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Alison Hobbie... ahobbie@exeter.edu
Veronica Ledoux... ledouxv@catlin.edu
Katie Jackson... KJackson@tcskailua.net
Melissa Goo... honukahiki@gmail.com
Krystle Richman... krystle.richman@voyagerpcs.com

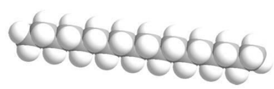
Teachers Across Borders Southern Africa
Yunus Peer, Director.... ypeer@punahou.edu

Investigating Combustion – an Exercise in Observation

In this investigation, students are challenged to make careful observations about a burning candle to discover the chemical and physical changes that make it work.

- Tea light candle
- Matches
- Small cup of water
- Balance
- ruler

1. Obtain a tea light candle, matches, and any measuring equipment available to you.
2. Before lighting the candle, make as many as three qualitative observations and three quantitative observations. Write them down on a separate piece of paper.
3. Use a match to carefully light the candle.
4. Repeat the process of making qualitative and quantitative observations of the burning candle. For your observations and measurements, consider not only the physical candle, but also consider its influence on the air in the space surrounding it. Again, write down your observations.



5. Blow out the candle and record two qualitative and two quantitative observations of the candle immediately after it is extinguished.

Interpreting Evidence and Discussing Results

Part One – States of Matter

Here is a model of a molecule similar to candle wax: $C_{18}H_{38}$.

➢ Draw three boxes on a piece of paper, and create three diagrams: one that represents wax as a solid, one as a liquid, and one as a gas. Using small, single shapes to represent wax molecules, sketch their arrangement in these three physical phases.

Part Two – Physical Changes

➢ Based on your observations of the burning candle, what evidence did you find for one or more of the *physical changes* described in the processes below?

$2\ C_{18}H_{38}\ (s) \rightarrow C_{18}H_{38}\ (l) \qquad C_{18}H_{38}\ (l) \rightarrow C_{18}H_{38}\ (g) \qquad C_{18}H_{38}\ (s) \rightarrow C_{18}H_{38}\ (g)$

Part Three –Chemical Change

➢ Based on your observations, did you find evidence for the *chemical change* described in the process below?

$2\ C_{18}H_{38}\ (s) + 55\ O_2\ (g) \rightarrow 36\ CO_2\ (?) + 38\ H_2O\ (?)$

➢ What are the states of the products of this reaction? Refer to specific observations.

➢ Complete the following sentence that restates this equation:

Two molecules of wax react with _________ molecules of oxygen to produce…

If less oxygen is available, one possible outcome in the combustion of wax is

$C_{18}H_{38}\ (s) + 37\ O_2\ (g) \rightarrow 18\ C\ (s) + 18\ CO_2\ (g) + 38\ H_2O\ (g)$

6. Relight the candle and lower the bottom of a small glass into the flame so that the flame touches the surface of the glass. Hold it there for a moment and then remove it. Observe the glass.
   ➢ What could this substance be and where did it come from?
   ➢ How does this provide evidence that a chemical reaction is taking place?
7. Wipe the bottom of the glass clean and place an ice cube inside it. Hold the glass several centimeters *above* (not in) the flame. Observe the bottom of the glass.
   ➢ What could this substance be and where did it come from?
   ➢ Could it have come from the melting ice inside the beaker?

Part four – One Last Look

8. Blow out the candle and very quickly bring a lit match close to the wick.
   ➢ Based on your observations, in which phase (solid, liquid, or gas) is the wax most likely to undergo a chemical change?
   ➢ Explain why this is the case based on your sketches of wax in solid, liquid, and gas phases.

Reflecting on the Investigation

In a short paragraph, summarize the changes that a candle undergoes when it burns. Incorporate the following words into the paragraph in a meaningful way: wax, wick, phase change, chemical reaction, vaporize, melt, transforms, solid, liquid, gas, energy, light, chemical change, and heat.

Unit Conversions in Chemistry – A Tutorial

Dimensional analysis is a method of performing multi-step conversion calculations by keeping track of units. In this method, equalities (i.e., conversion factors) are set up in fraction form. The equalities are then lined up sequentially and units used on the top and bottom of neighboring fractions are alternated so that units cancel.

Example #1: It is helpful to use English unit conversions as an example. Consider the conversion of inches to centimeters (1,00 in = 2,54 cm). How many centimeters are in 5,00 inches?

5 in = ? cm

$$5.00\ \text{in}\ \frac{\square}{\square} = \square\ \text{cm}$$

For this problem, the following equalities exist:

$$1.00\ \text{in} = 2.54\ \text{cm, or}\ \frac{1.00\ \text{in}}{2.54\ \text{cm}}\text{, or}\ \boxed{\frac{2.54\ \text{cm}}{1.00\ \text{in}}}$$

All three are equivalent, but only the last has inches in the denominator. By choosing the last equality, we can cancel units in the conversion.

$$5.00\ \cancel{\text{in}}\ \frac{2.54\ \text{cm}}{1.00\ \cancel{\text{in}}} = 12.7\ \text{cm}$$

Example #2: More complex problems can be solved by using equivalencies in sequence. Consider the following: How many centimeters are in 1,00 mile?

1 mi = ? cm

(1 mi = 5280 ft, 1ft = 12 in, 1 in = 2.54 cm)

$$1\ \cancel{\text{mi}}\ \frac{5280\ \cancel{\text{ft}}}{1\ \cancel{\text{mi}}}\ \frac{12\ \cancel{\text{in}}}{1\ \cancel{\text{ft}}}\ \frac{2.54\ \text{cm}}{1\ \cancel{\text{in}}} = 1.61 \times 10^5\ \text{cm}$$

Notice that the units alternate. Because we start out with miles, the first equivalence must have miles on the bottom in order to cancel. If miles are on the bottom, then feet must be on the top because 1,00 mi = 5.280 ft is the only equivalence given that uses miles. The second fraction must have feet in the denominator with inches on top in order to cancel feet. Subsequently, inches must be on bottom in the last fraction to cancel inches which leaves centimeters on top.

Try these. Even if you can do a few of these without dimensional analysis… use the method of cancelling units to perform each calculation.

1. How many deciliters are in one milliliter? *[0,01 dL]*
2. How many dozen eggs do you have if you have 414 eggs? *[34,5 dozen eggs]*
3. How many seconds are in a year? *[3,15 x 10^7 seconds]*
4. A tree has, on average, 63.000 leaves. A leaf from that tree weighs 13,5 grams. How many trees would supply enough leaves to equal the mass of an elephant: 7.000 kg? *[8,23 trees]*
5. CHALLENGE: A car is travelling 45 km/hr. What is its speed in m/s? *[12,5 m/s]*

M&Ms and the Mole – Working with Unit Conversions in Chemistry

Your assignment is to eat a package of candies such as M&Ms. Well, there is a bit more than that…

Record the following data:

(a) The number of candies in the package. ____________

(b) The mass of all the M&Ms in the package – read this on the package. _____________

(c) The time (in seconds) that it takes you to eat the entire package of candies. ____________

Using the data collected above, calculate the following on a separate piece of paper:

1. The average time it takes (in seconds) for one person to eat one M&M.
2. The average time it takes (in seconds) for one person to eat one dozen M&Ms.

NOTE – There is a quantity used in chemistry called a "mole." Not sure what that is… look it up!

3. How many M&Ms do you have if you have a <u>mole</u> of M&Ms?

<u>That is a big number! Fun Facts:</u>

- One mole of paper would make a stack that would reach to the moon more than 80 billion times.
- One mole of grains of sand would be more than all of the sand grains on all the beaches on earth.
- One mole of blood cells would be more than the total number of blood cells found in every human on earth.
- There are 2 types of mole-like creatures that live underground in South Africa: the golden mole and the mole-rat.
- One mole of seconds is about 19 quadrillion years, 4 million times the age of the earth, or almost a million times the age of the universe itself.
- One mole of cents could repay the South African National Debt 28 billion times.

Now calculate the following. You will find UNIT ANALYSIS helpful here…

4. The time it would take (in <u>years</u>) for one person to eat one mole of M&Ms.
5. The time it would take (in years) for your entire school to eat one mole of M&Ms.
6. The time it would take (in years) for the entire population of earth, (assume 7 billion folks on earth) to eat a mole of candies.
7. The mass (in <u>grams</u>… and in <u>kilograms</u>) of one mole of M&Ms.
   For comparison: the mass of the moon is $7{,}5 \times 10^{22}$ kg.

NOTE – A little known fact: Each regular M&M has a "packed" volume of 1.0 mL.

8. What would be the volume (in <u>milliliters</u>… and in <u>liters</u>) of one mole of M&Ms?
   For comparison: The volume of Lake Victoria: $2{,}7 \times 10^{15}$ L
   The volume of the Mediterranean Sea: $3{,}0 \times 10^{18}$ L
   The volume of the Pacific Ocean: $1{,}6 \times 10^{20}$ L
   The volume of all the oceans: $1{,}3 \times 10^{21}$ L
   The volume of the moon: $2{,}2 \times 10^{22}$ L
   The volume of the earth: $1{,}1 \times 10^{24}$ L

One more question

9. Assuming M&Ms are pure sugar and that one sugar molecule weighs $5{,}7 \times 10^{-22}$ grams, how many M&Ms would you have to eat to consume one mole of sugar molecules?

Station #1: calcium chloride

Formula: $CaCl_2$

➢ There are 4,5 x 10^{24} chloride ions in this bottle.

❖ How many moles of calcium chloride are in the bottle?

Answer: 3,74 moles

Station #2: copper

Symbol: _______________ Molar mass: ___________

❖ What mass of this copper wire would you have to weigh out to provide 4,5 x 10^{22} copper atoms?

Answer: 4.75 grams

Station #3: copper(II) sulfate

Formula: $CuSO_4$

➢ The sample here contains 9,91 x 10^{24} oxygen atoms.

❖ How many moles of oxygen atoms are in the sample?
❖ How many moles of copper(II) sulfate are in the sample?

Answers: 16,5 moles O atoms, 4,11 moles copper(II) sulfate

Station #4: carbon dioxide

Formula: _______________ Molar mass: ___________

➢ The balloon contains 0,125 moles of exhaled breath.
➢ 5,5% of exhaled breath is carbon dioxide gas.

❖ What is the mass of carbon dioxide in the balloon?

Answer: 0,303 grams

Station #5: water

Formula: _______________ Molar mass: ___________

➢ The density of water is 1,00 g/mL. There is 35 mL of water in this glass.

❖ How many individual water molecules are in the cylinder?

Answer: $1{,}17 \times 10^{24}$ molecules

Station #6: sodium carbonate

Formula: Na_2CO_3 Molar mass of just sodium: ___________

➢ This sample contains 37,1 g of sodium (only).

❖ How many moles of sodium ions are present in the sample?
❖ How many moles of sodium phosphate are in the sample?

Answers: 1,61 moles sodium, 0.805 moles sodium carbonate

Station #7: aluminum

Symbol: _______________ Molar mass: ___________

➢ The mass of the aluminum foil ball can be easily measured.

❖ How many individual atoms of aluminum are in the ball of foil?

Answer: Unique to mass of ball…each gram has $2{,}23 \times 10^{22}$ atoms

Station #8: acetone (nail polish remover)

Formula: C_3H_6O Molar mass: ____________

➢ Weigh the empty bottle with cap, add a small amount of acetone, and weigh again.

❖ How many moles of acetone are in the beaker?
❖ How many moles of hydrogen atoms are in the beaker?

Answers: Unique to mass of acetone… each gram has 0,017 moles of acetone… and 0,103 moles of hydrogen atoms.

Equation writing and balancing

Balancing Equation HINTS FOR SUCCESS

- Balance elements that appear in multiple reactants or multiple products **last**.
  - Usually that means <u>oxygen last</u>, and <u>hydrogen next-to-last</u>.
- Don't touch the subscripts!
- Write the equation so that the coefficients are the smallest set of integers possible

1. ______ GaF_3 + ______ Cs → ______ CsF + ______ Ga
2. ______ Na_3PO_4 + ______ $CaCl_2$ → ______ NaCl + ______ $Ca_3(PO_4)_2$
3. ______ C_5H_{12} + ______ O_2 → ______ CO_2 + ______ H_2O
4. ______ MgF_2 + ______ Li_2CO_3 → ______ $MgCO_3$ + ______ LiF
5. ______ $RbNO_3$ + ______ BeF_2 → ______ $Be(NO_3)_2$ + ______ RbF
6. ______ C_2H_6 + ______ O_2 → ______ CO_2 + ______ H_2O
7. ______ $AlBr_3$ + ______ K_2SO_4 → ______ KBr + ______ $Al_2(SO_4)_3$
8. ______ $AgNO_3$ + ______ Cu → ______ $Cu(NO_3)_2$ + ______ Ag
9. ______ Na_3PO_4 + ______ KOH → ______ NaOH + ______ K_3PO_4
10. ______ $Ca(HCO_3)_2$ + ______ HNO_3 → ______ CO_2 + ______ H_2O + ______ $Ca(NO_3)_2$

For each of the following reactions, write a balanced chemical equation, including STATES.

1. Propane gas (C_3H_8) in the presence of oxygen gas (O_2) and a spark will create carbon dioxide and water vapor.

2. Gaseous phosphorous trihydride reacts with oxygen gas to produce solid tetraphosphorous decoxide and water vapor.

3. Methane gas (CH_4) in the presence of ammonia gas (NH_3) and oxygen gas will produce gaseous hydrogen cyanide (HCN) and water vapor.

4. When hydrobromic acid (HBr) is combined with an aqueous solution of magnesium hydroxide [$Mf(OH)_2$], the products are water and magnesium bromide ($MgBr_2$), which is soluble in water.

Stoichiometry Puzzle #1:

Percent Yield of Carbon Dioxide in the Reaction between Alka-Seltzer and Hydrochloric Acid

Introduction:
The compound that is used to form the bubbles of carbon dioxide when Alka-Seltzer is added to water is sodium hydrogen carbonate (common name: baking soda). Each Alka- Seltzer tablet also contains an acid which, when in contact with water, reacts with the baking soda to release the carbon dioxide gas. If additional acid, like HCl(aq) is added to a tablet, the reaction proceeds more quickly.

Reaction:
Sodium hydrogen carbonate [$NaHCO_3$(s)] reacts with hydrochloric acid [HCl(aq)] to produce sodium chloride (NaCl), water and carbon dioxide gas.

Before you enter the lab, perform the following on a separate piece of paper:
Identify the chemical equation. Write a balanced equation for the reaction you will perform, as described above. Remember to include states.

Determine theoretical yield: The package label states that there are 1916 mg of baking soda (sodium hydrogen carbonate) in each Alka-Seltzer tablet.

1. Using stoichiometry, calculate the ***theoretical yield*** of carbon dioxide per tablet, that is, the mass of carbon dioxide you expect to be produced in the reaction.
   Step #1: Mass of baking soda to moles of baking soda – use molar mass.
   Step #2: Moles of baking soda to moles of carbon dioxide – use molar ratios in balanced equation.
   Step #3: Moles of carbon dioxide to grams of carbon dioxide.

Identify the **minimum** volume of HCl required for a complete reaction.

2. Using stoichiometry, calculate the moles of HCl (not mass…) needed to completely react with this amount of baking soda.

3. The amount of HCl(aq) in the solution used in this lab is 6.00 *M*. This is a unit of solution concentration called ***molarity***, and is defined as *moles of acid per liter of solution*. Using this information, calculate the minimum volume of the acid solution you will need to provide the number of moles of HCl(aq) you calculated above.

Lab Procedure:
Determine the actual yield of carbon dioxide.

- ❑ Using a calibrated straw pipette, add the calculated volume of acid (from #3 above) to a Styrofoam cup, then ADD 5 mL MORE acid to the cup. (Do you know why?)
- ❑ Weigh the beaker with the acid and record: ___________________________
- ❑ Weigh the tablet and record: ____________________________
- ❑ Perform the reaction by dropping the tablet in the acid.
- ❑ Swirl the cup gently for at least two minutes, until you are sure the reaction is complete. Then weigh the beaker plus the contents and record: _____________________________

Data collection and Analysis. Answer the following questions on a separate piece of paper:

4. Use your data to determine the mass of carbon dioxide gas that has been produced in this reaction. This is the ***experimental yield***.

5. Determine the percent yield of this reaction.
   NOTE: the equation for percent yield is… $\frac{Experimental\ yield}{Theoretical\ yield} * 100$

Stoichiometry Puzzle #2:

Identifying the Charge of the Iron Ion Produced in a Reaction

INTRODUCTION

In this investigation, solid iron will be added to a solution of copper(II) ions. A reaction will occur in which the solid iron will become a positively charged ion and will "replace" the copper ions, which will appear as a solid copper precipitate (uncharged). Iron forms two types of positive ions, Fe^{2+} and Fe^{3+}. You shall collect data and use stoichiometry to determine which of these ions is formed in the reaction.

REACTION

When solid iron is added to a solution of copper(II) sulfate ($CuSO4_{(aq)}$), a single-replacement reaction occurs that produces solid copper and an iron(?) sulfate solution.

PROCEDURE

<u>Prepare hot copper(II) sulfate solution:</u>

- ❑ With a styrofoam cup on a balance, "tare" the balance and add between 9 and 10 grams of copper(II) sulfate to the cup. Record the exact mass on a separate piece of paper, providing units and a label for the measurement.
- ❑ Fill your cup half way with very hot water. Stir to dissolve the solid.

<u>Measure the iron filings and perform the reaction:</u>

- ❑ While the solution is cooling a bit, tare a plastic cup and add between 1,4 and 1,6 grams of iron filings. Record the exact mass of iron filings. Again, provide a label and units.
  NOTE: This mass of iron is small enough that all of it will react, thus it is called the *limiting reactant*.
- ❑ Stir the iron filings into the hot solution.
- ❑ Allow the reaction to sit for at least 3 minutes to ensure completeness of reaction.

<u>Isolate and rinse the solid product</u>

- ❑ Write your initials on and then weigh a piece of coffee filter paper. Record this data below.
- ❑ Prepare a filtration apparatus using a plastic water bottle, as demonstrated by your instructor.
- ❑ Swirl the reaction mixture one more time and pour slowly into the prepared filtration apparatus.
- ❑ Rinse the beaker with about 10 mL of deionized water and pour this through the filter.
- ❑ Rinse the solid by squirting about 5 mL of deionized water directly into the filter paper. Repeat.
- ❑ Finally, rinse your solid and the paper with acetone.
- ❑ Carefully remove the filter paper and place on a dry flat surface and allow to dry for 10 minutes.

<u>Determine the *actual yield*</u>

- ❑ Weigh the filter paper and dry solid. Record this data and determine the mass of solid produced.

PRELIMINARY ANALYSIS (while you are waiting for your solid copper product to dry…)

Because there are two possible charges on the iron ion, there are two possible balanced equations that govern the molar ratios involved with this reaction. Using the mass of iron used in the reaction, use stoichiometry to calculate the two possible values for the *theoretical yield* of copper.

- ➢ If Fe^{2+} is the ion produced… **$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$**
  Step #1: mass of iron to moles of iron (use molar mass)
  Step #2: moles of iron to moles of cupper (use mole ratios in the balanced equation)
  Step #3: moles of copper to mass of copper (use molar mass)
- ➢ If Fe^{3+} is the ion produced… **$2\ Fe(s) + 3\ CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(aq) + 3\ Cu(s)$**
  (Same three steps…)

RESULTS (Once your copper is dry and you have recorded your final piece of data)

1. Use your collected data to identify the charge on the iron ion produced in the reaction.
2. Calculate the percent yield of the reaction: $\frac{Experimental\ yield}{Theoretical\ yield} * 100$

CHALLENGE: Additional Calculations

3. Assuming the reaction went to completion, what mass of copper(II) sulfate *reacted with* the iron?
4. What mass of copper(II) sulfate remained *unreacted* when the reaction was over?
5. What mass of iron would be needed in order to consume the unreacted copper(II) sulfate?

Thermochemistry Activities

1. Acetone on Hands – Bond Breaking and Forming
   METHOD: This is an easy way to get discussion going. Put some acetone (nail polish remover) into a glass with a wide opening. Have students dip their hands in, take them out, and wave them around.
   DISCUSSION: Liquid to gas phase change; Bonds are broken; It feels cold because heat (energy) is *leaving* your hand; Potential energy of the particles increases; Create an energy diagram of energy absorption; Identify as *endothermic*.
   Repeat the process for a process in which bonds are formed…

2. Baggie Demo – Heat changes with physical change
   METHOD: Put a good amount of calcium chloride (di-icing crystals) into one set of zippable clear plastic bags, and put a good amount of ammonium nitrate (garden supply store) into another set. It is best to have about 4-5 students per bag. Have students pour in a cupful of water into each bag. Seal tightly and pass the bag around. Then have students share bags with another group.
   DISCUSSION: Students are likely to predict an endothermic process here, as the bonds within the solids are broken as it dissolves. But how can the process be exothermic? Bonds of hydration are formed during dissolving, too: attractions between the charged particles in the solids (ions) and the water molecules. Exothermic vs. endothermic depends on whether the breaking or the forming is greater.

3. Alcohol Combustion – Heat changes with chemical change: an exothermic example.
   METHOD: Pour some isopropyl alcohol into a 2-L soda bottle, about 5 mL or so. Cover the opening with your hand and shake to distribute and vaporize the liquid. Place the bottle on a surface that is cleared both in front and behind it. Light a match and, *standing backwards from the opening*, place the flame in front of the opening.
   SAFETY NOTE: Flames will fly out the opening, while the bottle will shoot across the room.
   DISCUSSION: The students should recognize this as an exothermic change. The reaction and heat exchange can be quantified in a thermochemical reaction equation:
   $$C_3H_7OH(l) + 5\,O_2(g) \rightarrow 3\,CO_2(g) + 4\,H_2O \quad \Delta H = -\,2021\ kJ/mol.$$
   Note and discuss the negative sign… why is it negative? Refer back to energy diagrams above. Discuss how you could use this quantitatively: how much heat is released when 1,00 gram of alcohol is burned? *[33,7 kJ]*

4. Baking soda and vinegar – Heat changes with chemical change: an endothermic example.
   METHOD: Put a spoonful of baking soda (sodium bicarbonate) in a Styrofoam cup and add about 20 mL of vinegar (acetic acid). The products are carbon dioxide, water, and sodium acetate. Use a thermometer to register the temperature change. It is subtle.
   DISCUSSION: The decrease in temperature indicates that this is an endothermic reaction. The thermochemical equation is:
   $$NaHCO3(s) + CH3COOH(l) \rightarrow CO_2(g) + H_2O + NaCH3COO(aq) \quad \Delta H = +\,30{,}1\ kJ/mol.$$
   Note and discuss the positive sign… why is it positive? Refer back to energy diagrams above. Discuss how you could use this quantitatively: how much heat is released when 1,00 gram of baking soda is burned? *[33,7 kJ]*

Electrochemistry Activities

Create a Cola Can Battery

In this activity, each student group prepares one "cola" galvanic cell battery. When the batteries are connected in series, they should create enough current to light an LED bulb.

- A can of cola
- A copper coin
  - Can opener
  - Steel wool
  - Two pieces of copper wire (preferably with clips)

1. Open your can of cola and pour the contents into a cup and set it aside.
2. Using a can opener cut off the top of the can. Clean and dry the inside of the can.
3. To remove the protective plastic coating on the inside of the can, scrub with steel wool.
4. Pour the contents from the cup back into the can.
5. Take one of your wires and wrap it around (or clip it to) the copper coin, then dip it into the drink. Attach another wire to the top of the cola can.
6. When the two wires are connected, they produce a small current.

<u>The chemistry of the reaction</u>

Solid aluminum is oxidized to Al^{3+} ($E°_{cell}$ = -1,66) at the Al electrode, and water is reduced to H_2(g) and OH^- ($E°_{cell}$ = -0,83) at the Cu electrode. The wire allows electrons to flow between these two processes. The phosphoric acid in cola allows for charge neutrality

<u>Analysis and Discussion:</u>

Sketch a schematic diagram of the cell, showing the half reactions and the direction of electron flow through the wire. Identify which metal is the anode and which is the cathode. Discuss what will happen over time as the battery continues to supply current. Why will it go "dead?"

ALTERNATIVE: A Salt-Water Battery

Create a battery in a plastic cup by filling the cup with water, adding plenty of salt, and hanging a zinc-coated nail from one side and a strip of aluminum (perhaps from a soda can) on the other side. Connect the metals with a wire, and the battery is complete. As for the Cola Can battery, you would need to connect batteries in series to light an LED bulb.

Electrolysis of Water

In this demonstration, electricity from a battery is used to force a non-spontaneous redox reaction. If at all possible, don't make this a demonstration. Allow student groups to make their own.

  - Black permanent marker
  - Two metal thumbtacks
  - Epsom salt ($MgSO_4 \cdot 7\ H_2O$)
- 9-volt battery
- Water
- Scissors
- Glass or plastic cup
- Paper towels
  - Clean, empty, clear and colorless plastic water bottle with cap with the label removed

1. Remove the cap from the water bottle. Turn the lid over so that the top of the lid touches the two contacts of a 9-volt battery. Center the lid over the two contacts. Using a black marker, make two dots on the inside of the lid, one over the center of each contact.
2. Place the lid on a hard surface with the top of the lid facing up. Push a metal thumbtacks into the top of the lid directly over each of the dots. The two thumbtacks should not touch.
3. Using scissors, cut off the top half of the bottle. Tightly screw the lid back onto the bottle.
4. Fill the bottom half of the cut water bottle approximately half full of water. Add about a teaspoon of Epsom salt. Swirl to stir until most of the salt dissolves.
5. Pour the Epsom salt solution into the top half of the bottle (hold so the lid faces down).
6. Place the two thumbtacks so that each touches one of the contacts on the 9-volt battery.

7. Place the battery into the bottom of a glass or clear plastic cup, held upright with paper towels or modeling clay. The top of the bottle can then be rested on top of the battery.

Analysis and Discussion

There is so much you can do here… Ask questions like: What are the two gases? Might they be the same gas? What is the reaction? What is the purpose of the battery? Then you could demonstrate why this is a reaction in which there is a transfer of electrons by showing the two half reactions. A fun thing to do is to use some cabbage juice indicator and see if you see color differences around the thumbtacks.

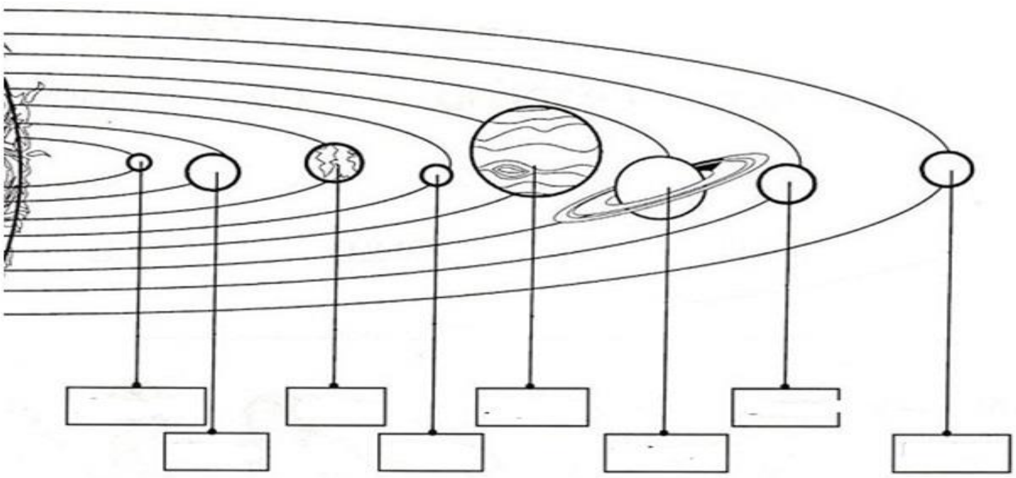
Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.631	33 **As** Arsenic 74.922	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 84.798
37 **Rb** Rubidium 84.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.711	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.294
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.328	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.085	79 **Au** Gold 196.967	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [268]	110 **Ds** Darmstadtium [269]	111 **Rg** Roentgenium [272]	112 **Cn** Copernicium [277]	113 **Uut** Ununtrium unknown	114 **Fl** Flerovium [289]	115 **Uup** Ununpentium unknown	116 **Lv** Livermorium [298]	117 **Uus** Ununseptium unknown	118 **Uuo** Ununoctium unknown

Lanthanide Series	57 **La** Lanthanum 138.905	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.243	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.055	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]

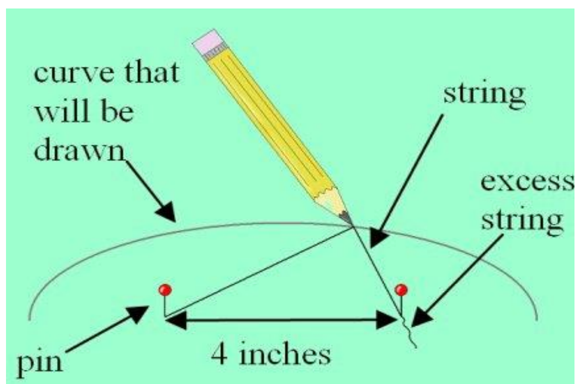
THE SOLAR SYSTEM

Can you correctly identify and label the planets below?			
URANUS	MARS	MERCURY	JUPITER
VENUS	NEPTUNE	EARTH	SATURN



ACTIVITY #1: MAPPING THE PATHS OF THE PLANETS

Planets travel around the sun in ellipses, not circles. The Solar System looks like a flat disc or plate. The Sun spins (rotates) at the centre and the planets and all other objects orbit around it in the same direction. A variety of objects orbit the Sun - eight planets and their moons, rocky asteroids, outer dwarf planets and many distant icy and dusty objects in the Kuiper Belt and Oort Cloud.



Supplies:

- ♦ A pencil
- ♦ A sheet of paper (8 ½" by 11")
- ♦ Six thumbtacks
- ♦ A piece of string 8 inches long
- ♦ A sheet of cardboard

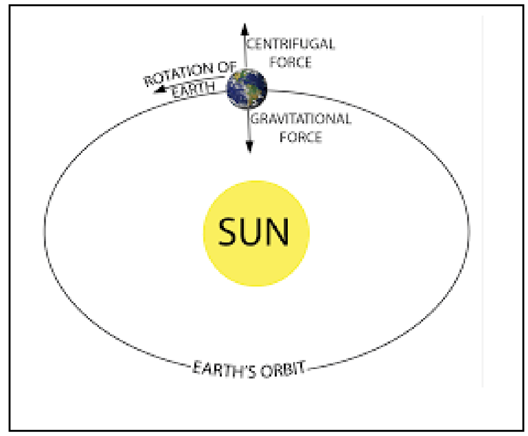
Procedure:

1. Lay the sheet of paper on top of the cardboard and pin it at each corner.
2. Take the remaining two pins and pin your string horizontally 5 inches apart and across from each other as shown in the picture above. There should be excess string dangling.
3. Take a pencil, keeping the string tight, and move from one pin to another, first above and then below
4. The result will be two curves that reflect each other. It is an oval, which mathematicians call an ellipse.
5. Pull the right pin off the paper and re-pin it through the very end of the string and back into the exact location as before. The pins will be in the same place, but with more string in-between and no excess.
6. Once again, use the pencil and string to draw two curves: one below the pins and one above them.

ACTIVITY #2: GRAVITATIONAL FORCE & CIRCULAR MOTION

The Sun is like all other stars – it produces large amounts of heat and light continuously. The energy in our Sun comes from powerful nuclear reactions during which hydrogen gas changes into helium gas. The immense mass of the sun keeps all the planets in their stable, predictable orbits due to the force of gravity. How does this happen? Circular motion requires a special kind of force. In this experiment we'll explore that force

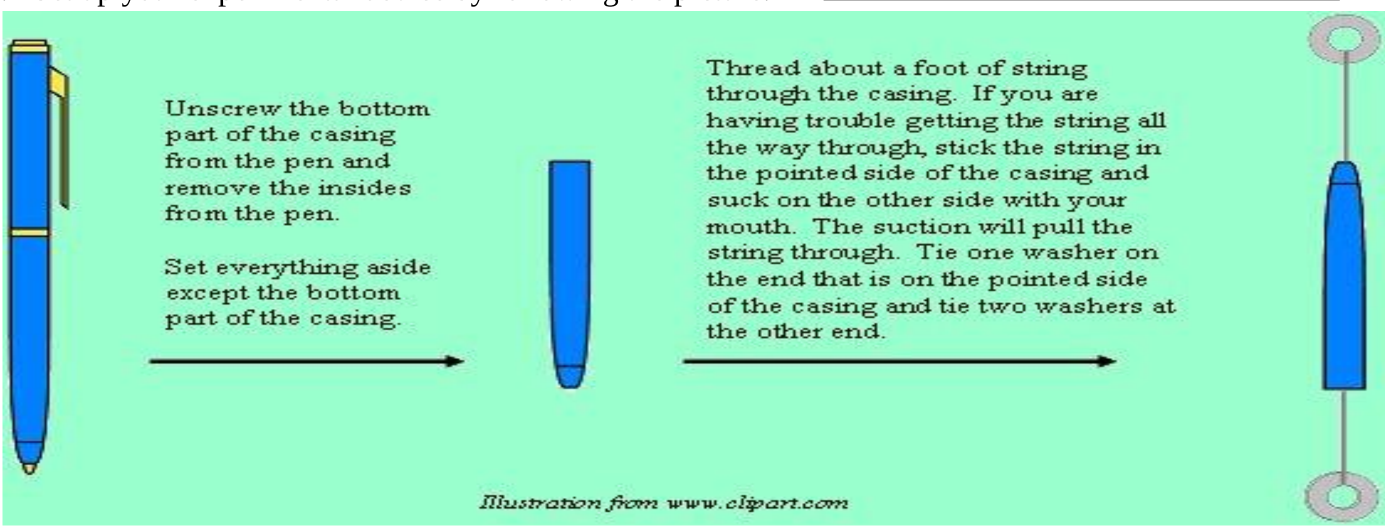
Supplies:



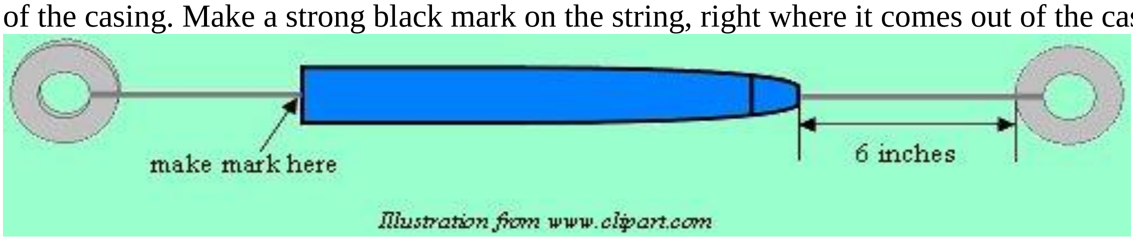
- A mechanical pen
- A black marker
- Thin string or thread (preferably white)
- Five metal washers, all the same size
- Stopwatch
- Scissors

Procedure:

1. Set up your experimental device by following the picture.



2. Lay your device on the table and pull the string so that about 6 inches of string comes out the pointed side of the casing. Make a strong black mark on the string, right where it comes out of the casing.



3. Hold the device by grasping the pen with the pointed end up and begin twirling the single washer.
4. The faster you twirl the washer the sweep to become larger. The slower you twirl, the smaller the circle
5. Adjust the rate you are twirling until the black mark is visible right at the bottom of the pen casing.
6. Time how long it takes for the washer to make 20 full circles with the black mark visible at the bottom.
7. Add two more washers to the two washers already on the string. There are now four washers on one end
8. Repeat step 6 and determine how long it takes the single washer to make 20 circles against more mass.
9. Try to twirl the single washer so that the time it takes to make 20 full circles is *equal* to what you got in step 6. In other words, try twirling the heavier at the same rate as the lighter one. Watch the black mark
10. Finally, while the washer is still twirling around, cut the four washers off the string with the scissors. **Make sure no one else is near when you do this.** What happens?

Name: ______________________________ Period: ______ Date: ______________

Why Do They Call it "Space"?

Our solar system, with the sun at the center, is like our own little cosmic neighborhood. We have our close neighbors, the **terrestrial, inner planets**, and those a bit farther, the **gaseous, outer planets**. Our neighbor closest to the sun, **Mercury**, is the smallest planet with the biggest daily swings in temperature; from 801°F during the day to -279°F at night. Between us and the sun is **Venus**, a planet with a thick atmosphere that creates a surface pressure 90 times greater than that of Earth. Our own planet, **Earth**, is unique within our solar system in its ability to support life. Moving farther out, **Mars**, known as the "red planet," has some qualities similar to Earth like crustal movement, volcano activity, and polar ice caps that change with the season and may have supported life at one time in its history. Passing the **asteroid belt** we come to our first gas giant, **Jupiter**. Named for the Roman king of the gods, Jupiter is the largest planet in our solar system known for its large red spot that is a spinning storm that has been raging for over 300 years. Next in line **Saturn** is perhaps the most easily identified planet with its beautiful rings and, with 52 known moons, is almost a cosmic neighborhood on its own! Saturn's neighbor, **Uranus**, has an upper atmosphere comprised mostly of methane, absorbs red wavelengths of light causing it to be a beautiful blue-green color in the small amount of sunlight that is able to reach this far out in space. We knew about our final planetary neighbor, **Neptune**, through mathematical calculations by Galileo before we ever spotted it with a telescope.

Though knowing your neighbors is a great way to get to know your community, nothing gives you a sense of place better than a map. Today in lab we're going to do just that. You and your partners will be making a scale map of our solar system to get a clearer idea of our place in our cosmic neighborhood.

Question: Why do they call space "space"?

Materials:

- ✓ Cash Register Tape
- ✓ 2 meter sticks
- ✓ Tape
- ✓ Rulers
- ✓ Markers

Pre-lab Questions:

Use the paragraph above to complete the matching below.

_______ Venus

_______ Mercury

_______ Earth

_______ Mars

_______ Jupiter

_______ Saturn

_______ Uranus

_______ Neptune

A. Its atmosphere absorbs red wavelengths of light

B. The only planet in our solar system to support life

C. Has a 300+ year old storm in its atmosphere

D. Has extreme temperature swings in a single day

E. Its polar ice caps change with the seasons

F. Galileo discovered it with math

G. Would have mega tides with its 52 moons

H. Has a surface pressure 90 times that of Earth

1. Complete the tables below. Use the scale **1 mm = 1,000km** for the Planetary Diameter table. Use the scale **1 mm = 100,000 km** for the Distance from the Sun table.
2. Once you have completed your tables, use your rolls of toilet paper to make your scale model of our solar system. Label your planets and make sure your distances AND diameters are to scale!!

Planetary Diameter **Scale: 1 mm = 1,000 km**

	Diameter			
Planetary Body	**Kilometers (km)**	**Millimeters (mm)**	**Centimeters (cm)**	**Meters (m)**
Sun	1,391,900			
Mercury	4,866			
Venus	12,106			
Earth	12,742			
Mars	6,760			
Jupiter	142,984			
Saturn	116,438			
Uranus	46,940			
Neptune	45,432			

Distance from the Sun **Scale: 1 mm = 100,000 km**

	Distance From Sun			
Planetary Body	**Kilometers (km)**	**Millimeters (mm)**	**Centimeters (cm)**	**Meters (m)**
Sun	0			
Mercury	57,909,227			
Venus	108,209,475			
Earth	149,598,262			
Mars	227,943,824			
Jupiter	778,340,821			
Saturn	1,426,666,422			
Uranus	2,870,658,186			
Neptune	4,498,396,441			

Name ____________________________ Date ____________________ Class ____________

EXPLORING SPACE: Design and Build a Water Rocket

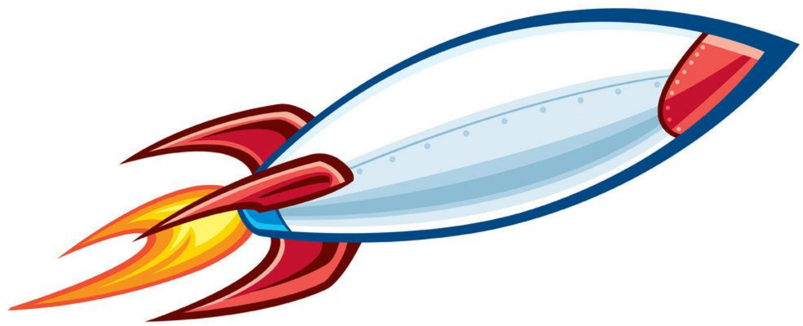
In this lab, you will learn how to design and build a water rocket.

Problem

Can you design and build a rocket propelled by water and compressed air?

Design Skills

observing, evaluating the design,
redesigning



Materials

large round balloon
scissors
tap water
graduated cylinder
50 paper clips in a plastic bag
empty 2-liter soda bottle
poster board
modeling clay
hot glue gun or tape
bucket, 5 gallon
stopwatch
tire pump (one per class)
water rocket launcher (one per class)

Procedure

PART 1 Research and Investigate

1. Copy the data table on a separate sheet of paper.
2. In an outdoor area approved by your teacher, blow up a large round balloon. Hold the balloon so that the opening is pointing down. Release the balloon, and observe what happens. **CAUTION:** *If you are allergic to latex, do not handle the balloon.*
3. Now place 50 mL of water in the balloon. Blow it up to the same size as the balloon in Step 2. Hold the opening down, and release the balloon. Observe what happens.
4. Repeat Step 3 two more times, varying the amount of water each time. Write down your observations.

PART 2 Design and Build

5. You and a partner will design and build a water rocket using the materials provided. Your rocket must

- Be made from an empty 2-liter soda bottle
- Have fins and a removable nose cone
- Carry a load of 50 paper clips
- Use only air or a mixture of air and water as a propulsion system
- Remain in the air for at least 5 seconds
- Be able to be launched on the class rocket launcher

PART 3 Evaluate and Redesign

6. Begin by thinking about how your rocket will work and how you would like it to look. Sketch your design and make a list of materials that you will need.

7. Rockets often have a set of fins to stabilize them in flight. Consider the best shape for such fins, and decide how many fins your rocket needs. Use poster board to make your fins.
8. Decide how to safely and securely carry a load of 50 paper clips in your rocket.
9. Based on what you learned in Part 1, decide how much, if any, water to pour into your rocket.
10. After you obtain your teacher's approval, build your rocket.
11. Test your rocket by launching it on the rocket launcher provided by your teacher.

CAUTION:
Make sure that the rocket is launched vertically in a safe, open area that is at least 30 m across. All observers should wear goggles and stand at least 8–10 m away from the rocket launcher. The rocket should be pumped to a pressure of no more than 50 pounds per square inch.

12. Use a stopwatch to determine your rocket's flight time (how long it stays in the air).
13. Record in a data table the results of your own launch and your classmates' launches.
14. Compare your design and results with those of your classmates.

Analyze and Conclude
Write your answers on a separate sheet of paper.
1. Observing What did you observe about the motion of the balloon as more and more water was added?
2. Drawing Conclusions What purpose did adding the water to the balloon serve?
3. Designing a Solution How did your results in Part 1 affect your decision about how much water, if any, to add to your rocket?
4. Evaluating the Design Did your rocket meet all of the criteria listed in Step 5? Explain.
5. Evaluating the Design How did your rocket design compare to the rockets built by your classmates? Which rockets had the greatest flight time? What design features resulted in the most successful launches?
6. Redesigning Based on your launch results and your response to Question 5, explain how you could improve your rocket. How do you think these changes would help your rocket's performance?
7. Evaluating the Impact on Society Explain how an understanding of rocket propulsion has made space travel possible.

CommunicateOn a separate sheet of paper, write a paragraph that describes how you designed and built your rocket. Include a labeled sketch of your design.

ACTIVITY #3: An Expanding Universe

The Universe is so vast, people have to measure distances beyond the Solar System in light years – or how far light travels in a year. Our closest neighboring star is *Alpha Centuri* at 4,2 light years away and our sun is one of billions of stars in the larger Milky Way Galaxy. Beyond the Milky Way lie BILLIONS of additional galaxies in the Universe and yet Astronomers believe the Universe continues to expand. There are many possible ways the universe could be expanding. This experiment demonstrates one of them.

Supplies:

- Balloon
- A marker (You need to be able to write on the balloon with the marker.)

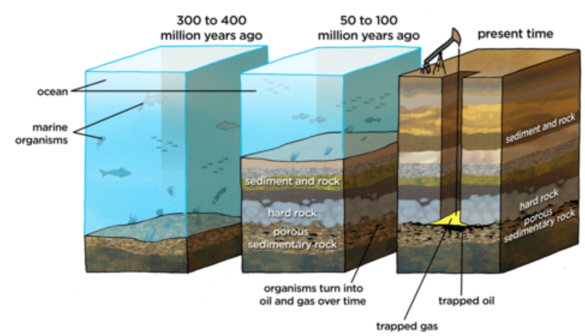
Procedure:

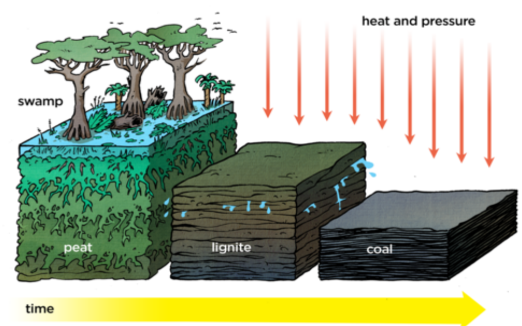
1. Lay the balloon flat on a table and use the marker to put many dots on both sides of the balloon.
2. Bring the balloon to your mouth and hold the balloon so that you can see the dots.
3. Blow up the balloon. What do the dots do? How do they move in relation to one another?

FOSSIL FUELS: Formation of coal, crude oil and natural gas

Long ago plants captured the Sun's energy and manufactured carbohydrates through the process of photosynthesis, just like plants do today. Through changes in the conditions on Earth, the land was increasingly covered by water, forming swamps. Over time the plants died, forming a thick layer of dead **vegetation** on swamp bottoms. Subjected to pressure and heat, this material eventually became coal.

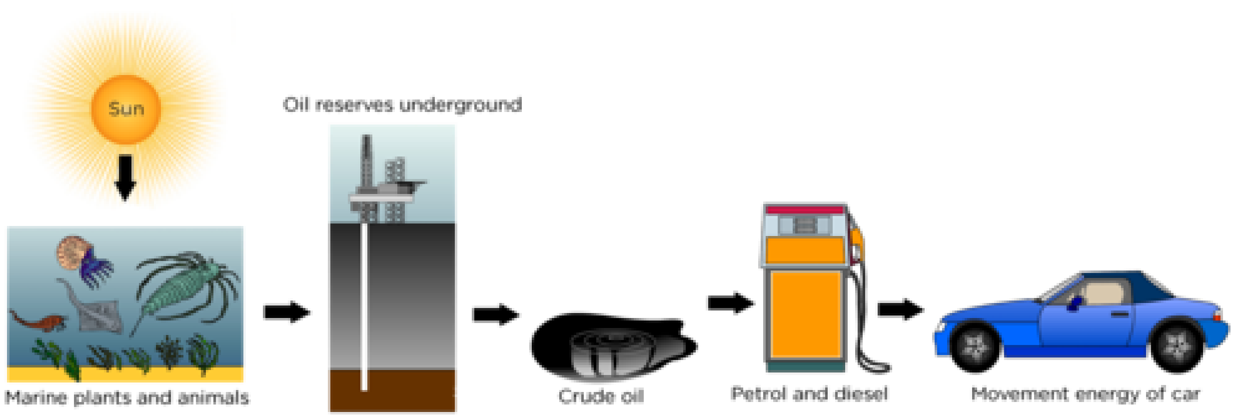
Oil, also known as crude oil, and natural gas were also formed by processes similar to those leading to the formation of coal. Sea animals and plants died in the oceans and were deposited on the ocean floor. Through the actions of temperature and pressure, the deposits were changed into crude oil and natural gas. Today, oil and gas are trapped under layers of rocks and sediment and have to be drilled and pumped out of the Earth. South Africa has some gas fields off the coast of Mossel Bay, but we do not have any oil reserves.





INSTRUCTIONS:

Petrol is made from crude oil, a fossil fuel. Use the diagram below to answer the questions about how the Sun's energy is captured in petrol and how this helps life on Earth.



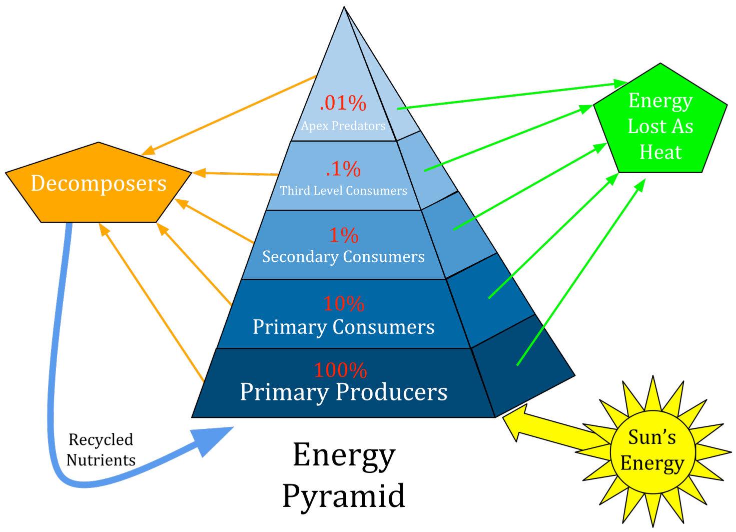
QUESTIONS:

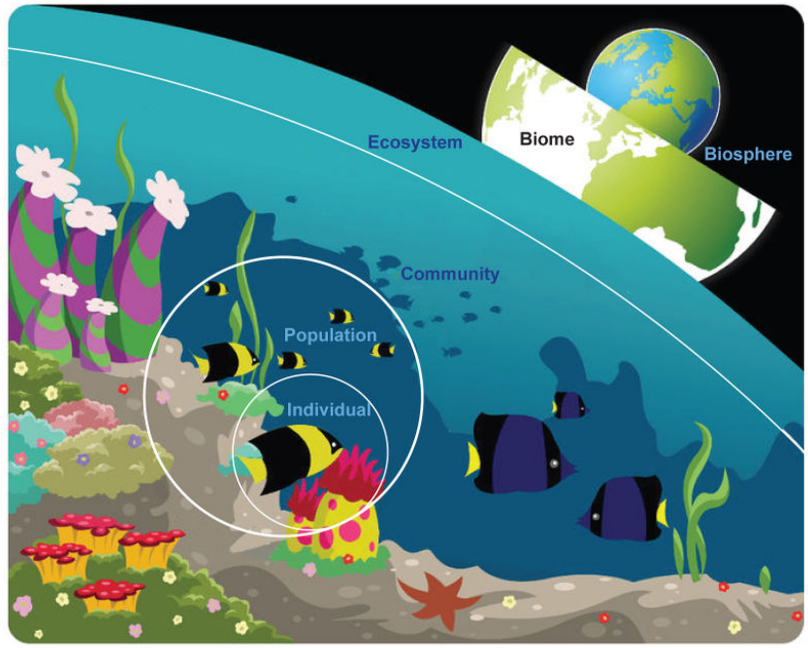
Using the diagram, explain how the Sun's energy is captured in petrol and used in cars.

Adapted from: http://www.mstworkbooks.co.za/natural-sciences/gr7/gr7-eb-01.html#toc-id-0

Ecology and Biodiversity

Energy Flow





Activity: Food Web Interactive

Estimated time: 10 minutes (can last as long as you want depending on how much you develop the activity).

Materials: yarn, index cards, hole puncher, marker.

Objective: Students will understand the interrelatedness of food webs and see how populations affect other populations.

Content:

1. Write the names of various plants and animals (a variety of types) on index cards. You can use the list below, construct your own, or have participants select their own organism. Be sure to include the sun, plants, plant eaters, and flesh eaters in the array.

   sun, grasshopper, robin, grass, berry brush, hawk, quail, dandelion, mouse, worm, rabbit, cow, flea, meadowlark, owl, wheat, tick, fox, weeds, coyote, mushrooms, microscopic bacteria

2. Punch holes in each card and give each participant a card and a piece of string to hang the card around his/her neck.

3. Have individuals identify energy (or food) sources. As each one is identified, pass a ball of yarn between the two people. For example: One student is a cow, and one is the grass. The cow will take the ball of yarn, hold onto one end of the string and pass the rest of the ball to the grass. The grass will hold onto the yarn and pass the rest of the ball to "what it eats," in this case, the sun. Be sure that the sun is connected to all the plants. Once the string gets to the sun, cut it off, and start again in another place.

4. Continue building the web, making the relationships as complex as time and numbers of participants allow. Define terms such as herbivore, carnivore, insectivore, decomposer, etc and include them in your web.

[Note that insectivores are specialized carnivores.] Students can be in as many chains as you have time for; they do not have to be in all of the chains.

5. Discuss the nature and complexity of the food web that is formed. Note that it is not as complete or complex as most natural food webs, but that it illustrates how living things are dependent upon one another. Biologists feel that more complex food webs are more stable than simple ones.

6. After discussing the food web, the leader could ask what would happen if a species were removed from the web. Have a student pull on the strings they hold; anyone who feels a tug is directly affected by that organism. Those “organisms” affected directly could then pull on their strings and more organisms are affected. Have different students pull on their strings. When the “sun” pulls on its string, everyone should be affected. Have some organisms drop their string (become extinct) and see who is affected. Have students tell you if certain populations will grow or decline. The teacher can represent nature and cause any type of problem to occur; for example, a wildfire could occur, but some birds were able to fly away and some types of trees reseed well after a fire. The teacher defines what happens and who is affected; the students then reveal what would happen. New species could also move into the area at any time disrupting the web.

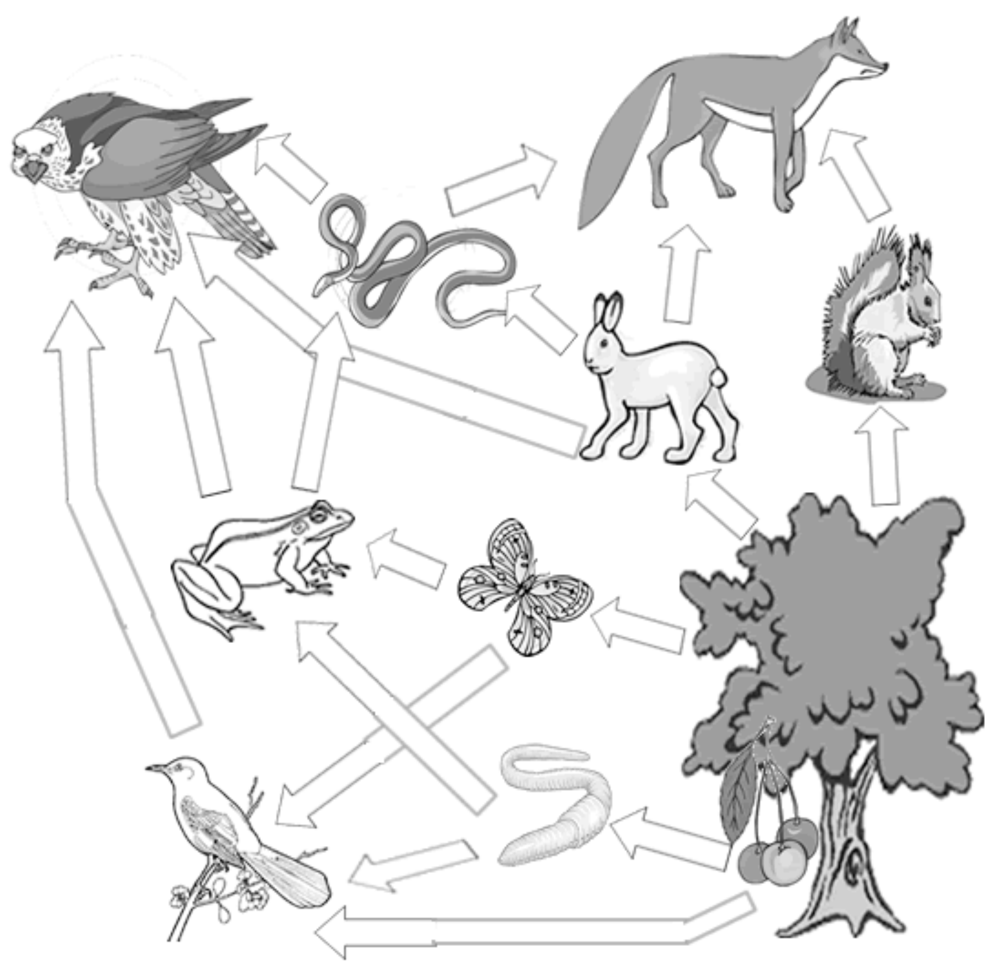
7. Discuss what would happen if all of the predators were removed. Some species might exhaust their food supply and starve, but others will continue to reproduce only until the food supply becomes limiting or their interactions limit population size.

8. If desired, discuss the simplified food webs that produce most foods used by people. Remind the participants that such food webs are inherently unstable and require large amounts of management (raising/slaughtering cows, chickens, etc) to avoid problems.

Closure: Review everything with students telling them that this is the way a food web works. They can throw away their yarn pieces.

Assessment: The activity could be assessed by participation, or students could complete a worksheet to demonstrate their mastery of the concepts, as seen below:

For the food web, label each organism (some may have more than 1 label): producer, primary consumer, secondary consumer, tertiary consumer, quartenary consumer. Then, label each organisms as either a herbivore, carnivore, or omnivore.



African Grassland Food Web Activity

In this African Grassland Food Web activity, students will be asked to connect all the individual food chains that make up this food web. Once complete, students will be asked to label which trophic level each organism belongs.

Directions: The following organisms are part of an African Grasslands food web. Using these notes, construct a food web of this ecosystem in the box by drawing arrows between the organisms, making sure to use different colors to represent each food chain in the food web. After, label what trophic level each organism belongs to: producer, primary consumer, secondary consumer, tertiary consumer, etc.

If this were to be a complete food chain/food web, what is one thing missing? Explain why it is important to include that missing part of the food chain/food web?

<u>Organisms (photos):</u>

Dung Beetles

Zebra

Vulture

Baboon

Termites

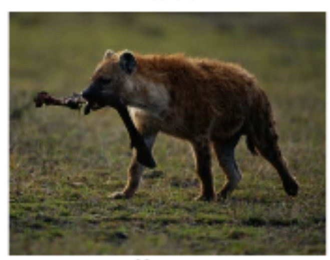
Fungi (including mushrooms)

Acacia

Grasses

Giraffe

Lion

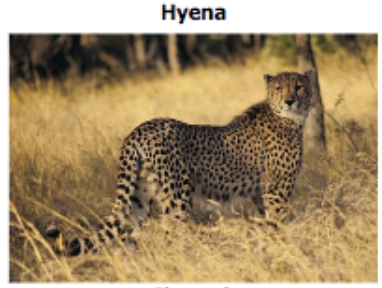


Hyena

Hunting Dog

Impala

Wildebeest



Cheetah

Leopard

Organisms (dietary habits):

- Baboon: eats grasses and other producers
- Vulture: scavenger that will feed on the remains of any dead animal
- Grasses: producer
- Acacia: producer
- Hunting Dog: eats zebra, impala, wildebeest, baboon, and hyena
- Hyena: eats impala and zebra
- Leopard: eats cheetah, impala, baboon, and hyena
- Cheetah: eats impala and zebra
- Zebra: eats grasses
- Dung Beetles: decomposers that feed on the solid waste of other animals
- Fungi (including mushrooms): decomposers of dead plants and animals
- Termites: feed on wood from the Acacia tree and will feed on grasses also
- Lion: will hunt and feed on cheetah, leopard, giraffe, impala, baboon, zebra, wildebeest, and hyena
- Giraffe: eats the leaves and new shoots of the Acacia
- Wildebeest: eats grasses
- Impala: eats grasses and the leaves of the Acacia

Food Web

The Fox and the Rabbit game

Jackie Sibenaller
Fergus Falls High School, Fergus Falls, MN 56537
Based on an original activity from "Biology: A Community Context" predator-prey simulation.

Summary

This simulation illustrates how predator-prey interactions affect population sizes and how competitive interactions affect population sizes. The student simulates the interactions between a predator population of fox and a prey population of rabbits in a meadow. After collecting the data, the student graphs the data and then analyzes the graph to predict the populations for several more generations. Students can also examine the co-evolutionary interaction between predator and prey (how predators react to selective pressure by increasing their efficiency and how prey becomes more skillful at evading their predators).

Learning Goals

One goal of this activity is to have students understand how predator-prey interactions affect population size. Students will also analyze data to predict future population sizes. A third goal is for students to explore the major factors that influence the predator-prey relationship.

Key concepts the student should acquire from this activity include how carrying capacity of the environment for the prey population defines the maximum number of prey individuals that can be maintained. They should also see how the reproductive rates of both predator and prey play a crucial role in both population sizes. A third concept students should identify is that behavioral responses of the predators to changes in prey density (migration or change in prey) will affect the pressure on prey.

Before playing this game students should be able to define a food chain, population, immigration, carrying capacity, predator and prey.

Context for Use

I use this activity with a special education inclusion class in 10th grade biology. It can be used in the regular biology classroom, but I would increase the rigor of the game by adding additional predators and other biological factors that can affect populations. This activity is used during a study of populations and ecosystems. The game takes approximately 30 minutes to play. So with an introduction to the game and a closure after the game, I usually allow 45 minutes.

Materials:

-50 10x10 cm tagboard squares of one color (representing the fox)
-200 5x5 cm construction paper squares of another color (representing the rabbits)
-1 50x50 cm square section of table top (the meadow)
-Masking tape (to mark off the meadow)
-Data table
-Graph paper

Rules of the game:

You will start the first round with 3 rabbits and 1 fox. The surviving rabbits each produce one offspring for the start of the next round. The fox will survive if it captures (lands on) at least one rabbit, but will only reproduce if it lands on three or more rabbits during one drop in one round. If the fox does not land on any rabbits during a round, it dies, and a new fox will immigrate into the meadow so you will always have at least one fox to start each round. If all the rabbits are captured during a round, three new rabbits will immigrate into the meadow to start the next round. Each round represents one year or a generation.

Procedure:

Use masking tape to outline a 50x50 cm square on a flat surface to simulate a meadow in an ecosystem.

Randomly distribute 3 rabbit cards in the meadow.

Take the fox square and drop it from a height of 10 to 15 cm above the rabbits in an effort to catch a rabbit. (At this point in the activity there is no way that the fox can catch the 3 rabbits that it needs to survive and reproduce. The fox is not allowed to skid and the rabbits should be distributed throughout the field.)

Complete the data table for generation #1. The fox will starve if it did not land on a rabbit and there will be no surviving fox or new baby fox.

At the beginning of generation #2, double the rabbits left at the end of generation #1. A new fox immigrates into the meadow. Be sure to disperse the rabbits in the meadow.

Eventually the rabbit population increases to a level that allows the fox to catch 3 rabbits in a single toss. If the fox catches 3 rabbits it not only survives but it reproduces too! It has one baby fox for each 3 rabbits that it catches. Therefore, if it catches 6 rabbits it will have 2 babies. Fox are not allowed to cheat, but they should try to be efficient. Stupid foxes result in an overabundance of rabbits.

As the number of fox increases, throw the tagboard square once for each fox. Record the number of rabbits caught by each fox. The simulation is more realistic if the number of new baby fox is based on each foxes' catch rather than merely the total number of rabbits caught in a generation.

There are always at least 3 rabbits at the beginning of a generation. If and when the entire rabbit population is wiped out, then three new rabbits immigrate into the meadow.

Remember that the number of rabbits in the meadow needs to be correct at all times. Remove the rabbits caught and add new ones as indicated by your data table.

Model about sixteen generations and predict nine more or up to a total of 25 generations. Base the prediction on the pattern observed during the first sixteen generations.

Analysis:

Graph the data for 25 generations. Place both the rabbit and the fox data (the first two columns of the data table) on the same graph so that the interrelationship can be easily observed. Label the vertical axis "Number of Animals" and the horizontal axis "Generations." Use one color of line for rabbits and another color of line for fox.

Resources:

There are many versions of this simulation in use. Other versions include owl and mice, etc. If your students are unable to run the simulation at their own workstations then it may be played on an overhead projector. You may wish to introduce disturbances in the cycle such as killing off the fox or starving the rabbits. This activity serves as a good introduction to computer models.

Teaching Notes and Tips

Students play the game in groups of three to four.

You could introduce a new predator, such as a wolf, that would require more rabbits for survival, (by using a different color card) to the game as students are playing or after they are finished to see how this new "invader" can affect the population sizes of the existing predator and prey populations.

Assessment

Students will develop a graph from their data. They will need to analyze their graph to identify limiting factors and carrying capacity of the populations. Also, the graphs will be presented, group by group, to the entire class.

Generation	Rabbits	Fox	Rabbits Caught	Fox Starved	Fox Surviving	New Baby Fox	Rabbits Left
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

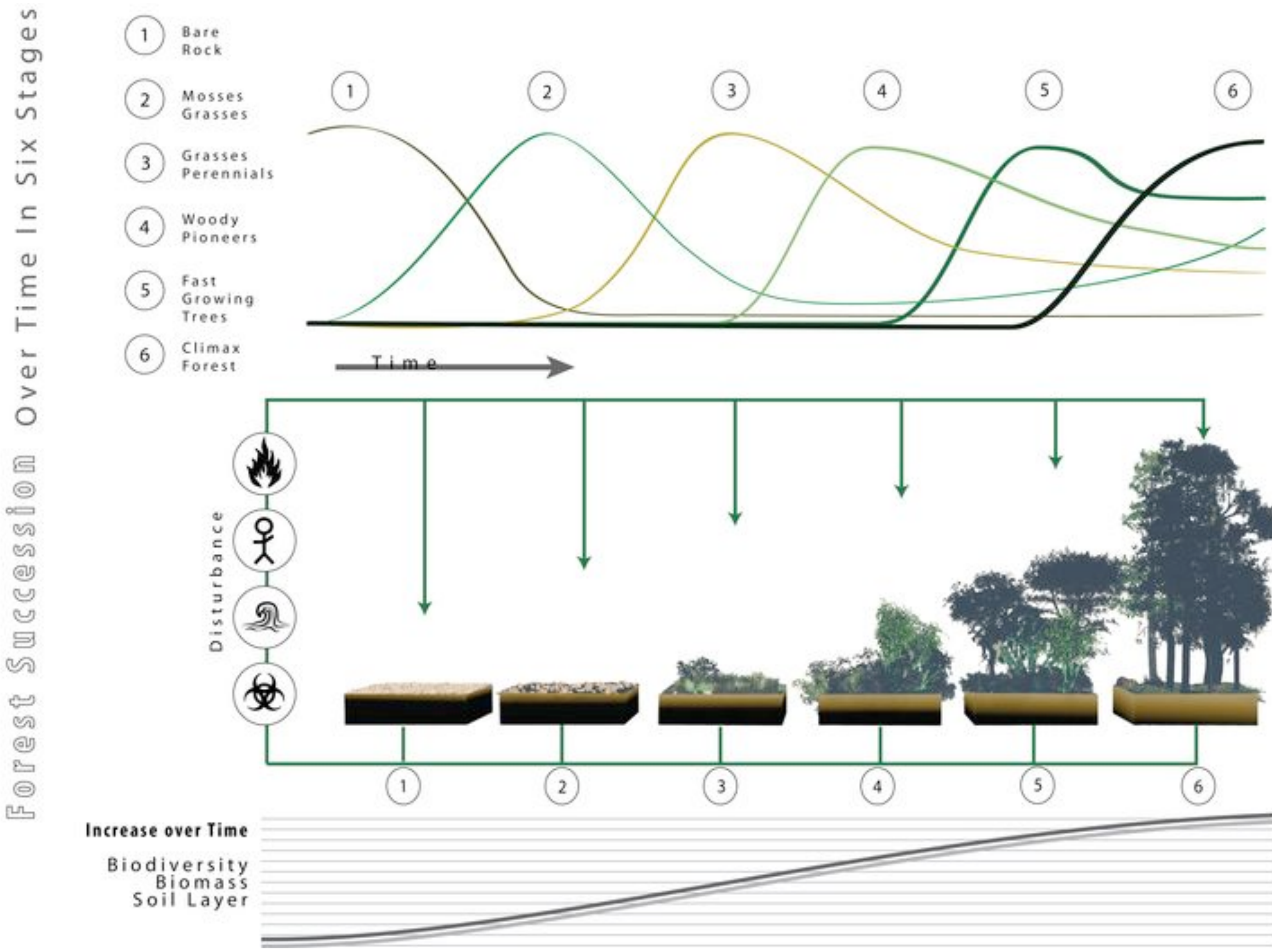
Symbiotic Relationships

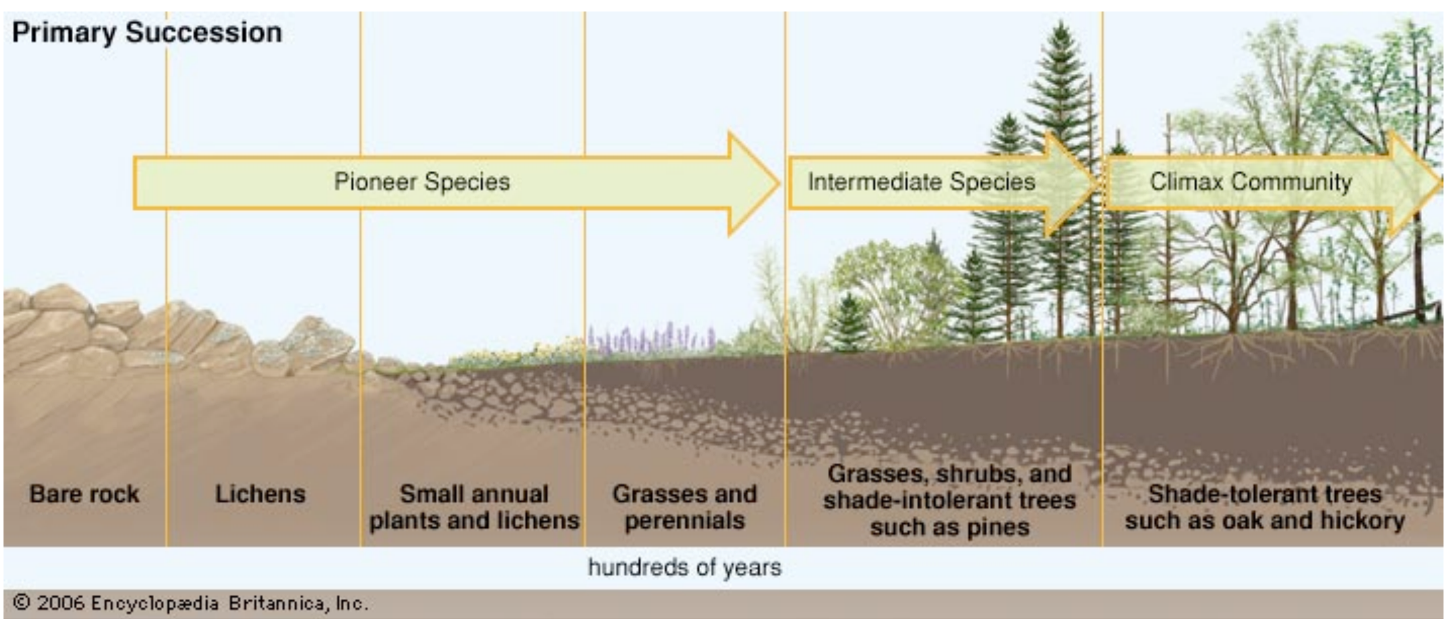
Students will be given several examples of symbiotic relationships and will need to decide if the relationship is an example of parasitism, mutualism or commensalism. Students will put each example in Pocket Foldable. Have students write the definition of each symbiotic relationship on the front of foldable.

Directions: Read the following descriptions of symbiotic relationships and decide which example of symbiosis it belongs. Cut out the description and place in the corresponding pockets of the symbiosis pocket foldable: Mutualism, Commensalism or Parasitism. Pick three of the examples and either draw illustrations on your page or find pictures to paste in your notebook.

A barracuda takes a head up posture near a coral to let the cleaner fish, living in the coral, know that it's safe for them to come out and clean its gills.	The cuckoo bird lays it's eggs in a warblers nest. When the baby cuckoo hatches, it pushes the warbler's eggs out of the nest and the warbler feeds and raises the cuckoo's young.	Whales are seen having barnacles attached to them, creating a home site for the barnacle.	Orchids grow inside bromeliad plants, which don't harm the bromeliad, but allows the orchid to obtain water and nutrients.
The tree sloth has algae growing in its fur. The alga camouflages the sloth in the tree to hide it from predators.	Heartworms develop inside a dog's heart, living off the blood and causing severe health problems, and sometimes death.	Remoras attach themselves to a shark's body, feeding on scraps leftover from the shark's meal. The remoras neither hurt nor harm the shark.	In the rainforest, the acacia tree provides nectar and shelter for acacia ants and in return the ants kill herbaceous insects and any nearby plant competing for the space.
Honey guide birds alert and direct badgers towards bee hives. The badger exposes the hive to eat the honey, then the honey birds take a turn to eat the honey.	A spruce tree starts to die when mistletoe seeds grow into the spruces' roots, extracting water and nutrients from it.	The cattle egret follows herds of cattle eating the insects stirred up by the cattle.	The oxpecker rides on the back of rhinos eating off the ticks and alerting the rhinos to predators.
A wasp will lay its eggs on the back of a caterpillar called the catalpa worm. When the larvae hatch, they will feed on the caterpillar and kill it.	A solitary golden jackal will follow a tiger at a safe distance alerting the tiger to a kill, then eating the leftovers when the tiger is done.	The Egyptian plover lands inside a Nile crocodile's mouth, getting a good meal, and cleaning the crocodile's teeth at the same time.	Hermit crabs live in shells made by snails who have since abandoned them.

Ecological Succession: Primary and Secondary





Ecological Succession Flip Book

Students will create an Ecological Succession Flipbook to show examples of primary and secondary succession.

Directions:

1. Make a flip book foldable according to your teacher's instructions.

2. Label the foldable according to the following diagram and cut the top three tabs up the middle (see the dotted lines).

Primary Succession - After Volcano	Secondary Succession - After Wildfire
After 3-5 Years	After 3-5 Years
After 15-30 Years	After 15-30 Years
After 100 Years	After 100 Years

3. On the front tab, for each side, draw an illustration of how the area would look after the disaster.

4. Read the following descriptions of each type of succession, Using what you know about succession, write a description about what is happening for each time frame, then add plant and animal species to each tab that correlates with the number of years after each disaster.

Primary Succession

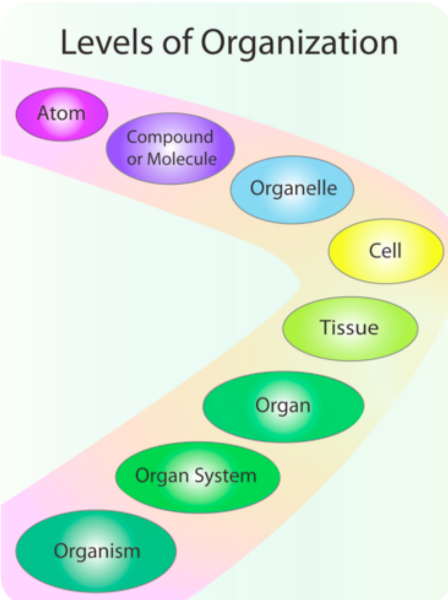
After a volcanic eruption, the land is mostly bare for three to five years until lichens, moss and small pioneer species of plants begin to grow in cracks of rocks. Eventually these pioneer plants die and begin to form soil. About 20 years later a soil layer has formed able to support herbs, grasses and small berry bushes and shrubs. Insects live in grassy areas eating herbs, while mice live in burrows eating berries and insects. After 100 years the soil is able to support larger shrubs, berry bushes and small trees where some birds can build their nests, rabbits can hide and foxes can live in burrows, coming out to hunt birds, mice, rabbits and insects.

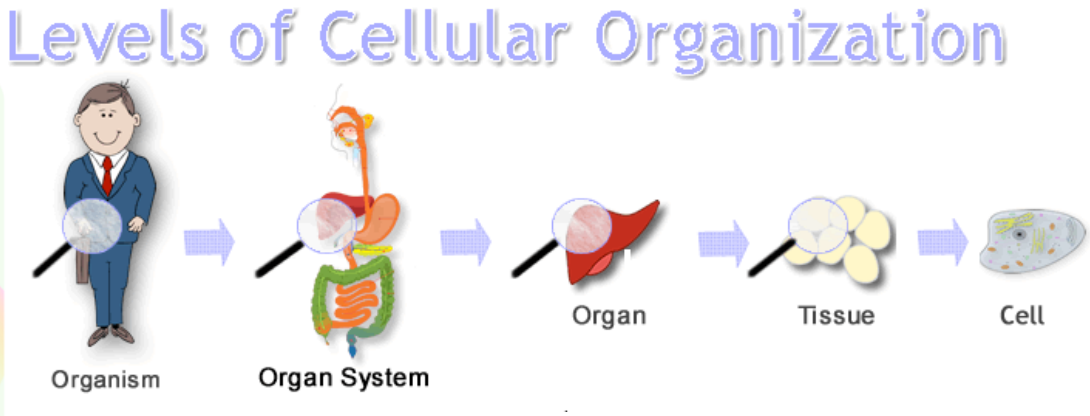
Secondary Succession

The wildfire that burned the forest has released many of the nutrients in stumps and branches, as well as opened up some seeds that need heat to start reproducing. In three to five years grasses, weeds and small plants have taken over. Saplings are starting to spring up, along with large berry bushes, such as blackberry. Small animals that eat insects and berries have taken resident in the larger bushes and ground covering. A noticeable change occurs about 20 years later when the area begins to start looking like a forest, with pines and cedars growing. Acorns and other nuts are being produces allowing squirrels to inhabit the trees, along with a variety of birds, including owls who feed on mice below. 100 years later, the forest has pines and oaks that are 70-100 feet tall, that tower over the smaller trees and berry bushes. The mature forest allows covering for many animals, including deer and bears. Birds are singing in trees and small rodents are rustling along the ground collecting food and making shelters.

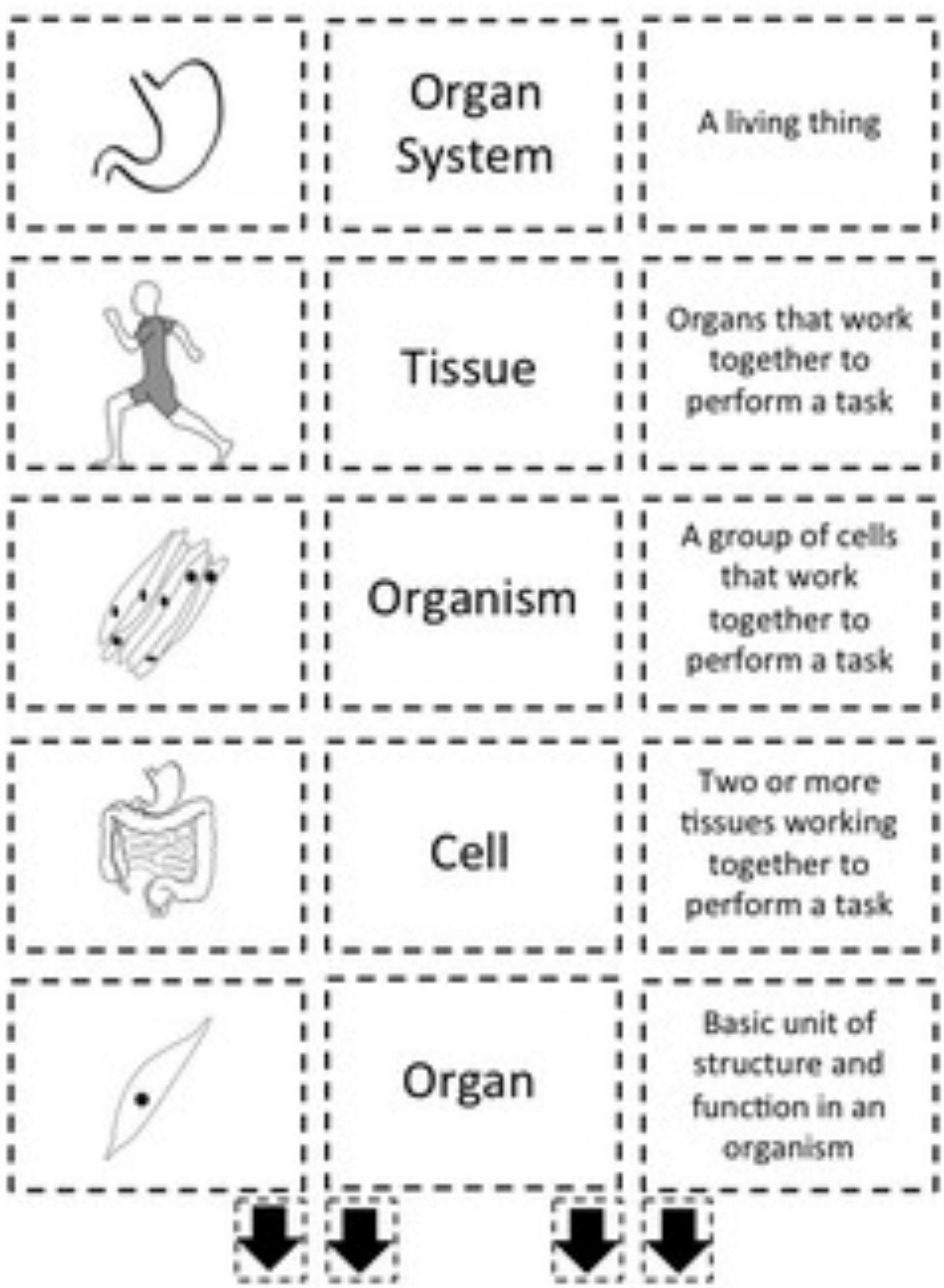
Human Body and Healthy Living

<u>Levels of Organization</u>

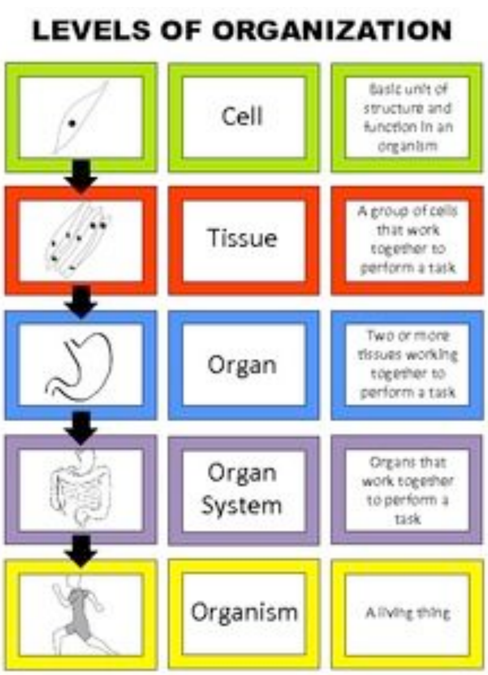




Task:
Using three columns (picture, term, and definition), cut out and arrange the 15 boxes into the levels of organization in order from the cell to the organism. Additionally, give an example at each level.



Answer Key:

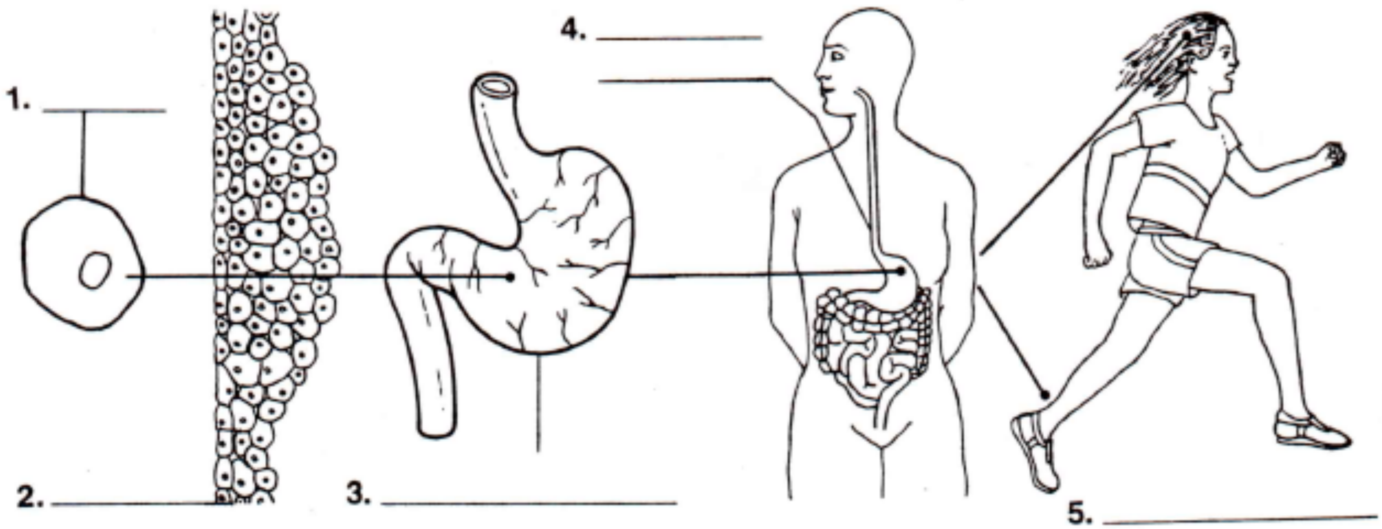


These drawings show how WE are made of CELLS.

Directions:

1. Match the correct word from the **WORD LIST** below to the drawings 1-5.
2. Color each drawing the CORRECT color noted under the word.
3. Use your colored drawings and the same words to fill in the blanks for questions 1-10.

Word List:	**organism**	**organ system**	**organ**	**tissue**	**cell**
color to use	(purple)	(blue)	(green)	(yellow)	(red)



1. A________________is the smallest unit of structure and function of a living thing.
2. An example of a **cell** is a________________cell.
3. A **tissue** is made of a group of similar________________working together.
4. An example of a **tissue** is_____________________tissue.
5. An **organ** is made of different ________________working together to do a special job.
6. An example of an **organ** is the ________________.
7. An **organ system** is made of many _____________working together to do a special job.
8. An example of an **organ system** is the ______________________ system.
9. An ________________is a living thing that carries our its own life activities.
10. An example of an **organism** is______________________.

Digestive System

What Happens When You Eat?

Objectives: These activities will show students what organs aid in digestion and how digestion occurs in the human body.

Activity #1: How Long is the Digestive System?

- yarn

Have students cut a piece of yarn according to the following measurements. Allow students to use different color yarn to represent different organs. After the yarn has been cut tie the pieces together.

Esophagus: 25 cm, Stomach: 20 cm, Small Intestine: 700 cm, Large Intestine: 150 cm; TOTAL: 895 cm

Activity #2: Digestion

- sugar cubes
- granulated sugar
- 2 clear cups filled with water

Place a sugar cube in a cup of water. Place about a spoonful of granulated sugar in the other cup of water. Observe what happens.

Activity #3: Carbohydrate Digestion

- unsalted soda crackers (2 per student)

Have the students chew two unsalted soda crackers for two minutes without swallowing.

Activity #4: How do Villi aid the Small Intestine in Absorption?

- paper towels (10 per group)
- 4 cups of an equal amount of water
- graduated cylinder

Compare how 1, 2, 3, and 4 folded paper towels absorb. Dip each paper towel into a cup of water (use the same amount of water in each cup). Record the volume of water left in the cup (using a graduated cylinder).

Activity #5: A Digestive System Simulation

- large thin plastic bag
- newspaper
- markers & paper
- sponges
- paper sacks (2 sizes)
- Zip-lock bags
- candy
- masking tape
- trash can
- labeled spray bottles of water

Procedure:

1. FOOD TUBE: Lay out two parallel lines of tape on the floor, 3' apart and long enough for half the class to stand shoulder to shoulder on one side of the parallel lines.
2. FOOD PARTICLE: The food particle consists of M&M's placed in small zip-lock bags.These are placed in wadded newspapers in small paper sacks. Place the small sacks in larger sacks with added newspaper. Place all sacks and add newspaper until the large plastic bag is full. This bag is then taped or tied closed to complete the food particle.

Action:

1. Peristaltic Movement: Put the food particle to be eaten at one end of the food tube and a large trash can at the other. Have students line up on both sides, facing each other, squeeze the food particle the length of the food tube.
2. Digestion: Label and/or instruct the players. As the food comes to a student they should narrate what they are doing and why.

Teeth - tear food apart (break plastic bag)
Saliva - use spray bottles to moisten food particle
Stomach - tear small bags apart
Pancreatic juices - spray food
Small Intestine - absorbs food, find bags of candy and pass to blood (teacher plays role of the blood)
Large Intestine - reabsorbs water, sponge up water on the floor
Rectum/Anus - puts the waste papers in the trash can

Performance Assessment: At the completion of this simulation, answer the following questions:

1. What system in your body is the same length as the completed piece of yarn? What is it's length (in centimeters, in feet)?

2. From your observations in Activity #2, what can you conclude must be done to food before digestion begins?

3. What physical and chemical changes occurred to the soda cracker?

4. What caused the physical and chemical changes to the soda cracker?

5. Did you notice a taste change in the soda cracker?

6. How was mechanical or chemical digestion simulated in Activity #4.

7. Which paper towel had the largest surface area?

8. Which cup had the highest volume of water left?

9. How do the villi (of the small intestine) aid in absorption?

10. Follow the path of a food particle through the digestive system; include the organs and their functions.

Cardiovascular/Circulatory System

Note: For children ages 6-15, the normal resting heart rate is 70-100 beats per minute. Resting heart rates for children and adolescents are typically faster than adults' because they have smaller bodies.

The Heart: What a Muscle!

Directions: Part 1: Find your pulse and use it to calculate your heart rate. Next, you will complete a list of physical activities then count and record your heart rate after each activity. Use your data to create a bar graph (or use the grid below) and compare with others in your group. Part 2: Label and color the heart diagram.

Measuring Heart Rate

To measure your heart rate you will need to use your pulse. To find your pulse, gently place your index and middle finger on the artery shown in the diagram. Do not use your thumb because it has its own pulse they you may feel.

Count the pulses for 20 seconds, then multiply by 3 to get the number of heart beats per minute.

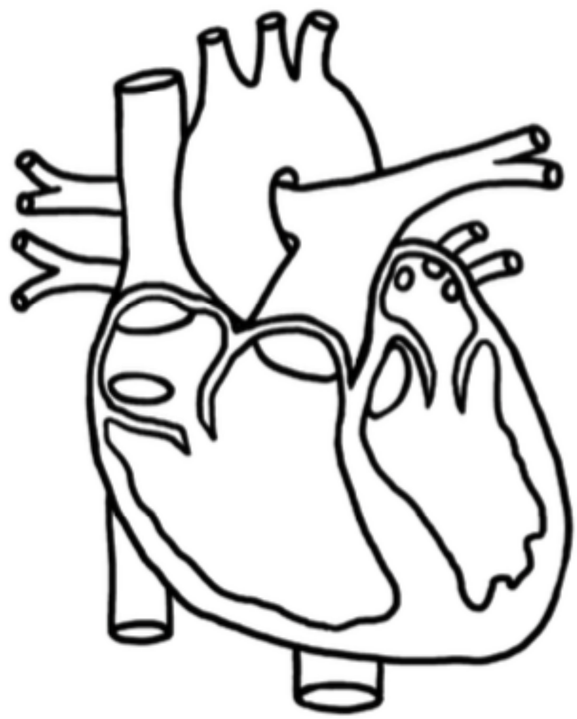
Data Table and Graph

After each activity rest for at least two minutes in order to let your heart rate recover.

Physical Activity	Heart Rate
Sitting in a chair	
Standing	
Walk a leisurely pace for 2 minutes	
Speed walk for 2 minutes	
Jog in place for 2 minutes	
Do 30 jumping jacks	
Run fast in place for 1 minute	

Heart Diagram

Color and label the heart diagram below.



Discussion

In your notebook, give a description of what you observed between your physical activities and your heart rate. Why do you think this occurred?

Respiratory System

The Respiratory Flap Book is a great way for students to see how the parts of respiratory system work together. They will be able to see the individual structures and will need to identify each in order to write the function of each.

Respiratory System Flap Book

Directions: Cut out Diagrams A, C and D along the solid lines. Cut out Diagram B around the shape. Paste each diagram by stacking in order A - D. (Note that Diagram B will actually be glued to the top of the trachea.) For Diagram C and D, fold along the dotted lines to make tabs for gluing., then cut up the center to make "flaps". On the back of each diagram "door" write the function or importance of each part of the respiratory system. Finally, draw in the alveoli and explain their function.

Diagram A: The trachea and the bronchi

Diagram B: The pharynx

Diagram C: The lungs

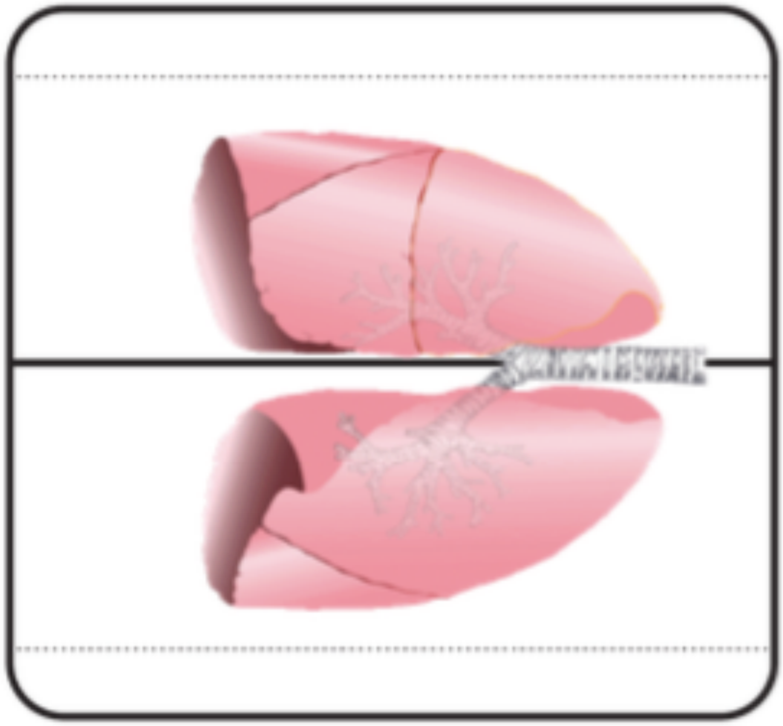
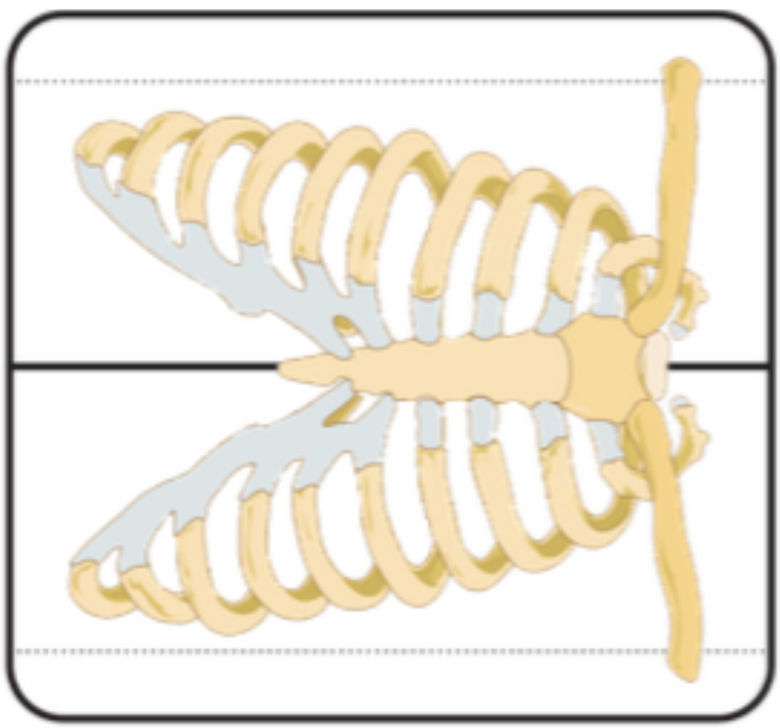


Diagram D: The ribcage



Excretory System

Students learn and understand how the excretory system removes waste from your body by sorting the stages for When You Gotta "Go"! The stages start with blood entering the kidneys and finish with the body going pee.

When You Gotta Go!

Directions: Cut out and unscramble the stages that describe how your body produces urine. Paste in proper order on the diagram.

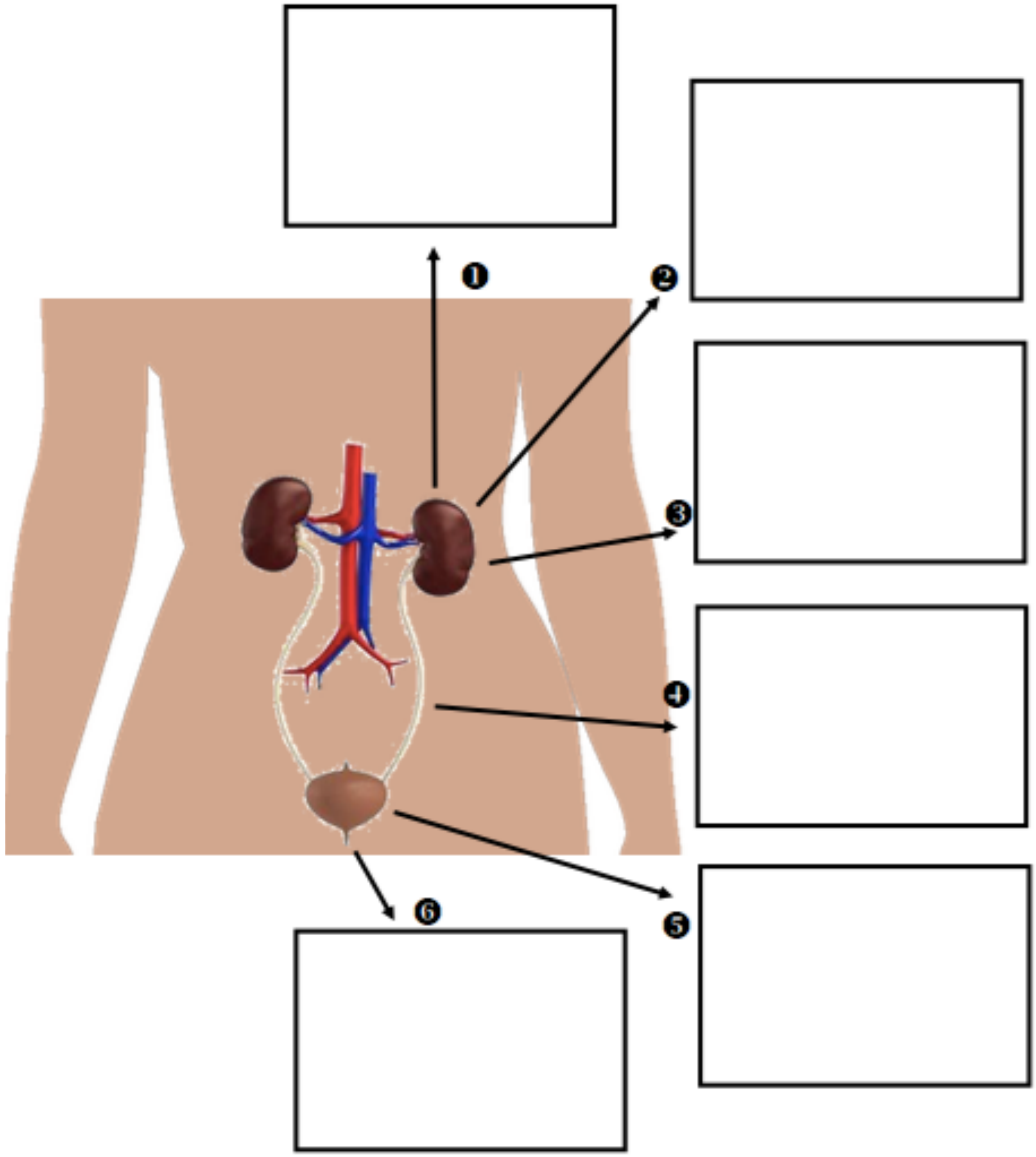
When you pee your bladder empties and urine leaves body through urethra

When bladder is halfway full, a signal is sent to brain telling your body you have to pee.

Capillaries in nephrons are surrounded by a capsule where urea, glucose and some water enter from the blood.

Urine slides down tubes called ureters into the bladder.

Blood enters kidneys and reaches cluster of capillaries in nephron



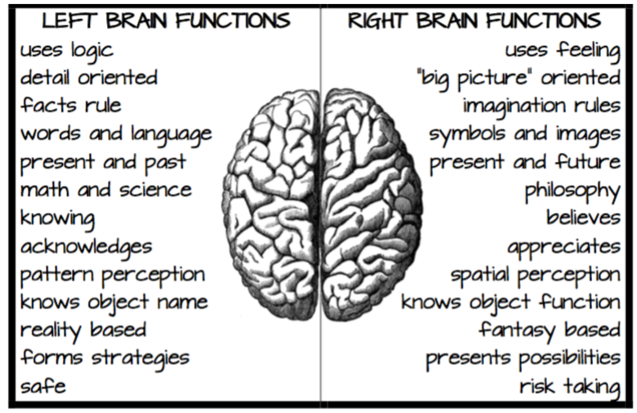
Some filtered materials, such as glucose and water are returned to blood, leaving urea and other waste products, called urine, in tube.

The Nervous System: Central Nervous System and Peripheral Nervous System

This is a great activity to get students thinking about the nervous system and their brain. They will love determining which side of their brain is more dominant which will lead to discussions among group members about other possible personality traits or actions that may be controlled by the right and left brain.

Right or Left Brain Dominant?

Introduction: Human brains are like a complex computer system that is composed of two hemispheres. Each hemisphere controls different skills or ways of thinking. The right hemisphere of the brain is referred to as the analog brain. It controls three-dimensional sense, creativity and artistic senses; processing information from the “big picture” first then looking at the details. The left brain is sometimes referred to as the digital brain since it controls logical thinking, reading and writing and processes information in an analytical and sequential way.

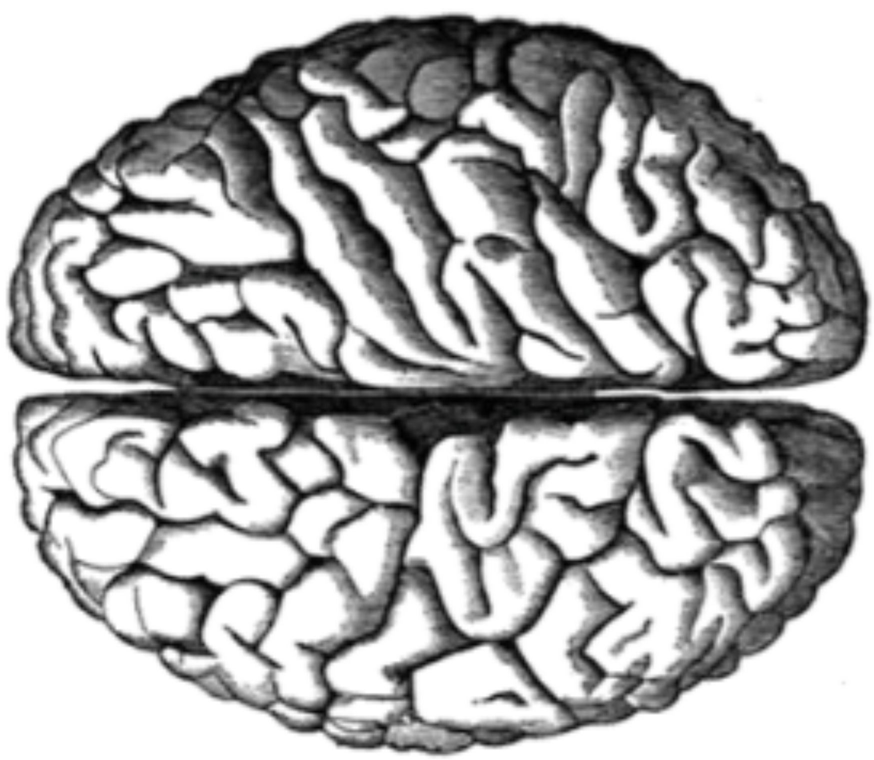


The funny thing about our brain, however, is that our right and left hemispheres control the opposite side of our bodies. For instance, the right hemisphere controls our left side movements and what our left eye sees, whereas our right hemisphere controls the right side of our body and processes what our right eye sees.

Even though humans tend to have a more dominant side, both sides of the brain are used and thought processes shift between the two sides since they have overlapping skills and different ways of thinking. So, next time you’re working with your partner on a project, try to be aware that he or she may be using a different brain hemisphere and that they may process information differently. It’s also important to be self-aware of your most successful way of learning and understanding.

Directions: Identify which of your brain hemispheres may be more dominant by completing each task in the data table. Mark whether the task was right or left side dominant, or mark both if the task could be done easily with both your left and right sides. When you are finished with the tasks, cut out the table and fold it shutter style with opening in center. Paste brain diagram on the front of shutter foldable, cut up the center, and then color the hemisphere that was your dominant side.

Brain Diagram



Left Side ☑		Task	Right Side ☑
	Hand dominance	Write your name - which hand did you use?	
		Give someone a "high five" - which hand did you use?	
		Fold hands - which thumb is on top	
		Throw a paper ball in wastebasket with both right and left hand - which was easier?	
	Foot dominance	Start to run - which foot did you start with?	
		Kick a ball - which foot did you use?	
		Stand on one foot - which side has better balance?	
	Visual dominance	Look through a "telescope" made with your two hands. -which eye did you use to look through it?	
		Draw a horse (side view) - mark which direction the horse is facing.	
		Draw a circle with right hand then with left hand. If both circles were drawn clockwise mark right, counterclockwise mark left, if one in each direction mark both.	
		⬅ TOTALS ➡	

Which body side seems to be your dominant side? ______________________

Which is your dominant brain side? ______________________

Projectile Motion

Objective:
To predict the landing spot of a projectile

Equipment: ramp, marble, meter stick, stopwatch, cup

Introduction:
An object in uniform motion has the equation for (horizontal) distance (x) travelled as: $x = v\,t$ (eqn. 1)
The velocity of an object is thus: $v = x/t$ (eqn. 2)

When you drop a rock on Earth, it falls to the ground and the distance it covers in each second increases. Gravity is constantly increasing the speed of the rock. If we let y represent vertical distance then the equation of the vertical distance fallen in t seconds is$y = ½\,gt^2$ (eqn. 3) where g is acceleration due to gravity.

Starting from rest, the instantaneous falling speed v after time t is $v = gt$ (eqn. 4)

What happens when you toss a rock horizontally? The curved path that it takes is a combination of two straight line components of motion: one vertical and one horizontal. The vertical motion undergoes acceleration due to gravity, the horizontal motion does not. The secret to analyzing projectile motion is to keep the components separate.

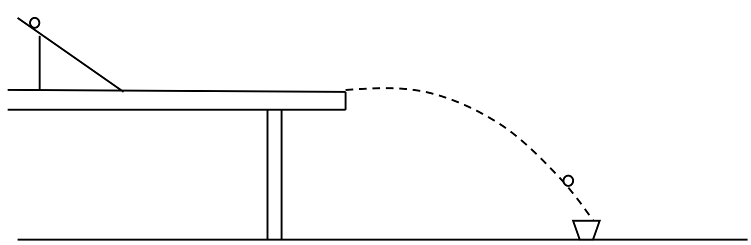
For the horizontal motion, use eqn. 1. For the vertical motion, use eqn. 3.

Horizontal motion	
How far	$x = v\,t$
How fast	$v = x/t$
Vertical motion	
How far	$y = ½\,gt^2$
How fast	$v = gt$

When engineers design bridges and architects design skyscrapers, they do not design and build by trial and error. It must be done correctly the first time! Your goal is predict where the marble will land when released from a certain height from a ramp. The final test of your computations and measurements will be to position the cup so the marble lands inside of it the first time!

Procedure:

1. Place a ramp on the table at least 1 m from the edge of the table. The marble must roll off the table horizontally. The vertical height of the ramp should be at least 40 cm.
2. Place a piece of tape on the ramp to mark the starting position of the marble. Place two more pieces of tape some distance apart on the horizontal part of the path that you will use to measure the time it takes the marble to travel across to calculate the velocity of the marble.



3. YOUR MARBLE IS NOT ALLOWED TO GO OFF THE END OF THE TABLE! Place a barrier to stop it (meter stick). Release the marble from its starting position on the ramp and record the time it takes to travel the distance you marked on the horizontal surface. Calculate the average time and determine the velocity of the marble for the horizontal speed.

Horizontal distance travelled by marble:_________

Trial	1	2	3	4	5
Time, t (s)					

Average time, t:________________ Horizontal speed, v_x =______________

4. Measure the vertical distance, *y*, the marble will drop from the end of the table.

Y = ___________________

5. Using the appropriate equation, find the time *t* it takes the marble to fall from the end of the table to the floor (relate *y* and *t*).

Equation for vertical distance:

Solve this equation for vertical time of fall: **t = __________**

6. Now you need to predict the horizontal distance the marble travels, *x,* once it leaves the edge of the table. Write the equation and solve for your predicted distance.

Equation for horizontal distance:

Predicted distance: ***x***= __________

7. Measure and mark the location on the floor where you predict the marble will land. Be sure and account for the sides of the cup.
8. Notify the teacher and place the cup on your mark. Release your marble from the ramp and cross your fingers!

Summary:

1. Did the marble land in the cup on the first trial?______ Did the cup stay upright? What possible errors would cause the marble to miss or topple the cup over?

2. What is the relationship between the horizontal speed and the horizontal distance the marble travels once it leaves the table?

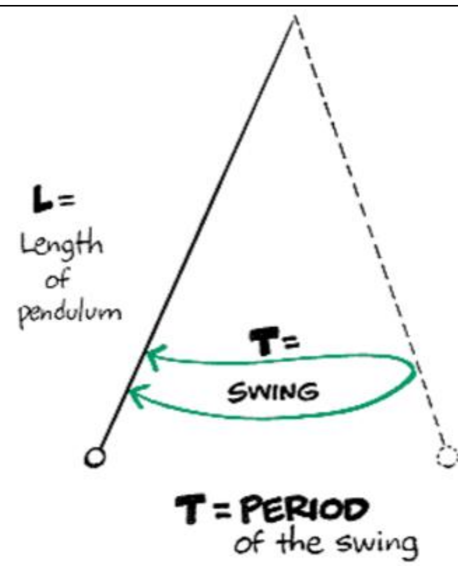
3. If you don't know it, is it possible to calculate the marble's initial horizontal speed? Suppose you know how far it will land on the floor.

4. Consider a bowler throwing a ball in a cricket game. If he is on a mound in the pitch that is4.8 m high when the ball leaves his hand, and the ball lands 18 down the pitch, the speed can be calculated. What is the speed, and why does the 4.8 m elevation make the calculation convenient?

Measuring Gravitational Acceleration with a Pendulum

Materials:
stopwatch
pendulum = tie a mass to a string and hang it

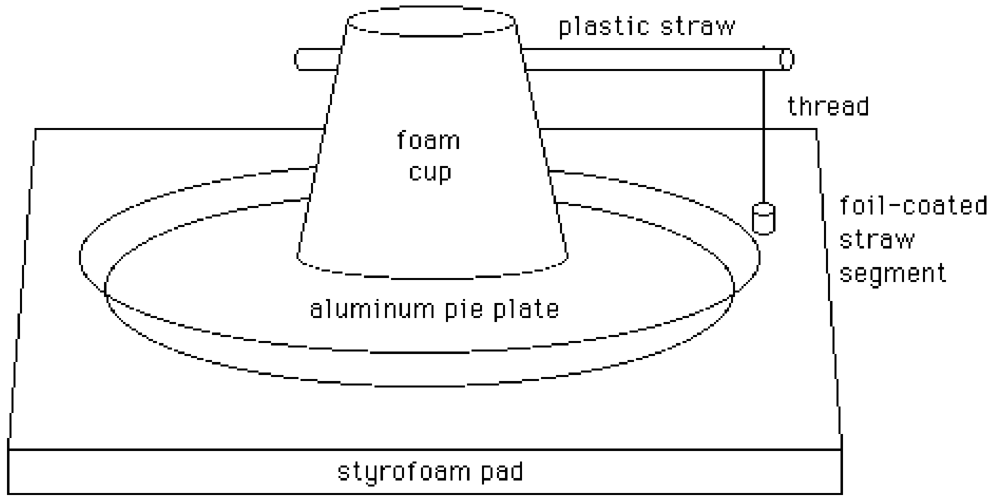
$$T = 2\pi\sqrt{\frac{L}{g}}$$



Do:
1. Set the pendulum length at 0.5 m.
2. Time how long the pendulum takes to make 10 oscillations.
3. Using the formula given above, calculate the gravity.
4. Now set the pendulum length to .75 m and repeat the experiment. Once again, calculate the gravity.

Discuss:
How well do your measurements agree with the accepted value of ~9.81 m/s/s? How well do the two values compare? What may have caused the difference in the two values? (HINT: Think about the effect of pendulum length on the period.)

Static Electricity



A. Build the electrophorus device. Tape a plastic straw horizontally to the top of the cup so that it extends over the edge of the pie plate. Cut slits in the end of the straw and suspend a pith ball so that it is just touching the rim of the plate as in the diagram. Use a few Styrofoam plates for the base if you don't have a Styrofoam pad.

B. Vigorously rub the Styrofoam pad with a piece of wool fabric for one minute. Now, lower the electrophorus plate onto the foam. What happens to the pith ball? Move the electrophorus plate up and down above the foam. What happens to the pith ball? What does this tell you about charges on the rim of the electrophorus plate and the pith ball as you move the electrophorus plate closer to the foam?

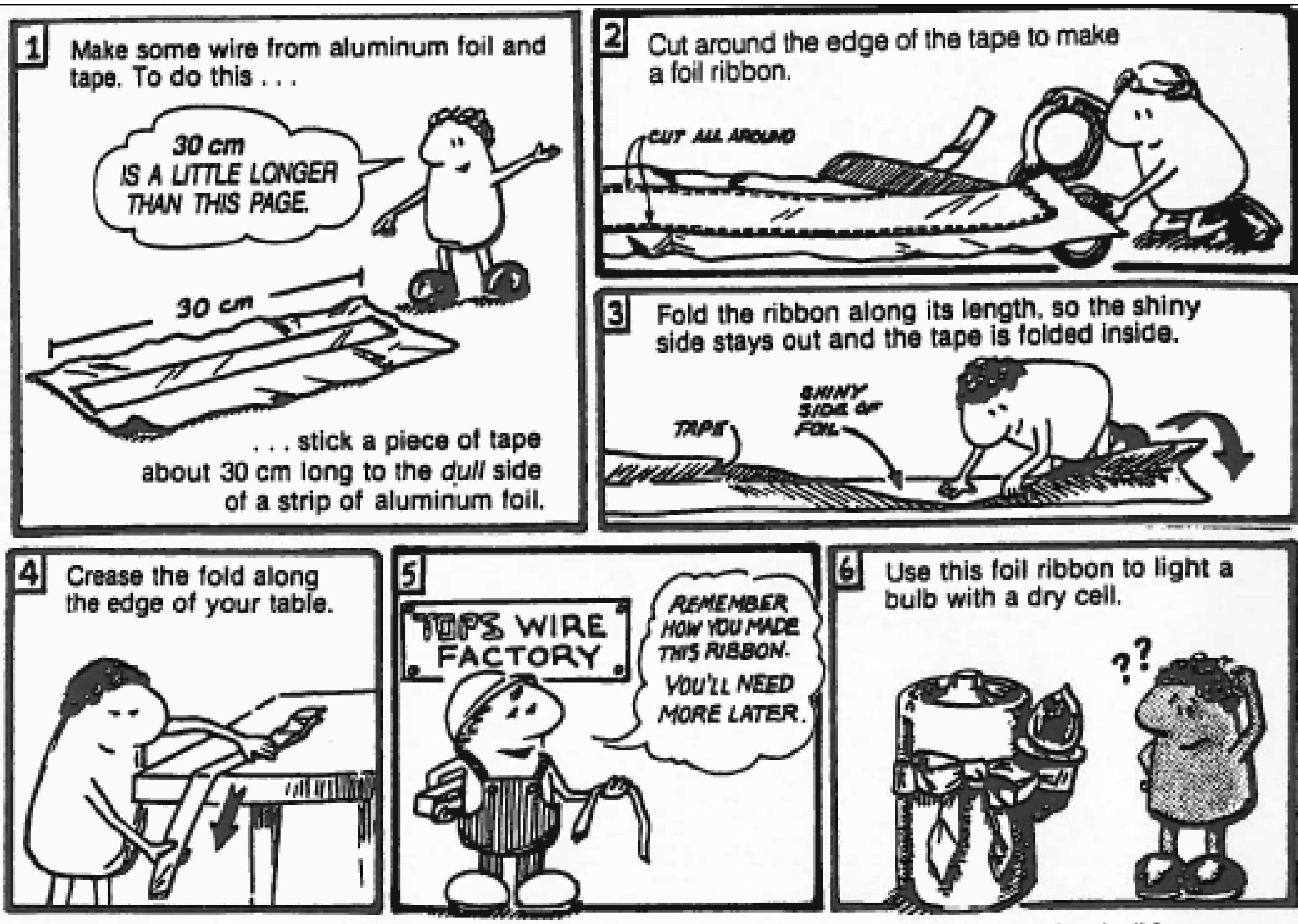
C. Discharge the electrophorus plate with your finger while it is in the air, lower the electrophorus plate onto the foam and bring a charged balloon near the pith ball. What happens?

- What can you infer about the amount of charge on the rim of the electrophorus plate? Where must the charge on the rim come from? Is the charge on the electrophorus plate the same type as the charge on the pith ball?
- When electric charge flows from one place to another, we say that there is an electric current. Is there an electric current between the two plates? How do you know?
- Does the behavior of the pith ball tell you anything about how fast the charge is transferred? What does this tell you about the size of the current that is flowing? Explain using your model of charge.

Electricity Misconceptions

Learners' INCORRECT understandings of electricity include these non-scientific ideas:

1. The electricity companies supply electrons for your household current.
2. We pay electricity companies for power.
3. 'Static' and 'current' electricity are two types of electrical energy.
4. 'Electricity' is used up in electric circuits.
5. Charge is used up in electric circuits.
6. Energy is used up in electric circuits.
7. More devices in a series circuit mean more current because devices 'draw' current.
8. Electrical power is the same as electrical energy.
9. Electricity means the same thing as current, or voltage, or energy.
10. Batteries store, and supply, electrons or 'electricity' to the electric circuit.
11. A wire from a battery to a bulb is all that is needed for the bulb to light up.
12. The electrical energy in a circuit flows in a circle.
13. Electric current is a flow of energy.
14. The stuff that flows through wires is called 'electric current'.
15. Electrons travel at, or near, the speed of light in the wires of an electric circuit.
16. Voltage flows through a circuit.
17. Voltage is energy.
18. High voltage by itself is dangerous.
19. Electrons move by themselves.
20. Current is the same as voltage.
21. A conductor has no resistance.
22. The bigger the battery, the more voltage.
23. Batteries create energy out of nothing.
24. Alternating current (AC) charges move all the way around a circuit and all the way back.



2. Using one bulb, your wire, and one battery, find four different ways to make the bulb light up. Sketch all four successful attempts and 2 unsuccessful attempts. Show in detail where the bulb and wire are touching the battery. Use these shapes to represent the components:

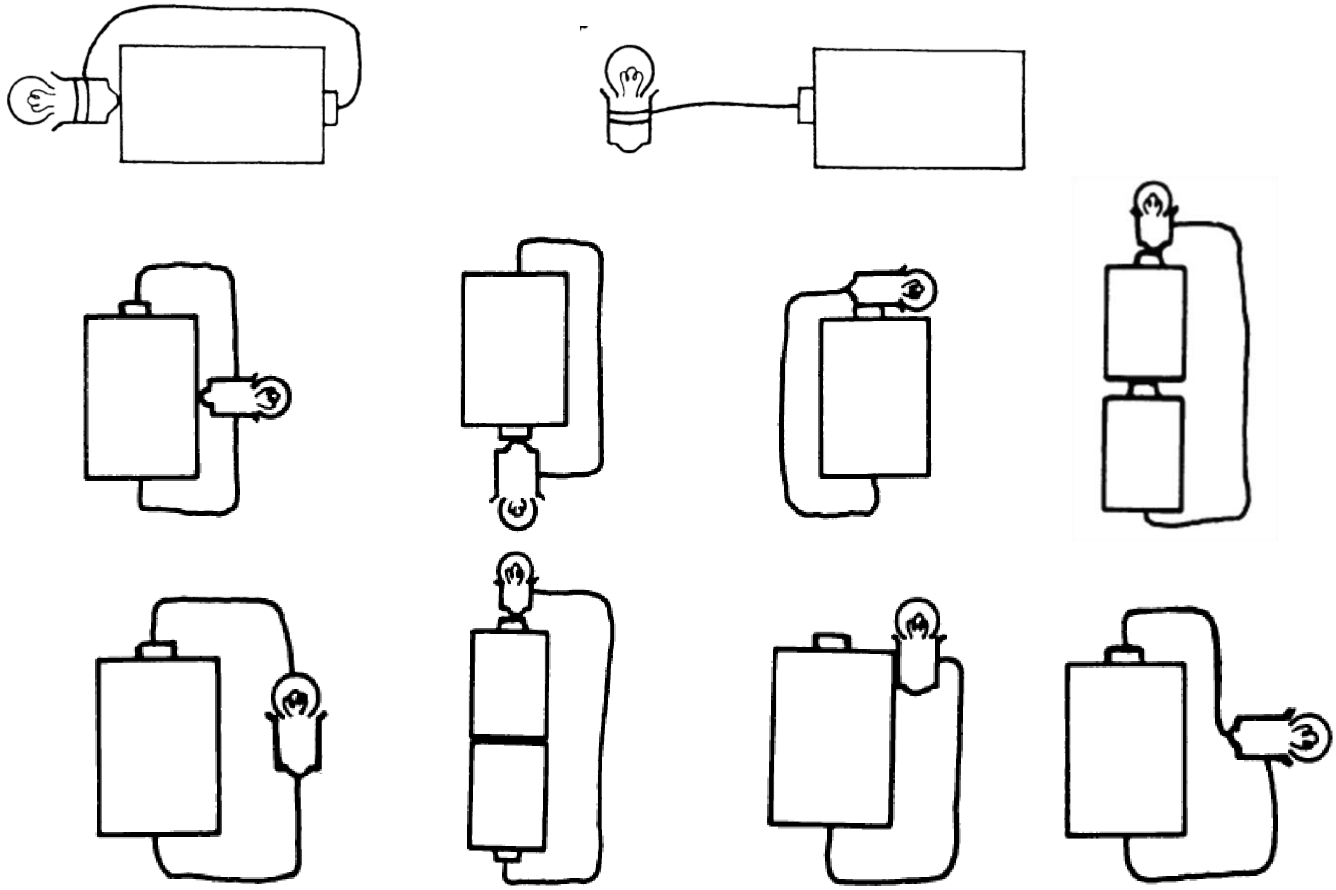
Success!☺	Success!☺	Unsuccess☹
Success!☺	Success!☺	Unsuccess☹

3. Use two foil wires. The bulb may NOT touch the battery. Draw it:

4. To light a bulb, ______ places on the battery must connect to ______ places on the bulb.

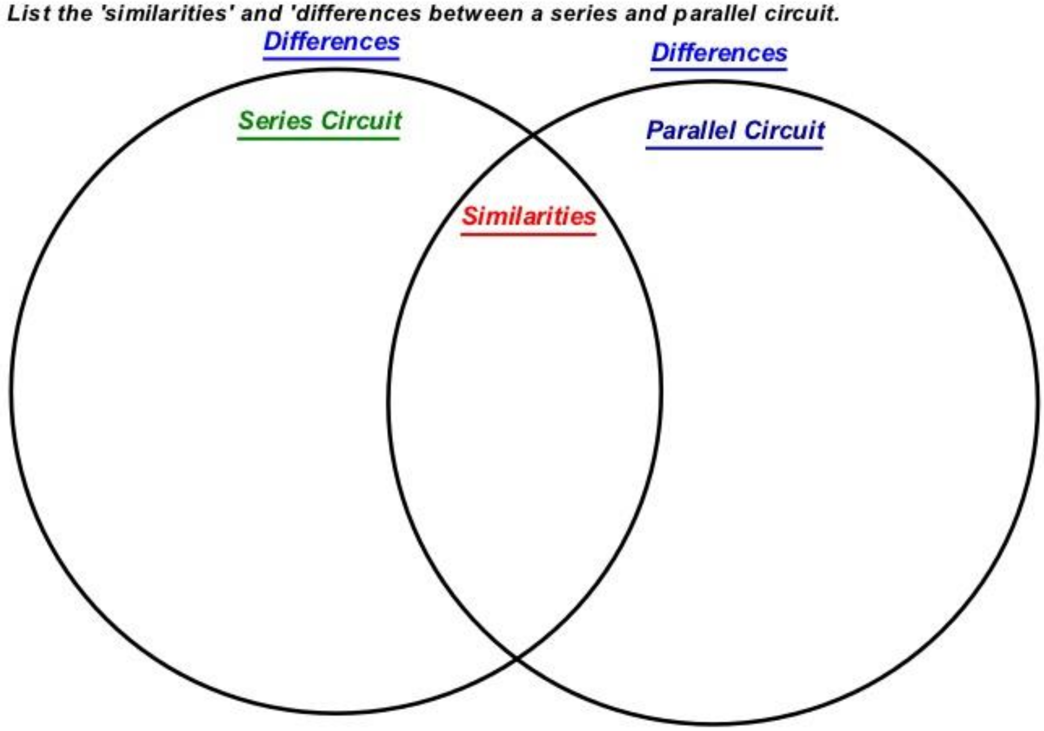
Which Circuit Works?

Which bulbs are correctly connected to the battery and will be able to light up?



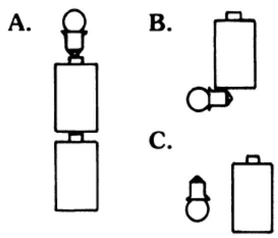
Series vs. Parallel Circuits

List the 'similarities' and 'differences between a series and parallel circuit.

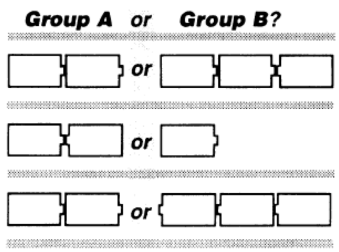


Electricity Challenge Questions

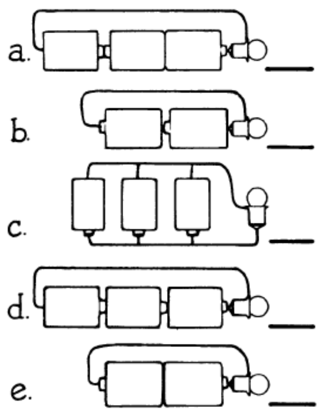
Connect bulbs and dry cells with lines to show how to light each bulb.



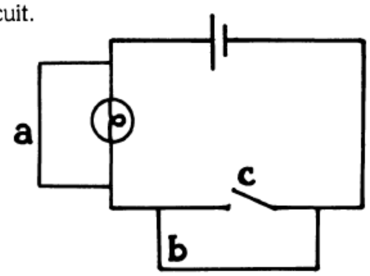
Circle one group (A or B) to show which cells make a bulb shine brighter. Do this in all three rows of problems.



Number these 5 groups of cells by how bright they make the bulb shine. Write *1* in the blank next to the brightest, *2* for the next brightest, and so on.

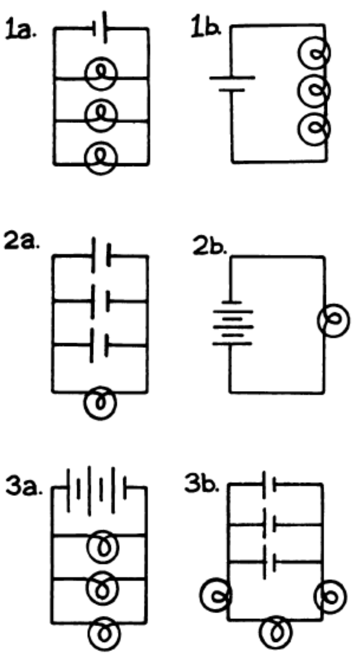


This circuit has a bypass at ***a***, another bypass at ***b***, and an open switch at ***c***. Circle all true sentences about this circuit.



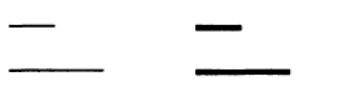
1. The bulb lights if you close ***c***.
2. The bulb lights if you remove ***a***.
3. The bulb lights if you remove ***b***.
4. The bulb lights if you remove ***a*** and ***b***, then close ***c***.

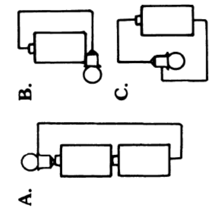
Compare each pair of circuits. Circle the one that produces more light.



In which pair of circuits is the difference in the amount of light the greatest? Why?

Six copper wires, 3 thin and 3 thick, have different lengths as shown. *Circle* the wire with the greatest resistance. Draw a *box* around the wire with the least resistance.



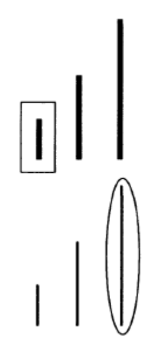


Circle Group A.
Circle Group B.
Circle Group B.

a. 4 b. 2 c. 3 d. 1 e. 5

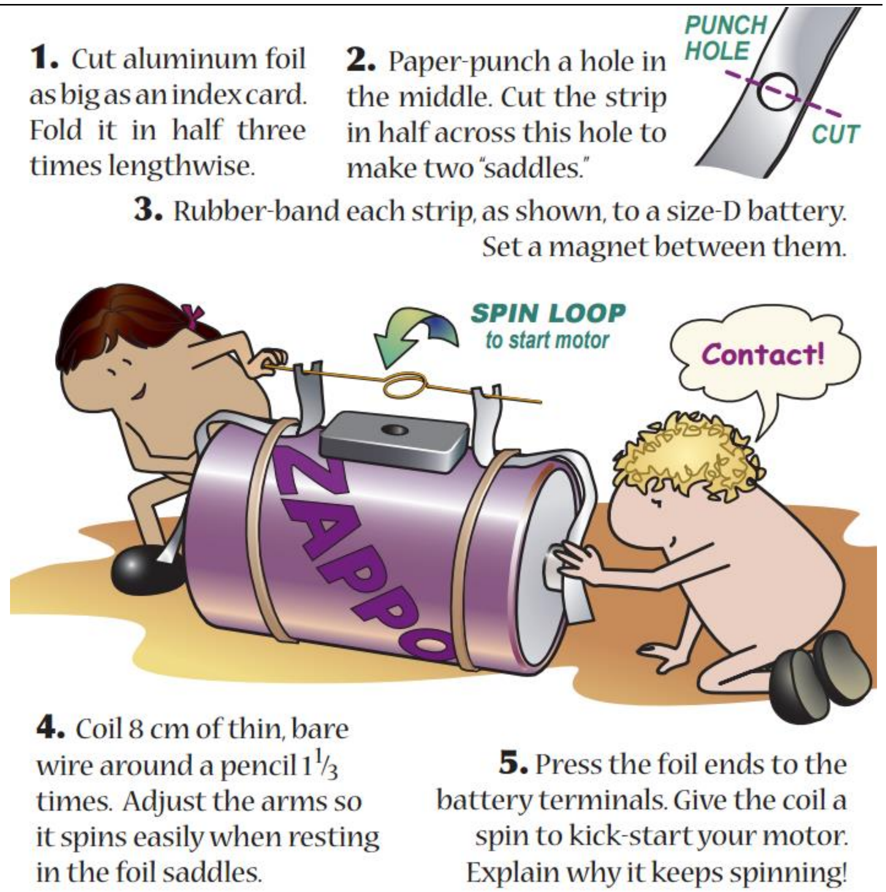
Sentences **2** and **4** are true.

Most light: 1a, 2b, 3a. The third pair has the greatest difference in the amount of light produced. The cells are changed to parallel, producing less light and the bulbs are changed to series, also producing less light.



Electromagnetic Induction

Simple Motor:

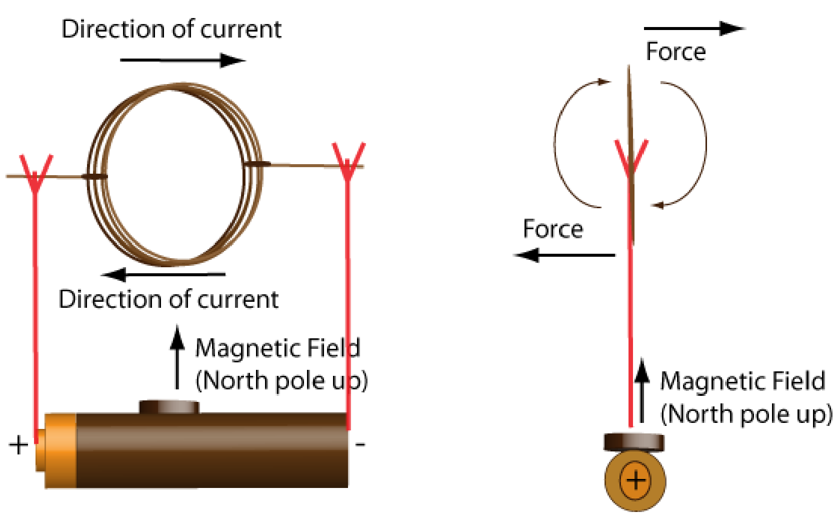


<u>Objective</u>:
To build a motor that spins by turning on and off.

<u>Materials</u>:
Aluminum foil; hole punch; scissors; 2 rubber bands; small magnet, 8 cm of bare thin copper wire - thinner is better. Heavier wire will not work. Discarded household appliance cords may be braided into suitably thin strands. Almost sever the cord with cutting pliers, then pull off the insulation
fresh battery

- Wire that circles $1^{1}/_{3}$ times yields a loop that is fairly evenly balanced. Natural spring in the loop prevents the bare wire from contacting itself and shorting out the coil.
- The tiny coil tends to spin in fits and starts, often reversing direction. A well-balanced coil may spin with impressive speed. Electricity flows around the wire loop, creating associated electromagnetic poles perpendicular to the plane of the loop. These poles rotate into alignment with the field of the permanent magnet, causing the loop to turn. But before these electromagnetic poles can lock into stable alignment with the permanent magnet, the wire bounces 'off' then back 'on' in random ways, allowing the loop to keep on turning.
- Will your on-off motor work without the permanent magnet attached to the battery?
    - No! Without the permanent magnet, the magnetic poles created by electricity flowing through the loop would have no strong field to align with. So there would be no attractive or repelling forces to turn the coil.
- What would happen with a bigger magnet? A bigger battery? Thicker wire?

<u>How does it work</u>? The metal & wire create a closed loop circuit that carries current. Current flows from the negative battery terminal, through the circuit, and to the positive battery terminal. Current also induces a magnetic field in the coil, which helps explain why the coil spins. Magnets have two poles, north and south. North-south interactions attract, and north-north and south-south interactions repel. The magnetic field created by the current in the wire is not perpendicular to the magnet taped to the battery, so at least some part of the wire's magnetic field will repel and cause the coil to continue to spin.



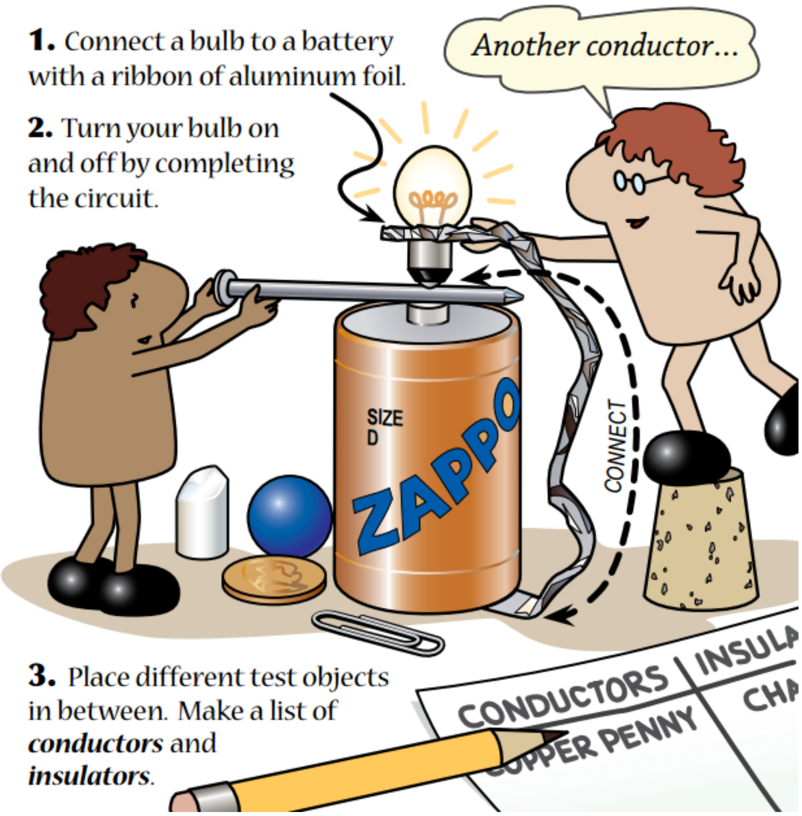
** the coil is wound clockwise

Veronica Ledoux 7

Electrical Conductors & Insulators

Objective:
Use a bulb and battery to find materials that conduct or resist electric current.

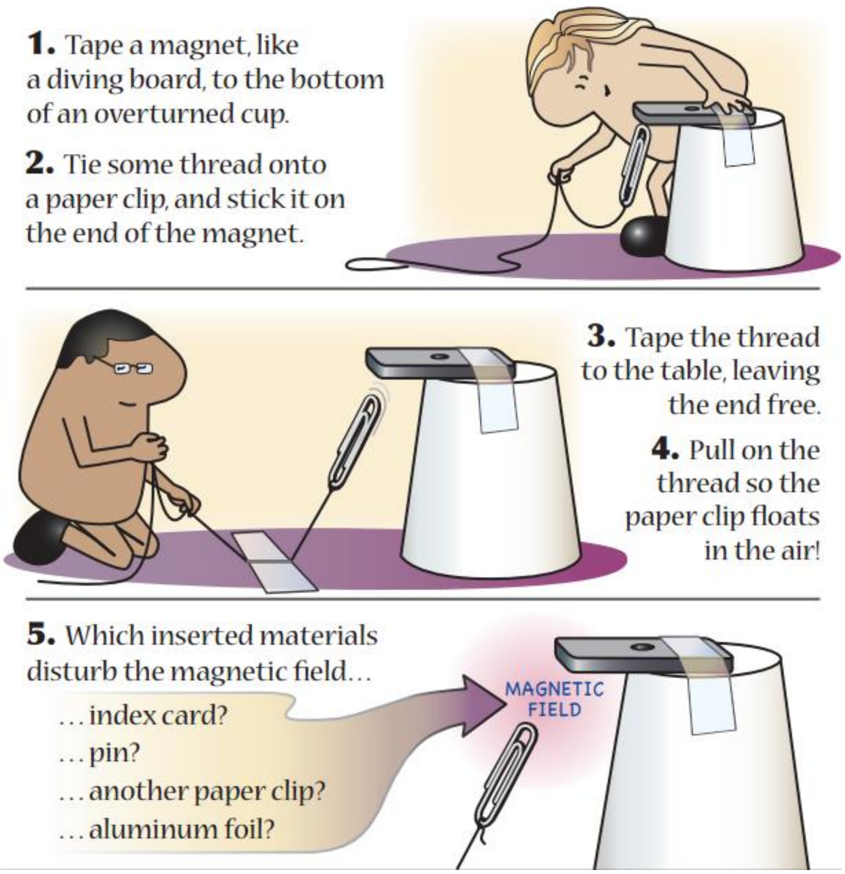
Materials:
Battery and bulb
Aluminum foil strip, 8" long, folded for strength.
Test objects: metal/rubber washer, button, glass, painted surfaces, string, leaf, copper, chalk, skin, candle, tin, eraser, aluminum, wood



Magnetic Force at a Distance

Objective: To observe that a magnetic field passes through solid objects if they are not magnetic.

Magnetic Force acting at a Distance:
Magnetic lines of force pass undisturbed through nonmagnetic materials (paper, aluminum, plastic, glass), with no visible effect on the floating clip. The field is altered by magnetic materials like iron or steel. When passing through a magnetic field, steel pins and clips become temporary magnets and interact with the field, causing the floating clip to wobble or fall.



Motion & Forces

Which of these are true and which are misconceptions?

1. If an object is stationary there are no forces acting on it	2. If a force acts on an object it must move	3. The weight of an object is always equal to its mass	4. distance travelled = average speed x time
5. An object moving at a steady speed has equal and opposite forces acting on it	6. If the average speed is 20 m/s a car can have gone at lots of different speeds or even stopped	7. If an object is accelerating it must have a force acting on it	8. Forces can change the direction of an object while its speed stays the same
9. On a distance time graph an object travelling at a steady speed is shown as a straight horizontal line	10. An object falling at a steady speed will slow down if the resultant force on it is zero	11. All objects have the same acceleration due to gravity on Earth	12. As an object falls its speed remains the same
13. When an object runs out of force it stops moving	14 Work = force x distance moved in the direction of the force	15. The steady speed reached by a falling skydiver is called the terminal velocity	16. According to Hooke's Law doubling the force doubles the extension

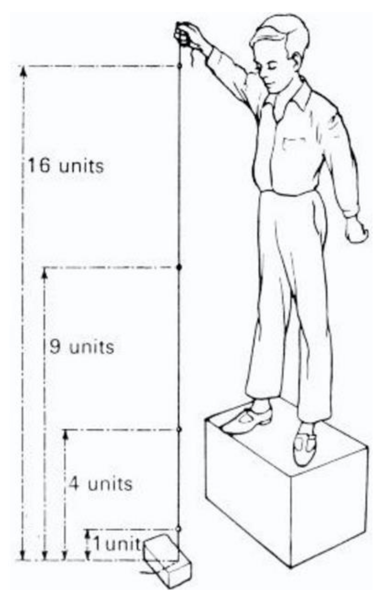
Truths:

- Force can speed an object up or slow an object down.
- Forces can change the direction of a moving object.

String Drop Challenge

Objective: Tie metal objects to a piece of string so that when it is vertically dropped from a high spot, the sounds the metal makes in hitting the floor are evenly spaced "beats".

- To make the sounds occur at even intervals, should you tie the metal pieces at evenly spaced intervals along on the string? No!
- What sort of sound pattern will metal objects tied at evenly spaced intervals along the string produce?
- Consider acceleration due to gravity!



Graph:

- distance between objects vs. time (beat #) – what is the shape?
- distance between objects vs. time squared - what is the shape?

False: 1, 2, 3, 9, 10, 12, 13

Motion & Forces

Construct free-body diagrams for the following physical situations. Label all forces (e.g. F_{grav}, F_{norm}, F_{app}, F_{frict}, F_{air}, F_{tens}, etc.).

a. A physics book rests upon a level table.

b. A skydiver is falling and has reached a terminal velocity.

c. A large crate is being pushed leftward at a constant velocity.

d. A sledder has reached the bottom of a hill and is coasting rightward while slowing down.

e. A ball is moving upwards towards its peak. Ignore air resistance.

f. An air track glider moves rightward at constant speed.

g. The brakes are applied to a rightward moving car and it skids to a stop.

h. A spider is slowly descending a thin silk thread at constant speed.

i. A projectile is moving upwards and rightwards towards the peak of its trajectory.

j. An elevator is rising at a constant velocity; it is not touching the elevator shaft.

k. An upward rising elevator is slowing down; it is not touching the elevator shaft.

l. A force is applied to accelerate a crate across a rough horizontal surface.

<u>Draw 3 graphs</u> to illustrate the motion of each situation:

a. position-time graph
b. velocity-time graph
c. acceleration-time graph → what does the SLOPE of each graph tell you about the motion?

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