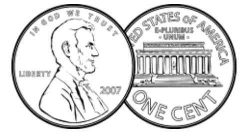
Name______________________________________



Scientific Cents: Experimental Design

Part 1 --- Observations, Inferences & Predictions

Background Information: One of the most important skills in science is that of **OBSERVATION**. Most of the time we think of observation as something we do with our eyes; when we see something, we observe it. However, all five of our senses can be used to make observations: sight, hearing, taste, touch, and smell.
A good scientist is observant and notices things in the world. She or he notices what's going on in the world and becomes curious about what's happening.
Observing can include reading and studying what others have done in the past because scientific knowledge is collective.
Observations in science are called **DATA**.

We can make two kinds of observations: those that are **FACTS**, and those that are **OPINIONS**. Facts are those things that are true for everybody. A scientist looks seriously at information and attempts to avoid all sources of bias in making observations. Opinions are beliefs based on personal preference. In science, we deal with FACTS. There must be **EVIDENCE** for an observation to be used in science.

An **INFERENCE** is an assumption or conclusion based on an observation. It is a logical interpretation based on observations and prior knowledge.

A **PREDICTION** is a guess what might happen based on observation. When making a prediction it is important to look at possible patterns and current observations.

Data may also be **QUALITATIVE** or **QUANTITATIVE**. Qualitative data is information that is hard to measure, count, or describe in numbers. It describes the qualities or characteristics of something. Examples are colors, tastes, and sounds. Qualitative data is recorded in **DATA CHARTS**. Charts may have numbers, pictures, or sentences. Quantitative data is information that can be expressed in numbers. If information can be counted or measured, then it is quantitative data. Tools are often used to collect quantitative data. Examples include amounts, temperature, mass, and length.
Quantitative data is recorded in **DATA TABLES**: Tables contain numerical data.

Purpose: to distinguish between fact, opinion, and inference

Materials: 5 pennies

What to do:
1. Work with your partner. Make sure you both know what to do; read the procedure carefully. *What kind of data will you and your partner collect? What do you have to do to collect it?*
3. Make a data table and/or a data chart to record your data before you begin. **Have your teacher check it before you begin recording data**.
4. Pick one penny (it does not matter which one).
5. Observe the penny carefully; both sides and edge.
6. Record [write down] your data in your table/chart.
7. Repeat with each penny.

Data: *Make your data table and data chart in the space below.*

Teacher Check:

Look at the observations you made about the pennies. Classify each observation as a factual observation or an inference. Have your teacher check these.

Teacher Check:

Factual Observation	Inference

Write a prediction about the pennies based on your observations. Have your teacher check the prediction before you move on to the next part.

Teacher Check:

____

____

Part 2 --- Writing Testable Questions

Background Information: Scientists ask questions and then try to answer them using science skills and practices. Different kinds of questions need different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve researching more information; some involve doing a fair test or experimenting; some involve discovery of new objects and phenomena; and some involve making models. When a scientific investigation is used to try to answer a question, the question is called a **RESEARCH QUESTION**.

When an experimental investigation is used to answer a question, the question must be **TESTABLE**. A testable question is one that can be answered by designing and conducting an experiment. Testable questions are always about changing one variable to see what the effect is on another variable.

Effect and **affect** are good words to use when writing a testable, research question.
Effect is a noun; it refers to the outcome or result of an investigation.
Affect is a verb; it means to influence or act upon something.
EXPERIMENTAL investigations involve the control or manipulation of variables. Variables are the parts of the experiment that can change, or vary.
• **INDEPENDENT VARIABLES** or **MANIPULATED VARIABLES** are those that can cause changes in other variables.
This means it is the ONE thing that has been chosen to be changed or manipulated by the scientist. It is what the investigator is testing; the difference between groups.

• **DEPENDENT VARIABLES** or **RESPONDING VARIABLES** are those that change in response to the manipulation of another variable. It is the response that can be observed and measured.
• **CONTROLLED VARIABLES** or **CONSTANTS** are those that are kept the same or constant. They could be changed, but the scientist keeps them constant so that they will not interfere with the investigation. Controlled variables make sure the investigation is a **FAIR TEST**.

What to do:

***Given this information*:**
You have been given a penny and three different liquids: plain water, a mixture of three parts water to one part liquid soap, and a mixture of one part water to one part soap. If you use an eyedropper you can drop each liquid on the penny, one drop at a time, and the liquid will stay on the penny.

<u>*Write a testable research question*</u>: Use the above information to write a question using either <u>*effect*</u> or <u>*affect*</u>. Have your teacher check your question.

____

____

____

Teacher Check:

<u>Part 3 --- Writing a Hypothesis</u>

Background Information: Sometimes scientists use a **HYPOTHESIS** to help guide an experimental investigation. A hypothesis is a special kind of prediction. It is an educated guess about the relationship between the independent and dependent variable. A hypothesis is testable; an experimental investigation can be done based on the hypothesis.

One way to write a hypothesis is to use an **"If…, Then…."** statement. An If, Then statement shows cause and effect.
In other words, what **effect** does the independent variable have on the dependent variable? Or what does the independent variable cause the dependent variable to do?

Write an If, …Then… hypothesis using this format:

IF the independent variable changes, **THEN** the dependent variable will change.
Of course, in a real hypothesis, you will state the actual variables and describe the type of changes you expect.

Write a hypothesis for this testable research question: *"Does the amount of soap mixed with water affect how well the water will stay on a penny?"* Use an If, Then statement. ***Have your teacher check it before you move on to the next part.***

If____

____

then____

____

Teacher Check:

Part 4 --- Designing an Experimental Investigation

Background Information: One way to investigate an answer to a testable question is by doing an **EXPERIMENTAL INVESTIGATION**. An experiment involves **VARIABLES**.

In an experiment, scientists ask a testable question [called a **RESEARCH QUESTION**] about how one variable [called the **INDEPENDENT VARIABLE**] will affect another variable [called the **DEPENDENT VARIABLE**.]

Some variables are held **CONSTANT** – they do not change during the experiment because the scientist controls them. These are called **CONTROLLED VARIABLES**.

The experiment must be **REPEATED SEVERAL TIMES** to be confident in the accuracy of the results.

A written **PROCEDURE is** a step-by-step recipe for an experiment. A good procedure is so detailed and complete that another scientist can duplicate the experiment exactly. Procedures include what is changed, how it is changed, what is not changed, what is measured, how it is measured, the tools that are used, and the number of trials that are conducted during the experiment.

What to do:

Given this research question: Does the amount of soap in a soap and water mixture affect how much of the mixture can be held on a penny?

1. Identify the independent variable in this question.

____

2. Identify the dependent variable in this question.

____

3. Identify at least 3 *controlled variables* for this question.

____

____

____

Given these materials*:*

1 penny	1 container of pure water	1 container of 1:3 soap/water mixture	1 container of 1:1 soap/water mixture
Paper towels	Tweezers	Large beaker of water	

1. Work with your partner. Make sure you both understand what to do.
2. Use the graphic organizer to plan your experiment.
3. Make sure to include:
    a. exactly what you will change
    b. exactly what you will observe and measure
    c. exactly what you will control
    d. how you will change the IV
    e. how you will measure the DV
    f. how you will control other variables
    g. how you will measure
    h. tools you will use
    i. how many times you will repeat the procedure (# of trials)
    j. what data you will collect
    k. how long you will do something
    l. any safety precautions you will take
4. You do not have to include:
    a. "gather materials"
    b. "make a chart"
    c. "graph the data"
    d. "write a conclusion"
5. Use the left side of the organizer to write IN ORDER the steps you will follow.
6. Use the right side of the organizer to explain why you are including that step.
7. You may have more or less than 10 steps
8. Have your teacher check your procedure before you move on to the next part.

Steps (What needs to be done)	Why this step is needed
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Part 5 – Collecting and Recording Data

Background Information: Data gathered during an experimental investigation must be collected in some organized manner. A **DATA TABLE** is usually used. The data table is frequently designed as part of the experimental design.
Quality tables have a title. The title describes exactly what the data in the table or chart refers to.
Tables include the variables and units of measurement. The units of measurement are put in parenthesis. They are always metric units.
The data table includes the **REDUCED DATA** – average, percent, frequency, range or other **MEASURES OF CENTRAL TENDENCY**.
The reduced is data is frequently **GRAPHED** so that **PATTERNS**, **TRENDS**, and **RELATIONSHIPS** can be seen.
For the testable question and hypothesis above, design a data table to record your observations and have your teacher check it before you move on.

Teacher Check:

Part 6 --- Implementing Your Investigation

What to do:

1. Work with your partner. Make sure you both understand what to do.
2. Follow your procedure to collect data to test your hypothesis.
3. Record your data in the chart you created in part 5.

Part 7 --- Display Your Data

Background Information: After data is recorded it must be **ANALYZED**. Often scientists have so many numbers, that the data needs to be **REDUCED** to make sense. Reducing data often includes finding a measure of central tendency, or one number that can represent many numbers. The mean, median, and mode are measures of central tendency. Frequencies and ranges are also often used.

Graphing the reduced data helps scientists observe patterns and relationships between variables quickly. Bar graphs allow scientists to compare data, line graphs show trends – especially over time, and scatter plots show correlations between variables.
Graphs need to have a descriptive title, labels for the independent variable on the X-axis, labels for the dependent variable on the Y-axis, and appropriate scales and intervals. This information helps others understand the data.

1. Reduce your data to find the means, (averages) and then graph the means in a graph.
Which type of graph is best for this data? Why?

____

What to do:

1. Work with your partner. Make sure you both understand what to do.
2. Make a graph to communicate your data.
3. Decide which type of graph is best for the data.
4. Make sure to:
    a. Title the graph (DV vs IV)
    b. Label the axes
    c. Use an appropriate scale and interval
5. Have your teacher check your graph before you move on.

Teacher Check:

Part 8 ---

Analyze Your Data

Background Information: Graphs can be used to help analyze data. Use the graph to look for **RELATIONSHIPS** - two variables are related if one of them changes whenever the other one changes. There are two kinds of relationships:

- **DIRECT RELATIONSHIP**: When one variable increases the other variable increases.
- **INDIRECT or INVERSE RELATIONSHIP**: When one variable decreases the other variable increases.

What relationship(s) do you see in your graph?

____

____

Part 9 --- Draw a Conclusion

Background Information: After the data have been analyzed, **CONCLUSIONS** can be drawn. A conclusion is a written answer to the question. Sometimes the answer is "I don't know."
Sometimes a conclusion is an inference.
Whatever conclusion is drawn it is **always, always** supported by actual data from the experiment. An answer without evidence is meaningless.

What to do:
Write a conclusion for your experiment. Conclusions are written **independently**. (Not with your partner)

1. Answer the original question.
2. Restate the question and your hypothesis.
3. Explain whether or not the data supported your hypothesis. Remember a hypothesis never right or wrong, just supported or not supported. You can learn as much when your hypothesis is not supported as you do when it is!
4. You must give **actual data** [evidence] from your experiment to back up what you say.
5. Describe the relationship(s) in the data.
6. Explain any inferences.
7. Describe any sources of error, the possible impact they may have, and explain how to correct them.
8. Describe any possible extensions or elaborations to this investigation. What further research can be done?

____

____

____

____

____

____

____

____