

## The Scientific Method

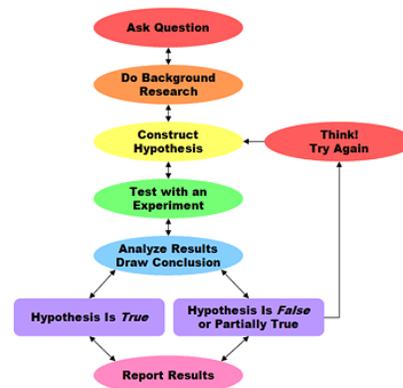
- The Scientific Method is an effective method of gaining, organizing, and applying new knowledge.

Or

- A logical approach to solving problems by observing and collecting data, testing hypothesis, and formulating theories that are supported by data.

## The Scientific Method

- Identify a problem/ask a question.
- Research the problem.
- Make an educated guess—a **hypotheses**—about the answer.
  - AKA Prediction
- Perform **experiments** to test predictions. (An organized process to test your hypothesis)
- Observe & Record.
  - Make **qualitative** and **quantitative** observations.
  - Record observations as data...."observation and measurements recorded during an experiment.
- Arrive at a **conclusion** about your hypothesis.
  - Was your hypothesis right or wrong, because....



## Scientific Hypothesis

- Must be testable...
  - Can be proven correct or proven wrong.
- Which of the following is a scientific hypothesis?
  - Atoms are the smallest particles of matter.
  - The universe is surrounded by a second universe, the existence of which cannot be detected by scientists.
  - Albert Einstein was the greatest physicist of the twentieth century.

## The Scientific Method

- Facts** – a fact is an agreement by observers who make observations about the same phenomenon.
  - Observations need to be testable.
- Theory**—the results of a large body of information that has been well-tested and verified.
  - Theories are not fixed, they undergo refinement and redefinition
  - For Example-----Theory of Evolution
- Laws** or **Principles** are the result of hypotheses being tested over and over again and never being contradicted.
  - For Example----The Law of Gravity

## Parts of an Experiment

- Design your experiment to only test 1 variable at a time.
  - **Variable** – A factor that changes in an experiment.
- Variables in an experiment
  - **Independent Variable** (AKA Manipulated Variable)
    - The variable that the experimenter changes/adjusts/manipulates during the experiment.
  - **Dependent Variable** (AKA Responding Variable)
    - The outcome of the experiment-the results based on the changing independent variable.
- **Constants** are the variables are variables that you do not change through out the experiment.
- Your **control** is the subject of the experiment that you DO NOT apply the Independent variable to. It proves that your results are due to the variable being tested.
- Remember:
  - Only test for one independent variable at a time.
  - You can get multiple dependent variables from one Independent Variable.

## Practice - Label the variables

- Four types of cars were tested for city and highway gas mileage.
- What is the IV?
- What is the DV?
- What about constants?
- The experiment must be fair and unbiased.

Car Model	City Mileage (kilometers per liter)	Highway Mileage (kilometers per liter)
J	25.4	21.7
K	25.1	28.0
L	10.3	13.2
M	8.5	11.1

## Label the Variables

- Four types of cooking flour were analyzed for the amount of protein in them.
- What is the DV?
- What is the IV?
- What must be constant?

Protein and Fiber Content of Different Flours

Type of Flour	Protein Content (grams per serving)	Dietary Fiber Content (grams per serving)
Whole wheat	4	4
White wheat	3	<1
Oat	4	3
Rice	3	1

## Design your own Experiment

- You want to test a variable to see how well plants grow.
  - Choose your **IV**: Amount of sunlight, amount of water, fertilizer/plant food.



## IV - Testing amount of water...

- Get ~10 plants.
- 2 get no water.
- 2 get ½ cup
- 2 get 1 cup
- 2 get 1 ½ cups
- 2 get 2 cups
- The amount of water a plant gets you control.
- The amount of water is the is the \_\_\_\_\_ variable...



## Constants

- We want to **ONLY** test the effect of various amounts of water (our Ind-Var).
- What must be held constant
  - Amount of sunlight
  - Type/amount fertilizer
  - Types of plants
  - Containers
  - Soil
  - Etc etc



## Design your own Experiment

- What was our control?



- A **control** is a subject in the experiment that DOES NOT receive the independent variable.
- The 2 plants that got NO water.

## Dependent Variable?

- So what is the Dependent variable(s) in this experiment where we tested the amount of water?
  - Plant height
  - Number of leaves
  - Circumference of stem(s)
- Remember there can be multiple DVs, but only 1 IV per experiment.

## Label the Variables

- Dr. Davis wants to examine whether a new drug increases the maze running performance of older rats. Just like aging humans, older rats show signs of poorer memory for new things. Dr. Davis teaches two groups of older rats to find a piece of tasty rat chow in the maze. One group of rats is given the new drug while they are learning the maze. The second group is not given the drug. One week after having learned the maze he retests the rats and records how long it takes them to find the rat chow.

- What is the independent variable?

*Hint: What did the researcher manipulate (allow to vary) in this study?*

- a) age of the rats.
- b) type of maze.
- c) length of time it took the rats to run the maze.
- d) presence or absence of the new drug.

- What is the dependent variable?

*Hint: What was the measure of the research subjects' responses?*

- a) age of the rats.
- b) type of maze.
- c) length of time it took the rats to run the maze.
- d) presence or absence of the new drug.

## Scientific Method Review

- Remember, an experiment isn't a failure if it proves your hypothesis wrong or if your prediction isn't accurate.
- No one will take points off for that.
- An experiment is only a failure *if its design is flawed*. A flawed experiment is one that
  - (1) doesn't keep its variables under control, and
  - (2) doesn't sufficiently answer the question that you asked of it.

## Scientific Method in Action

- You are a farmer who has a PROBLEM!!
- Your crop (wheat for example) is not growing to its full potential.
- You read an article in Farmer Monthly that adding Phosphorus fertilizer will cause your crop to grow taller faster.

### Scientific Method in Action

- So you decide to set up an experiment where you will divide your field into 4 equal sections.
- The first section you will not add any fertilizer.
- This section is your control. In experiment you always need a control (a **standard for comparison**) in other words a group you didn't experiment on.
- The second section will get 10% P fertilizer mixed in.

### Scientific Method in Action

- The 3<sup>rd</sup> section will get 25% P fertilizer.
- And the 4<sup>th</sup> section will get 50% P fertilizer.
- You (the experimenter) controlled the amount of fertilizer spread on the crop.
- The variable that the experimenter controls is the **INDEPENDENT VARIABLE**

### Scientific Method in Action

- Time Passes.
- Every 5 days you go to each section and measure the average height of randomly selected plants.
- The height that the plants in different sections grow depends on the amount of fertilizer you put there.
- So the height is the **DEPENDENT** variable.
- It depends on the independent variable.

### Scientific Method in Action

- **Analyze Result**
- **Conclusions?**

Time (days)	50% phosphorus fertilizer (cm)	25% phosphorus fertilizer (cm)	10% phosphorus fertilizer (cm)	no fertilizer (cm)
0	0	0	0	0
5	~2	~1.5	~1	~0.5
10	~5	~4	~2.5	~1
15	~10	~7	~4	~1.5
20	~25	~15	~8	~2

