

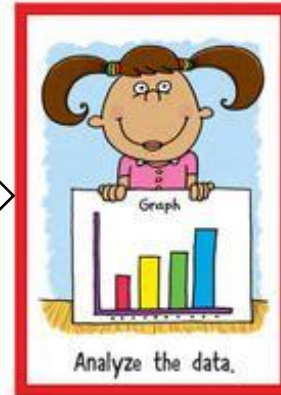
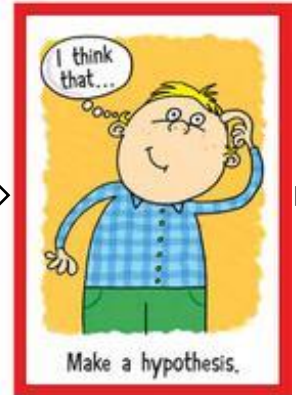
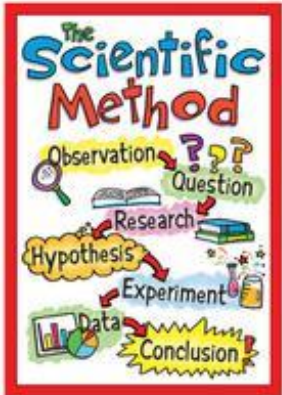
INITIAL OBSERVATION



WONDER

RESEARCH

HYPOTHESIZE



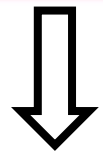
PLAN

EXPERIMENT
ADDITIONAL
OBSERVATIONS

DATA

ANALYSIS

CONCLUSION!



Describe the Elephant



It weighs 480 kilograms.

It has large ears and long trunk.

It has gray wrinkly skin.

~~**It is very cute!**~~

It is young.

It is about 1.5 yards tall.

Describe the Octopus Minor



Its body is about 20 cm long.

It has four tentacles.

It has two eyes.

It is covered with slime.

Qualitative vs Quantitative Data

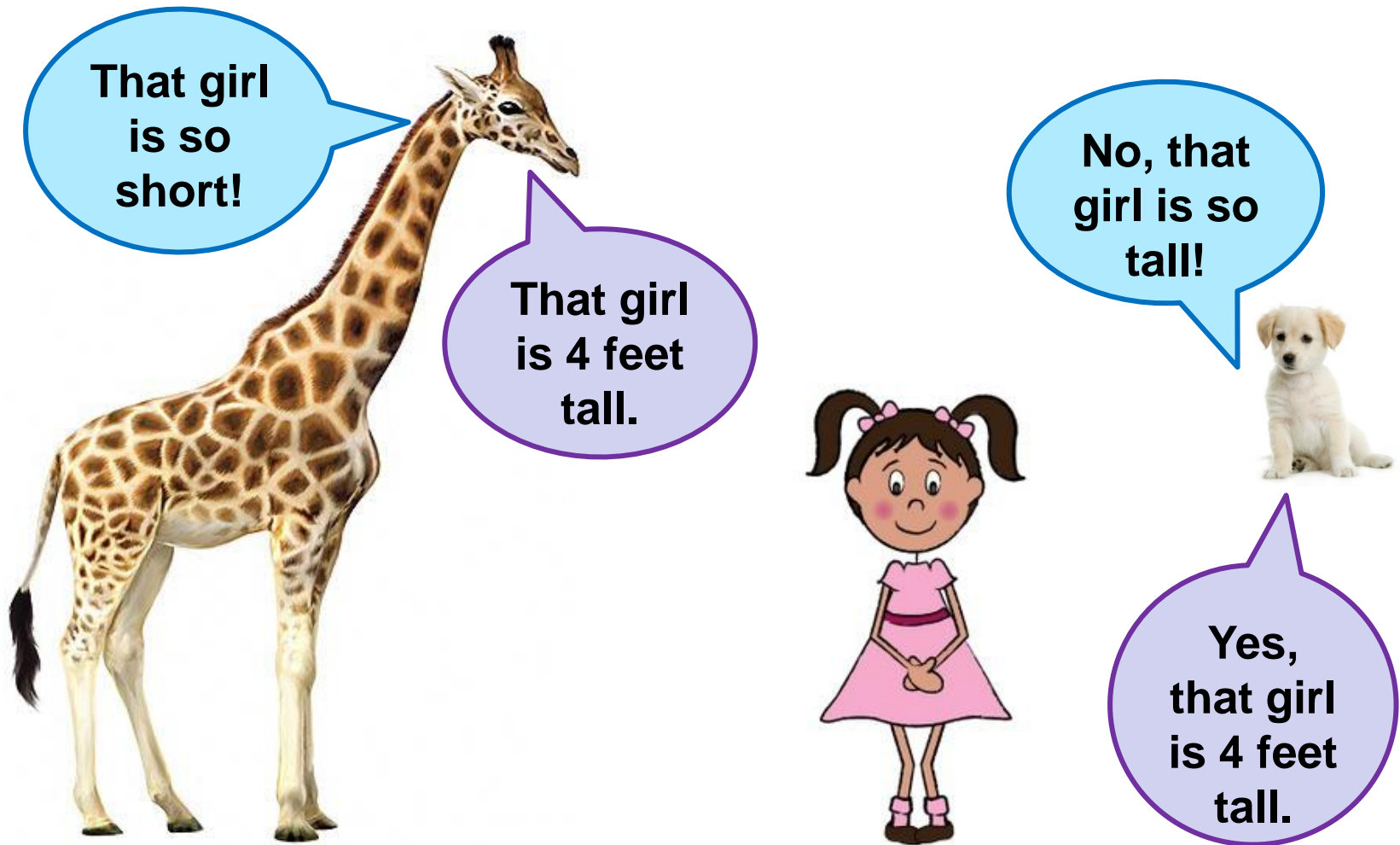
Qualitative (letters)

- **Descriptions** using words.
- Data which can be **observed** but **not measured**.
- What the object is *like*: texture, smell, taste, appearance, etc.
- ***Subjective, relative***

Quantitative (numbers)

- Specific **numbers**.
- Data which can be **measured**.
- Length, height, area, volume, weight, speed, time, temperature, humidity, sound levels, cost, age, etc.
- ***Objective, specific***

Qualitative observations are **subjective**



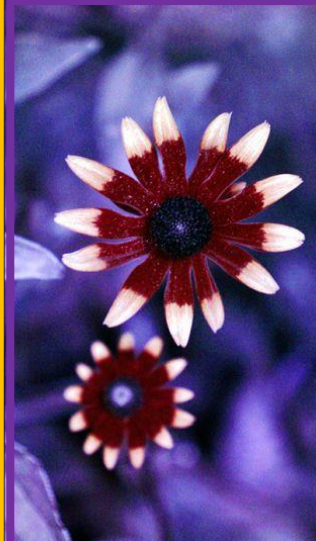
Quantitative observations are **objective**

Observation depends on observer

- Location and size of an observer
- Observer limitations



can only see visible light



can see ultraviolet light



Measurement

- the assignment of numbers to objects or events
- a type of **quantitative observation** made with a **measuring instrument**
- includes both a **number** and a **unit**
- **units** of measurement are essentially **arbitrary**: people make them up and then agree to use them

Measuring is an important part of everyday life!

What can we measure?

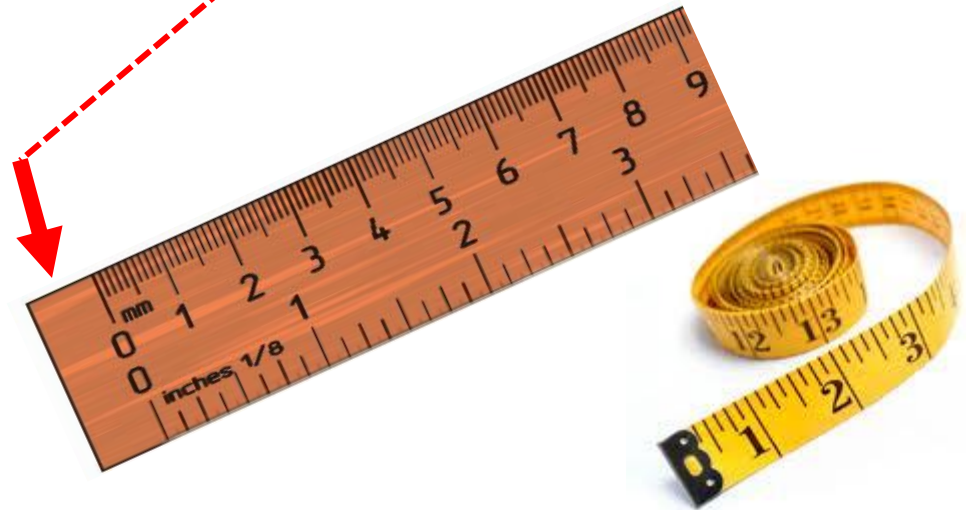
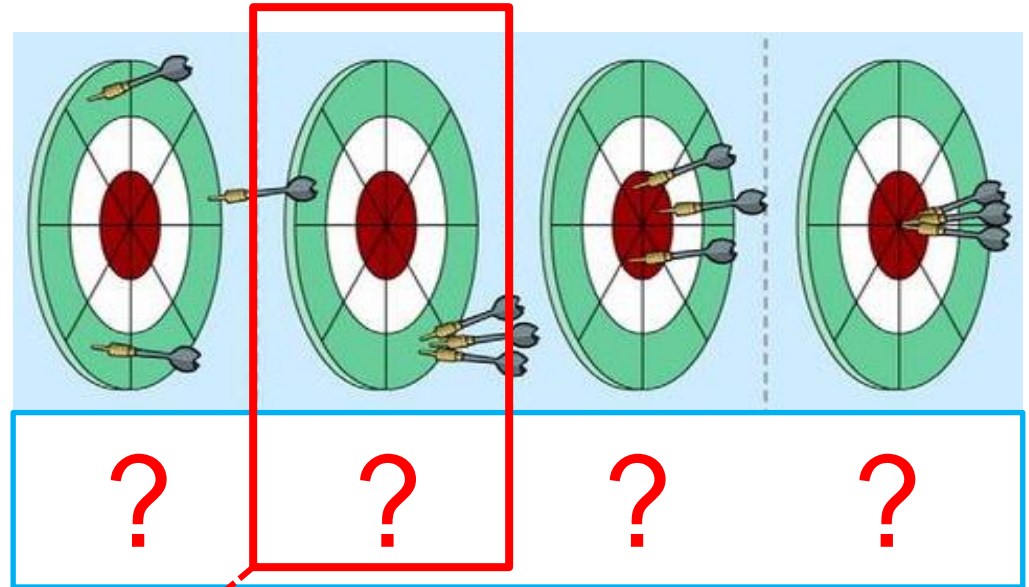
Why do we measure?

How can we measure?

How well can we measure?

How good is the measurement?

- **Accuracy** is how close a measured value is to the *actual (true) value*.
- **Precision** is how close the measured values are to *each other* (repeatability and reproducibility).
- **Bias** is a built-in (systematic) error which makes *all measurements wrong by a certain amount*.



WHAT can we measure?

- Length
- Distance on land
- Depth of water
 - Mass
- Temperature
 - Time
 - Light
- Electric current
 - Color

And HOW?

- ✓ Ruler
- ✓ Measuring Chain/Tape
- ✓ Sonar (echo sounder)
- ✓ Weighing scale
- ✓ Thermometer
- ✓ Clock, timer
- ✓ Photometer
- ✓ Ammeter
- ✓ Spectrometer

**AND
SO
ON...**

What is a System of Measurement?

A system of measurement is a collection of units of measurement and rules relating them to each other.

- Must have **base units** defined for all major quantities that need to be measured (example: a *foot*).
- Must specify **equivalency** relationship for all **additional units** used to measure the same quantity (example: length can also be measured in *inches* or *miles*, defined as 1 foot = 12 inches, 1 mile = 5280 feet).

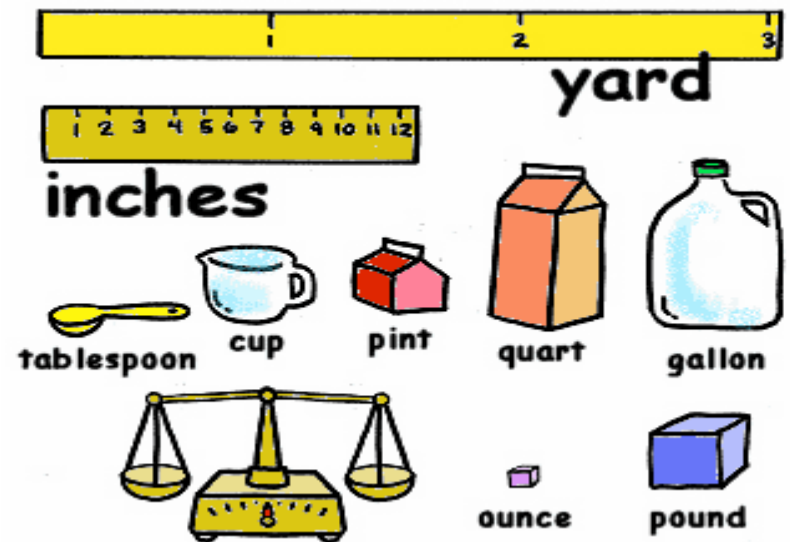
Systems of measurement have historically been **important, regulated** and **defined** for the purposes of science and commerce.

English Units Based Systems

- **Imperial System of Measurement (British Empire, 1824):**
 - Distance/Length: Inch, foot, yard, mile
 - Volume: fluid ounce, pint, quart, gallon
 - Area: Acre
 - Weight/Mass (three different systems!): grain, ounce, pound, stone, ton



- **US Customary System of Measurement:**
 - Mostly *same unit names*
 - **Units are not identical!**
(1 US gal=0.83 imp gal)
 - Different units for liquid and dry measures (liquid/dry ounce)



The Metric System

The metric system is an **internationally agreed decimal** (based on power of 10) system of measurement. It was originally introduced by France in 1799.

Modern "**Metric system**" term is a synonym for "**SI**" or the "**International System of Units**" (1960)—the **official system of measurement** in almost every country in the world.

