSITES ATTRACT!

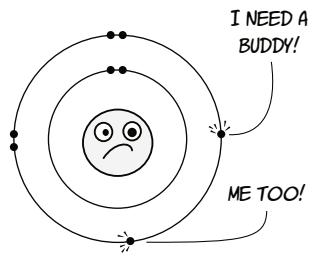


## YOUR DOODLE SPACE

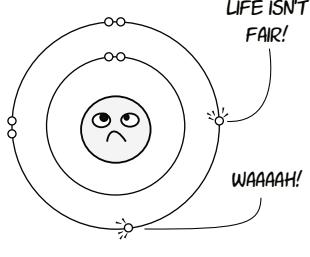
Draw your favorite moment from class or write a cool fact!

But if sodium gives its lonely electron to chlorine, then they're both happy. They've formed an ionic bond! Other atoms solve the same problem by sharing electrons.

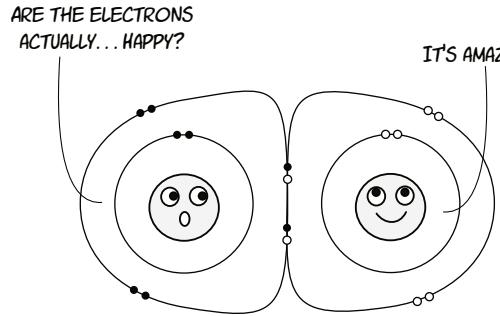




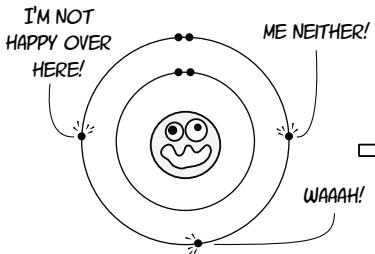
A single oxygen atom  
so miserable, it's rarely seen.  
When it does go out, it does a  
lot of damage.



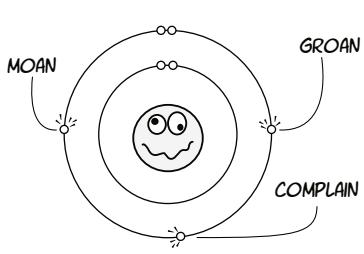
Another miserable  
lonely oxygen atom  
We've drawn the electrons differently  
here so you can better appreciate what  
happens next!



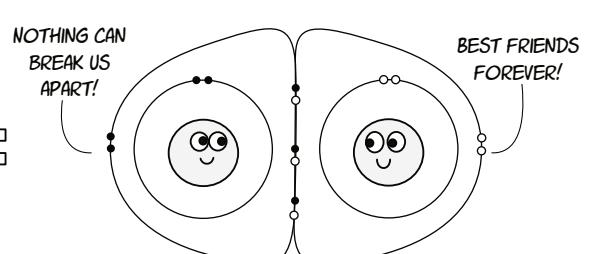
Oxygen gas - formula  $O_2$   
Since they share two pairs of electrons,  
we call this a "double" bond!



A single nitrogen atom

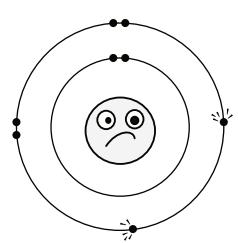


A single nitrogen atom

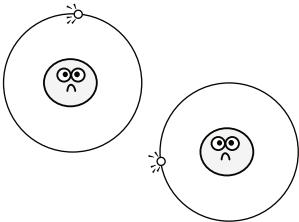


$N_2$  - atmospheric nitrogen  
Since they share three pairs of  
electrons, we call this a "triple" bond!

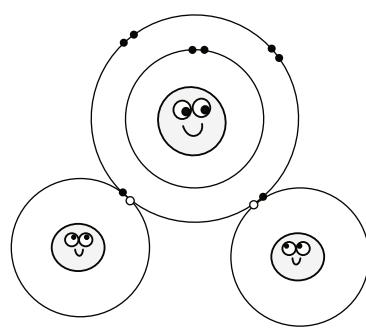
One oxygen + 2 hydrogens =  $H_2O$



A single oxygen atom



Two hydrogen atoms



A molecule of water!

**COVALENT BOND:** A CHEMICAL BOND WHERE ELECTRONS ARE SHARED BETWEEN TWO ATOMS. SOMETIMES THE ELECTRONS  
ARE SHARED EQUALLY. AND OTHER TIMES ONE ATOM (WE'RE TALKING ABOUT YOU, OXYGEN!) WILL BE A BIT GREEDY.

Your notes: \_\_\_\_\_

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# Make your own Element Cards!



Choose four elements to study. Research them and draw cards for them on the blank templates on the next page (you can print more pages to make more if you'd like!) Be sure to look up the chemical symbol and atomic number of your element. Research how your element behaves at room temperature and give it a hazard rating too. Then draw an avatar. It can look like anything! Be creative and have fun designing your cards.

NAME →

LEAD

Pb  
82

YOUR ELEMENT'S →  
AVATAR! IT CAN  
LOOK LIKE  
ANYTHING YOU'D  
LIKE. BE CREATIVE  
AND HAVE FUN!

At room temp:

SOLID. The metal is a silvery blue color and can be either shiny or dull.

Hazard rating:

Caution! Poisonous. Can cause permanent nerve and brain damage. Take care that old pipes (which contain lead) don't leach it into the water.

Other: Used in plumbing, bullets, and to make radiation shields. Few things are as good as lead at absorbing dangerous radiation.

IS YOUR ELEMENT A  
SOLID, LIQUID, OR  
GAS AT ROOM  
TEMPERATURE?

A NOTE ABOUT HOW  
HUMANS USE THE  
ELEMENT, WHERE IT'S  
FOUND, OR ANY  
OTHER COOL FACT  
YOU DISCOVERED.

A cartoon character of Lead, represented as a blobby, smiling head with a single wavy line for a body. It is holding a flag on a stick. The flag features a skull and crossbones logo and some illegible text.

At room temp:

Hazard rating:

Other:

# Element vs Mixture vs Compound

FILL IN THE BLANKS USING THESE WORDS:

mixture molecule element compound

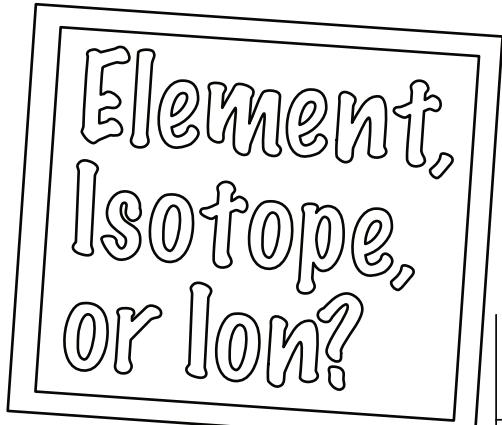
When more than one element combines to form a molecule, it's called a \_\_\_\_\_.

A \_\_\_\_\_ has different molecules that are not bonded together.

A \_\_\_\_\_ is a group of atoms that are bonded together. Molecules can be made of the same \_\_\_\_\_ or they can be made from different elements.

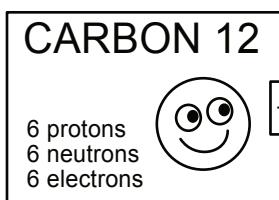
ELEMENT	ELEMENT	ELEMENT	COMPOUND
☺	☺☺	☺☺☺☺☺	☺
A MOLECULE OF HELIUM	A MOLECULE OF OXYGEN	A MOLECULE OF GOLD	A MOLECULE OF WATER
_____	_____	_____	_____
☺☺	☺	☺☺☺	☺☺☺☺☺
A MOLECULE OF NITROGEN	A MOLECULE OF AMMONIA	A MOLECULE OF VINEGAR	A MOLECULE OF IRON

WRITE DOWN WHETHER EACH OF THESE IS AN ELEMENT OR COMPOUND!

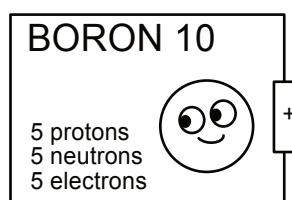
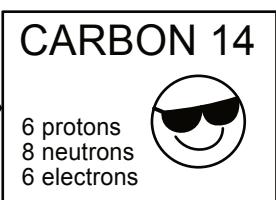


Each of the atoms below is going to gain or lose protons, neutrons, or electrons. Write down what the atom will be after that change!

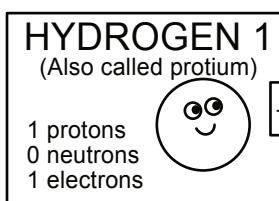
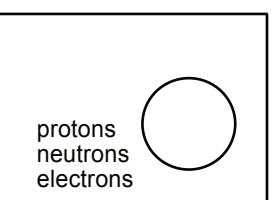
1 <b>H</b> Hydrogen	2 <b>He</b> Helium
3 <b>Li</b> Lithium	4 <b>Be</b> Beryllium
5 <b>B</b> Boron	6 <b>C</b> Carbon
7 <b>N</b> Nitrogen	8 <b>O</b> Oxygen
9 <b>F</b> Fluorine	10 <b>Ne</b> Neon
13 <b>Al</b> Aluminum	14 <b>Si</b> Silicon
15 <b>P</b> Phosphorus	16 <b>S</b> Sulfur
17 <b>Cl</b> Chlorine	18 <b>Ar</b> Argon
28 <b>Ni</b> Nickel	29 <b>Cu</b> Copper
30 <b>Zn</b> Zinc	31 <b>Ga</b> Gallium
32 <b>Ge</b> Germanium	33 <b>As</b> Arsenic
34 <b>Se</b> Selenium	35 <b>Br</b> Bromine
46 <b>Pd</b> Palladium	47 <b>Ag</b> Silver
48 <b>Cd</b> Cadmium	49 <b>In</b> Indium
50 <b>Sn</b> Tin	51 <b>Sb</b> Antimony
52 <b>Te</b> Tellurium	53 <b>I</b> Iodine
78 <b>Pt</b> Platinum	79 <b>Au</b> Gold
80 <b>Hg</b> Mercury	81 <b>Tl</b> Thallium
82 <b>Pb</b> Lead	83 <b>Bi</b> Bismuth
84 <b>Po</b> Polonium	85 <b>At</b> Astatine
86 <b>Rn</b> Radon	



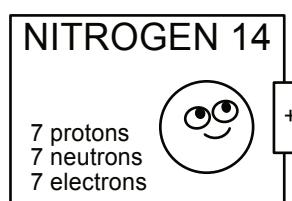
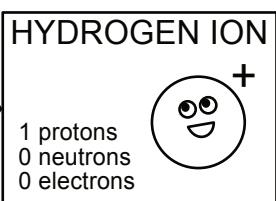
+2 neutrons



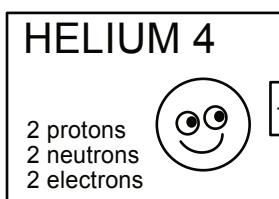
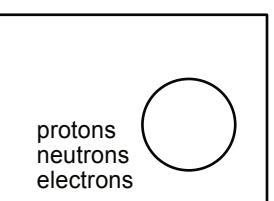
+1 neutron



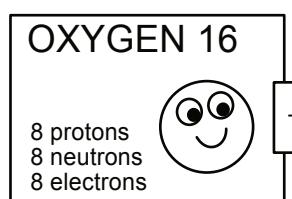
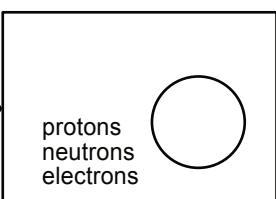
-1 electron



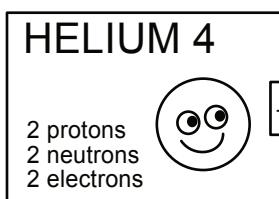
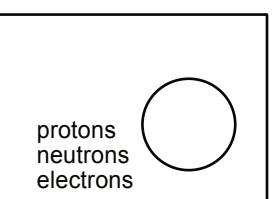
+1 proton



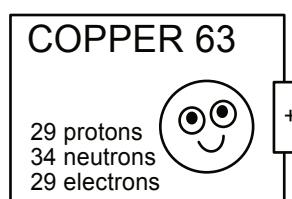
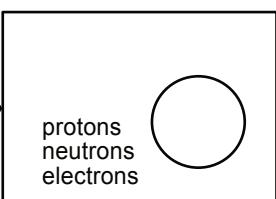
+1 proton



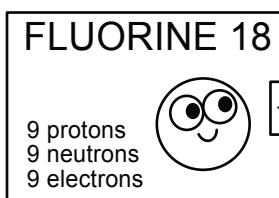
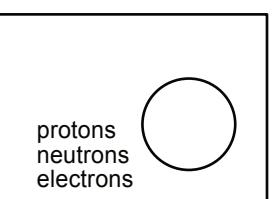
+1 electron



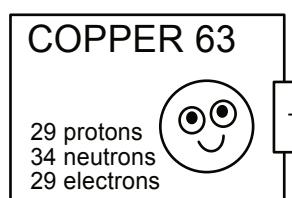
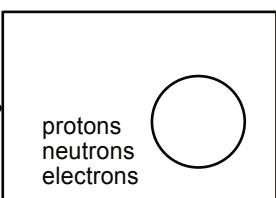
-1 proton



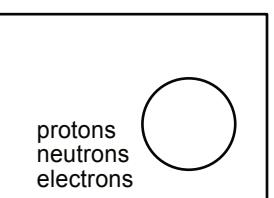
+1 proton



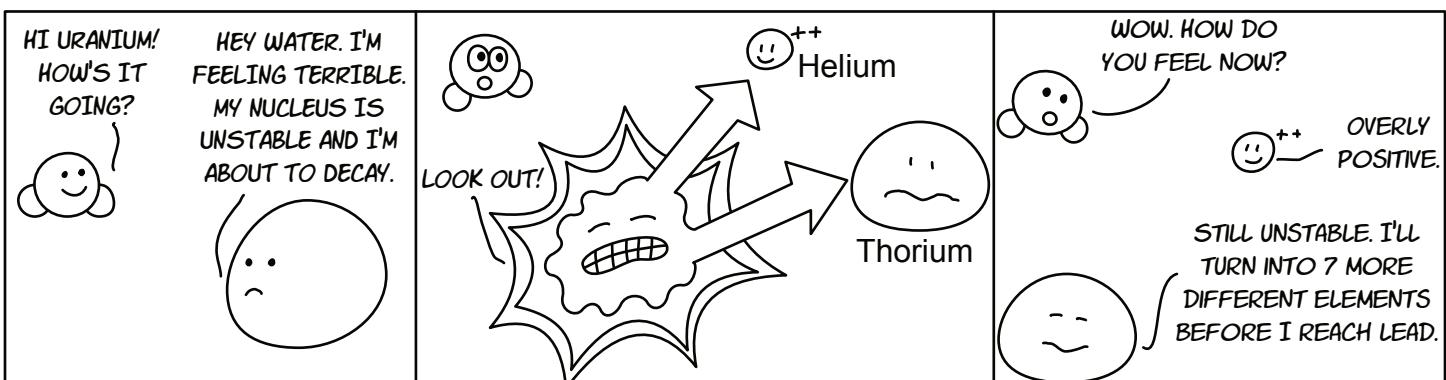
+1 proton



+1 neutron



# What is RADIOACTIVITY?



Unstable atoms decay. They split apart to form new elements. You might think that an equal number of protons and neutrons would be the most stable situation, but look at this graph and you'll see that's not the case! Hydrogen is most stable with no neutrons. Larger elements, like gold, need many more neutrons than protons.

Your notes:

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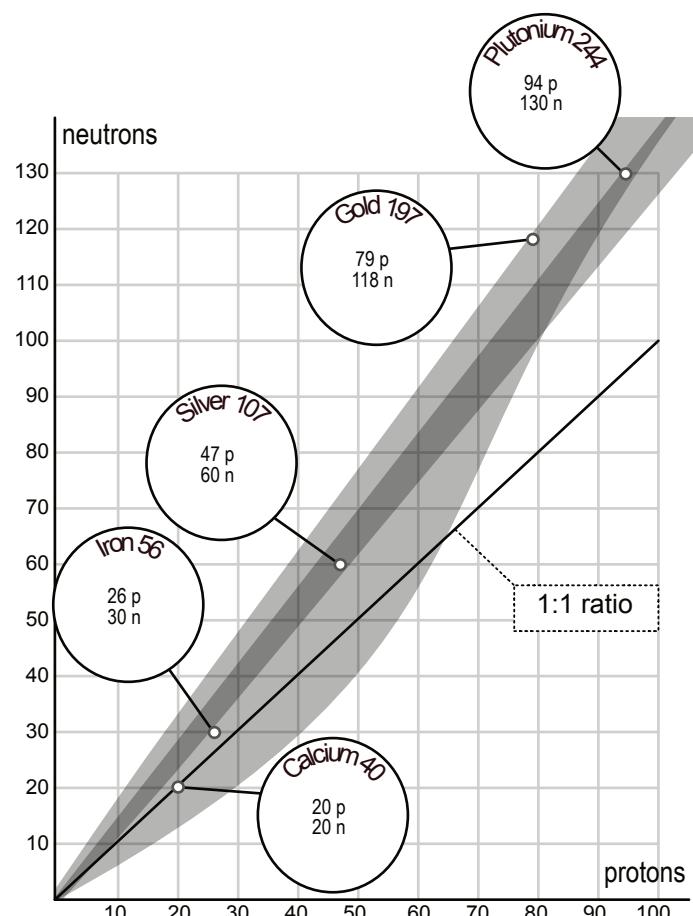
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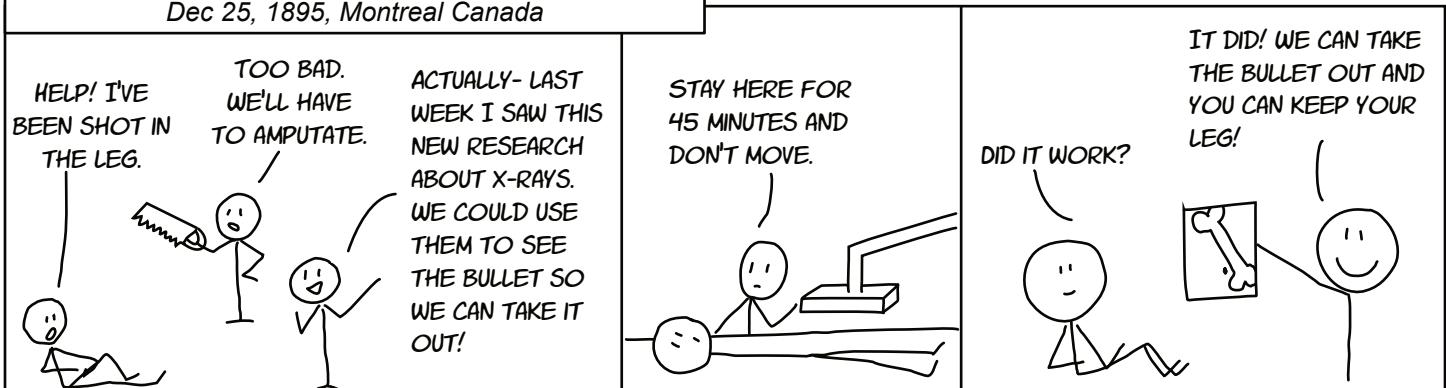


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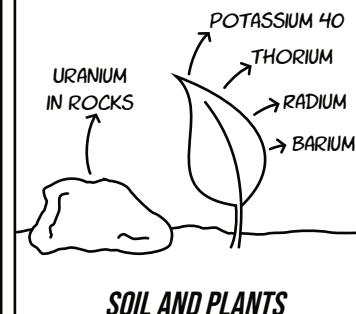


## THE STORY OF THE FIRST MEDICAL X-RAY

Dec 25, 1895, Montreal Canada



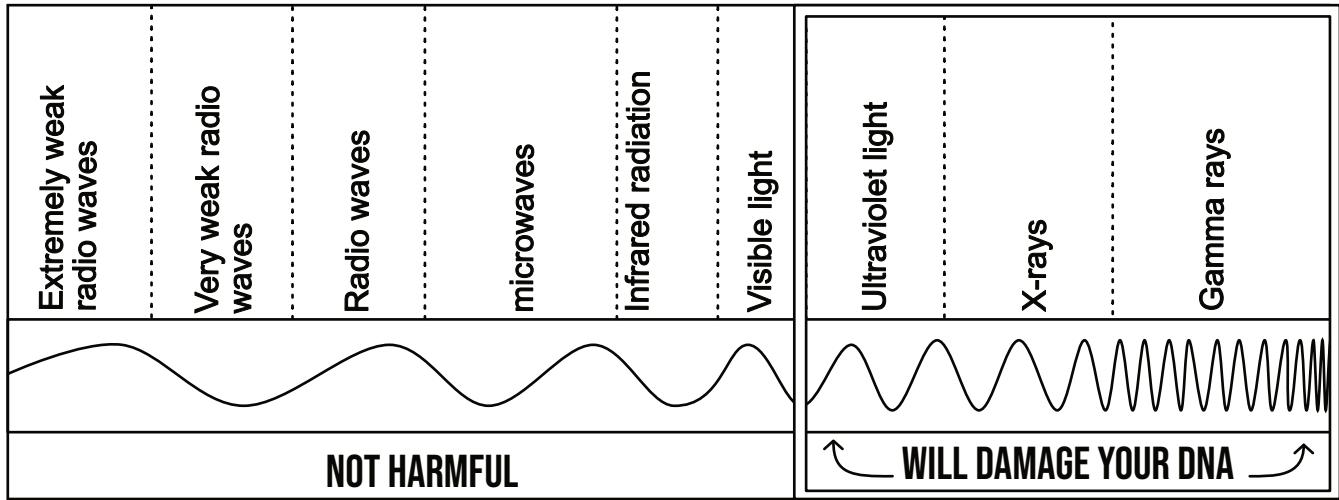
*Radiation is  
NATURAL*  
THAT DOESN'T MEAN  
IT'S GOOD FOR YOU.



IT'S THE DOSE  
THAT MAKES THE  
POISON

ANYTHING CAN BE TOXIC IF THERE IS  
TOO MUCH OF IT- EVEN WATER OR  
OXYGEN. WITH RADIATION, THE THING  
THAT REALLY MATTERS IS HOW MUCH.

All of these types of energy are called "radiation"



Your notes:

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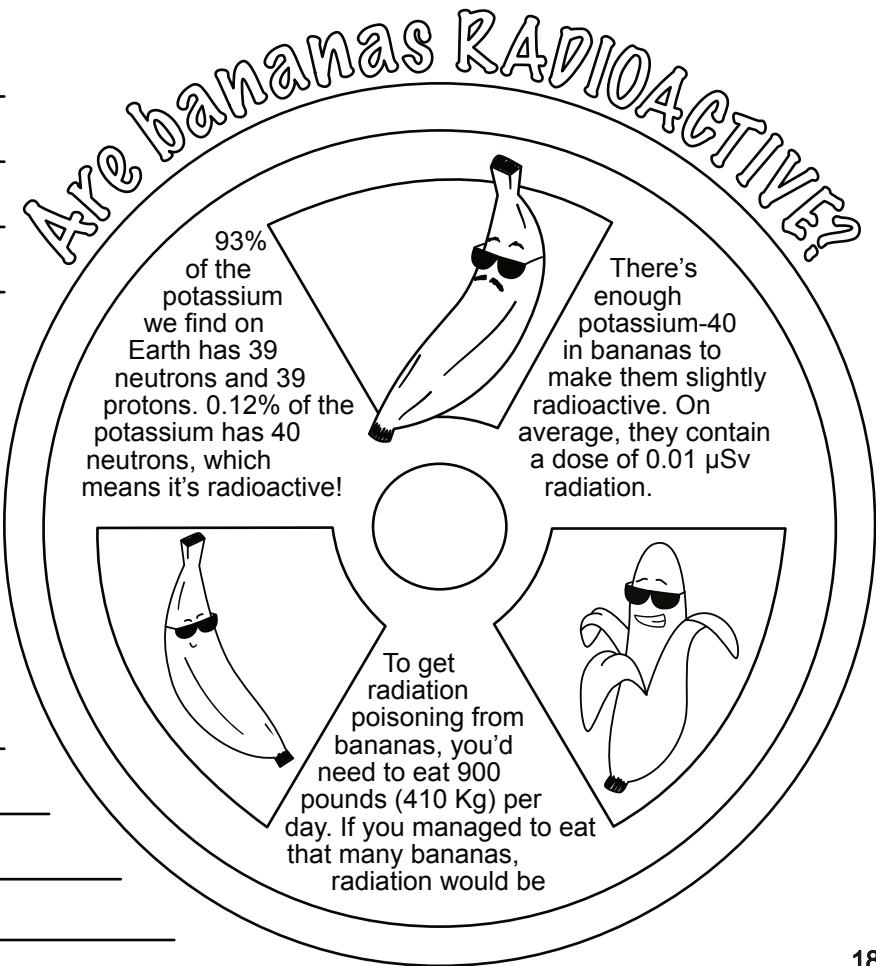
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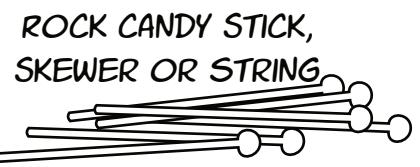
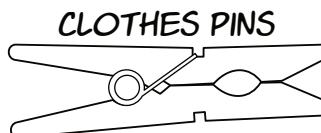
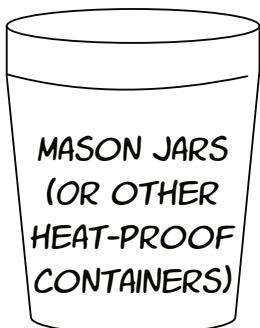
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# Hands-on Activity

## EDIBLE EXPERIMENTS - ROCK CANDY!

### MATERIALS:



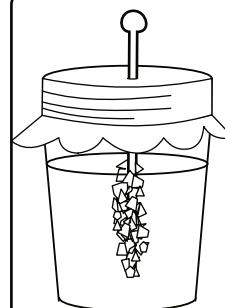
Don't have Kool-Aid?  
No problem! Use food  
coloring to color the crystals.

### ROCK CANDY

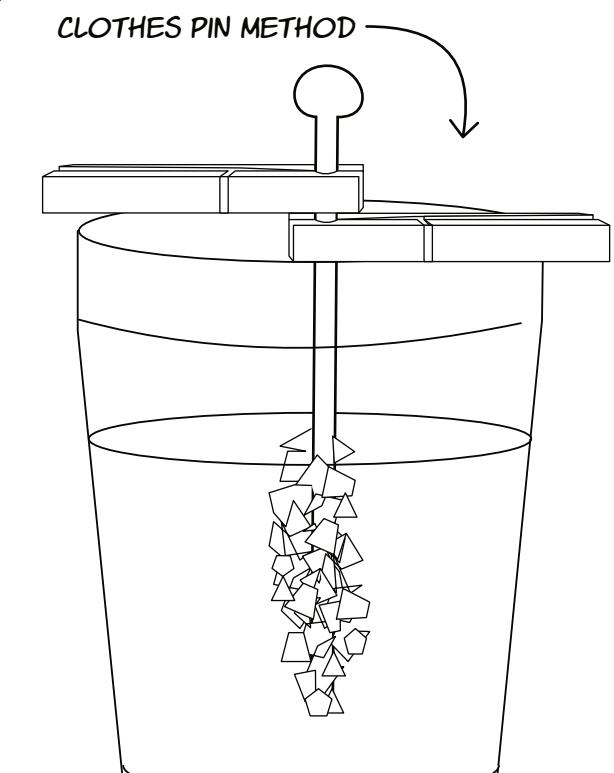
2 pint sized mason jars  
(Or other heat-proof containers)

1 cup water  
3 ½ cups sugar  
2 Kool-Aid packets

- ① Prepare the sticks or string by getting them wet and rolling them in dry sugar.
- ② Bring the water to a boil, then add the sugar and stir well. Reduce the heat and continue cooking until the solution turns clear and all the sugar dissolves.
- ③ Pour the powder from one Kool-Aid packet into each mason jar.
- ④ Very carefully, pour the sugar solution into the mason jars and stir well to make sure that the Kool-Aid mixes in.
- ⑤ Use the clothes pins or coffee filter to suspend the stick in the center of the jar.
- ⑥ Let the jars sit for 2 to 8 days. Crystal formation takes time, be patient!



COFFEE FILTER METHOD



CLOTHES PIN METHOD

## EDIBLE EXPERIMENTS CONTINUED ...

### YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

#### The science behind the treat:

When sugar dissolves into water it forms a MIXTURE - the sugar is still there and the water is still there. New molecules have NOT been formed. But the sugar molecules are attracted to the water and visa versa. When the water is HOT, it can hold more sugar than when it is cool. If you add as much sugar as the water can "carry" when it's hot, then as it cools the sugar will "come out" of the water and you'll see crystals form. If the sugar crystals grow slowly, you end up with larger crystals. If the sugar crystals grow quickly, they're smaller.

#### Troubleshooting tips:

What if there are no crystals on your stick? First, did you "seed" it by getting it wet and rolling it in dry sugar before-hand? This really helps! Second, sometimes the crystals take DAYS (up to 7 or 10) to form. If your first batch isn't working, you can try again and increase the amount of sugar (add an extra cup). The hardness of your water and measuring error can make a difference. If you don't see crystals after 14 days, probably best to try again with a fresh batch and add some extra sugar this time.

Do you think you could also make salt crystals using the same recipe? Why or why not?

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How did your crystals turn out? Did you see a difference between the size and shape of the crystals in different jars? How long did it take before your rock candy started growing?

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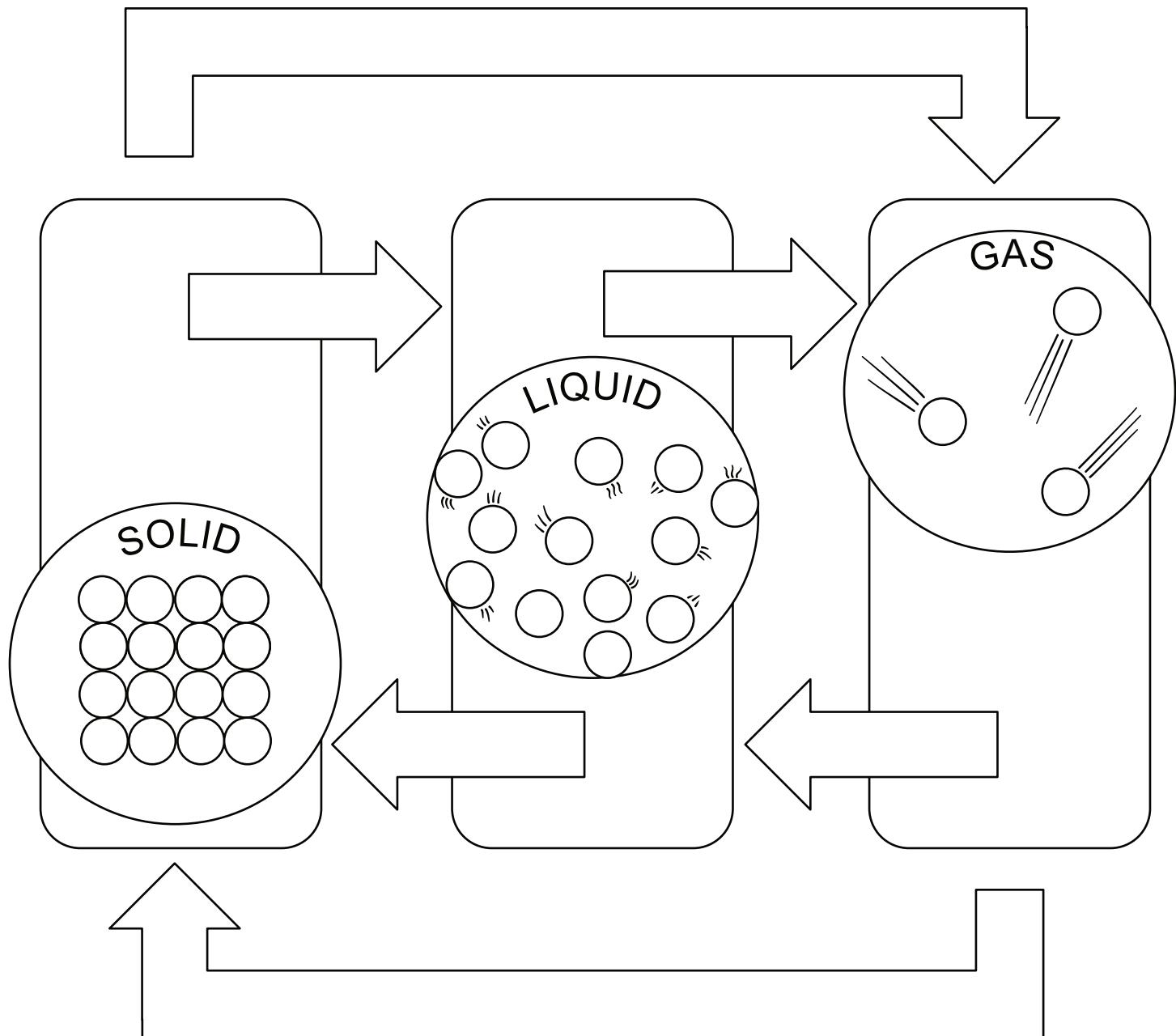
# CONSERVATION

## and states of matter

LABEL THE ARROWS WITH THESE WORDS:

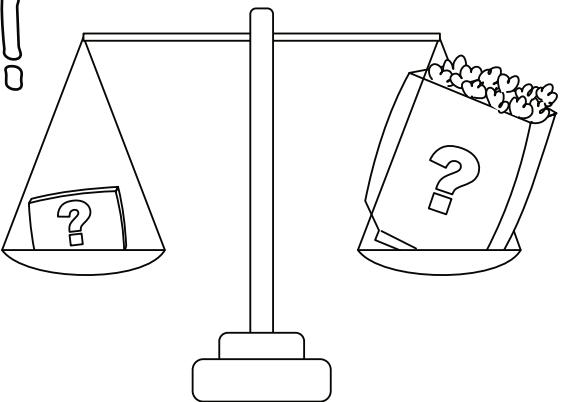
sublimation      freezing  
evaporation  
melting      condensation  
deposition

Solids keep their shape and volume. Liquids take the shape of their container, but the volume will stay the same. Gasses are super flexible! They will expand to fill whatever space they are in. Usually, solids are more dense than liquids, and liquids are more dense than gasses, but there is one compound where this rule doesn't hold! Solid water is less dense than liquid water. This is why ice floats.



# Popping Predictions!

WHICH WILL WEIGH MORE? A BAG OF POPCORN THAT IS POPPED OR UNPOPPED? WRITE YOUR PREDICTION HERE:



YOU CAN TRY THIS YOURSELF BY MAKING A SCALE! ATTACH TWO UNPOPPED BAGS OF POPCORN TO EACH SIDE OF A RULER AND BALANCE IT. THEN POP ONE OF THE BAGS AND REATTACH IT. DOES THE RULER TIP MORE TO ONE SIDE OR THE OTHER? WHICH SIDE IS HEAVIER?

Record the weights that Science Mom & Math Dad measure during class:

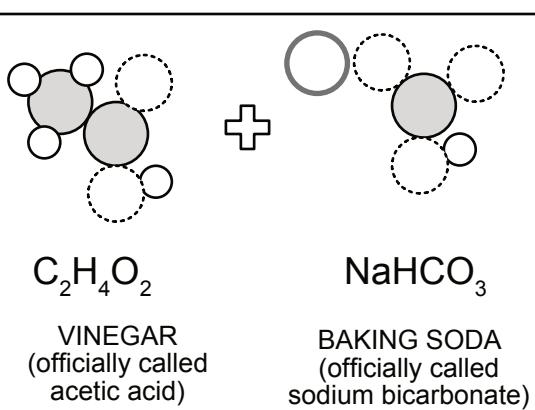
BEFORE POPPING:      AFTER POPPING:


## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

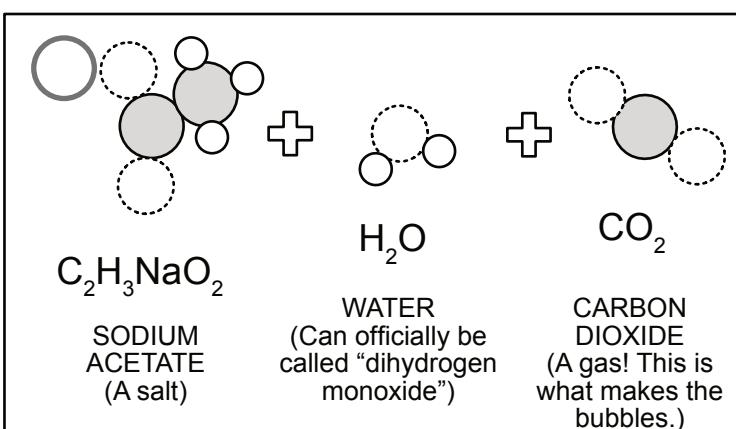
## Baking soda + vinegar

Count how many of each atom there are in each of the boxes. Record your observations in the charts below!



## REACTANTS

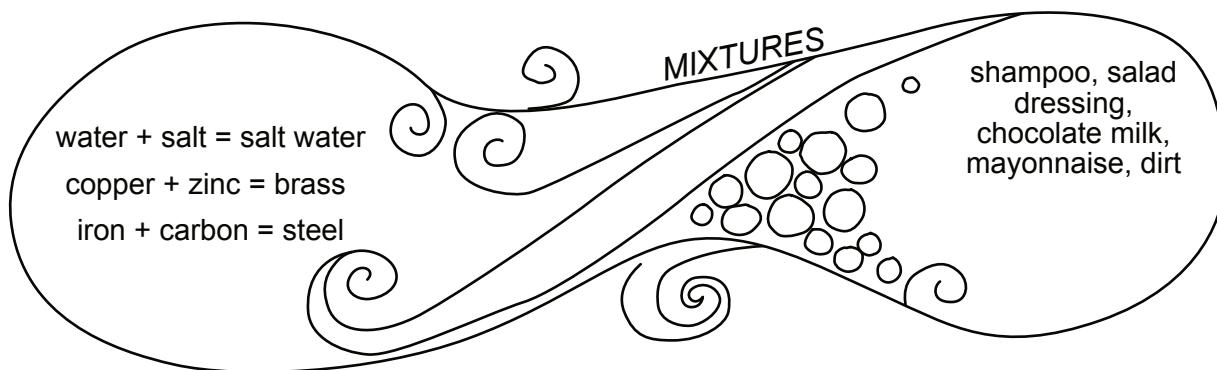
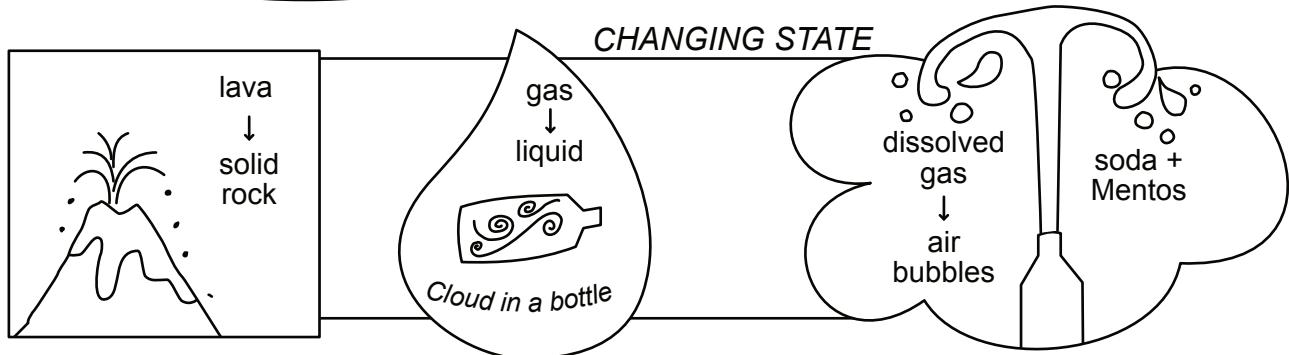
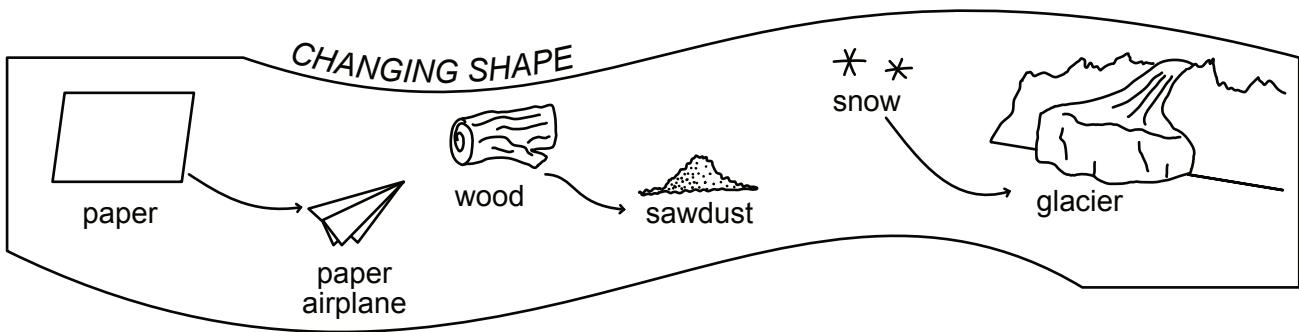
How many sodium atoms?	<input type="radio"/>	<input type="radio"/>
How many carbon atoms?	<input checked="" type="radio"/>	<input type="radio"/>
How many oxygen atoms?	<input type="radio"/>	<input type="radio"/>
How many hydrogen atoms?	<input type="radio"/>	<input type="radio"/>



## PRODUCTS

How many sodium atoms?	<input type="radio"/>	<input type="radio"/>
How many carbon atoms?	<input checked="" type="radio"/>	<input type="radio"/>
How many oxygen atoms?	<input type="radio"/>	<input type="radio"/>
How many hydrogen atoms?	<input type="radio"/>	<input type="radio"/>

# Physical Changes



Your notes:

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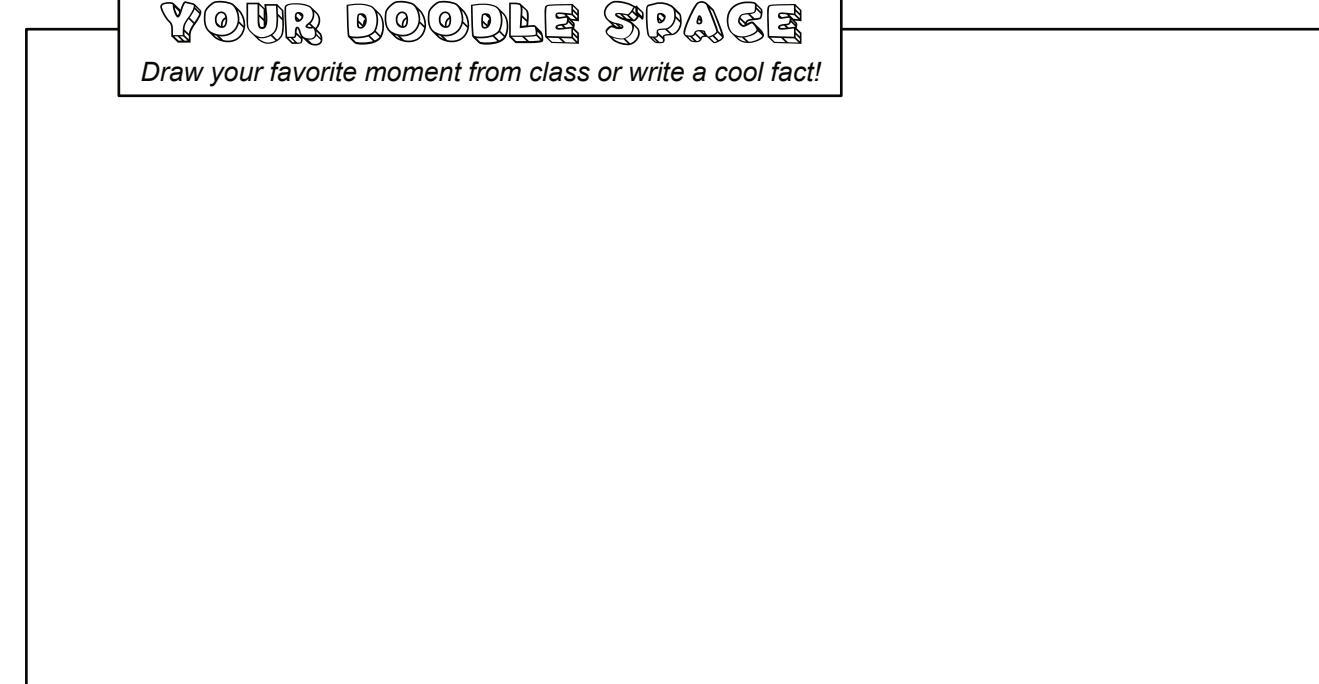
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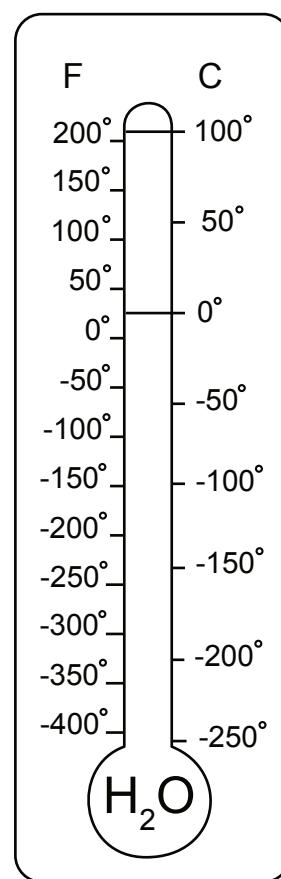
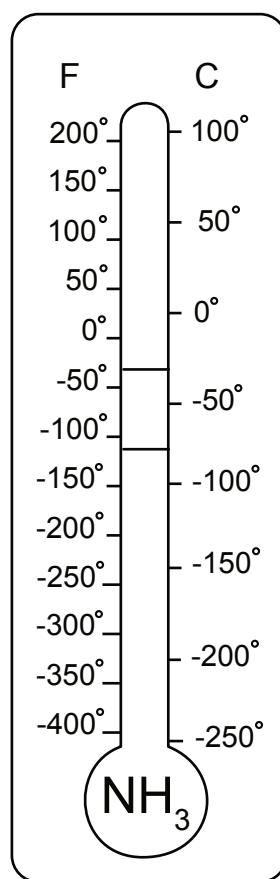
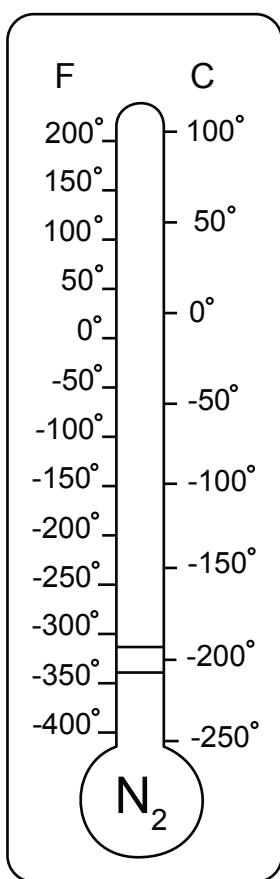
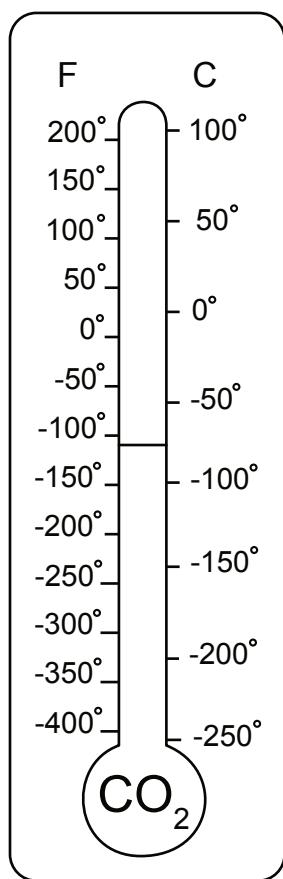
Liquids are rare and actually kind of weird

**YOUR DOODLE SPACE**

Draw your favorite moment from class or write a cool fact!



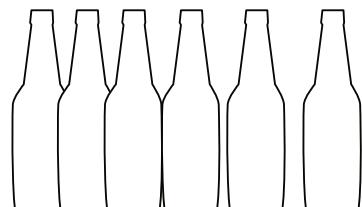
Color the thermometers to show when the substance will exist as a solid, liquid, or gas:  
(Hint:  $\text{CO}_2$  doesn't exist as a liquid on Earth unless you increase the pressure a lot!)



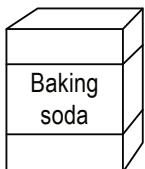
# Hands-on Activity

FIZZING FUN!

## MATERIALS:



6 BOTTLES OF SODA IN PLASTIC CONTAINERS WITH NARROW TOP



BAKING SODA



3 PACKAGES OF POP ROCKS CANDY



A MEASURING SPOON



A FUNNEL



6 BALLOONS



EYE PROTECTION

First, blow up each of the balloons once or twice to stretch them out, letting the air back out afterward.

*Record your observations here:*



1 Place a balloon over the top of the bottle so that it is firmly in place. Put on eye protection. Then shake the bottle and record what happens to the balloon.



2 Use the funnel to pour 2 TBL of baking soda in the balloon. Attach the balloon securely around the mouth of the soda bottle and then tip the balloon so that the baking soda pours from the balloon into the bottle.



3 Repeat the procedure with the Pop Rocks in a new balloon added to a new bottle of soda. Record your observations.



4 Mix baking soda and Pop Rocks together in a new balloon and put it over a new bottle of soda. Record your observations.

*With the last two bottles, experiment! You get to decide what to try:*



5



6

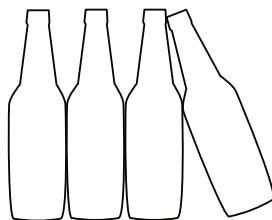
**QUESTION:** Why did the balloons expand? \_\_\_\_\_

Write your answer on another piece of paper!

# Hands-on Activity



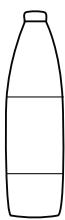
## MATERIALS:



4 EMPTY BOTTLES



6 ALKA-SELTZER TABLETS



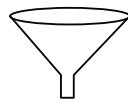
VINEGAR



WATER



OIL



A FUNNEL



FOOD COLORING

## QUESTIONS:

HOW DID THE TEMPERATURE OF THE WATER AFFECT THE LAVA LAMP? WHICH ONE WAS THE MOST DRAMATIC? WHICH LASTED THE LONGEST?

- 1 Pour the same amount of water into each of three of your bottles: hot water in one, room temperature water in the second, cold in the third. The level of the water should take up about  $\frac{1}{4}$  of the volume of the bottle.
- 2 Pour the same amount of vinegar into the fourth bottle.
- 3 Use your funnel to SLOWLY pour vegetable oil into all 4 bottles until they are mostly full. You may want to wait a few minutes for the oil and water to separate after this step.
- 4 Add 4 drops of food coloring to each bottle. Watch and observe how it interacts with the oil versus the water.
- 5 Break a seltzer tablet in half and add to each bottle, at the same time if possible. Watch and record your observations, especially how long the tablets took to react.
- 6 After all the bubbles have stopped, repeat the reaction. Record your observations and answer the questions.
- 7 With the final two bottles - YOU get to decide what to do! Which experiment will you try? What changes will you make?

HOW DID THE VINEGAR LAMP COMPARE TO THE WATER LAMPS?

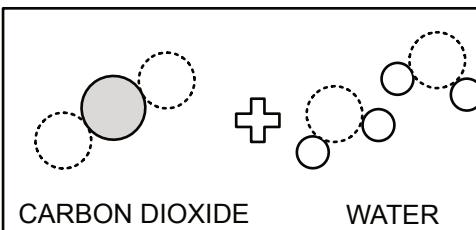
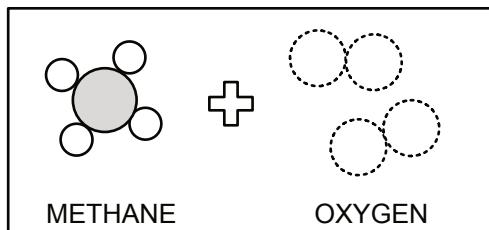
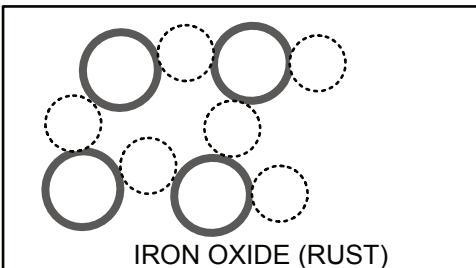
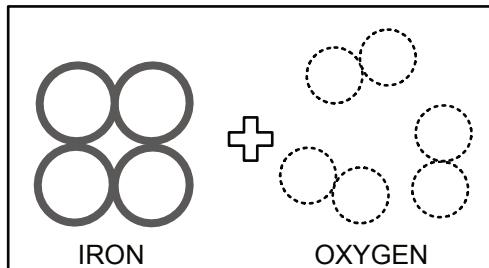
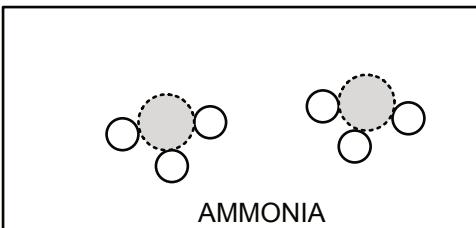
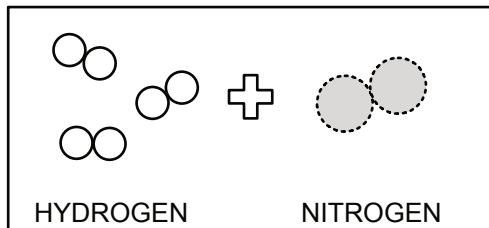
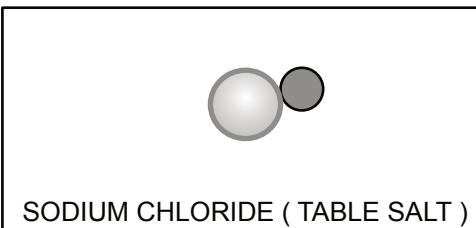
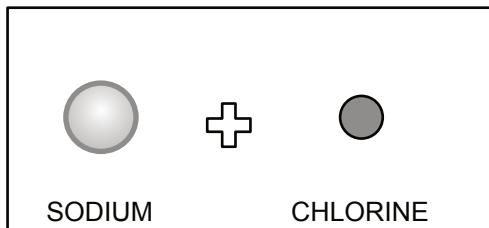
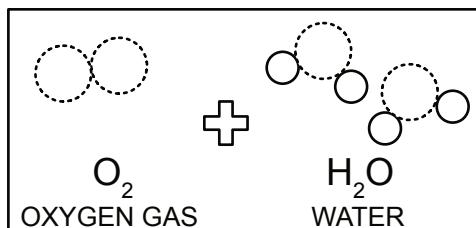
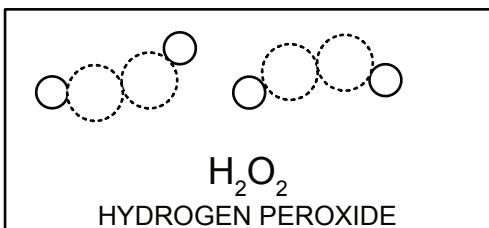
# Chemical Reactions

FILL IN THE BLANKS USING THESE WORDS:

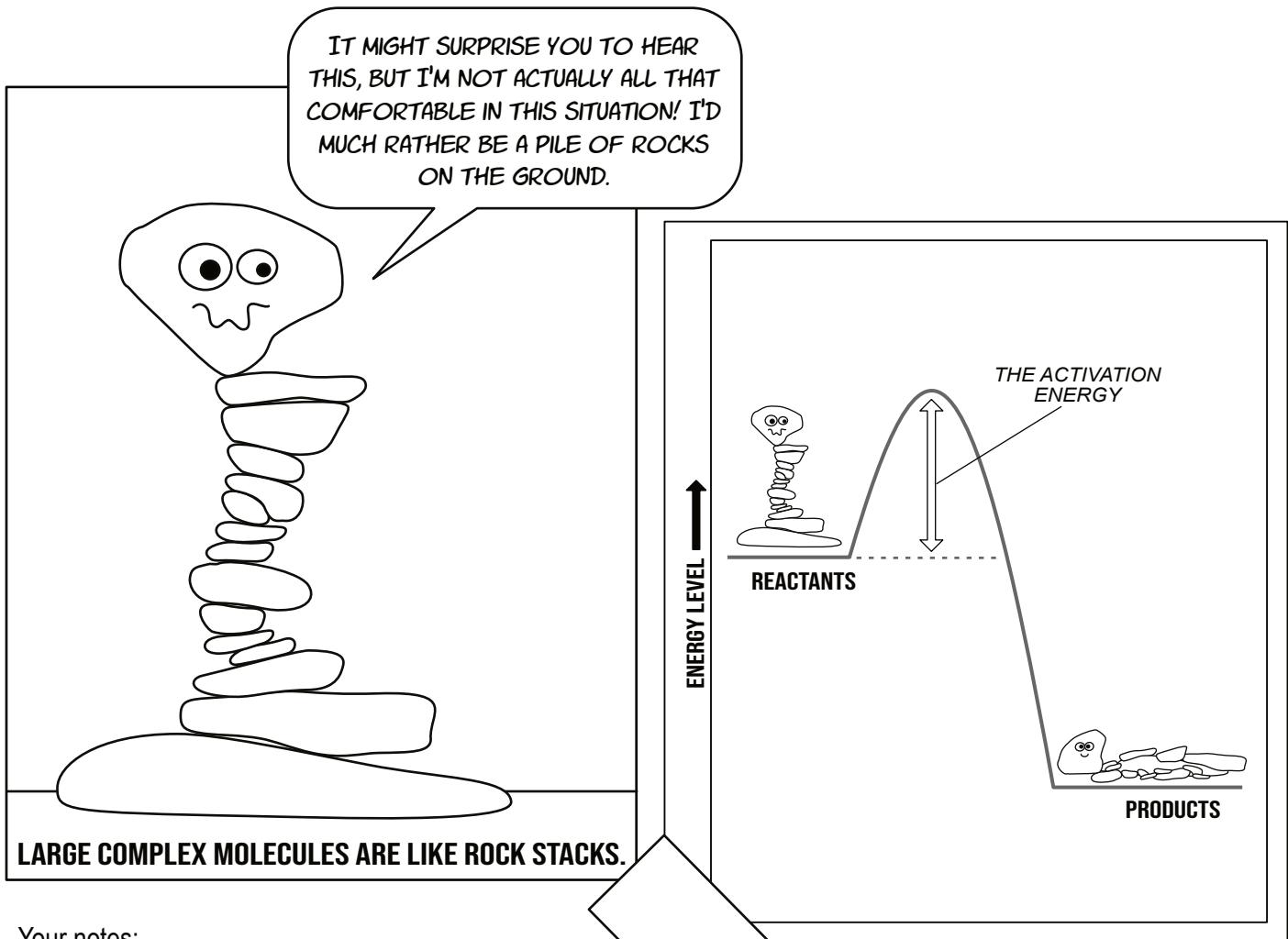
products      chemical      reactants  
physical      molecules

In a \_\_\_\_\_ reaction, new molecules are formed. The molecules that existed BEFORE the reaction are called the \_\_\_\_\_. The molecules that exist AFTER the reaction are called the \_\_\_\_\_.

In a \_\_\_\_\_ reaction, matter might change its shape or state, but no new \_\_\_\_\_ are formed.



# Why do things react?



Your notes:

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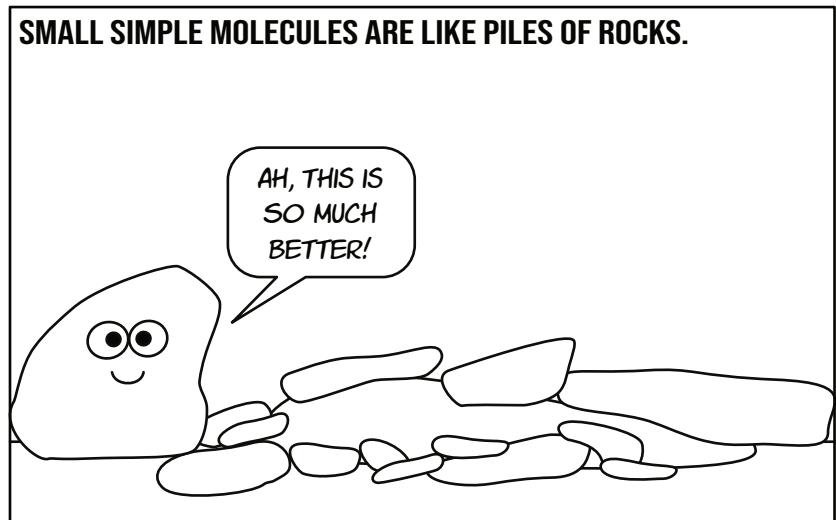
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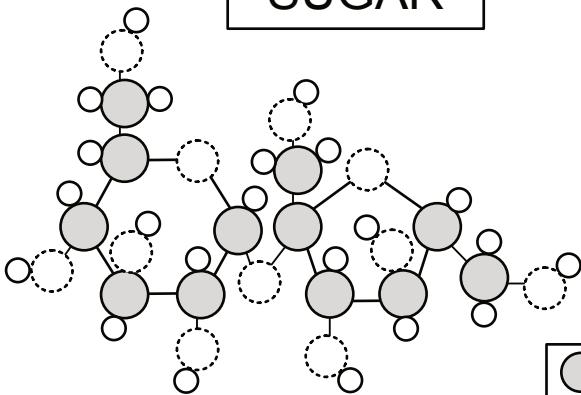
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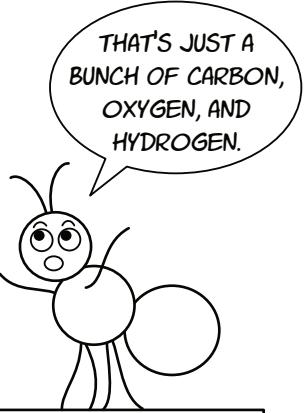
BEHOLD, THE  
GLORY OF A  
SUGAR MOLECULE!



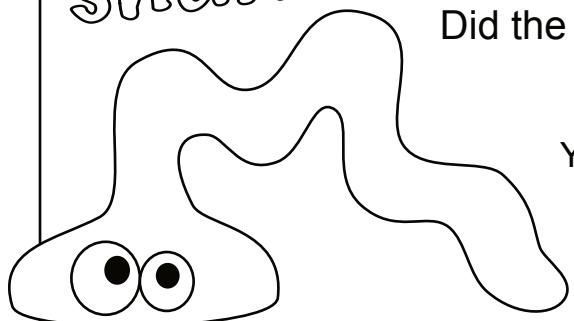
## SUGAR



CARBON  
OXYGEN  
HYDROGEN



## sugar snake



What did the sugar turn into? \_\_\_\_\_

Did the reaction create heat?

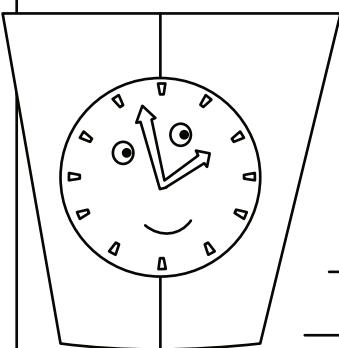
YES    NO    ?

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## iodine clock



What made the color change? \_\_\_\_\_

Did the reaction create heat?

YES    NO    ?

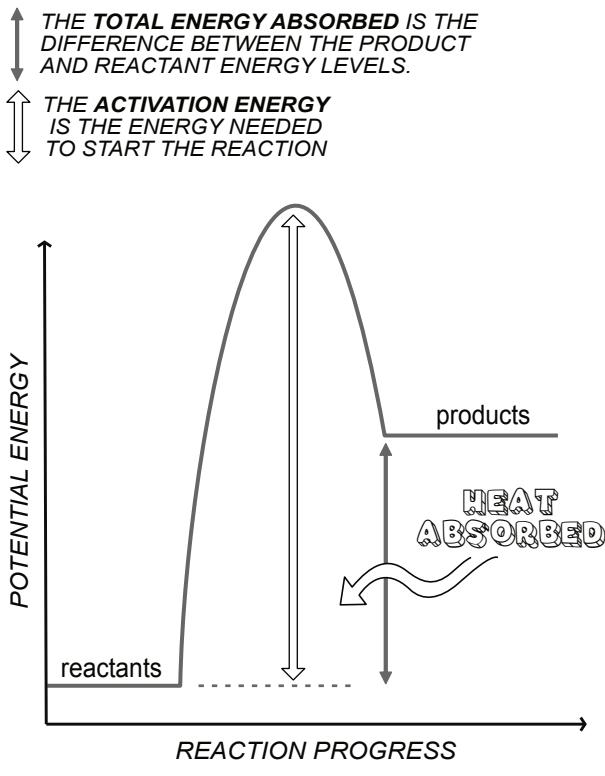
Your notes: \_\_\_\_\_

\_\_\_\_\_

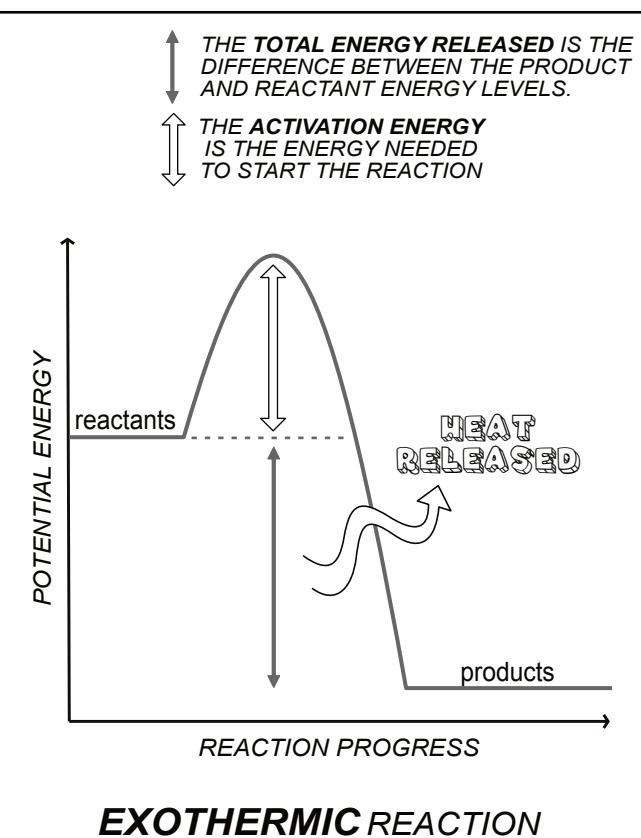
\_\_\_\_\_

\_\_\_\_\_

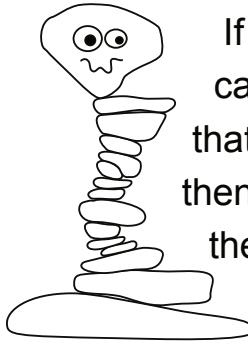
# How much energy?



## ENDOTHERMIC REACTION



## EXOTHERMIC REACTION



If complex molecules are like carefully balanced rock stacks that want to turn into rock heaps, then how do the stacks get built in the first place? It takes energy!

If energy is put INTO a \_\_\_\_\_ and the \_\_\_\_\_ have a **higher** energy state than the reactants, this is an \_\_\_\_\_ reaction. It **absorbs** \_\_\_\_\_. Evaporating water or dissolving ammonium chloride in water are examples of these “energy-requiring” reactions. When these reactions happen, the temperature \_\_\_\_\_!

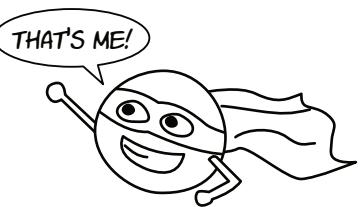
FILL IN THE BLANKS USING THESE WORDS:

rises	reaction	drops	energy
products	endothermic	determines	
reactants	exothermic	releases	

If a reaction PRODUCES energy, and the products have a **lower** energy state than the \_\_\_\_\_, this is an \_\_\_\_\_ reaction. It \_\_\_\_\_ energy. A burning match and rusting metal are examples of these “energy-producing” reactions. When these reactions happen, the temperature \_\_\_\_\_!



# CARBON THE BUILDING BLOCK OF LIFE!

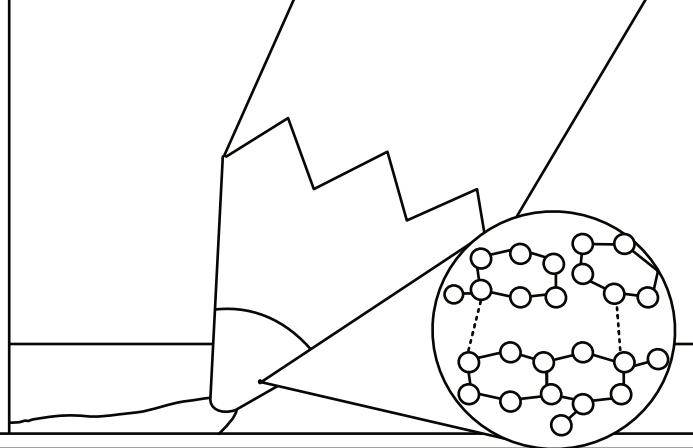


FILL IN THE BLANKS USING THESE WORDS:

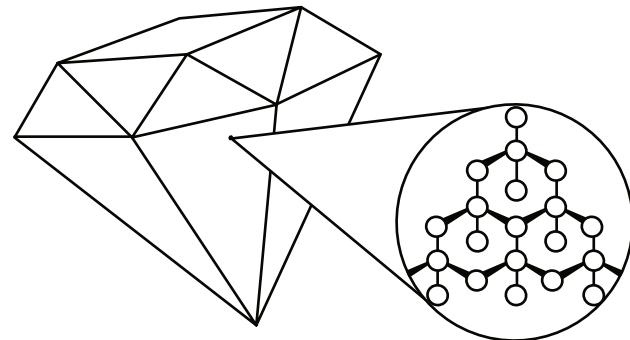
oxygen backbone electrons graphite  
four abundant unpaired carbon

Carbon is the second most \_\_\_\_\_ element in the human body. (The most abundant element is \_\_\_\_\_.) It's the \_\_\_\_\_ of all the molecules that cells are made of. Because it has four \_\_\_\_\_ that are \_\_\_\_\_, carbon likes to form \_\_\_\_\_ bonds with other atoms. Soft black pencil lead called \_\_\_\_\_ is made of carbon. The hard clear crystal of a diamond is made of \_\_\_\_\_ too.

## GRAPHITE



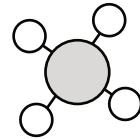
## DIAMOND



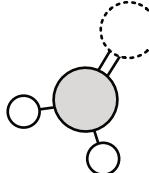
## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

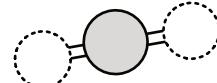
CARBON LIKES TO FORM 4 BONDS:



4 single bonds

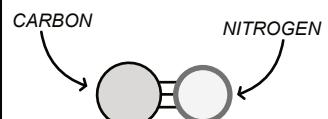


1 double & 2 single



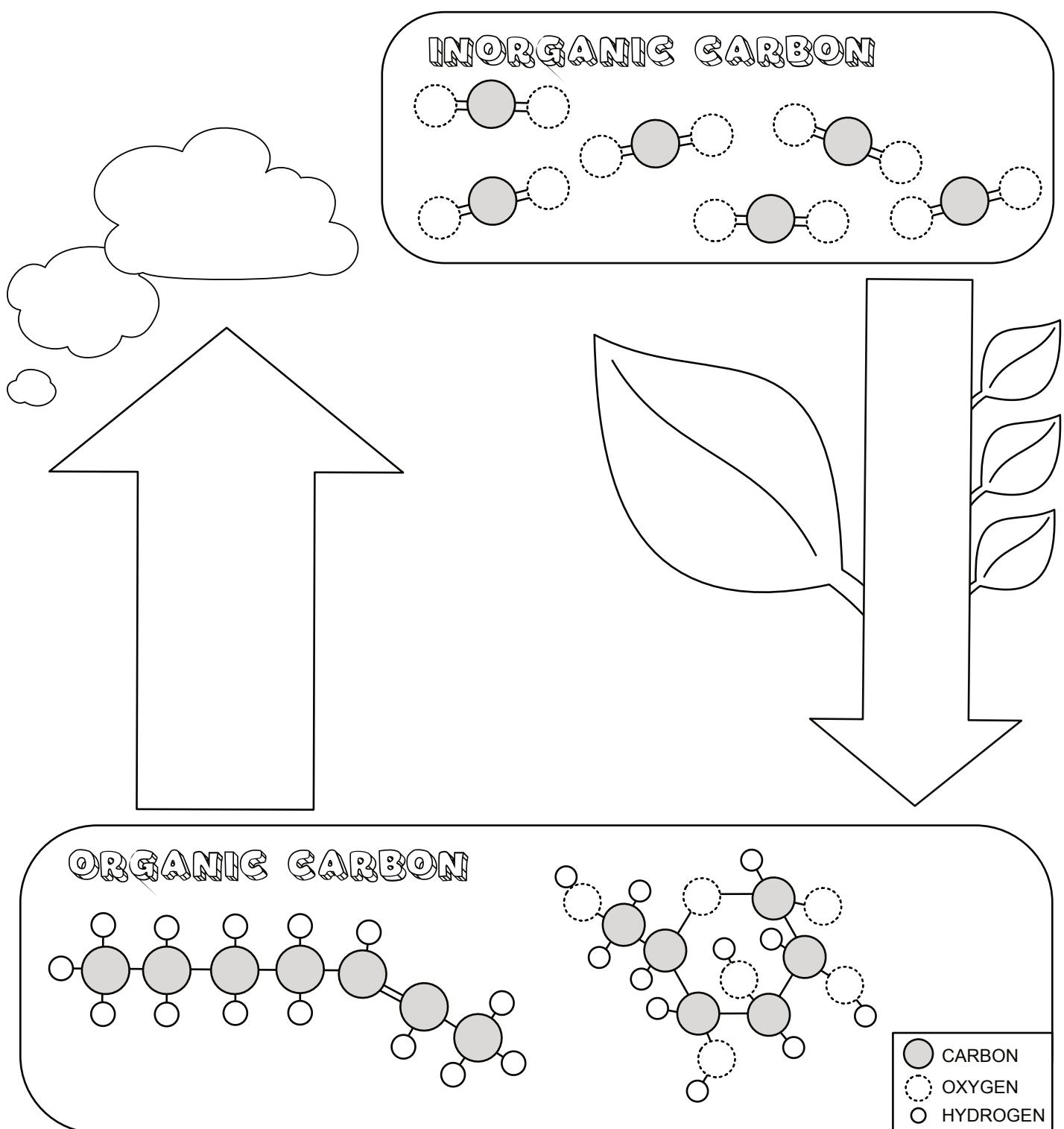
2 double bonds

But sometimes it only has three bonds:



LOOK OUT! THAT'S CYANIDE, WHICH IS VERY POISONOUS.

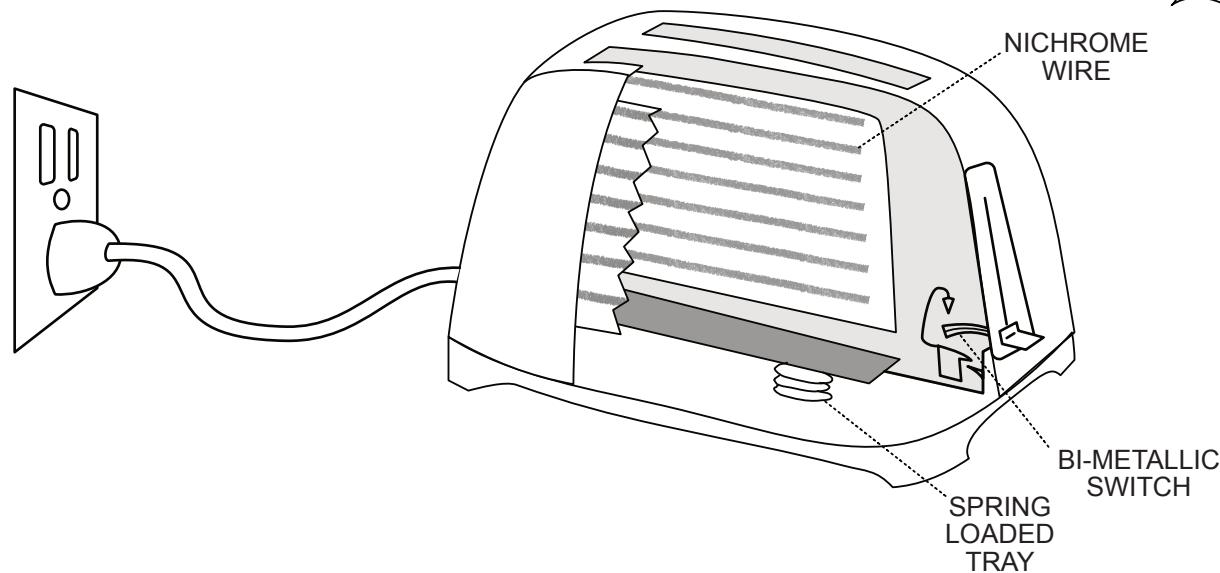
# The Carbon Cycle



Carbon really just has two forms: carbon dioxide (inorganic) and everything else (organic). When organic carbon is eaten or burned, energy is released and the carbon is converted into carbon dioxide. When algae or plants perform photosynthesis, carbon dioxide is converted back into an organic form. The same carbon atoms can travel in a huge circle from gas to organic matter to gas and back again. This is called the carbon cycle.

# HOW a TOASTER works

CHEMISTRY  
IN REAL  
LIFE!



FILL IN THE BLANKS USING THESE WORDS:

light	heat	glow	chemical	sugars
filaments	energy	reactions	proteins	

When the toaster is turned on, \_\_\_\_\_ passes from the outlet to the toaster in the form of electricity. The electric current passes through thin \_\_\_\_\_ that are uniformly spaced around the toaster slot. The filaments are specially designed to \_\_\_\_\_ up when electricity passes through them. They get so hot that they \_\_\_\_\_ bright red! The electrical energy has been converted into heat and \_\_\_\_\_. The steady supply of heat causes \_\_\_\_\_ to happen on the surface of the bread. The heat causes \_\_\_\_\_ and \_\_\_\_\_ to combine together, forming new molecules that change the color and flavor of the bread, turning it into delicious toast.

Your notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

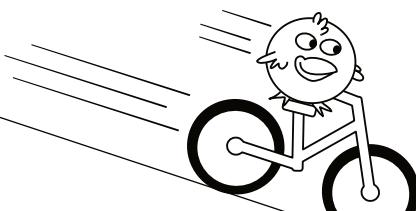
# ENERGY

YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

Chemical reactions can create electricity (this is how batteries work!), light and heat, sound (think fireworks), and movement too. The LAW OF CONSERVATION tells us that energy cannot be created or destroyed, instead it's transferred from one form to another.

**MOVEMENT** IF IT'S MOVING, THAT'S KINETIC ENERGY.  
IF IT COULD MOVE LATER, THAT'S POTENTIAL ENERGY.



**ELECTRICAL** THE FLOW OF ELECTRONS!



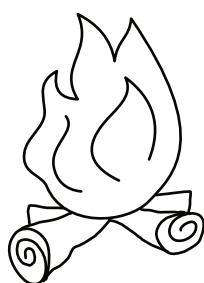
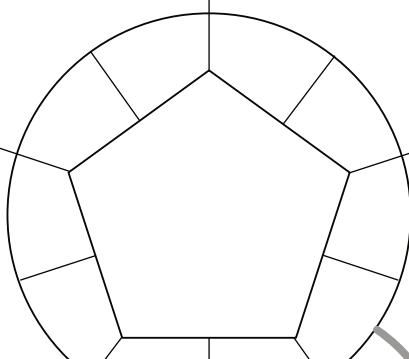
LIGHT and  
ELECTROMAGNETIC  
RADIATION

MADE OF PHOTONS! LITTLE PARTICLES  
OF ENERGY THAT MOVE SUPER FAST.



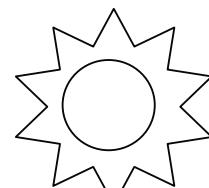
SOUND

VIBRATIONS! MUST  
TRAVEL THROUGH  
MATTER. CANNOT  
TRAVEL THROUGH  
EMPTY SPACE.



THERMAL (HEAT)

WHEN MOLECULES MOVE FASTER  
THEY HAVE MORE ENERGY



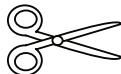
# Hands-on Activity

## LEMON BATTERY

### MATERIALS:



LEMONS (OR POTATOES, OR VINEGAR IN AN ICE CUBE TRAY)



SCISSORS OR KNIFE TO MAKE HOLES IN THE LEMON OR POTATO



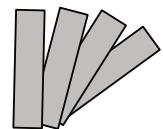
ALLIGATOR CLIPS OR COPPER WIRE



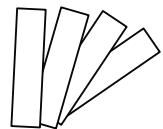
LED DIODE



ONE COPPER PENNY PER LEMON OR ONE PIECE OF COPPER FROM A LEMON BATTERY SCIENCE KIT



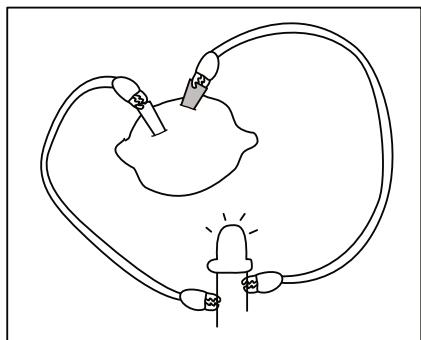
ONE GALVANIZED NAIL PER LEMON OR ONE PIECE OF ZINC FROM A LEMON BATTERY SCIENCE KIT



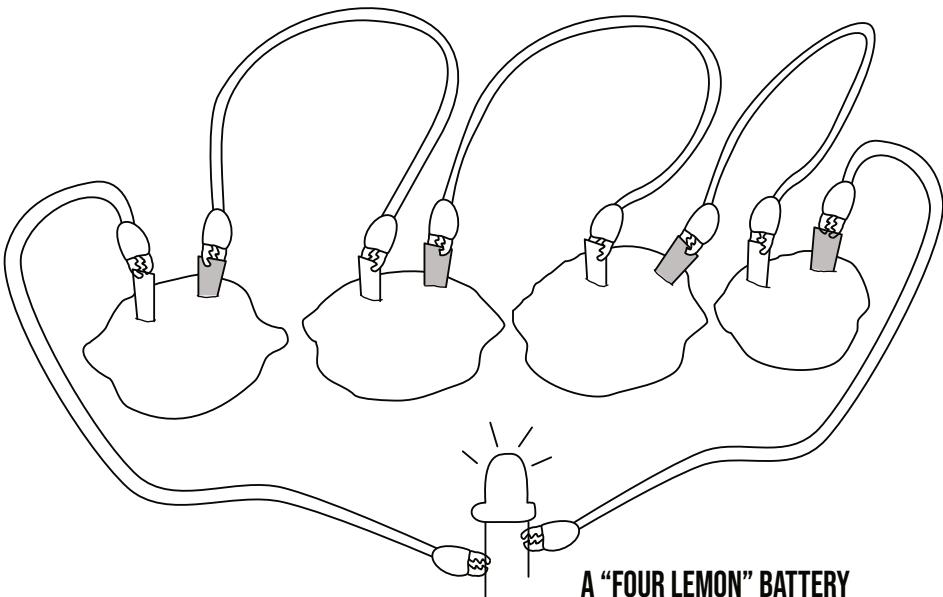
### INSTRUCTIONS:

Prepare two lemons or more (The more you have the stronger your battery is. For getting an LED light to light up, we recommend at least two. Potatoes or vinegar in an ice cube tray can be used instead of lemons.)

- 1 Squeeze and roll the lemons for several minutes. The individual segments of the lemon need to break up enough that a current can run from one end to the other.
- 2 Make two slits on either side of the lemon and insert the penny or copper into one slit and the galvanized nail or zinc into the other. Make sure that enough of the metal is sticking out of the lemon that you'll be able to attach the alligator clips or wire. Repeat with the remaining lemons.
- 3 To build the circuit between the lemons, attach one alligator clip around the zinc from the first lemon and connect it to the copper in the next lemon. If using multiple lemons, continue this pattern with each of the lemons.



A "SINGLE LEMON" BATTERY



A "FOUR LEMON" BATTERY

CONTINUED ON NEXT PAGE:

# LEMON BATTERY CONTINUED

For electricity to flow through the wires, the circuit needs to form a loop. If you connect the copper in the first lemon to the zinc in the last lemon, then you will have an electric current flowing through the wires - but this current is so small you won't be able to feel it or see it.

- 4 Attach the ends to the LED light or clock you are trying to power. Touch the wire attached to the first penny or copper to the **long leg** of your LED light. Simultaneously touch the wire attached to the nail of the last lemon to the short leg of the LED light. If you need help differentiating the long leg from the short look for a "flat spot" on the bottom edge of light. That is where you will find the short leg.

If your first attempt doesn't work, try adjusting the number of lemons or vinegar cells you are using.

What happens if you try powering the light with 1 lemon versus 2?

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What would happen if you had attached the copper wire from one penny to another penny and one nail to another nail instead of following the coin-nail-coin-nail pattern?

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What else do you think would serve as a good materials for this experiment? Are there any other conductors (the alligator clips or copper wire) or electron sources (copper and zinc) that you could use?

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Sometimes it can be tricky to get a lemon battery to work. Did you run into any trouble with your experiment? If so, what did you try?

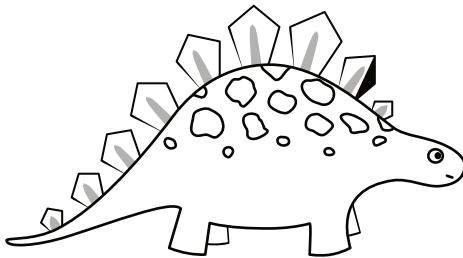
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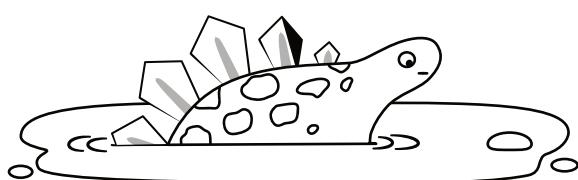
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# WHAT'S A FOSSIL FUEL?

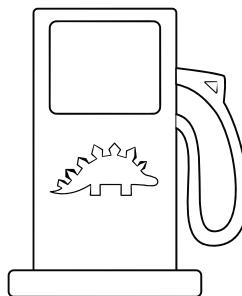
## STATES OF DINO-MATTER



SOLID



LIQUID



GAS

During the Carboniferous period, fungi hadn't yet developed the ability to break down cellulose, the main ingredient of wood. Without these decomposers, an enormous amount of plant material accumulated.

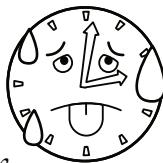


You've probably seen jokes that credit dinosaurs as the source of gasoline, but this isn't quite accurate. Fossil fuels like petroleum, oil, and natural gas come from organic matter that lived during the Carboniferous period, which occurred several million years before the first dinosaurs walked on Earth. The carbon in gasoline once existed in plants, algae, invertebrates, and fish, but not dinosaurs.

*How long will fossil fuels last?*

*The answer is 50 years or forever, depending on who you ask.*

*On this thing more people agree: the more fuel we burn, the warmer the planet becomes.*



## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

Your notes:

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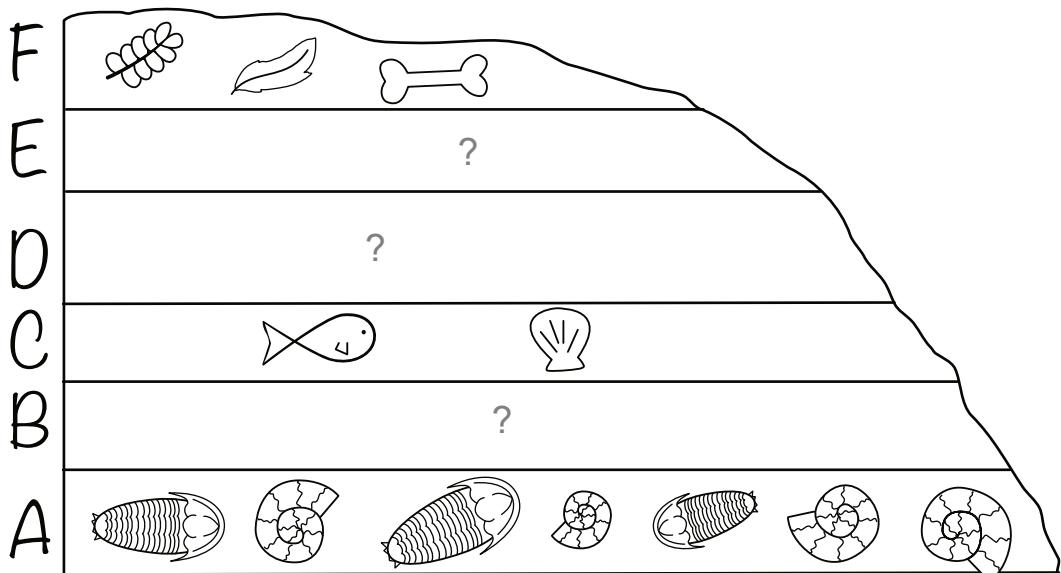
**KEY**

Fish		Ammonite	
Shell		Dinosaur	
Plant		Trilobite	
Bird		Mammal	

# ROCK LAYERS

You have joined a team of stratigraphers and paleontologists who are studying the layers of rock and fossils of this site!

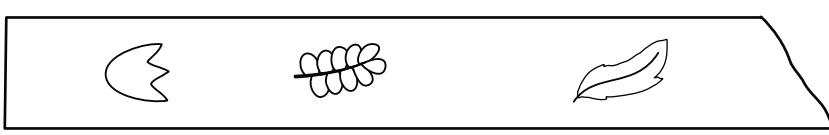
Your job is to complete the timeline and rock layer chart by studying the information available. What do the fossils in each layer tell you about each period of time? According to the timeline, what fossils would you find in each missing layer?



Cut out the rock layers and timeline boxes below. Can you paste them over the correct question marks?



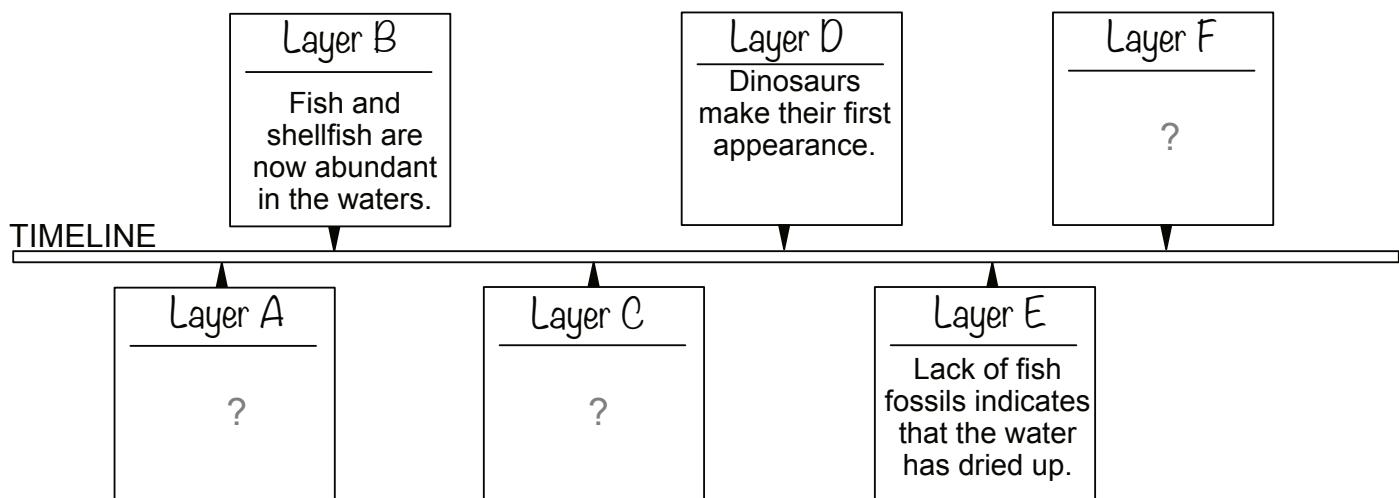
Ammonites and trilobites are abundant in the shallow waters.



Mammals and birds live in the area.

Ammonites and trilobites have gone extinct.

# ROCK LAYERS continued...



Which is the oldest layer? \_\_\_\_\_

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What layers indicate that water was present? What evidence do you have to support this?

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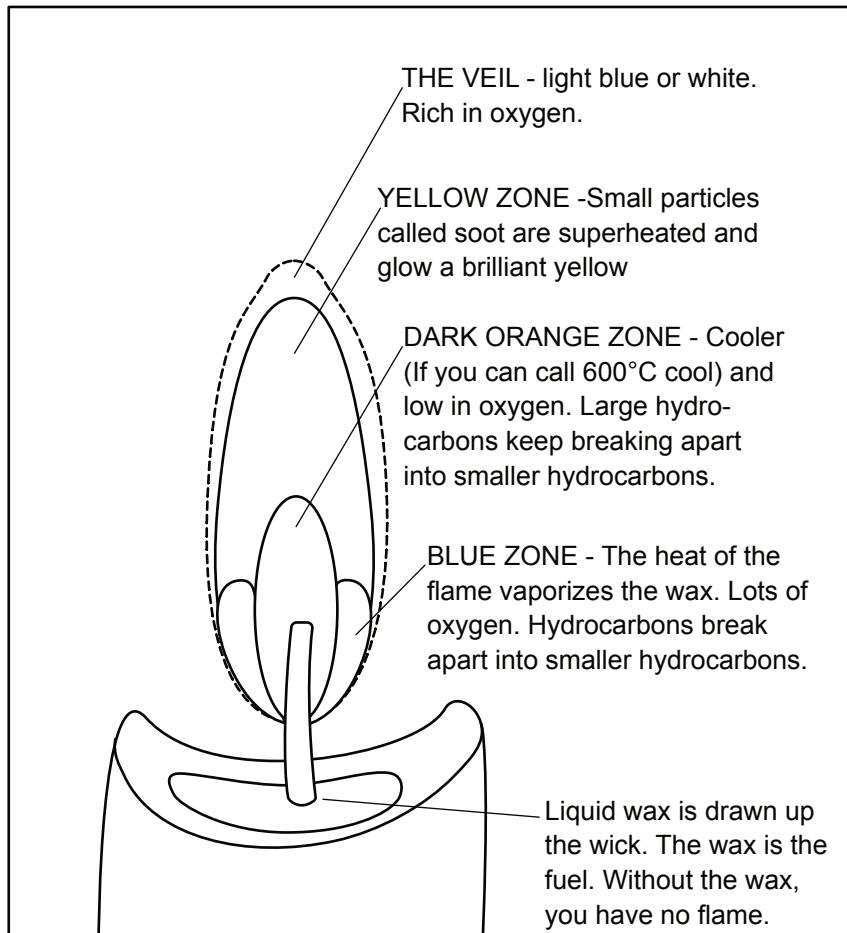
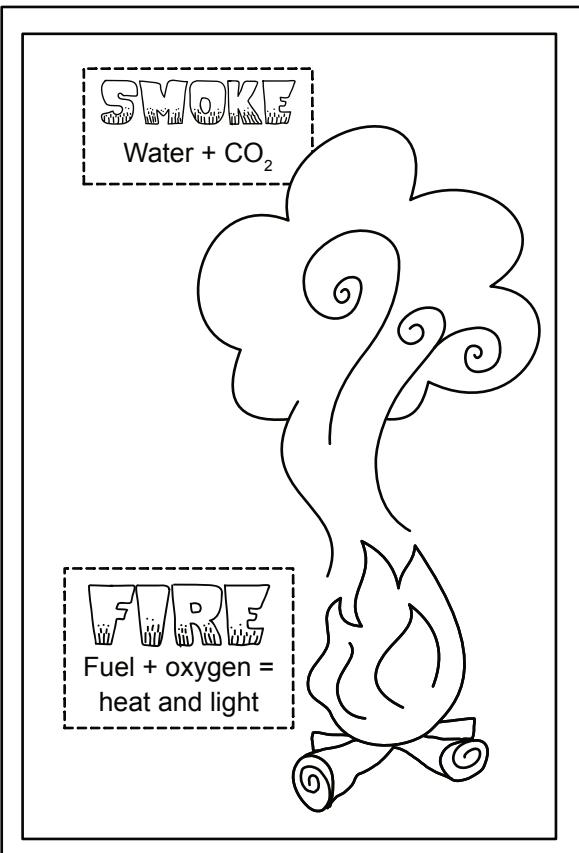
Why weren't mammal bones found in layer B?

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Cut out the rock layers and timeline boxes on the other side of this paper and see if you can match them over the correct question marks!

# What is FIRE? All about combustion



FILL IN THE BLANKS USING THESE WORDS:

oxygen      combustion      water  
hydrocarbons      carbon

Fire is the result of a chemical reaction called \_\_\_\_\_. Three things must be present for fire: \_\_\_\_\_, fuel, and heat. When a fuel like wood meets oxygen, the \_\_\_\_\_ in the wood combine with oxygen to form \_\_\_\_\_ dioxide and \_\_\_\_\_. Water is one of the main ingredients of smoke. It is also the main ingredient of clouds. If a forest fire gets large enough, it can produce a pyrocumulus cloud: a cloud so big that it makes rain and lightning.

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

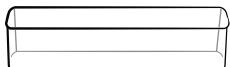
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# Optional Bonus Activity

This is an engineering activity from our 2020 class.  
These notes and a video are included as a bonus/optional resource.

## BUILD A LEVEE

### MATERIALS:



TUPPERWARE OR GLASS CONTAINER



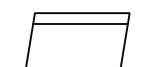
WATER



FINE-GRAINED BUILDING MATERIAL (SUCH AS 1 CUP FLOUR MIXED WITH 1 TBSP COCOA POWDER)



DUCT TAPE OR ELECTRICAL TAPE



PLASTIC BAG



COARSE-GRAINED BUILDING MATERIAL SUCH AS NUTS, DRIED BEANS, OR DRIED FRUIT.



(OPTIONAL) SMALL TOYS TO REPRESENT THE TOWN

### INSTRUCTIONS:

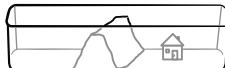
1 First, arrange a small pile of "large particle size" material in the center of your Tupperware container. Slowly pour in 1/2 cup of water on one side of your levee and observe what happens. Does the water stay on one side of the levee or does it leak through to the other side?



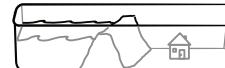
2 Next, prepare your "small particle size" material. If using flour and cocoa powder, mix one cup of flour with 1 tbsp of cocoa powder and 1/2 cup hot water. Add the water slowly and mix well, kneading it into a stiff dough.



3 Form half of your dough into a levee and arrange some small objects on the other side to represent the town. If desired, you can press some of the large particle-size material into the sides of the levee to reinforce it.



4 Slowly pour water on the side of the Tupperware that is opposite of your town and observe. It should be keeping all the flood waters away from the town!



5 Make your levee fail. You could create a small hole with a toothpick, or keep adding water until the water pours over the top.

6 Dry out your container and use the other half of the dough to make a new levee!

### A FEW FACTS ABOUT LEVEES

A levee is more than a big pile of dirt, although at first glance that's pretty much what it looks like!

For a levee to work well, it has to be made out of the right material and have the correct slope. In general, finer materials such as clay and silt will do a better job of holding back water than coarse materials like sand, gravel, or rocks.

There are two main ways that levees can fail: one is by being overtopped (the water flows over the top of the levee and then begins to erode it). The other is by breaching (basically a hole forms in the levee and then a big portion of it breaks). Before a levee breaches, there will often be a "sand boil." Water will begin flowing through a weaker spot in the levee and out the other side.

If you live in the United States, you might think that cities along the Mississippi River are the only ones that have levees. But there are levees in all 50 states and more than 40% of the US population lives in a county with at least one levee. When they work, we hardly notice them. When they fail, the flooding can be catastrophic.

## BUILD A LEVEE CONTINUED...

Would your flour levee hold the water back indefinitely/forever or would the water eventually leak through?  
What could you do to make this levee stronger?

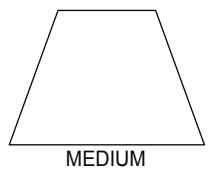
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Which slope would make the strongest levee?  
Super steep, medium, or broad? Explain why:



SUPER STEEP



MEDIUM



BROAD / GENTLE SLOPE

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Pretend you are in charge of building two real-life levees, what are some different considerations to take into account for designing an urban vs rural levee? Would you need to do anything differently for the urban levee (protects a city area with stores, houses, and other buildings) versus an agricultural levee (protects fields)?

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What are some other natural earth process that affect humans? What kind of designs and solutions have we come up with to cope with them?

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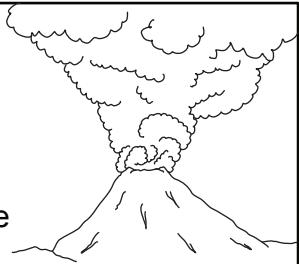
# The chemistry of LAVA

Oxygen and silicon are the most abundant elements in lava.

They combine to form silica, and the amount of silica determines what type of lava you have!

Lots of silica produces pale rocks like rhyolite. When melted, this type of lava is super thick and tends to be explosive, like the eruption of Mount St Helens.

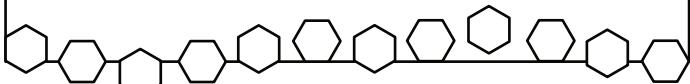
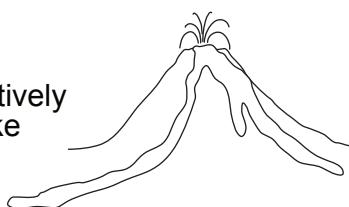
Low silica makes dark basalt rock and is relatively runny when melted, like the slowly oozing pahoehoe lava in Hawai'i.



HIGH SILICA

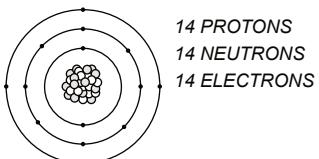
VS

LOW SILICA



## Silicon

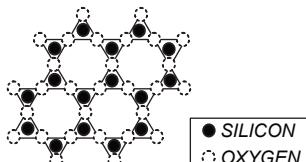
Element



The second most abundant element on Earth after oxygen. Very rarely found in pure form, it loves to bond with oxygen. Widely used in electronics, especially computer chips.

## Silica

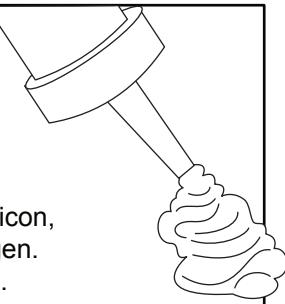
Compound



A compound of silicon and oxygen, most often a crystal of  $\text{SiO}_2$ . Quartz is silica. The mineral is also found in sand, glass, and many other rocks.

## Silicone

Compound



A polymer (long chain) of silicon, oxygen, carbon, and hydrogen. Can be a solid, liquid, or gel.

## How hot is lava?

It all depends on the type of rock and what minerals it contains. Liquid rock (usually called lava) can be as cool as 700 °C and as hot as 1,200 °C. That's 1300 - 2200° Fahrenheit!

Your notes: \_\_\_\_\_

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## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

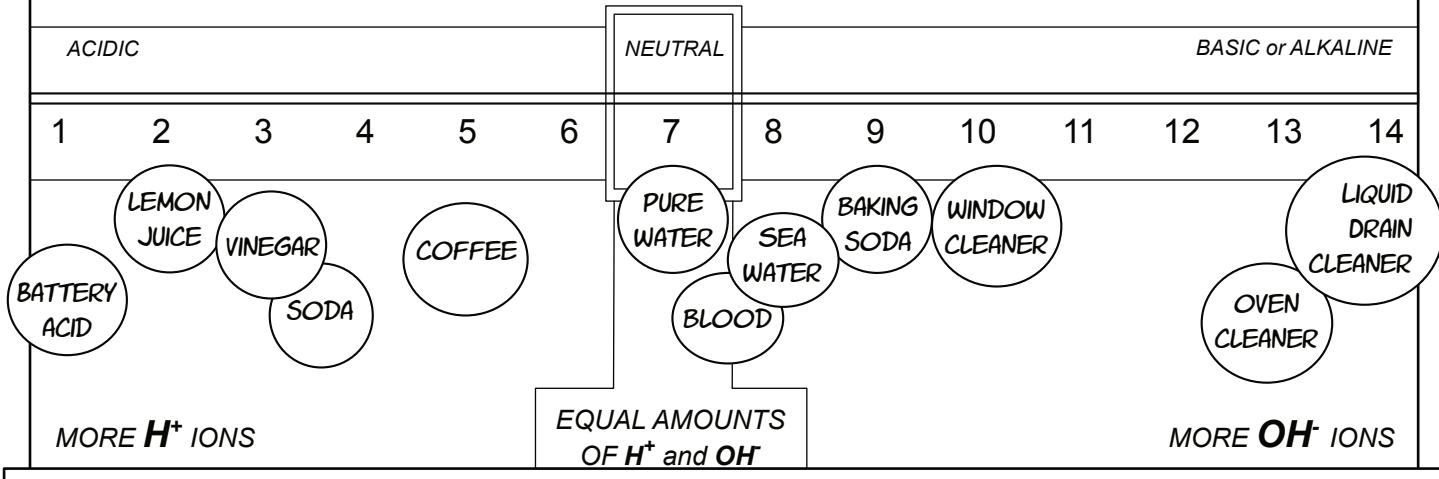
# ACIDS & BASES

FILL IN THE BLANKS USING THESE WORDS. (One word will be left over):

basic  
pure  
acidic  
 $H^+$  molecules  
hydrogen  
water

pH stands for "potential of \_\_\_\_\_" or "power of hydrogen." It is a scale used to measure how \_\_\_\_\_ or basic a solution is. At room temperature, \_\_\_\_\_ is neutral with a pH of 7. At neutral pH, the amount of hydrogen ions ( $H^+$ ) equals the number of hydroxide ions ( $OH^-$ ). In an acidic solution, there are more \_\_\_\_\_ ions than  $OH^-$  ions. In a \_\_\_\_\_ solution, there are more \_\_\_\_\_ ions than  $H^+$  ions.

## The pH scale



## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

Your notes:

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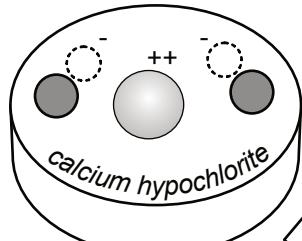
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# Why do we CHLORINATE SWIMMING POOLS?

HYPOCHLORITE AND HYPOCHLOROUS ACID ARE THE DISINFECTANTS THAT ELIMINATE HARMFUL BACTERIA, ALGAE, AND FUNGAL DISEASES FROM A SWIMMING POOL.



CARBON
OXYGEN
HYDROGEN
CHLORINE
NITROGEN
CALCIUM

The chemistry of swimming pools is fascinating! To keep a pool safe for people but inhospitable to bacteria and algae, the pH, salts, water hardness, and chlorine levels have to be just right.

As UV light shines down, water evaporates, and people swim in the water, chemical reactions happen and everything changes! You don't need a degree in chemistry to keep your pool healthy – but you do need to check its chemicals frequently to maintain the right balance!



NEVER PEE IN A POOL! URINE CONTAINS URIC ACID. THE NITROGEN IN URIC ACID REACTS WITH CHLORINE TO FORM TRICHLORAMINE AND CYANOGEN CHLORIDE, BOTH OF WHICH ARE POISONOUS AND HARMFUL TO YOUR HEALTH.

Your notes:

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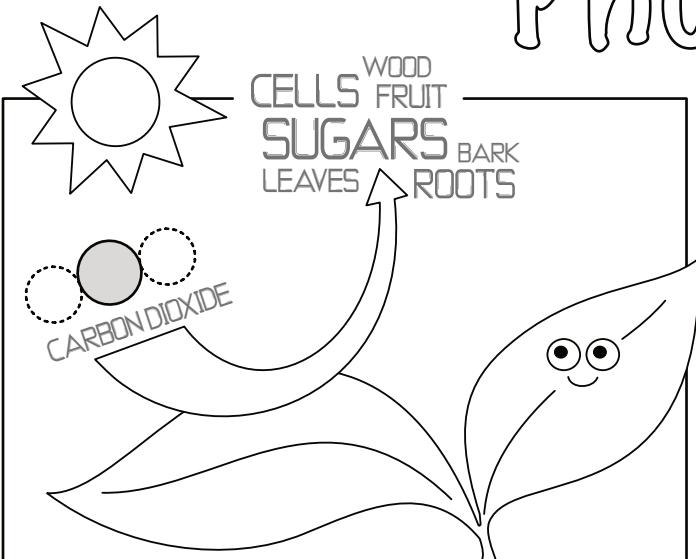
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## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

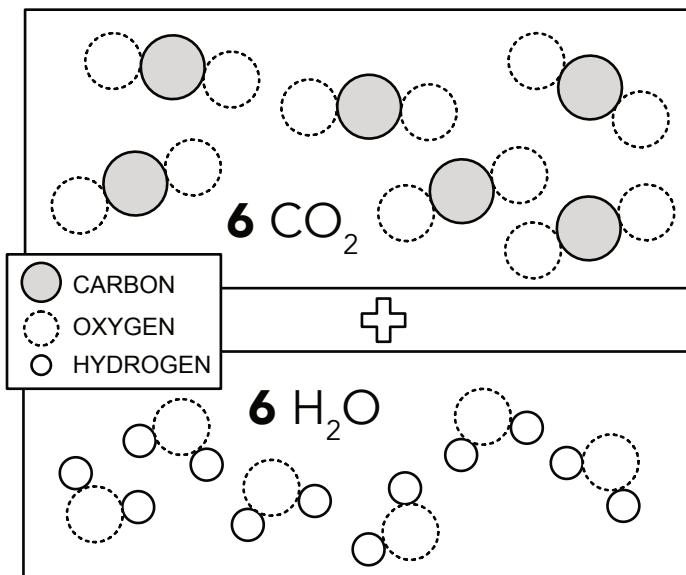
# Photosynthesis



## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

THE CHEMICAL EQUATION FOR PHOTOSYNTHESIS



A lot of people think that plants grow out of soil - that atoms in the soil becomes the plant. Actually, most of the plant comes from AIR. More than 98% of the plant's mass comes from carbon dioxide and water.

Your notes: \_\_\_\_\_

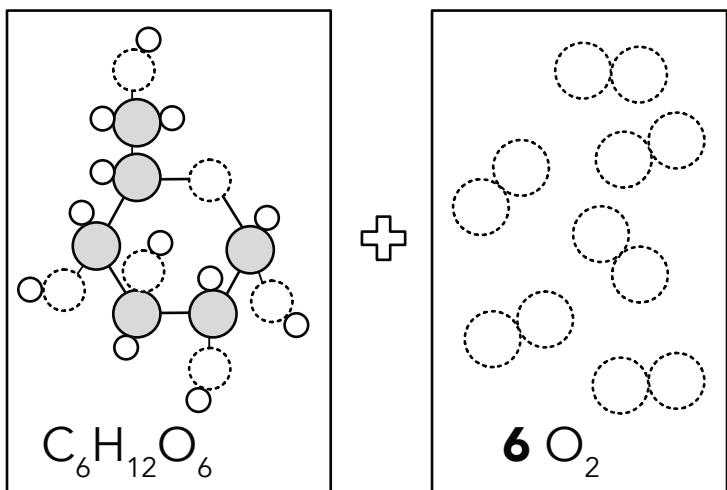
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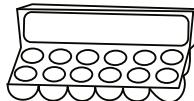
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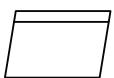
# Hands-on Activity

## FRANKENSEEDS!

### MATERIALS:



EGG CARTON



ZIPLOCK BAGS



SCISSORS OR KNIFE TO CUT  
THE EGG CARTON



PAPER TOWELS



AT LEAST 6 TYPES  
OF SEEDS FROM  
YOUR KITCHEN



EMPTY BREAD OR  
PRODUCE BAG



WATER

Choose six types of seeds from your kitchen and make predictions about which ones will sprout and which ones will not. If you expect that they will sprout, draw pictures of what you expect your plants to look like. Will they have two small round leaves or will they look more like a blade of grass? Will the seed split when it germinates? What shape will the leaves have?

- 1 Cut your egg carton in half so that you have two containers, each with six pockets.
- 2 Moisten two paper towels with water. Place a wet paper towel along the inside of each of the egg carton halves. Then put your seeds in the cartons. Arrange the cartons to be as identical as possible with three types of each seed in each pocket.
- 3 Next get two more paper towels wet and place them inside two ziplock bags. Place three of each of your seeds on these paper towels as well.
- 4 Cover the egg cartons with empty produce bags or bread bags to ensure that they stay moist. Place one in the fridge and one by a window.
- 5 Tape one of your plastic bags to a window so that it gets some sunlight. Place the other plastic bag in a different location. You can choose to put it in the fridge (cold and dark) or to place it somewhere that has less light.
- 6 Check on your seeds everyday and record your observations. Make sure the paper towels do not dry out (add water as needed) and that the seeds do not get too wet (they should not be covered in water).
- 7 After one week, move the seeds that were in the fridge to a location with light and warmer temperatures. After 2 weeks compare your predictions to the results that you observed.

### Is it a seed?

yes no

Rice	<input type="checkbox"/>	<input type="checkbox"/>
Popcorn	<input type="checkbox"/>	<input type="checkbox"/>
Bean	<input type="checkbox"/>	<input type="checkbox"/>
Basil	<input type="checkbox"/>	<input type="checkbox"/>
Peppercorn	<input type="checkbox"/>	<input type="checkbox"/>
Peach pit	<input type="checkbox"/>	<input type="checkbox"/>
Pinecone	<input type="checkbox"/>	<input type="checkbox"/>
Cashew	<input type="checkbox"/>	<input type="checkbox"/>
Peanut	<input type="checkbox"/>	<input type="checkbox"/>
Tapioca pearls	<input type="checkbox"/>	<input type="checkbox"/>
Hazelnut	<input type="checkbox"/>	<input type="checkbox"/>
Almond	<input type="checkbox"/>	<input type="checkbox"/>
Rosemary	<input type="checkbox"/>	<input type="checkbox"/>
Nutmeg	<input type="checkbox"/>	<input type="checkbox"/>
Coconut	<input type="checkbox"/>	<input type="checkbox"/>
Fig	<input type="checkbox"/>	<input type="checkbox"/>



IF YOU'RE CARVING PUMPKINS FOR HALLOWEEN, THEIR SEEDS WOULD BE GREAT TO USE IN YOUR EXPERIMENT!

# FRANKENSEEDS CONTINUED...

Label your 6 types of seeds A through F. Two or three days after you plant your seeds, start tracking whether or not they have germinated. Put an x in the box on the first day you see germination (a small rootlet coming from the seed). Draw a leaf on the first day you see green cotyledons or leaves growing from your seed! After two weeks, move the seeds from your fridge to a windowsill. Keep them moist and keep tracking their progress (another piece of paper will be needed to continue your chart).

**WEEK ONE CARTON FROM THE WINDOWSILL:**

	SUN	MON	TUE	WED	THURS	FRI	SAT
A							
B							
C							
D							
E							
F							

**CARTON FROM THE FRIDGE:**

	SUN	MON	TUE	WED	THURS	FRI	SAT
A							
B							
C							
D							
E							
F							

	SUN	MON	TUE	WED	THURS	FRI	SAT
A							
B							
C							
D							
E							
F							

	SUN	MON	TUE	WED	THURS	FRI	SAT
A							
B							
C							
D							
E							
F							

How long did the seeds take to sprout? Which seeds sprouted and which seeds did not? Why do you think the seeds did not sprout?

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Why do plants need water?

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Why do plants need air?

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Why do plants need soil?

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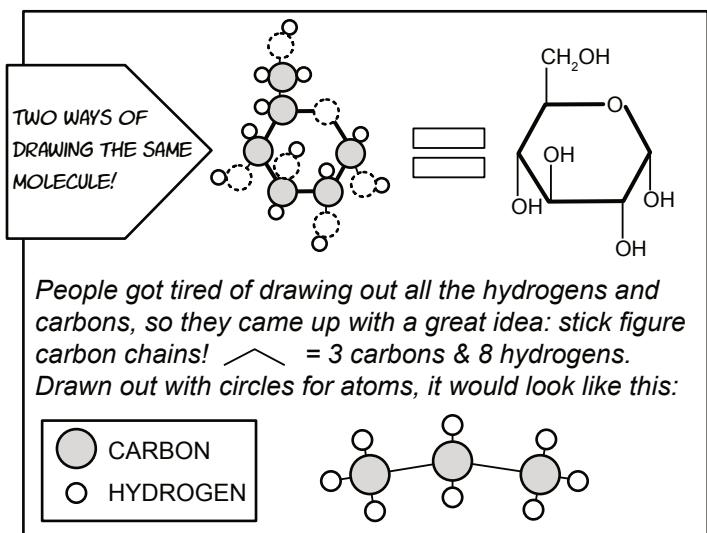
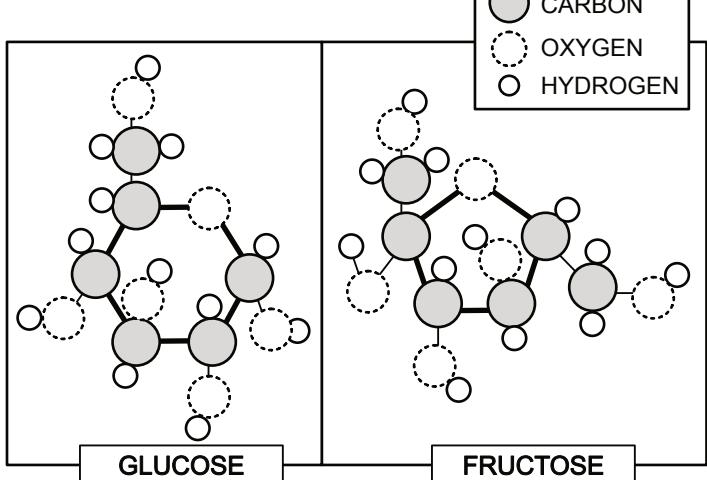


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# SUGARS

## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!



## HFCS EXPLAINED:

HFCS stands for High Fructose Corn Syrup, an artificial sweetener made by converting glucose to fructose. Why would people designing special chemical reactions to increase the amount of fructose in corn syrup? Because glucose doesn't taste very sweet! Pretty much all of the taste and sweetness of regular sugar (sucrose) comes from the fructose. Increasing the amount of fructose increases the sweetness.

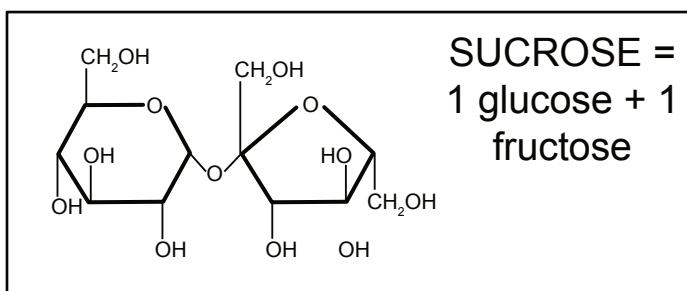
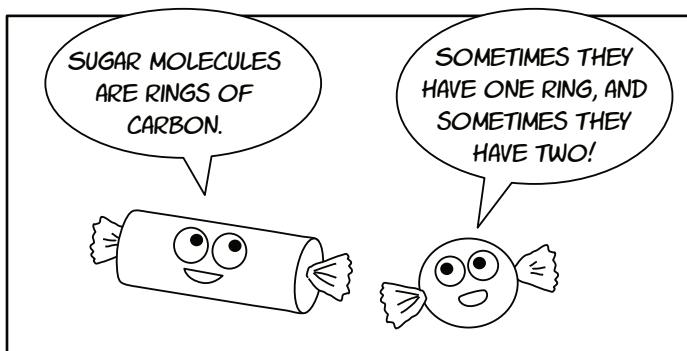
Your notes: \_\_\_\_\_

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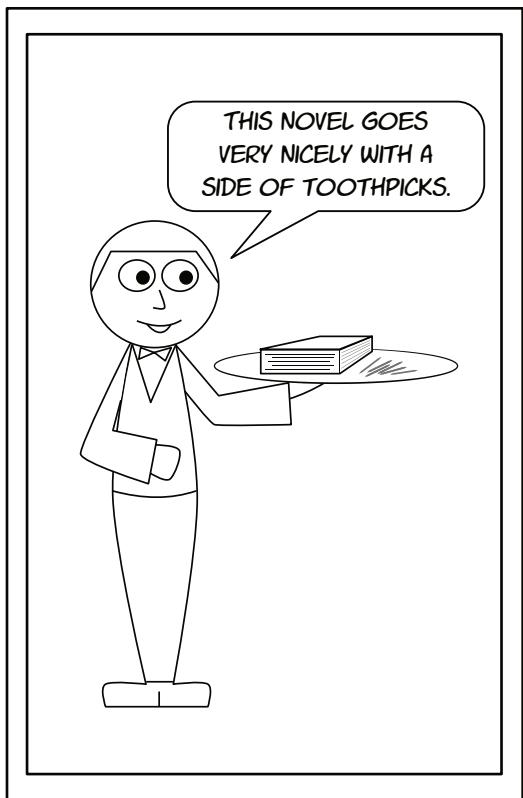
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# Why can't we eat wood?



I'M GLUCOSE! AN ENERGETIC CIRCLE OF CARBON AND OXYGEN AND THE MAIN INGREDIENT IN BOTH STARCH AND CELLULOSE!

Can you spot the difference between starch and cellulose?

String glucose together like this, and you get **starch**—A big ingredient in things like potatoes and corn and rice and wheat.

String glucose together like this, and you get **cellulose**—the main ingredient in things like leaves and straw and wood.

A termite can eat a piece of wood and get energy from it. A cow can eat grass and get energy from that. But if you eat wood or grass it's called *fiber*. Your body can't digest it and it passes straight on through. Have you ever wondered why? Why can you live for weeks on a diet of potatoes, but not newspapers or twigs?

Cellulose and starch are both polymers made of the same building unit: glucose. The difference between them is HOW the glucose molecules are linked together. In starch, all the molecules are facing the same way. We call this an alpha linkage. In cellulose, every other glucose is flipped upside down. We call this a beta linkage. When you eat starch, your body can break that alpha linkage apart so each of your cells can eat the glucose. But beta linkages are tricky. They can only be broken by bacteria and fungi. NOT A SINGLE ANIMAL can do it. So then how in the world do termites eat wood? How do horses cows, goats, and sheep eat grass? (Look at the next page to find out!)

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

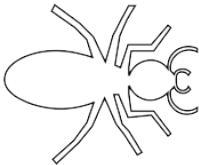
\_\_\_\_\_

\_\_\_\_\_

## The Termite

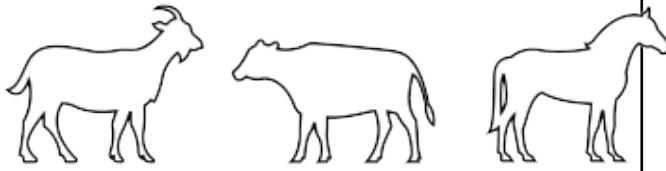
Termites have special bacteria living in their stomachs that digest cellulose for them, breaking it apart into glucose. Give a termite an antibiotic, and it would starve to death no matter how much wood it ate.

The termite can only digest wood with the help of its special "termite gut microbes."



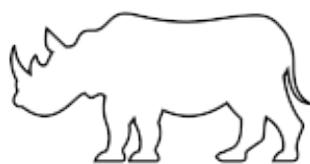
## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!



## The Herbivores

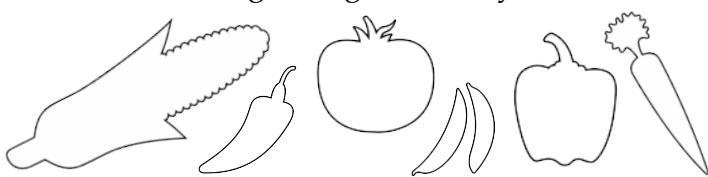
Herbivores also digest grass with the help of bacteria. Some herbivores (cows) have 4 stomachs to provide even better homes for those important little microbes. Others, like the camel and hippopotamus, have 3 stomachs. And horses have just 1, plus a long "water gut" that provides the perfect place for the bacteria to do their work.



CURIOUS WHICH FOODS HAVE THE MOST FIBER? THAT WOULD BE DARK GREEN VEGETABLES, LEGUMES, AND WHOLE GRAINS!

## Why fiber is important

We can't digest cellulose, but does that mean we don't want to eat it? Not so fast! If you were able to digest absolutely *everything* you ate, well, that would be a bit of a problem. How would you get rid of things your body didn't want, like extra cholesterol in your blood? If you have enough fiber, the fiber binds to the extra cholesterol and takes it out with the trash. If you don't have enough fiber, the cholesterol is reabsorbed into the bloodstream. Too much cholesterol can cause a heart attack. And that's just one of the many benefits of having enough fiber in your diet.



Your notes:

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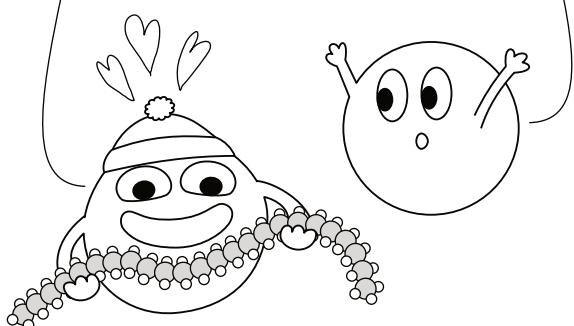
# LIPIDS AKA fat & oil

FILL IN THE BLANKS USING THESE WORDS:

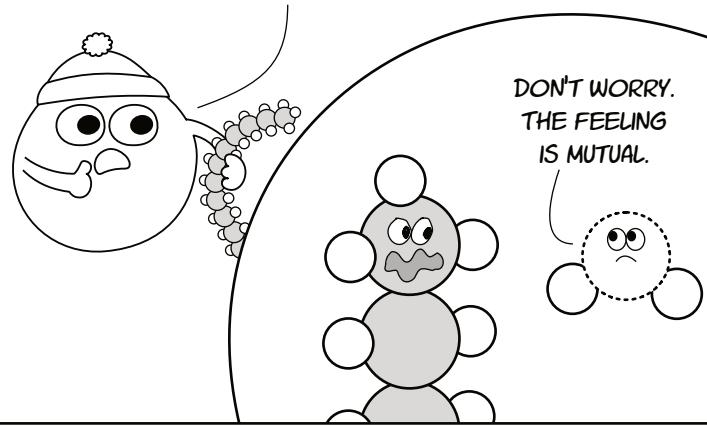
oils      carbon      hydrogen  
fats      hydrophobic      determines

Lipids are fats and \_\_\_\_\_. Chemically, they are very long strands of carbon and \_\_\_\_\_. How long the strand is and what types of bonds it has (single or double) \_\_\_\_\_ what type of oil or fat it is. But all \_\_\_\_\_ and oils are mostly made of just two atoms: \_\_\_\_\_ and hydrogen. Because these long strands don't have any charged areas, they are \_\_\_\_\_ which means water fearing. This is why oil and water don't mix together!

LOOK HOW MUCH MORE CARBON WE CAN STORE WHEN WE GET RID OF ALL THE OXYGENS!



BUT NOW THIS MOLECULE DOESN'T LIKE WATER VERY MUCH.



## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

Your notes: \_\_\_\_\_

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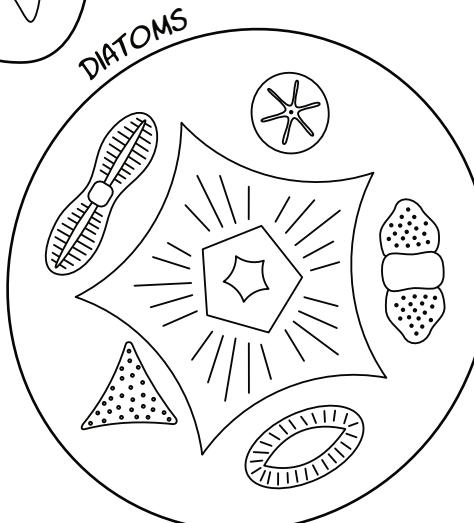
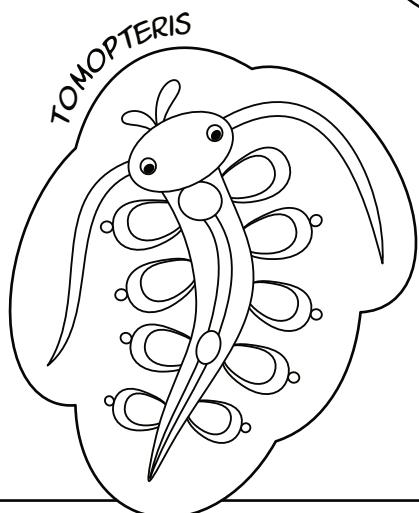
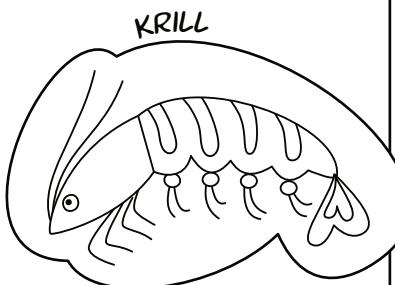
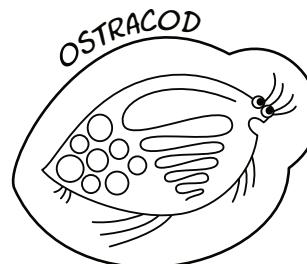
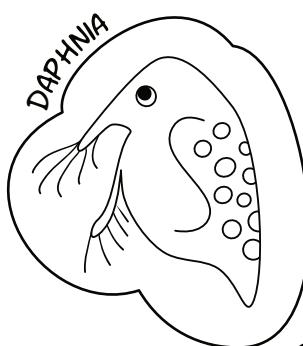
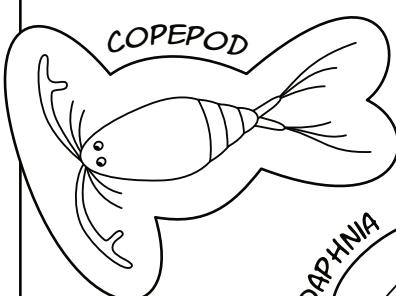
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# PLANKTON

Small but mighty!



Plankton are the microscopic organisms floating in seawater or \_\_\_\_\_ water. They can be plants, animals, viruses, or fungi!

\_\_\_\_\_, like diatoms, are photosynthetic.

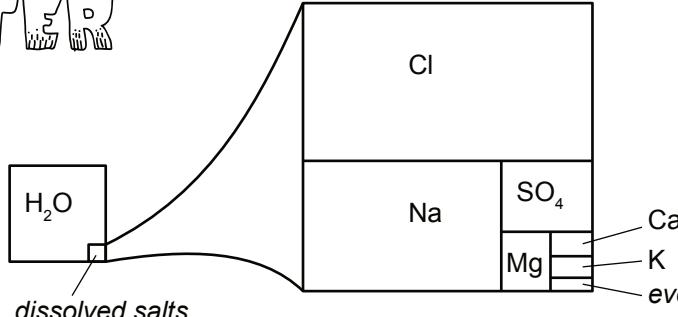
\_\_\_\_\_, like copepods or krill, are small animals that eat other plankton. All animals on Earth depend on plankton because they produce most of the world's \_\_\_\_\_ and absorb large amounts of \_\_\_\_\_.

FILL IN THE BLANKS ABOVE USING THESE WORDS:

zooplankton phytoplankton  
oxygen fresh CO<sub>2</sub>

## SEAWATER

96.5% water  
3.5% dissolved salts



The salts are mostly sodium chloride (~85%) but there's a decent amount of sulfate (7%), magnesium (4%), calcium (1.2%) and potassium (1.1%) too.

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# Optional Bonus Activity

This is an activity from our 2020 class.  
These notes and a video are included as a bonus/optional resource.

## MATERIALS:

A TUBER (SUCH AS A POTATO)  
A ROOT VEGETABLE (CARROT)  
A PINEAPPLE  
CUPS  
TOOTHPICKS  
WATER

## Plant propagation

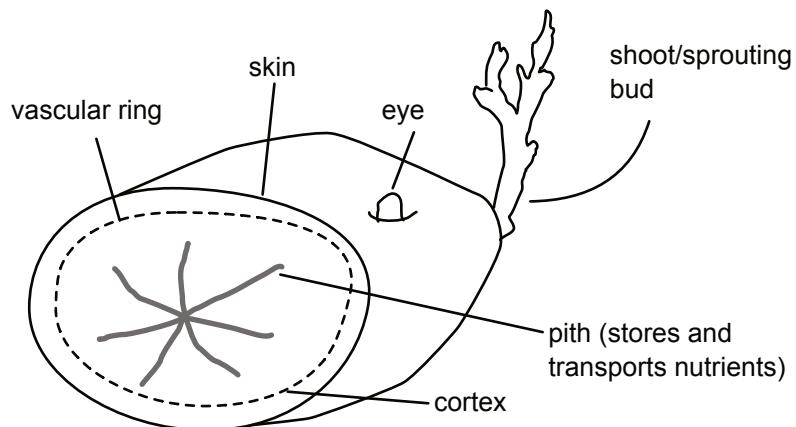
I CAN TURN  
INTO ANYTHING!

A leaf is very different than a root, and those differences come from the cells and how they behave. Not all plant cells can grow into roots or leaves or a new plant. But certain cells called meristems can! Try regrowing plants from foods in the kitchen to learn more about these amazing meristems and different types of plants.



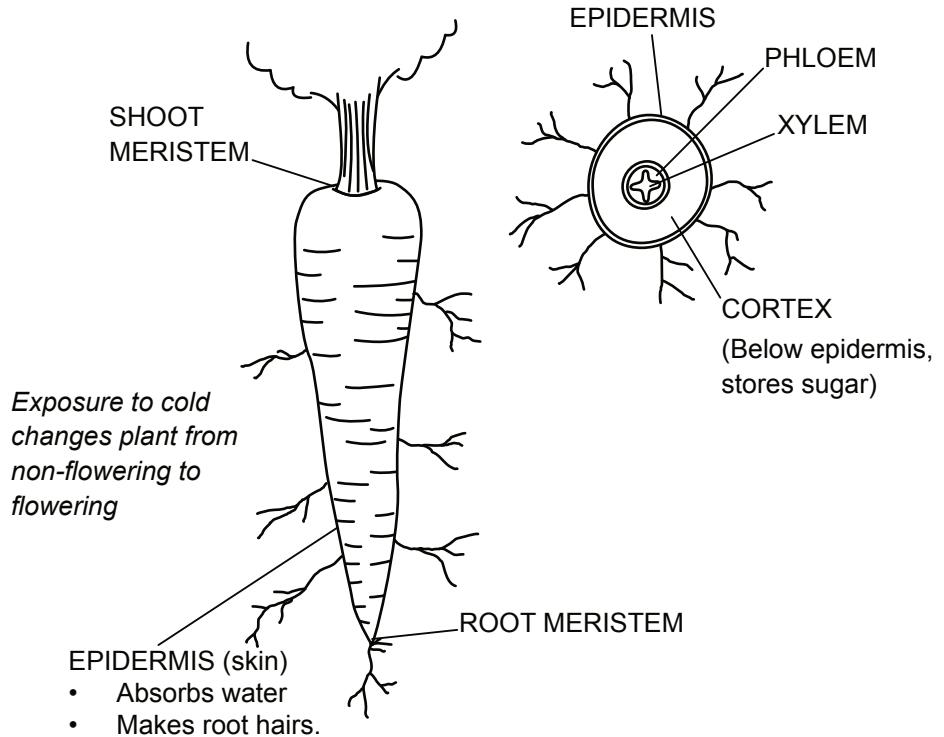
## TUBERS

In a tuber like a potato, sweet potato, turmeric, or ginger, there are small "eyes" or nodes where a new shoot and root can grow. If you cut a potato or other tuber and place toothpicks in it so that it is half submerged in water, a shoot and roots will grow from the node.



## ROOTS

Root vegetables like beets, carrots, turnips, rutabagas, parsnips, or onions can regrow from the top of the vegetable. Select a vegetable with some green at the top. Place the top in a cup that is partially filled with water. Use toothpicks to suspend it so that the bottom part is wet but the top is exposed to air. The plant will regrow from the top but it won't grow a new root vegetable -- only the leaves and potentially flowers and seeds.



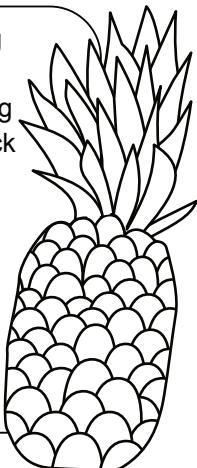
# Optional Bonus Activity

This is an engineering activity from our 2020 class.  
These notes and a video are included as a bonus/optional resource.



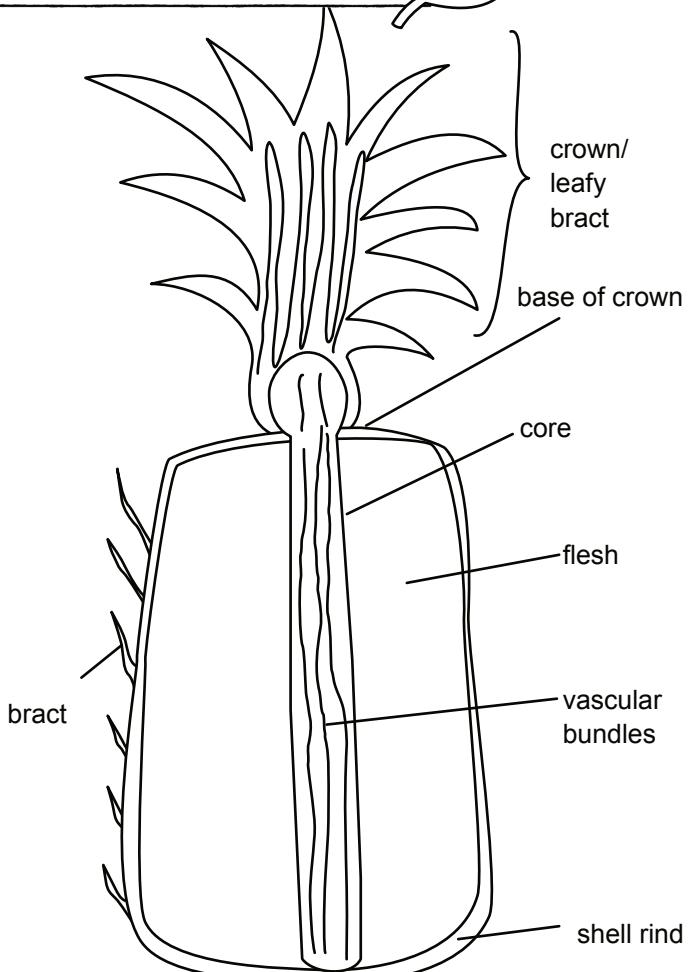
## PINEAPPLES!

Pineapples are a very interesting fruit because they have a full miniature pineapple plant growing on top of the fruit! If you peel back the leaves from the top of a pineapple, you will see tiny little rootlets. Place this top of the pineapple into a cup half full of water. Soon roots will emerge. Congrats! Your new pineapple plant is growing.

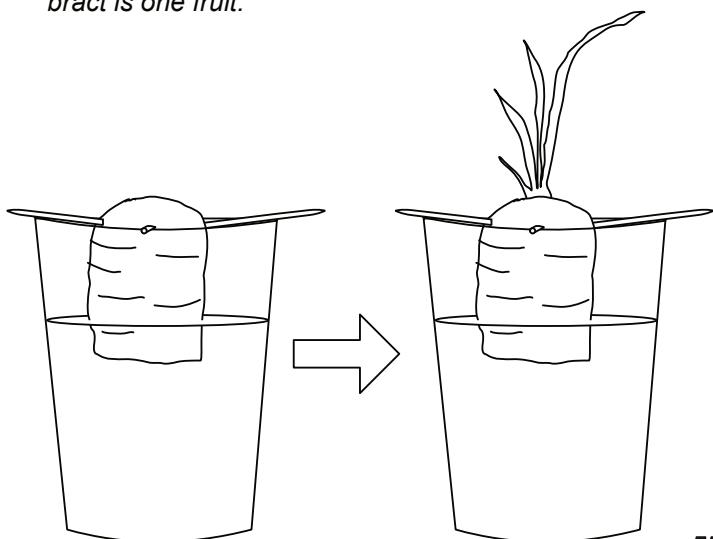


- 1 Cut off the pineapple top.
  - 2 Pull off fruit and first two layer of leaves from the base.
  - 3 Look closely. Do you see tiny little nubs of roots? Yes? Put your pineapple in a cup with some water. No? Keep removing leaves until you find the small nubs of roots.
- 

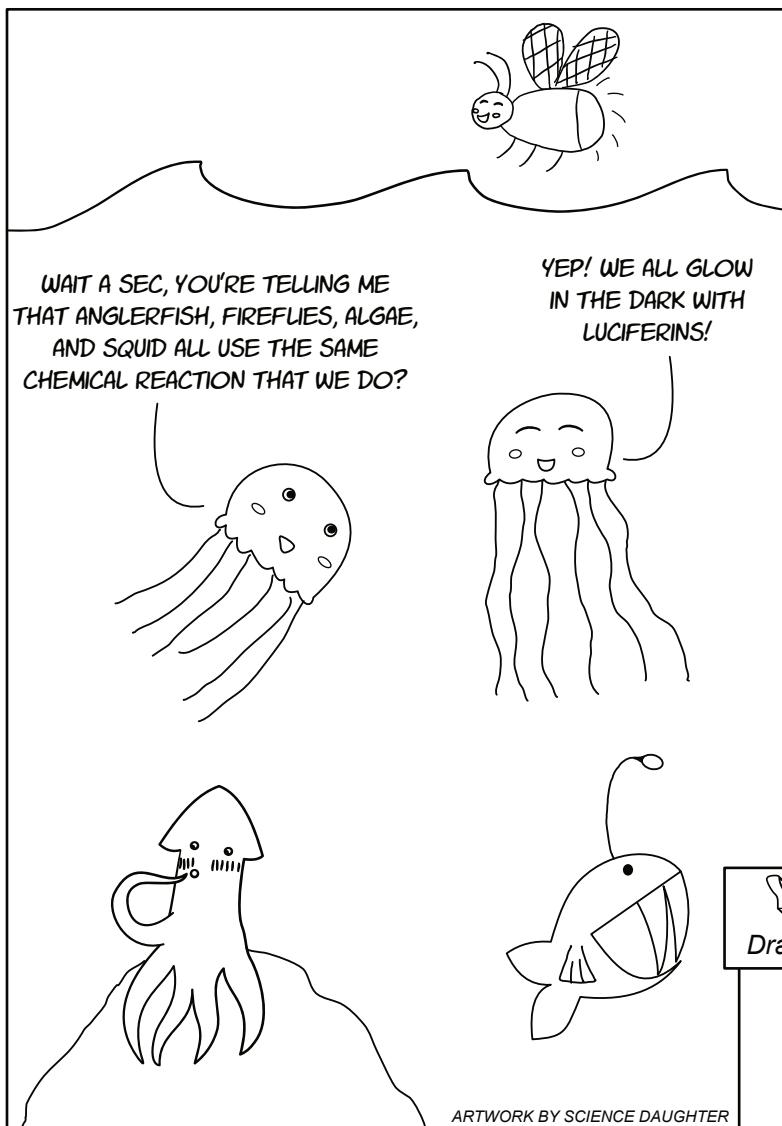
You can also try: an avocado pit, basil leaves, the base of a bok choy, cabbage leaves, celery base, cilantro stems, garlic, green onions, mushroom stocks, onion base, or romaine lettuce base.



A pineapple is a “sorosus.” That’s greek for heap. It’s a cluster of berries that all grew together! Each bract is one fruit.



# BIOLUMINESCENCE



WAIT A SEC, YOU'RE TELLING ME THAT ANGLERFISH, FIREFLIES, ALGAE, AND SQUID ALL USE THE SAME CHEMICAL REACTION THAT WE DO?

YEP! WE ALL GLOW IN THE DARK WITH LUCIFERINS!

When living animals make light it is called \_\_\_\_\_. Certain types of insects, fish, invertebrates, and algae can create \_\_\_\_\_ using a special \_\_\_\_\_ reaction. While there are several different types of chemicals are used, the main idea is that \_\_\_\_\_ provides energy for a chemical reaction that creates light. The \_\_\_\_\_ can control when the reaction starts and stops, creating \_\_\_\_\_ of light to communicate, lure in prey, or escape from predators.

FILL IN THE BLANKS ABOVE USING THESE WORDS:

light	animal	bioluminescence
chemical	oxygen	flashes

## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

Your notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# From CELLS to COLONIES

THE BRAIN SAW A SPIDER, AND NOW ADRENALINE IS HERE!

HOLD ON, SHOULDN'T SOMEONE TELL THE HEART CELLS NOT TO PANIC? THE LAST TIME WE SAW A SPIDER NOTHING BAD HAPPENED.

I'LL TELL THE BLOOD CELLS TO MOVE FASTER!

ON IT!

ADRENALINE ALSO KNOWN AS EPINEPHRINE. IT'S THE MAIN MOLECULE BEHIND "FIGHT OR FLIGHT." A LITTLE BIT GOES A LONG WAY!

CARBON  
OXYGEN  
NITROGEN  
HYDROGEN

TOO LATE! ADRENALINE ALREADY GOT HERE AND WE'RE FREAKING OUT!

HEART MUSCLE CELLS

This panel illustrates the fight-or-flight response. A brain cell sees a spider and releases adrenaline. The adrenaline molecule is shown with a carbon ring containing nitrogen and hydrogen atoms, and oxygen atoms attached by dashed lines. The adrenaline then travels through blood vessels to heart muscle cells. The heart cells are depicted as three large, triangular shapes with faces, looking shocked and sweating. A legend at the bottom left shows the symbols for carbon (solid circle), oxygen (dashed circle), nitrogen (grey circle), and hydrogen (open circle).

## CHEMISTRY IS EVERYWHERE!

How does a nerve cell learn to send signals, or a blood cell to carry oxygen? How does one ant tell the rest of the colony where to find food? The answer to both questions comes down to chemistry! Chemical reactions power the life of the cell, and control how it communicates with other cells. And it's not just cells that communicate with chemicals - insect colonies do too!

PHEROMONES THERE ARE MANY DIFFERENT KINDS! ANTS MAKE TRAILS OF PHEROMONES THAT TELL OTHER ANTS WHERE (AND HOW MUCH) FOOD THEY CAN FIND.

PHEROMONES!

WAIT, HOW DID YOU KNOW WHERE TO FIND ME?

SUGAR

This panel shows a group of ants laying a trail of pheromones from a sugar container back to their colony. The sugar container has a face and says "SUGAR". A single ant is shown following the trail. The pheromone molecule is shown with a six-membered ring containing nitrogen and hydrogen atoms, and oxygen atoms attached by dashed lines.

Your notes: \_\_\_\_\_

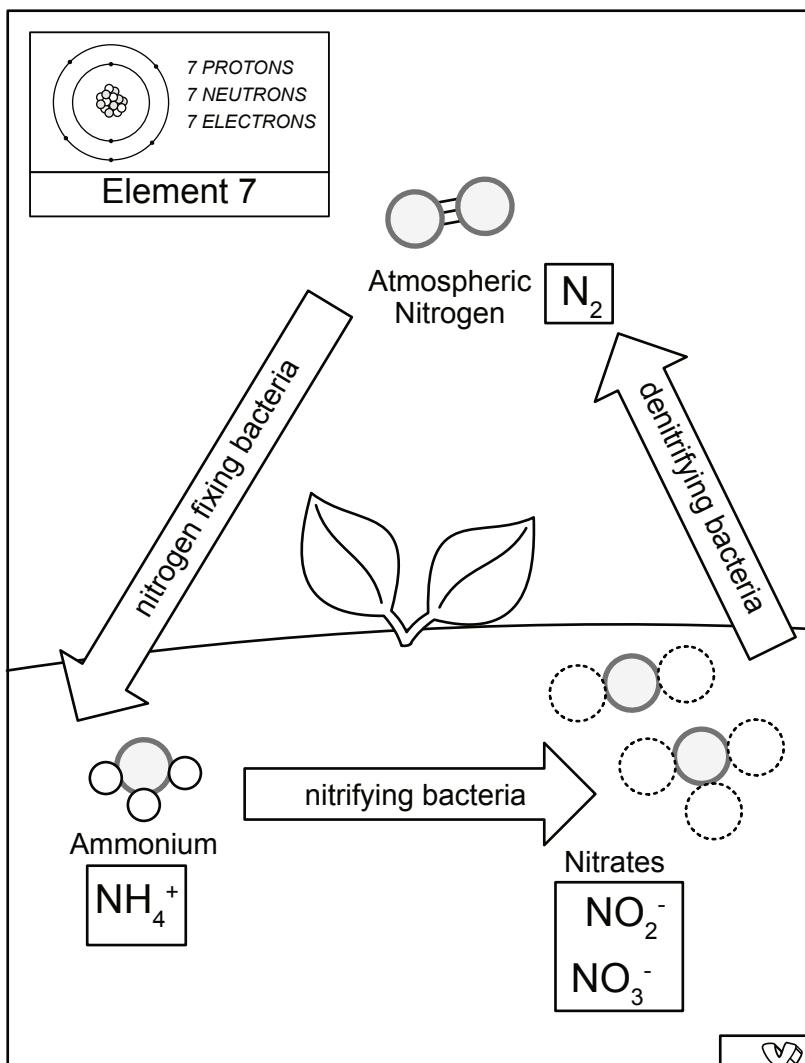
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# NITROGEN

Essential nutrient  
& most of our air



Nitrogen is an essential element used to make \_\_\_\_\_ and DNA. Every \_\_\_\_\_ and plant needs it, and 78% of Earth's \_\_\_\_\_ is nitrogen. So you might think that it would be easy to get, but the nitrogen in the air is  $N_2$ . It's two atoms bound with a very strong \_\_\_\_\_ bond and that bond is very hard to break! No animals can do it. No plants can do it. Only \_\_\_\_\_ can change atmospheric nitrogen into a form that \_\_\_\_\_ and animals can use. We call this "fixing" nitrogen.

FILL IN THE BLANKS ABOVE USING THESE WORDS:

bacteria	proteins	animal
triple	plants	atmosphere

Your notes:

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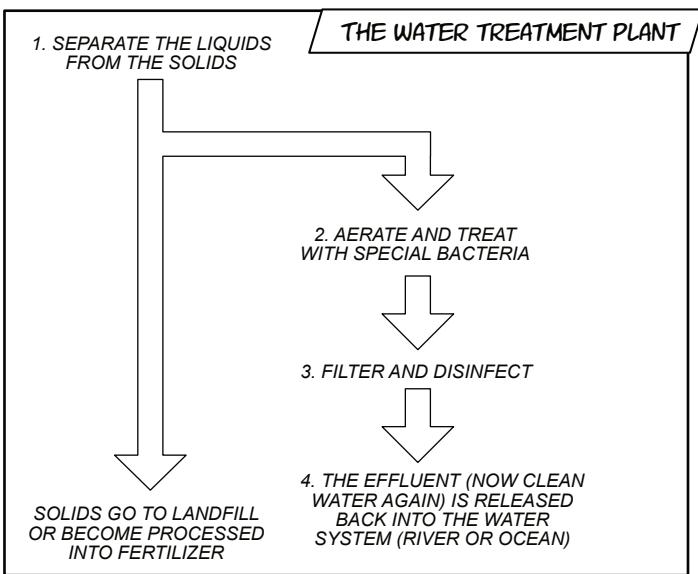
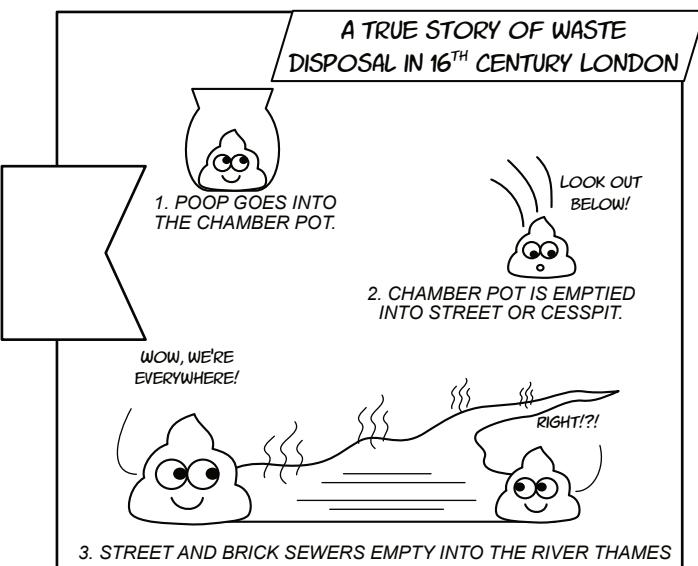
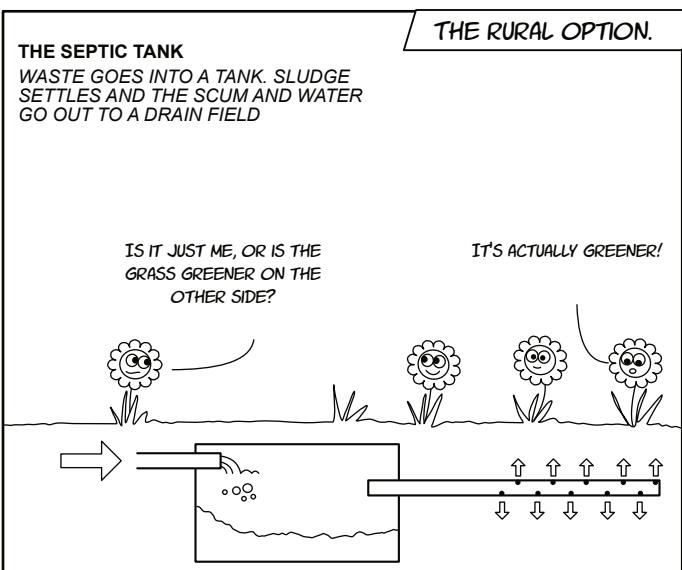


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## YOUR DOODLE SPACE

Draw your favorite moment from class or write a cool fact!

# Water Reclamation



**YOUR DOODLE SPACE**  
Draw your favorite moment from class or write a cool fact!

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Water is our most precious and interconnected resource.

Your notes: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# Hands-on Activity

## DIY water filter

### MATERIALS:



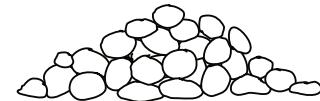
A PLASTIC BOTTLE  
(16 OR 12 OUNCES)



COTTON BALLS OR A PIECE  
OF COTTON FABRIC



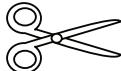
WATER



1/2 CUP GRAVEL



2 COFFEE  
FILTERS



SCISSORS OR KNIFE TO  
CUT THE PLASTIC BOTTLE



1/4 CUP ACTIVATED CHARCOAL



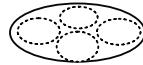
1/2 CUP SAND

### INSTRUCTIONS:

1 Carefully use scissors or knife to cut off the bottom of the water bottle to create a tall funnel.

Your observations: \_\_\_\_\_

2 Trim one of the coffee filters into four smaller circles.



3 Place one or two cotton balls on top of two of the coffee filter circles. Carefully place them in the neck of the water bottle. If they flip and turn sideways simply turn the bottle upside down and shake them back out and then try again. It may help to use a chopstick or wooden skewer or straw.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

4 Once you have your coffee filter circles and cotton balls in place, put the remaining coffee filter circles on top to make a "coffee filter cotton ball sandwich." This is the lowest layer of filtration.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5 Next, carefully pour 1/4 cup of activated charcoal onto a coffee filter and lower it into the bottle. Then fold the coffee filter over the top of the charcoal to completely enclose it.

\_\_\_\_\_

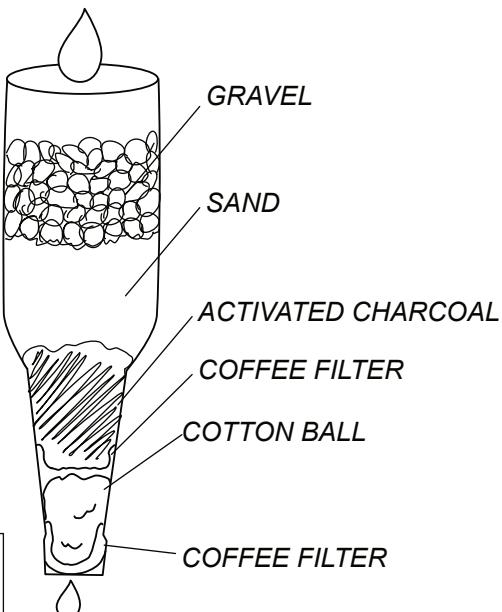
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Run a little bit of water through the filter to help the two lower layers compress and make sure that they are pressed against the sides of the bottle.

Next add 1/2 cup of sand, then add the final layer of 1/2 cup of gravel.



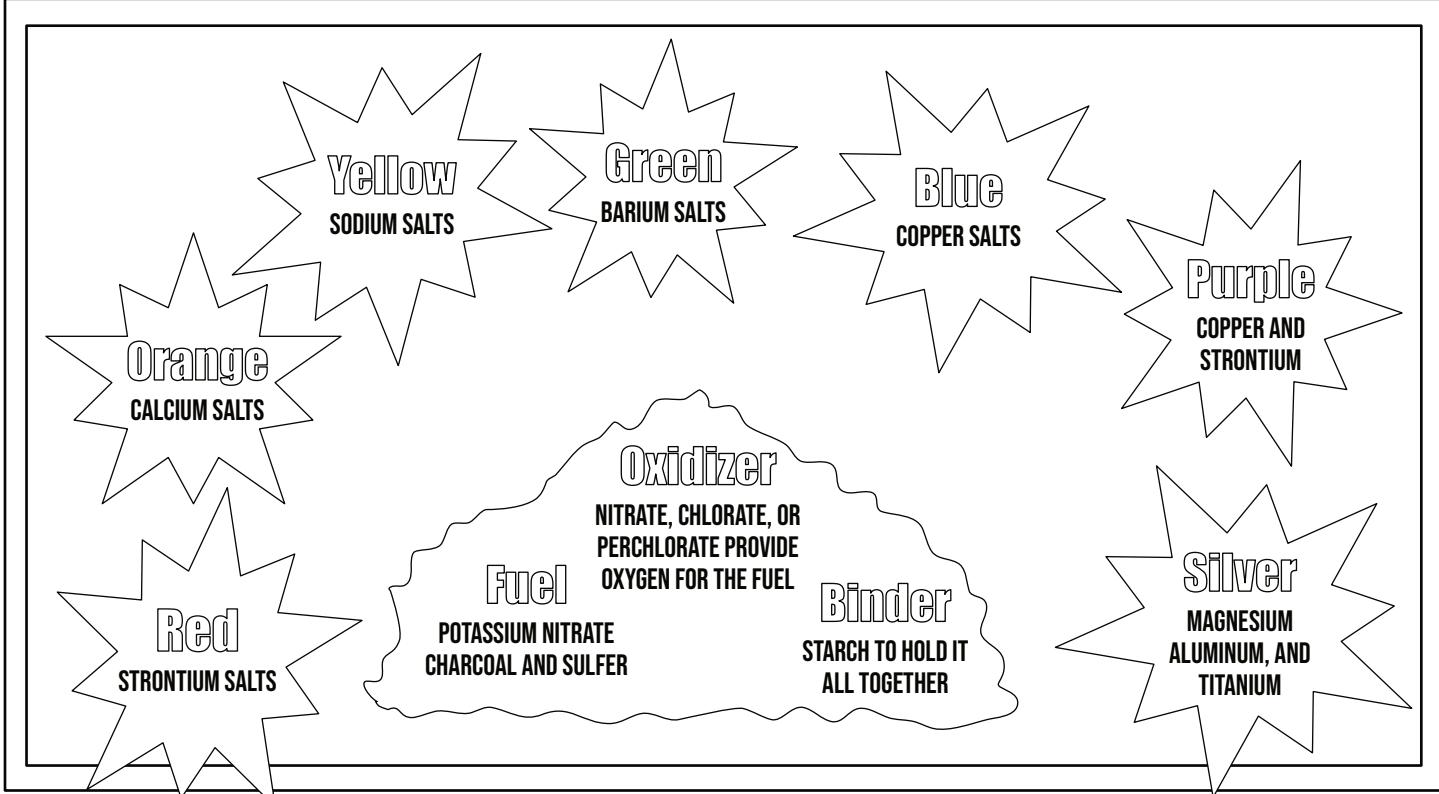
6 Experiment by running different liquids through your filter. Start with relatively clean water such as the leftover water from cooking vegetables. If you run it through your filter, does it still smell like vegetables or have color to it? Or did the filter clean the water?

7 Next, add some food coloring to your water or go outside and get some mud. See how your filter does cleaning that water.

**Warning! Only drink water that you know is safe to drink!**

While this filter is similar to modern filtration systems, it is small enough that contaminants can overwhelm it and "sneak" through.

# FIREWORKS and lab safety



FILL IN THE BLANKS USING THESE WORDS:

safety      chemical      reactions  
pressure      safe

Fireworks are controlled \_\_\_\_\_ . These explosive devices delight us with their bright colors on holidays around the world, and they're also a good reminder of the importance of \_\_\_\_\_ precautions. Can chemistry be a lot of fun? Absolutely. Can a little knowledge be a dangerous thing? Sometimes! Make sure you think ahead about what might happen during a reaction. If your future chemistry experiment will produce a gas, be extra careful because \_\_\_\_\_ might build up. Always wear safety glasses, and make sure to clean up after yourself when your experiments are done! Keeping your laboratory space clean and organized isn't just good manners. It keeps you and your equipments \_\_\_\_\_.

Your notes: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# The end

of our course... Hopefully the beginning of many more adventures in science!

We hope you enjoyed this chemistry course! These doodle notes were all drawn by Science Mom (with help from Math Dad, Science Daughter, and Science Moms Liza, Krista, and Emily). If you enjoyed this course, we think you'd also enjoy Theodore Gray's three books: Elements, Reactions, and Molecules.

Last but not least, we have two "go the extra mile" activities, which you'll see on the next few pages. If you complete either of these activities, take a picture of your work and send it to us at [jenny@science.mom](mailto:jenny@science.mom) or tag us on social media.

Twitter: @jennyballif

Facebook: @TheScienceMom

Instagram: @the.science.mom

Work hard, grow smart, and stay curious!

-Science Mom

# MEMORIZE THE PERIODIC TABLE CHALLENGE

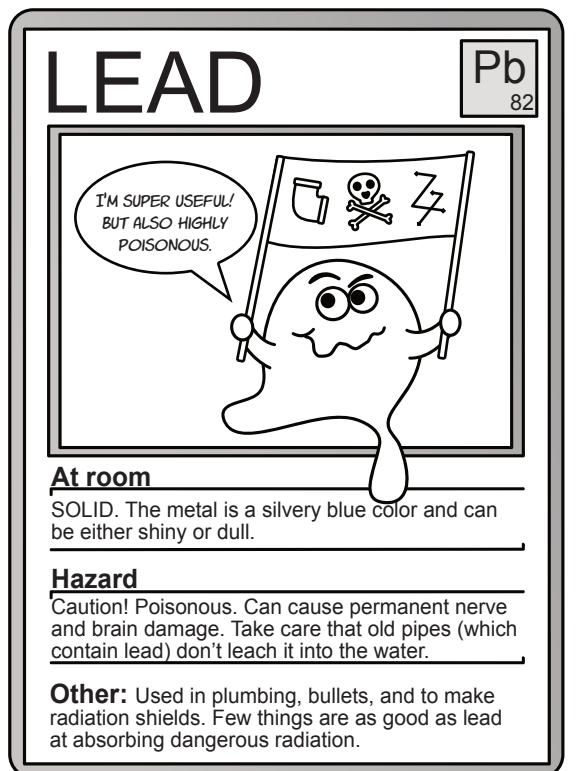
1	2	3	4	5	6	7	8	9	10
11	12	19	20	21	22	23	24	25	26
		37	38	39	40	41	42	43	44
		55	56	72	73	74	75	76	77
		87	88	104	105	106	107	108	109
		19	20	21	22	23	24	25	26
		37	38	39	40	41	42	43	44
		55	56	72	73	74	75	76	77
		87	88	104	105	106	107	108	109

Can you memorize the periodic table? Practice filling in this chart (print extra copies!) and see if you can learn the entire table. Color in the different families too!

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103

Nonmetals	Metaloids
Alkali Metals	Halogens
Alkali Earth metals	Noble gases
Transition metals	Transactinides
Metals	Lanthanides
	Actinides

# MAKE A FULL DECK OF ELEMENTAL TRADING CARDS



Remember the element trading cards from page 13 and 14? You made 4 of them, now here's a super challenge. Can you create a FULL DECK with all 118 known elements?

Print out extra copies of these templates or make your own! If you complete this epic challenge, email us. We'd love to see your work!

Not all elements have an easily findable hazard rating. You may choose to include other details instead. There are interesting facts to find for each element, so don't feel constrained to match the example or template if you have ideas you'd like to include.

At room temp:

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---

Hazard rating:

---

---

Other:

At room temp:

---

---

Hazard rating:

---

---

Other:

At room temp:

---

---

Hazard rating:

---

---

Other:

At room temp:

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Hazard rating:

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Other:

At room temp:

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Hazard rating:

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Other:

At room temp:

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Hazard rating:

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At room temp:

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At room temp:

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Other:

At room temp:

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Hazard rating:

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Other:

At room temp:

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Hazard rating:

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Other:

# Subatomic Particles

Jenny Ballif



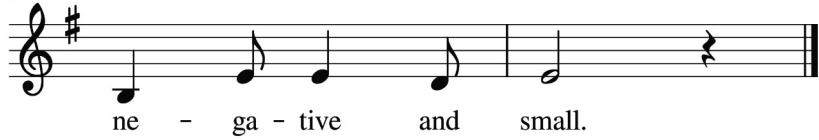
Sub - a-tom - ic part - i-cles here's a group of three. Pro-tonsin the nu - cle-us are po - si-tive you

8



see. Neu-tronsin the nu - cle-us have no charge at all. E - le - ctronsin their or - bi-tals are

15



ne - ga - tive and small. ||

# Ions and Isotopes

Serge Ballif



**Ion**

8      The small - est par - ti - cle of all is one called the e - lec - tron.

**Isotope**

8      Chang - ing the neu - tron count chang - est the mass but not the name. An

**Piano**

8      8      8      8

6      A(C)      D(F)      E(G)      A(C)

**Ion**

8      Take aw - ay or add it in that's how you get an i - on

**Iso.**

8      is - o - tope is what it's called a - tom - ic num - ber stays the same.

**Pno.**

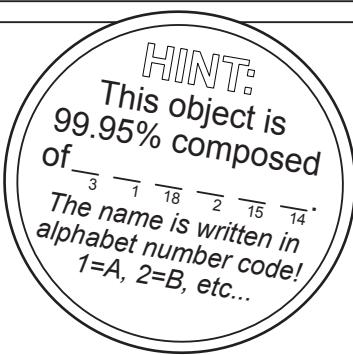
8      8      8      8

# SECRET CODES

for your eyes only!

Hello Special Agent. Something very valuable has been stolen from the vault of the Bank of Big Bucks! We need your help to decode information about the object, location, and sneaky spy so that it can be retrieved.

Here is a binary code that uses the number zero to represent a white square, and the number one to represent a black square. Fill in the grid accordingly to create an image of the stolen object!



## THE BINARY CODE:

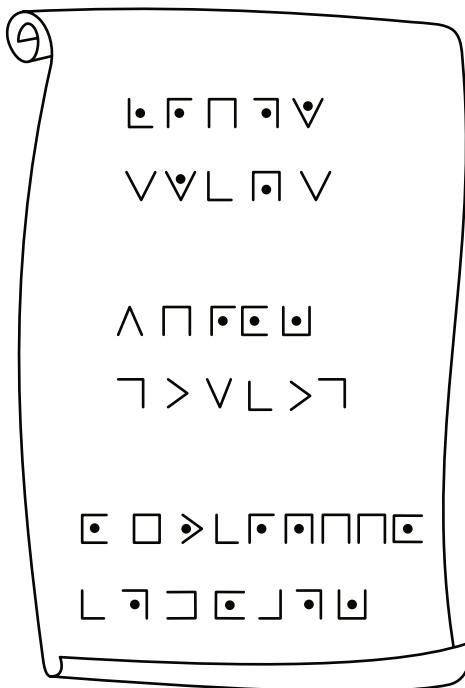
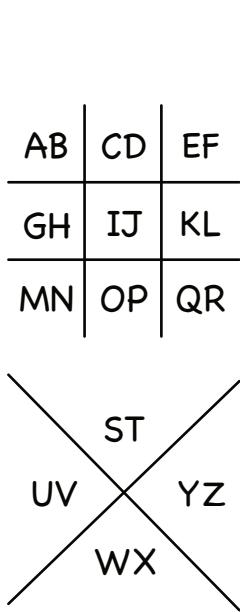
Row one: 0000000000000000  
Row two: 001111111111000  
Row three: 0010000100000100  
Row four: 01010001010001010  
Row five: 10001010001010001  
Row six: 0111111111111110  
Row seven: 00101000000010100  
Row eight: 0001000000001000  
Row nine: 00001000000010000  
Row ten: 00000100000100000  
Row eleven: 00000010001000000  
Row twelve: 00000001010000000  
Row thirteen: 00000000100000000  
Row fourteen: 00000000000000000

Row 1:															
Row 2:															
Row 3:															
Row 4:															
Row 5:															
Row 6:															
Row 7:															
Row 8:															
Row 9:															
Row 10:															
Row 11:															
Row 12:															
Row 13:															
Row 14:															



Wonderful! Now that you know what you are looking for, you need to figure out where it is being hidden. The location has been encoded in "alphabet grid" format. Take a look at the grids below. The first letters in each space are represented by the line around it. The second letters get an additional dot included. For example: The "I" looks like a square, and "J" looks like a square with a dot in it. "S" looks like a V, and "T" looks like a V with a dot in it.

I = <input type="checkbox"/>	J = <input checked="" type="checkbox"/>
S = <input type="checkbox"/>	T = <input type="checkbox"/>



The object is under the:

of the:

Located in:

Last, find the spy who stole the object from the vault. Their description has been encrypted using reverse alphabet coding. We have started the cypher for you by including the original alphabet. To complete the cypher start at the end with letter Z, and write an A under it. Next write a B under the letter Y, then a C under the letter X. Continue this pattern until you finish by writing a Z under the letter A. Once you are done you can decode!  
Ex. XZG = CAT, SZKKB = HAPPY

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

### GSV HKB:

Mznv: ZOVC HNRGS

Ztv: URUGB

Vbv: TIVVM

Szri: IVW

Gztll: HSZIP

### THE SPY:

Name: \_\_\_\_\_

Age: \_\_\_\_\_

Eyes: \_\_\_\_\_

Hair: \_\_\_\_\_

Tattoo: \_\_\_\_\_