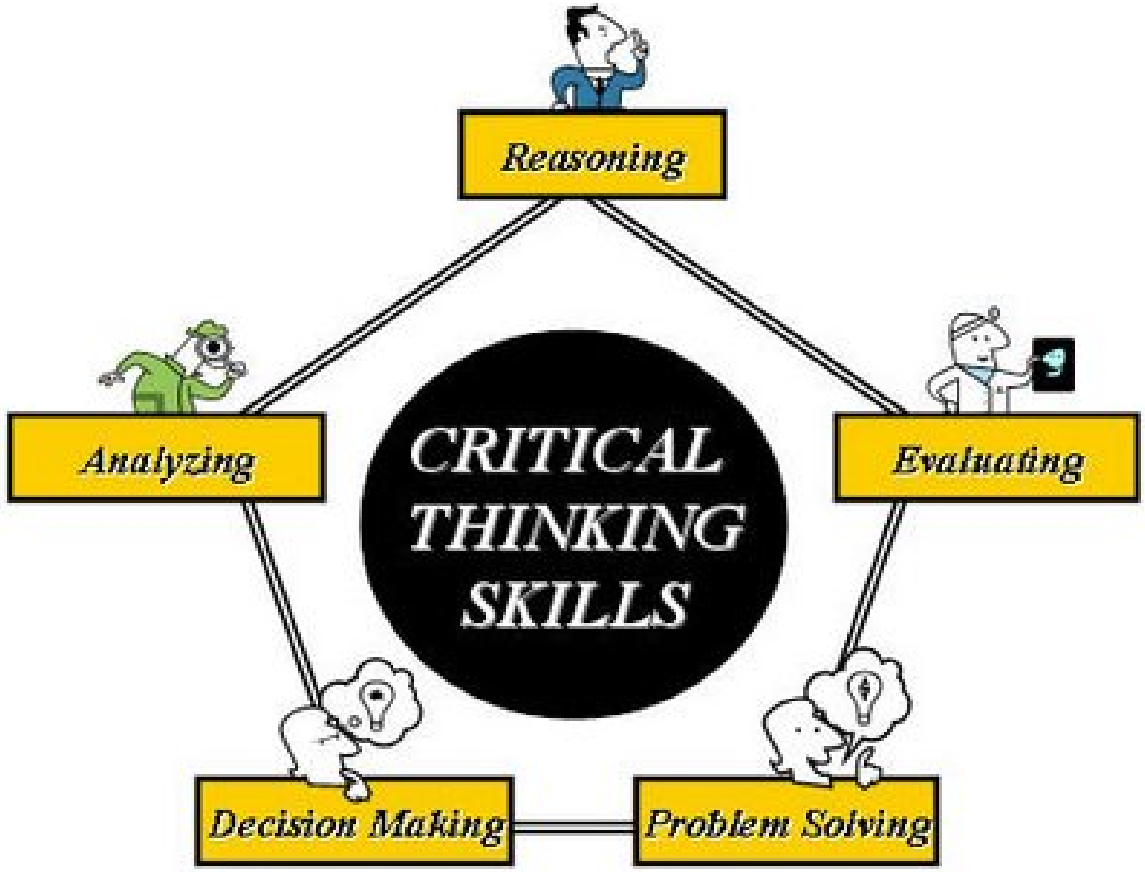
Scientific Method

Scientific Attitude

- **Mental outlook distinguished by an impartial and *unbiased* method and the application of empirical approaches in the quest for *understanding***
- ***Includes:***
  - ✓ ***Curiosity:*** **passion to explore & understand**
  - ✓ ***Skepticism*****: questioning, taking nothing for granted**
  - ✓ ***Humility*****: awareness of your vulnerability to make errors, open-minded to new ideas & perspectives**

Critical Thinking

- A scientific attitude enables to think “smarter”.



Observation vs. Inference

- **Observation:** receiving knowledge of the outside world through our senses, or recording information using scientific tools and instruments.
  - Any data recorded during an ***experiment*** can be called an observation.

- **Inference:** the act or process of reaching a ***conclusion*** about something from known facts or evidence

Take a Good Look at This Picture

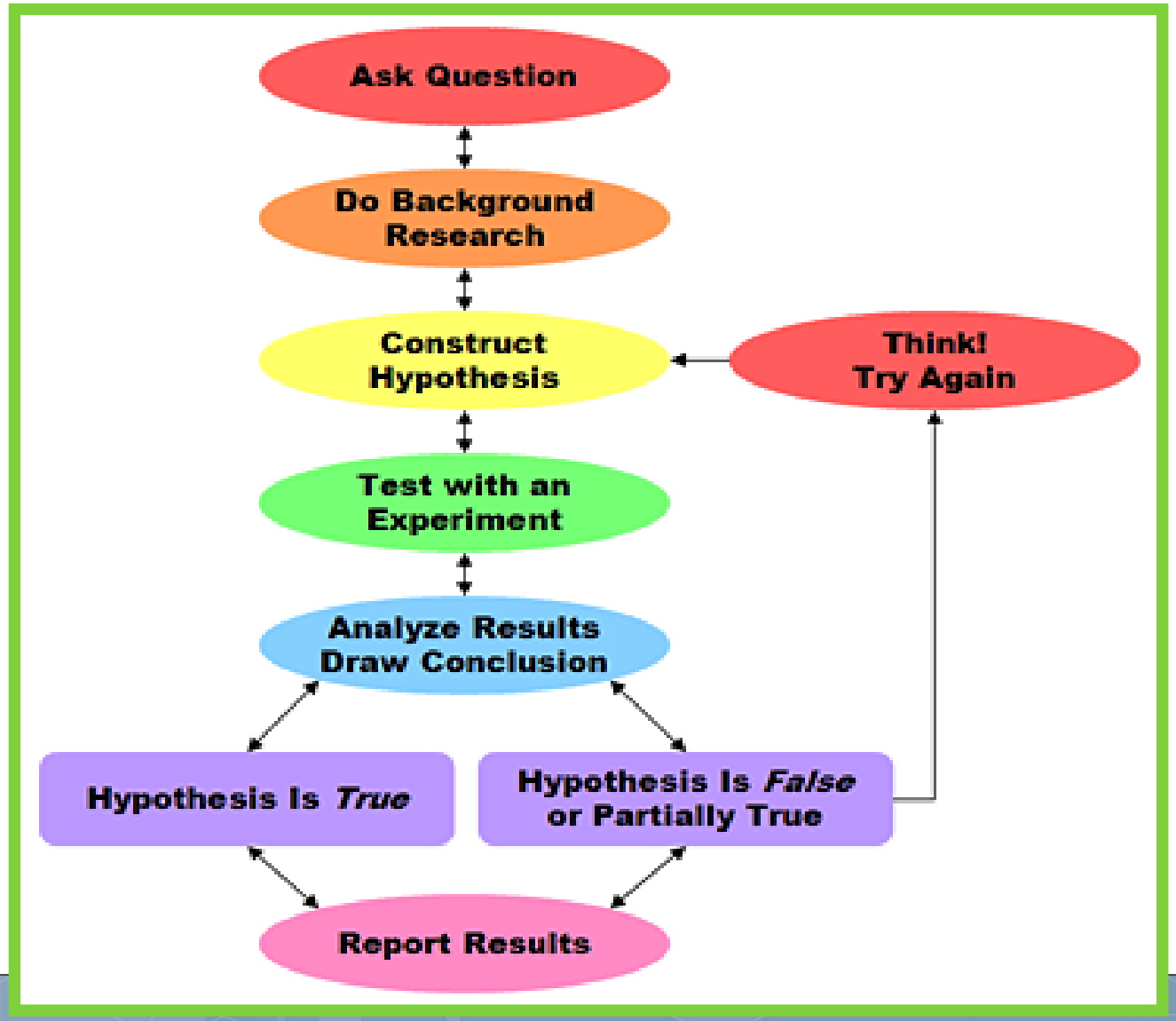
Check your Observations

- Are there cars parked on both sides of the road?
- What color is the pick-up driving in the street?
- What is the color of the paper posted on the first tree on the right side of the road?
- What is the speed limit?
- Where there any pedestrians crossing the road?
- What did the sign on the telephone pole indicate?

Observation or Inference?

- The coin is old.
- The date 1722 is imprinted on the coin.
- The face depicted on the coin is the “head” of his nation.
- The coin was made in 1722.
- There is depiction of a flower on the back of the coin.

Scientific Method



Problem vs Hypothesis

- **Problem:** the research question; question or problem you are trying to solve
- **Hypothesis:** a measurable statement that is serves as a possible explanation of the problem being investigated. It is an educated prediction that deals with cause and effect relationships.

Defining the Problem

- Make observations
- Ask questions
- Conduct background research to back up observations and see what other scientists have studied with respect to your problem

Formulating a Hypothesis

A hypothesis should:

- be in statement form
- Be measurable
- Contain both the independent and dependent variables
- Name the population that is being tested
- It is quite helpful if you write your hypothesis formally, using *"if"* (this happens) **"then"** (this will occur)

Example:

- ***Problem:*** How with the height of the ramp affect the distance the car travels?
- ***Hypothesis***: If the car is placed on the 8 cm. ramp, then the car will travel the farthest distance.

Scientific Method – the Experiment

- The only research method that can establish **cause and effect.**
- **Experiment:** a series of trials of tests designed to test the validity of the hypothesis.
- Carried out in laboratories under controlled conditions with careful measurements of data.
- **Experimental variable:** the factor that is being ***changed or altered.*** ***An experimental variable can be broken into 2 parts:***
- ***Independent Variable (IV):*** the factor that ***changes*** in the experiment (***"if" part*** of hypothesis)
- ***Dependent Variable (DV):*** the factor being ***measured*** in the experiment (***"then" part*** of the hypothesis)
- Essentially, the ***IV*** is the **cause** and the ***DV*** is the ***effect.***

Scientific Method (cont'd)

- **Control of the experiment:** the standard of comparison for the experiment.
  - By having a *control,* you can compare the experimental group to the control group to see if there are any changes as a result of manipulating the variable.
- ***Controlled Experiment:***
  - ***One variable** is changed during the experiment*
  - *There is **a control to compare** your results to*
  - *In a controlled experiment, you can **infer that that a measured change (DV) is a result of altering the Independent variable (IV)***

Scientific Method (cont'd)

- **Constants (controlled variables): all other variables in an experiment should REMAIN THE SAME!**
- **Example:**
  - **If you are testing the effects of light on the growth in height of rose bushes then:**
    - ***The rose bushes have to all be the same variety, similar age and health***
    - ***Grown in the same type of soil; watered at the same time of day with the same volume of water***
    - ***Same intensity and duration of light***
    - ***What else can you think of?***

Scientific Method (cont'd)

- If you write your hypothesis in *if….., then….* form,
  - --"*if part*" represents *the independent variable*
  - --"*then part*" represents the *dependent variable*

Example:

- *Problem: How does sun affect plant growth?*
- *Hypothesis: If rose bushes are exposed to sunlight every day, they will grow taller in height.*

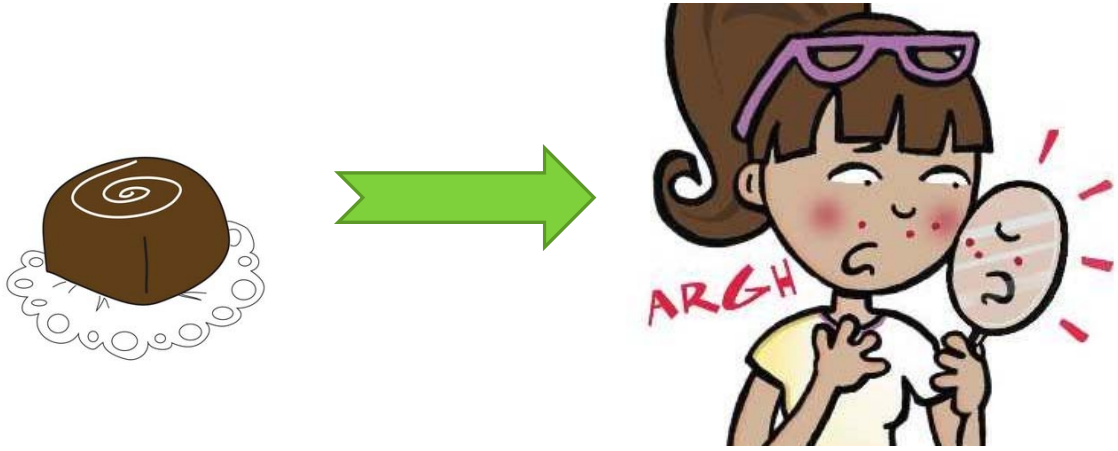
Independent variable: type of light

Dependent variable: growth in height

Population being studied: rose bushes

Practice With Hypotheses

- A scientist is investigating if chocolate actually causes pimples.
  - Write a formal hypothesis using **"if" "then"** format.
  - ***Identify the IV***
  - ***Identify the DV***
  - What is the ***population*** being studied?



Controlled Experiments with Animals and Humans

- **Experimental Group:** group receiving the treatment
- **Control group:** Group receiving the placebo
- **Placebo:** a fake pill (usually sugar) or injection (usually saltwater) that looks, tastes, and/or feels just like the actual medication
  - Given to the control group so that no one knows who is getting the real or fake medication.

Controlled Experiments with Animals and Humans (cont'd)

- A **placebo** is necessary to keep all other variables the same between the experimental and control groups.
- **Placebo Effect (subjective bias):** we must control for ***potential psychological effects*** that may occur if a participant thought he/she did not get the test medication. Without a placebo, the participant could become sad, angry, and/or depressed, all which could affect the experimental results.

placebo effect

Controlled Experiments with Animals and Humans (cont'd)

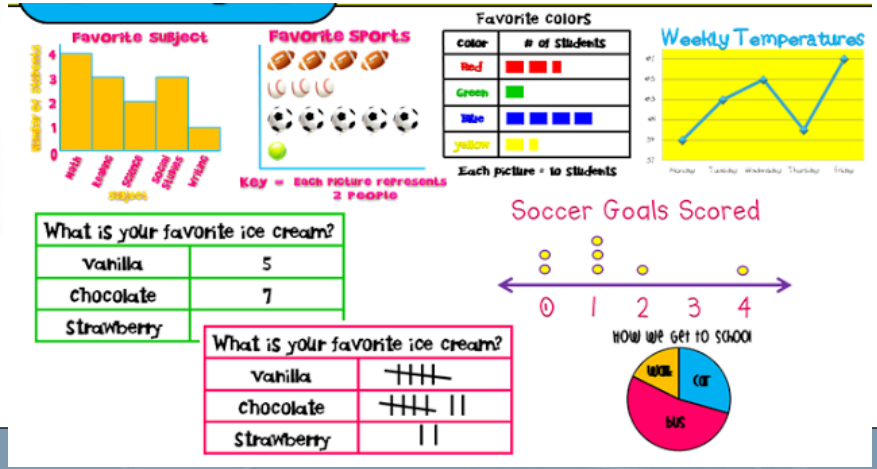
- **Single Blind Study:** Only the researchers (not the participants) know which group is getting the active medicine/treatment and which group is not. This helps to ***eliminate the placebo effect*** from the experimental results.
- **Double-blind study:** Neither the participants or the experimenters know who is receiving a particular treatment.
  - particularly useful for preventing bias due to the placebo effect.

RESEARCH POPULATIONS

- **Population:** all the cases in a group that is being studied.
- **Random Sample:** a sample that is fairly representative of the population because each member of that group had an equal chance of participating in the study
  - ✓ ***The larger the sample size, the greater chance that that the sample is representative of the given population being studied.***
  - ✓ ***Minimizes the effects of individual (genetic) differences among study participants.***

Data Collection

- Once you have outlined the steps of your procedure, you can begin your experiment and **collect data**, which includes all measurements and observations.
- Charts and tables are useful in helping to organize and keep track of data collection.

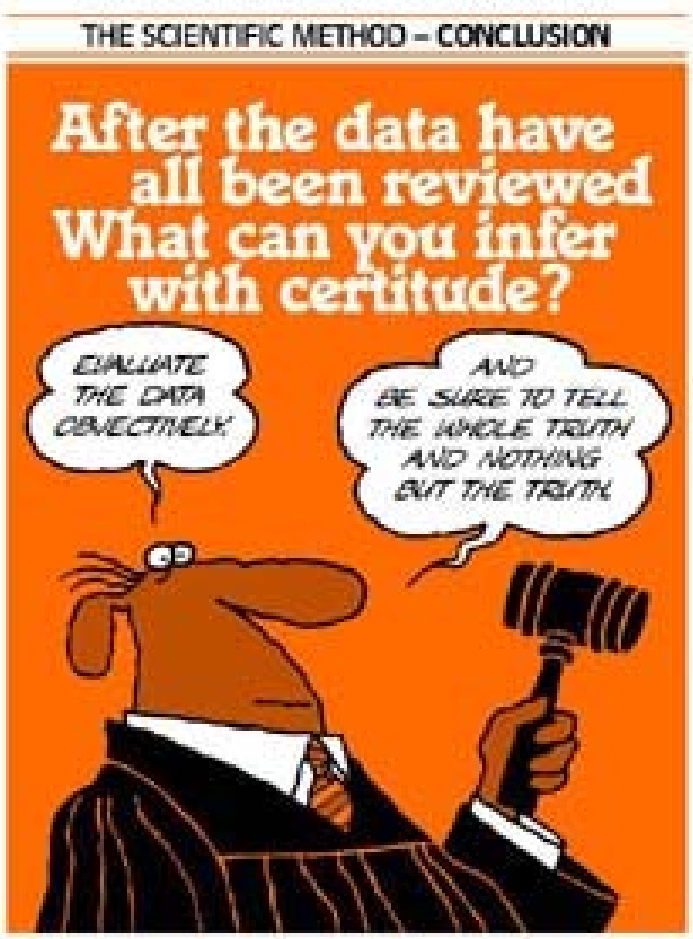


Data Analysis (Results)

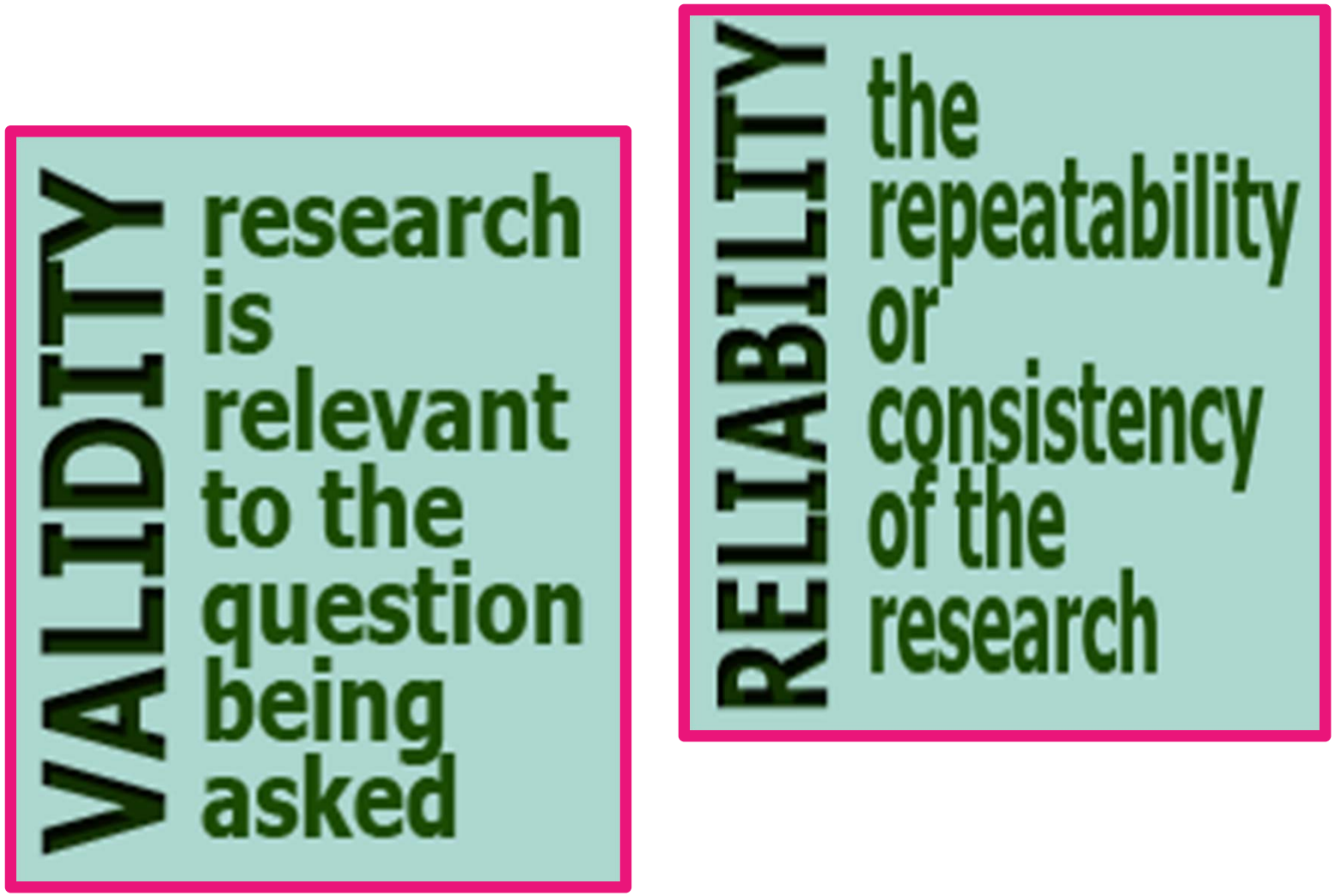
- Simplest form of data analysis is to calculate percentages.
- Statistical analyses are performed to determine if the observed changes are due to manipulation of the independent variable (IV) when compared to the control.
- Statistical analyses are necessary to determine if the results are **significant**. Quite often results may appear to be important, but when analyzed mathematically, the results ***are really due to chance and do not provide support for the hypothesis being questioned.***

Drawing Valid Conclusions

- Results either **SUPPORT** or **REFUTE** your hypothesis
- Results ***NEVER PROVE*** that the hypothesis is true!
- You should always repeat your experiment to **VALIDATE** that your results are **RELIABLE**



Validity vs. Reliability



Hypothesis vs Theory

- ***Hypothesis:*** **a testable prediction of how two or more factors are related. Often implied by a theory.**
- ***Theory:*** **Organized set of principles or concepts that explain specific phenomenon**