Doing Science

Science is a way of examining and finding order in the natural world. Science involves a process of asking questions and seeking answers to those questions by making observations and doing experiments. From our observations we can make tentative explanations or "best guesses" about the answers to our questions. In science, a probable explanation for our question is the **hypothesis**. We experiment to obtain information that will support (or not support) our hypothesis. From the data and results obtained, we are able to make conclusions about our hypothesis.

This laboratory is designed to look at the process of science by investigating reaction time – how long it takes for you to react to a stimulus. You will make a hypothesis, design experiments and analyze your data. Making hypotheses and designing procedures to test hypotheses are among the most important things one does in science. Without a good testable question and good experimental design, there is no good science.

Science as a process uses the scientific method, which is based on objective observation of experiments that are repeatable and systematic. The scientific method uses a common "outline" discussed here.

- Make observations that can lead to a testable question (or questions).
- Identify the problem or question for which you are seeking an answer.
- From the question, make a tentative hypothesis, or reasoned guess, about the answer. A hypothesis must be testable in a way that could prove the hypothesis to be false. If repeated tests do not prove the hypothesis false, then your hypothesis gains support. A hypothesis, regrettably, can never be proven true, only supported by the evidence. It can be shown to be false if the evidence from experimentation does not support the hypothesis.
- Good science also requires a **null hypothesis**, one which predicts what would happen if your hypothesis was not correct.
- Make predictions about the results expected if the hypothesis is correct. This will help design the experiments needed to test the hypothesis. (The hypothesis may even be stated as a prediction.)
- Define the experimental independent, dependent and controlled variables.
    - The **independent variable** is the thing you are testing or manipulating. It can be things such as density, temperature, light, concentration, time, a type of drug therapy, etc. For example if we are measuring reaction rate, it might be time of day when we are testing the reaction rate or the ages of those being tested. For a pharmaceutical company, it might be the type of drug given to achieve a desired effect, such as a new drug to lower blood pressure.
    - The **dependent variable** in an experiment is the aspect of the system that is showing a response to the changes of the independent variable. It is what we measure, or count or record in the experiment. In today's experiment we are testing reaction rate by measuring the distance a ruler falls before it is caught. For a drug test for lowering blood pressure, it may be any of a number of things that might affect the person's heath relative to another person whose blood pressure is closer to normal (i.e., things that might prove life threatening and impact the results apart from the potential lowering of blood pressure than might take place as a result of the drug therapy). There may be many dependent variables in an experiment.

    - **Controlled variables** are aspects of the experimental condition made constant, or standardized, during the experiment that could vary if not kept standard for the experiment. They would be other possible independent variables. They could be things such as how we hold ruler for the reaction test, how frequently we do the test, the kind of ruler, plus any number of physical characteristics of the individual such as age, gender, etc., not being measured in the experiment. With a drug test, the dose, frequency of dose, age of person, and other health characteristics can be controlled or standardized for the experiment.
- Define the tests, procedures and methods of the experimental design. In other words state what you are going to do to test your hypothesis. An ideal experiment will also have a **control**. A control has the same standardized variables but is not subjected to the independent variable of the experiment. An experimental **treatment group** is defined as a test group of individuals that are subjected to the same independent variable.
- Perform the experiments and collect the data.
- Analyze the results, which should lead to a conclusion about whether or not the results support or do not support the hypothesis. The data will either support or not support the null hypothesis as well.
- Repeat the procedures to further validate your experimental conclusions, and/or to refine your question.

Exercise I – Making Observations about Reaction Time

One of the characteristics of living organisms is response to environmental stimuli. We blink if something is too close to our eyes, startle at unexpected sounds, and have a number of other "reflex" reactions to stimuli. Sunflowers tract the sun, Venus fly-traps close their leaves in response to touch and rotifers swim away from toxic chemicals. The reaction time is the time it takes to begin the response to a stimulus. The responses to stimuli listed above are just a few of the myriads of stimuli-responses you could list.

This experiment will test your ability to catch a ruler dropped between two of your fingers, and whether your reaction time is fast enough to catch it at all.

Procedure

1. Work in pairs
2. Place a ruler in the crevice formed by the index finger and second finger of one of your partner's hands. (Your partner can choose which hand he/she wants to use for this experiment. You should standardize the height from the floor at which the hand is being held.)
3. Orient the ruler so that the 1cm mark is facing down.
4. Your partner should now open two fingers as wide as possible. Measure this distance for consistency in experimental data collection.
5. Drop the ruler (You should also standardize the height above your partner's hand from which you are dropping the ruler.)
6. Record the mm mark on the ruler at the top surface of the fingers (assuming the ruler was caught).
7. Repeat several times. Record your data on the table below for both partners. Record your results on the board or overhead to collect class data

Trial	Subject's Name	
	1:	2:
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average		

Additional Information

Age		
Gender		
Ruler Distance from Floor		
Hand Distance from Floor		
Finger Spread		
Hours Slept		
Hours Since Eating		
Caffeinated Beverages		
Other:		
Other:		

What environmental or individual differences might affect reaction times?

Exercise II – Reaction Time Hypothesis and Experimental Design
From your observations with the ruler reaction time form a hypothesis and design an experiment that might explain differences in reaction time to your experiment.

For example, you might predict that those whose work requires good hand-eye coordination have a faster ruler reaction time than those who do not do work requiring hand-eye coordination, or that those who play a musical instrument have a faster ruler reaction time than those who do not play a musical instrument. Or you may think that reaction time depends on the time of day or how recently one has eaten, how much caffeine has been consumed or what kind of background noise is present during the test. Perhaps it is age or gender related.

Identify the independent variable that you want to observe (manipulate in the experiment). What is your dependent variable in this experiment? Identify the controlled variables that you would want to be kept constant in this experiment.

Define the “treatment” or test group that you are going to subject to the same independent variable. For example, you might want to compare the age of those in the test group. Other treatments might be hours of sleep the night before, or time since the latest meal, or the cups of caffeinated beverages consumed in the last 4 hours.

Design your experiment for testing ruler reaction time

Hypothesis

Null hypothesis

Independent variable

Dependent variable

Controlled variables

Procedure

Conduct the Reaction Time Experiments

1. Conduct the “drop the ruler” reaction time experiment, collecting at least 10 reaction times per test person.
2. Record your data for the test groups in the tables below.

Test Group 1: Independent variable being tested _____

	Subject (Test Person)									
Trial #	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Average										

Test Group 2: Independent variable being tested _____

	Subject (Test Person)									
Trial #	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Average										

Test Group 3: Independent variable being tested _____

	Subject (Test Person)									
Trial #	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Average										

What conclusions can you make from the results obtained in the ruler reaction time experiment?