NAME: ______________________________

LAB TIME________________

LAB 1: Introduction to Science

PPE Required - None

The impression of **science** that some students get from science classes in school is that science is just facts to be memorized. Many of the facts are interesting but some seem obscure and irrelevant. The technical jargon is like a foreign language—but useless for ordering lunch in Paris.

For a scientist, on the other hand, science is a great job. You are pretty much your own boss. Your colleagues are smart and competitive—always **challenging you to look at things in a new way**. The work changes constantly, so it does not get boring. There is always a new question to answer, a new technique to learn, or another piece of equipment to build or repair. Scientists get to travel all over the worl, for field research, to give talks, or attend conferences.

To a scientist, science is not a collection of facts but is **something to do,** and that process begins with a **question**. Suppose you ask, "Why does excess salt in the diet raise blood pressure in some people, but not in others?" The current answer is, "Nobody knows." A nonscientist would say, "Well, I wish someone would figure it out and tell me." A scientist would say, "How could a person find out the answer?"

Over the past few centuries, scientists have developed certain ways of approaching questions about the natural world (the weather, the movement of stars, the web of life in the oceans, our own bodies) that consistently give reliable answers. To understand better how this process works, you will begin thinking like a researcher in this exercise.

NOTE: The main task you face in this lab is to be creative while staying inside the allowed parameters. Your main obstacle is to move beyond assuming that there is just one possible solution to a problem.

Part 1: Writing and Testing Hypotheses

STEP 1: Observations

All science begins with **observing** the natural world. We have to know **what** happens before we can wonder **how** it happens and set about finding the answer to questions. For example, what happens if you place salt water in the bottom of a beaker of distilled water? Follow the instructions below to try it.

1. Fill two small beakers full with distilled or **deionized water (dH_2O)**. Mix salt into one of the beakers until the solution is **saturated**, which means that no more salt will dissolve. Add food color to the salt water and stir it again.

2. Pour some of the salt water into a test tube, filling it to about 2 cm from the top. Place a straw in the test tube.

3. Holding your finger over the end of the straw, lift the straw out of the test tube and lower it into the beaker of distilled water. When the straw is resting on the **bottom** of the beaker, **gently** remove your finger from the straw and **s-l-o-w-l-y** lift the straw out of the beaker.

4. Draw and label your results.

You have just drawn your results. The drawing represents the data you must use throughout the rest of this lab exercise. This is very important to remember!

STEP 2: Explaining Your Observations

So far we have a neat trick and interesting observations, but we do not have science. The goal of science is to **explain** how the world works.

1. **Explain** what you observed when you lifted the straw out of the beaker.

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2. Why did that happen?

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This explanation of what you observed must be consistent with your observations (data). Does this mean that you have **proved** that this explanation is the correct one? Not so fast!

STEP 3: Alternative Explanations

There is no reason to accept an **explanation**, or **hypothesis** as the correct one if other hypotheses explain the observations just as well. In order to convince others of the correctness of your explanation (hypothesis), you must not only show that observations are consistent with your hypothesis, but also **disprove all of the other reasonable explanations** that someone else might think of.

For example: Imagine that your car will not start. Not only that, the gas gauge is on "Empty." **You might hypothesize** that your car will not start because you are completely out of gas. Someone else might point out that perhaps your battery is so completely dead that the gas gauge will not work. You could then **disprove** their alternate hypothesis by turning on the radio, and if it plays, their alternate explanation is **disproved** and your original hypothesis is still the best one.

When a scientist **publishes** an explanation of an observation, other scientists will always read the article critically. If they can think of other reasonable explanations that fit the data, they will not accept the published explanation as a scientific fact yet.

One explanation for your salt water data could be, "Colored salt water stays on the bottom of a beaker of dH_2O because the salt water is more dense than dH_2O, and therefore is heavier than dH_2O."

1. Consider your drawing (data) from Step 1. Write **another explanation** that would explain your results.

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2. Write **one more explanation** that would explain your data.

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You now have **three possible explanations** for what you observed. All of the explanations **could** account for what you observed when you placed colored salt water in the bottom of a beaker of salt water. But is one of them a correct explanation? How do you find out?

A **correct** explanation of something that you have observed in the natural world must:

be a **reasonable**, **logical** explanation of what you have observed

Allow you to **predict accurately** what will happen in **other** situations that you have not yet observed.

You've been doing this all of your life although you may not have been calling it science. For example, babies seem to enjoy exasperating their parents by dropping things and throwing things over and over again. A baby will hold a toy and let go of it. *Down!* Cup of milk? *Down!* Cereal bowl? *Down!* Spoon? *Down!*

Baby is learning about gravity.

Things go *down!*

This radio I'm pulling toward the edge of the shelf will go *down!* too if I can just get it a little farther . . .

Think about what you have done so far:

Started with salt water and distilled water
Put food color in the salt water
Placed a salt water/food color mixture at the bottom of distilled water.

Step 4: Writing Your Hypotheses

Note: In this part of the exercise (Step 4) you will not actually do anything with the salt, food coloring, and water. You are **planning** what you will do later.

You need to consider which of your possible explanations would correctly **predict** what **would** happen in **other** situations, using the **same** materials.

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In order to do this, you need to convert your explanations into specific statements called **hypotheses**.

A sample hypothesis has already been written for you, as an example, in Table 1-1. Note that it is written in such a way that it has **three specific parts**.

a. "A salt....distilled water" is a brief description of **what will be done**

b. "stays at the bottom" is a **prediction** of what will happen

c. "because....distilled water" is an **explanation** of why it happens that way.

1. Use exactly the same format above, and write two more hypotheses in the remaining boxes of the first column of Table 1-1. Your two new hypotheses **must** be based on your drawing data from Step 1 of this lab.

   Your hypotheses must include only the **same materials and techniques** that you used in Step 1 of this lab. In addition, your hypotheses must be **testable** with only the materials used in Step 1 of the lab. These limitations allow you to control the **variables** described in your hypotheses.

2. Read the suggested tests you could perform, which are listed across the top row of Table 1-1. You've already done the first test.

3. For the first hypotheses on Table 1-1, **assume** that you would preform each test listed in the top row of the table. You are NOT going to perform the tests now, just **predict what result you would expect IF that hypothesis is correct**. Now, write your predicted results in the boxes under each suggested test.

4. Repeat the process above with the other two hypotheses. Remember, for each hypothesis, make your predictions based on the assumption of **THAT** hypothesis being correct.

5. Study the patterns of your predictions. They should be different for each hypothesis.

Step 5: Testing your hypotheses

Now you need to find out if your predictions match what you will observe when you do the tests.

1. **Do the tests** listed in Table 1-2. As you do each test, write "Yes" or "No" in the box under each test, according to your actual results. Answer the questions under Table 1-2.

Dispose of these materials by washing them down the drain with plenty of water.

TABLE 1-1

HYPOTHESES	POSSIBLE TESTS WHICH COULD BE DONE			
	Place salt water/food color mixture at the bottom of distilled water.	Place salt water/food color mixture at the top of distilled water.	Place distilled water/food color mixture at the bottom of salt water.	Place distilled water/food color mixture at the top of salt water.
	WRITE YOUR PREDICTIONS IN THE BOXES BELOW			
#1 A salt water/food color mixture placed at the bottom of a beaker of distilled water stays at the bottom because salt water is more dense than distilled water.				
#2				
#3				

TABLE 1-2

Tests To Do	Place salt water/food color mixture at the bottom of distilled water; it stays on the bottom of the beaker.	Place salt water/food color mixture at the top of distilled water; it stays on top.	Place distilled water/food color mixture at the bottom of salt water; it stays on the bottom of the beaker.	Place distilled water/food color mixture at the top of salt water; it stays on top.
Did you observe this result?				

1. Which hypothesis (1, 2, or 3) from Table 1-1 **accurately predicted** what happened when you did the tests in Table 1-2?

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2. Therefore, which hypothesis from Table 1-1 is most likely a **correct** explanation for what you observed in Step 1 of this lab exercise?

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3. Sometimes people get into an argument because each one has an explanation for something that happened which fits what was observed; but the different explanations don't agree. Apply what you have learned to the following situation.

   You and your friends are in your car. The CD player is not producing any music. Think of four possible explanations for this and tell how you would test for each one.

   a.

b.

c.

d.

Part 2: What "Science" Means. Is it True?

As long as a hypothesis continues to be a reasonable explanation of our observations, and if we can disprove any alternate hypotheses, the more **confident** we become that the first explanation is correct. After our methods, data, and proposed explanation are **published**, other scientists may think of observations and tests that disprove our original hypothesis, or alternate explanations that have not been disproved.

However, if no one is able to collect data that contradict our original hypothesis, and more and more alternate explanations are disproved, our explanation becomes the **best explanation**. A **hypothesis** that has been repeatedly tested by many different researchers over a long period of time and not disproved will generally be accepted as the **correct explanation** by most scientists.

If, in addition, a thoroughly tested hypothesis unifies and **explains many different observations** of the natural world and continues to predict accurately what will happen in new circumstances, the hypothesis will be called a **theory** or a **model**. To a scientist, the words theory and model mean something almost opposite from our everyday use of the word. It means a far-reaching explanation that is **highly likely to be true**.

And that is about as close as human beings can get to scientific truth.

1. In everyday speech, when we say "I have a theory that . . . ," the word "theory" means

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2. On the other hand, a ***scientific*** theory or model is

Part 3: Standard Lab Equipment

When doing the lab exercises in this class, it is important that you are able to identify and locate the items you will need to do the lab exercises.

The following items have been set out and labeled for you:

Electronic balance	Test tube
Beaker	Eppendorf tube
Erlenmeyer flask	Eppendorf tub"floatie" or carrier
Graduated cylinder	Petri dish (glass and plastic)
1-mL and 5-mL pipettes	Spot plate
Pipetter bulb	Squeeze bottle liquid dispenser
Automatic pipetter/micropipetter with tips	Parafilm®
Pasteur pipette and bulb	Magnetic stir bars
Disposable transfer pipette	Microscope slides
Cover slips	Kimwipes®
Weigh boat	

Draw a sketch of each item which you do not already recognize. Use the space below and the next page.

The End!