## **The Scientific Method**

- Science is a process, requiring skillful methods to gather, organize & interpret information.
- It is a <u>systematic</u> approach to problemsolving
- At the heart of science is **Testing Ideas**.



### **Scientific Method**

Observe and Record
 Propose a Theory
 Test the Theory



• a systematic approach to problem-solving

## **Reasons for Testing Ideas**

There may be many reasons why we might want to test ideas. They may include:

- <u>Curiosity</u>
- Personal motivation
- Addressing a <u>societal</u> issue or an everyday
  <u>problem</u>
- Testing someone else's idea
- A <u>surprising</u> observation







### How Do We Test Ideas?

- After you get an idea, coming up with a <u>testable</u> hypothesis is important.
- Two main parts:
  Gathering Data and Interpreting Data.
- The key is to come up with a good <u>question</u>.



### **Experiment Types**

There are generally 3 types of experiments:

- A <u>Controlled</u> Experiment
- A <u>Quasi</u>-Experiment
- An Observational Study

#### All experiments have some parts in common:

- Hypothesis or a research question
- Identification of variables
- Observations
- Interpretation of <u>data</u>

### <u>Variables</u>

- A variable is any <u>factor</u> that could affect what it is you're studying.
- Some variables you can <u>control</u> or change, some you cannot.
- The types of experiment vary in terms of the <u>amount</u> of control over variables the experimenter has.

## **Controlled Experiments**

- Experimenter is able to <u>control</u> or account for all aspects of the experiment.
- Allows us to establish cause-effect relationships and therefore claim <u>causation</u>.

### **Example**

Does sunlight affect plant growth?

## **Quasi-Experiment**

- Variable tested without any pre-selection process or control. Other factors could affect <u>result</u>.
- We cannot control all variables since it could lead to <u>ethical</u> issues or is logistically <u>difficult</u>.

### **Examples**

- Does smoking lead to cancer?
- Does campus crime affect applicants to university?

https://www.youtube.com/watch?v=vYglvcLw kK4&t=0s&list=PLiGUnsfEBCz8qlBP4mljcUGCf OTjvnvYP&index=22

## **Observational Study**

Experimenter cannot control any variables. They simply <u>observe</u> and <u>analyze</u> the data.

### **Examples**

- What traits produce the best hockey players?
- 1854 Broad Street Cholera Outbreak



### **Practice**

Classify the experiment type as either an experiment (controlled and quasi) or observational study.

1. A random selection of adults were surveyed in a study on what time they go to bed and how much coffee they drink per day. The study found people that drank more coffee tends to sleep later at night.

2. A group of adults were split into two groups. One group drank a moderate amount of coffee per day and the other drank no coffee. Both groups recorded their bed time.

## Hypothesis and Controlled Experiment



From The University of California Museum of Paleontology, Berkeley, and the Reagents of the University of California. www.understandingscience.org

### **Heart of Science**

### At the heart of science is the process of testing ideas.



Find a **problem** or something you want to figure out.

- Solving an <u>everyday</u> problem
- Building up or testing someone else's idea
- <u>Curiosity</u>
- Personal <u>motivation</u>

### **Before Testing Ideas...**

What kind of <u>background</u> knowledge do you think you might need? (exploring literature, discussion with colleagues)

Identify something <u>specific</u> you want to test and come up with a hypothesis.

## **Narrowing Down The Initial Question**

#### What is the effect of acid rain on plants?

- What <u>background</u> knowledge might you have to research before tackling this question?
  - Acidity and acid rain
  - How plants grow
  - Types of plants?

Try to be more <u>specific</u> in your question:

# What is the effect of acid rain on the growth rate of sunflower plants?



### Hypothesis...

- Is a possible <u>explanation</u> or a prediction based on limited evidence.
- Is the starting point for further investigation.
- Is developed from the original <u>question</u> in the inquiry/investigation
- Is based on prior knowledge
- Oftentimes an "if... then... because" statement.

## A Controlled Experiment...

For certain questions, you may be able to conduct a <u>controlled</u> experiment. In controlled experiment, all the <u>variables</u> are under control of the experimenter.

**Example:** What is the effect of acid rain on the growth rate of sunflower plants?

The factors that might influence the data are called variables.

### **Types of Variables**

- The variable that the investigator changes is called the <u>independent</u> variable.
- The variable that changes due to the change in the independent variable is called the <u>dependent</u> variable.
- All other variables that are kept the same are called <u>controlled</u> variables.
- It is important to always have a control in this type of experiment.

### Example #1

<u>Question:</u> How does temperature (heat energy) affect the rate at which water boils?

Hypothesis: If more heat energy is added to water, then the water will come to a boil faster because the water particles will be moving faster.

### Example #2

Question: How does the amount of time a student spends studying affect their grades?

**<u>Hypothesis:</u>** If a student studies more, then their marks will improve because they have a better understanding of the material.

**Try #1:** How does acid rain affect the growth of sunflowers?

A. What could our hypothesis be?

B. How could we conduct the experiment?

C. What would be our independent and dependent variables?

D. What are some controlled variables?

E. What is our control?

**Try#2:** We want to know whether seeds germinate faster if fertilizer is applied.

A. What could our hypothesis be?

B. How would we conduct the experiment?



C. What would be our independent and dependent variables?

D. What are some controlled variables?

E. What is our control?