

WHAT DOES IT MEAN TO BE  
A SCIENTIST?





# WHAT IS SCIENCE?

The goal of science is to investigate and understand the **natural world**, to explain events in the natural world, and to use those explanations to make useful **predictions**.

# WHAT IS SCIENCE?

Science deals only with the natural world.

Scientists collect and organize information in a careful, orderly way, looking for patterns and connections between events.

Scientists propose **explanations** that can be **tested** by examining evidence

Science is an organized way of using evidence to learn about the natural world.

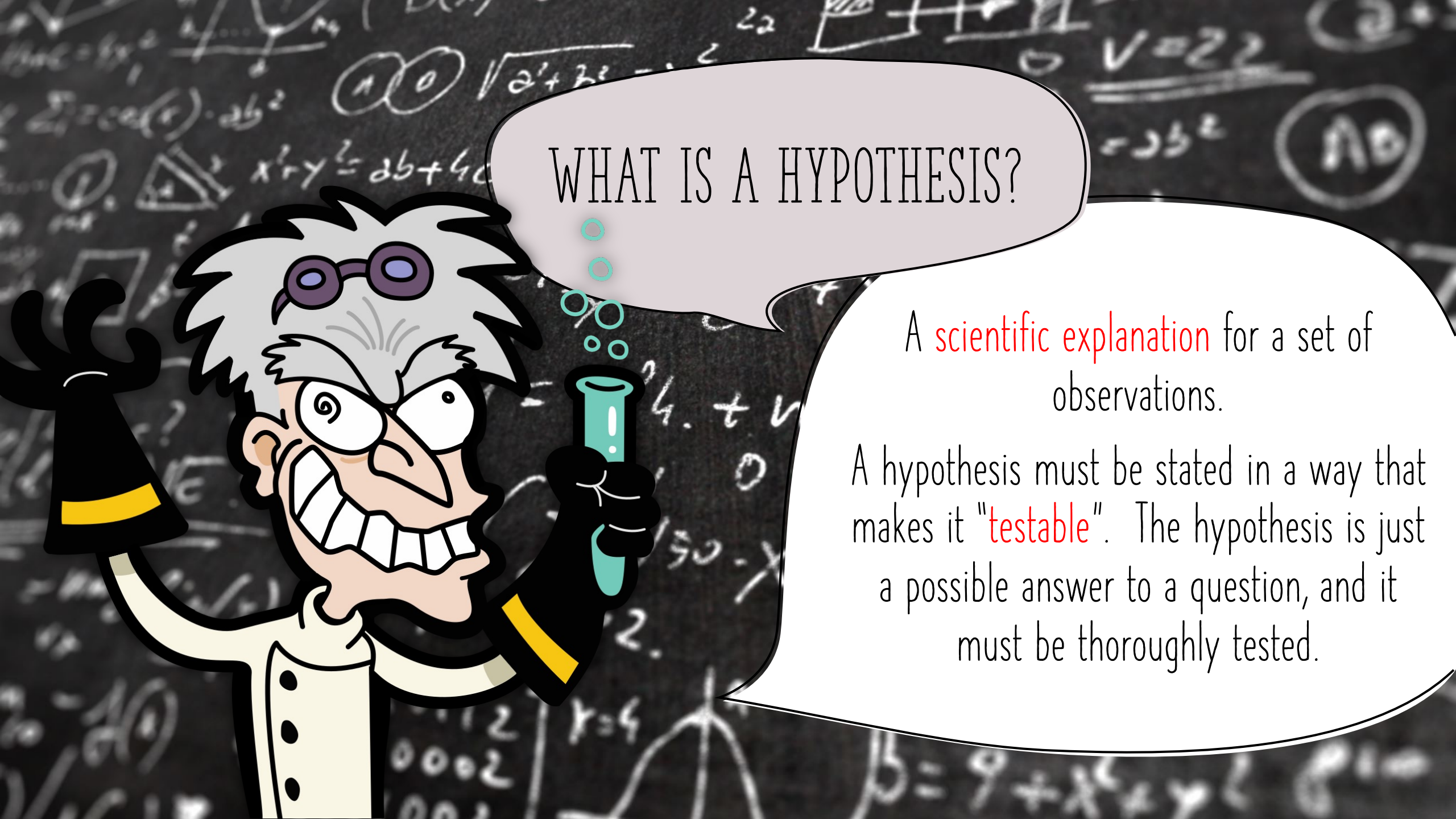
# HOW IS SCIENCE DONE?

Science begins with an **observation**.

This is the process of gathering information about events or processes in a careful, orderly way.

**Data** is the information gathered from making observations.





# WHAT IS A HYPOTHESIS?

A **scientific explanation** for a set of observations.

A hypothesis must be stated in a way that makes it "**testable**". The hypothesis is just a possible answer to a question, and it must be thoroughly tested.

# TYPES OF DATA

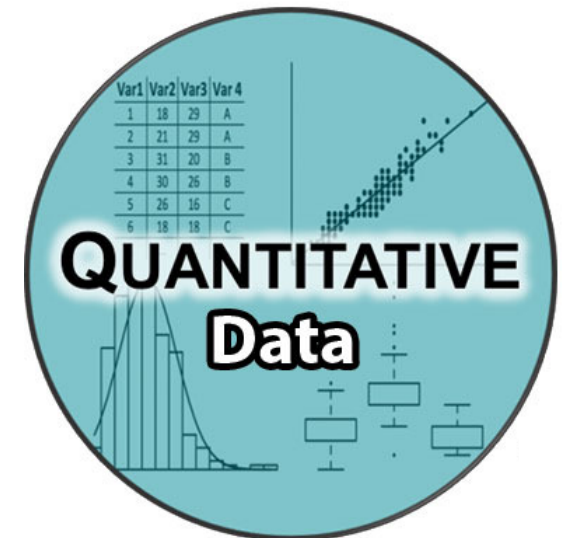
## Qualitative Data

- Descriptions and involve characteristics that **cannot** be counted.
- Made using your senses to observe results.



## Quantitative Data

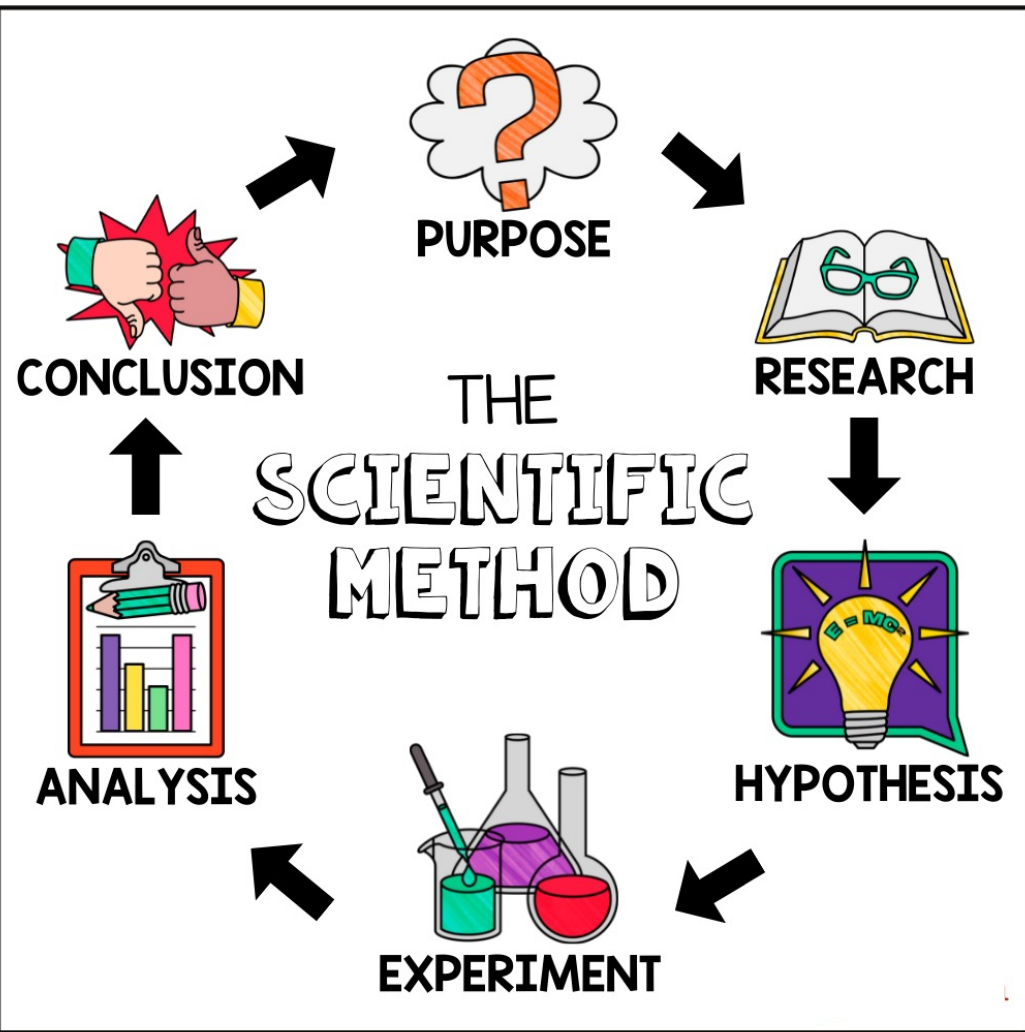
- **Numbers** and are obtained by counting or measuring.
- Made using instruments (e.g. rulers, balances, thermometer, beakers, etc...)





# THE SCIENTIFIC METHOD

Is a series of steps used by **scientists** to solve a **problem** or answer a **question**.



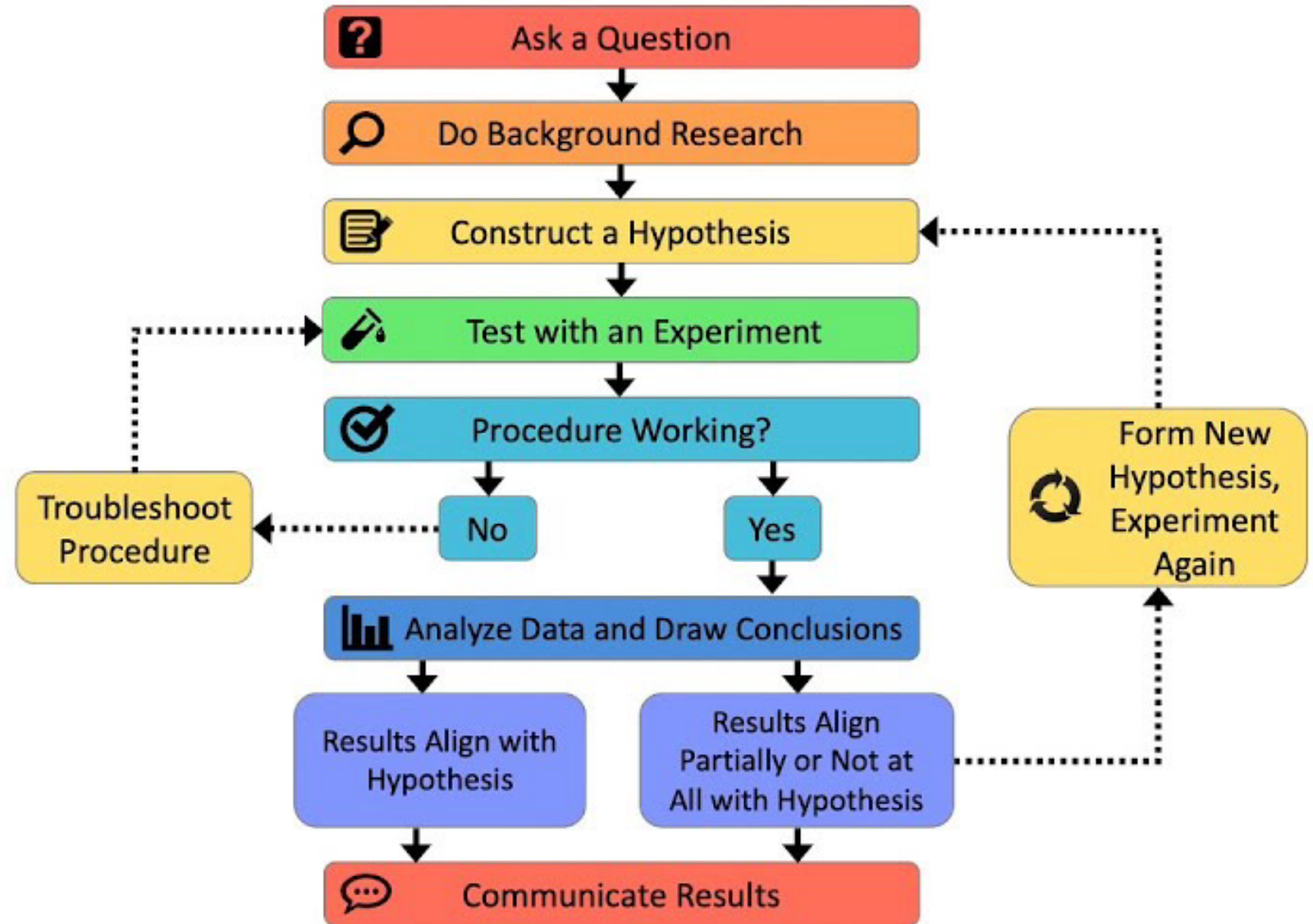
## THE SCIENTIFIC METHOD

The Steps to the Scientific Method:

1. Observation / Asking a Question
2. Form a Hypothesis
3. Design a Controlled Experiment
4. Record and Analyze Results
5. Draw Conclusions



# Scientific Method



# THE SCIENTIFIC METHOD

Step 1: Observation / Asking a Question

A problem or a question must first be identified.

Examples:

- ✓ How much water can a root hair absorb?
- ✓ Why does a plant stem bend toward the light?
- ✓ What effect does temperature have on heart rate?



# THE SCIENTIFIC METHOD

## Step 2: Form a Hypothesis

A possible explanation to the question or problem.

### Criteria

- ✓ It is simply a prediction and has not yet been proven or disproven.
- ✓ It must be stated in a way that is testable.
- ✓ A statement is considered "testable" if evidence can be collected that either does or does not support it.



# THE SCIENTIFIC METHOD

## Step 3: Designing a Controlled Experiment

1. The factors in an experiment that can be changed are called variables. Some examples of variables would be: Changing the temperature, the amount of light present, time, concentration of solutions used.
2. A controlled experiment works with one variable at a time. If several variables were changed at the same time, the scientist would not know which variable was responsible for the observed results.

# THE SCIENTIFIC METHOD

## Step 3: Designing a Controlled Experiment

3. In a "controlled experiment" only one variable is changed at a time. All other variables should be unchanged or "controlled".

# THE SCIENTIFIC METHOD

## Step 3: Designing a Controlled Experiment

4. An experiment is based on the comparison between a **control group** with an **experimental group**
  - a) These two groups are identical except for one factor.
  - b) The control group serves as the comparison. It is the same as the experiment group, except that the one variable that is being tested is removed.
  - c) The experimental group shows the effect of the variable that is being tested.

# THE SCIENTIFIC METHOD - EXAMPLE

In order to test the effectiveness of a new vaccine, 50 volunteers are selected and divided into two groups. One group will be the control group and the other will be the experimental group. Both groups are given a pill to take that is identical in size, shape, color and texture.

Describe the control group. Even though the volunteers are given identical looking pills, the control group will not actually receive the vaccine.

Describe the experimental group. This group will receive the vaccine.

What variables are kept constant? The size, shape, color, and texture of the pill.

What variable is being changed? Whether or not the pill contains the vaccine.

# TYPES OF VARIABLES

## Independent (Cause)

- Is the variable that is changed or manipulated by the scientist.

## Dependent (Effect)

- Is the one observed during the experiment where data is collected during the experiment.

In our vaccine example what is the Independent and Dependent variable?

Independent

- It is the addition of the vaccine to the pills

Dependent

- The observed health of the people taking the pills..



# THE SCIENTIFIC METHOD

## Step 4: Recording and Analyzing Results

1. The data that has been collected must be organized and analyzed to determine whether it is reliable.
2. Does the data support or not support the hypothesis?

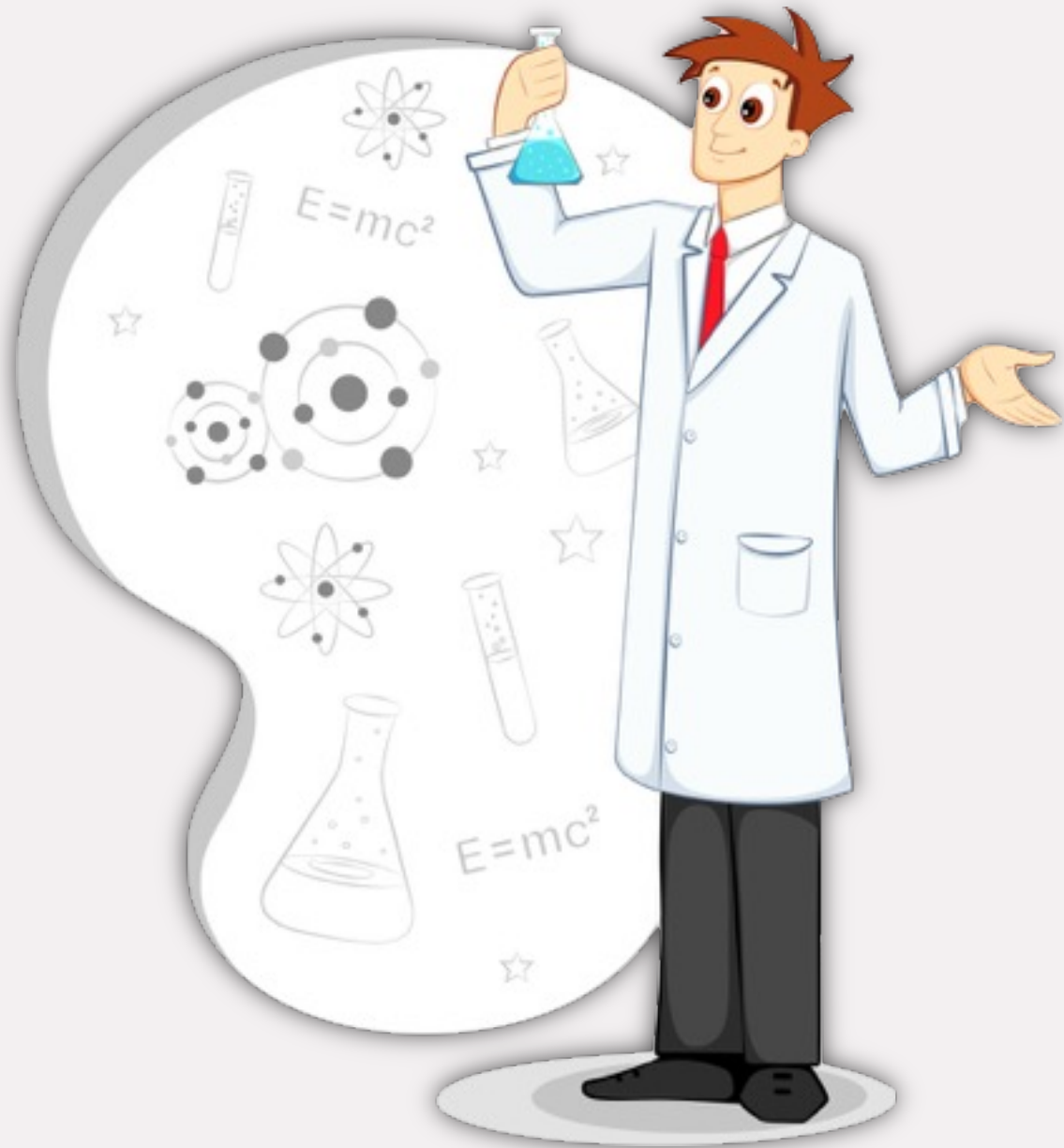


# THE SCIENTIFIC METHOD

## Step 5: Drawing Conclusions

- ✓ The evidence from the experiment is used to determine if the hypothesis is proven or disproven.
- ✓ Experiments must be repeated over and over. When repeated, the results should always be the same before a valid conclusion can be reached.





## FORMING A THEORY


A theory may be formed after the hypothesis has been tested many times and is supported by much **evidence**.

### Theory

A broad and comprehensive statement of what is thought to be true. A **theory** is supported by considerable evidence.



IN A "CONTROLLED EXPERIMENT", ALL VARIABLES MUST BE KEPT **CONSTANT** EXCEPT THE ONE VARIABLE THAT IS BEING CHANGED.

A cartoon illustration of a scientist with wild, grey hair, large round glasses, and a white lab coat over a red tie. He is pointing upwards with his right hand. The background features a grid of stylized human figures in green and grey.

## ANALYSIS QUESTIONS

Why is it important to have a large sample size in any experiment?

Results obtained by testing a large number of individuals would be much more accurate than if only a few individuals had been tested.

# ANALYSIS QUESTIONS

Why is it important to repeat the experiment many times?

- ✓ Experiments should be repeated to see if the same results are obtained each time.

What is the importance of the control?

- ✓ The control shows what will happen when the experimental factor is omitted. Without the control, there would be no basis for comparison



# ANALYSIS QUESTIONS

How is a theory different than a hypothesis?

- ✓ A hypothesis is an "educated guess" that is testable through an experiment. A theory is a broad statement of what is believed to be true based on many experiments.

Why is it so important that a scientist accurately describes the procedure used in the experiment?

- ✓ It allows other scientists to repeat the experiment and verify the results.



# ANALYSIS QUESTIONS

What is the difference between the independent and the dependent variables in an experiment?

- ✓ The independent variable is the variable that is deliberately changed by the scientist. The dependent variable is the one observed during the experiment---the data we collect.

In a "controlled experiment", why must all of the variables, except one, be kept constant throughout the experiment?

- ✓ If several variables were changed at the same time, the scientist would not know which variable was responsible for the results.