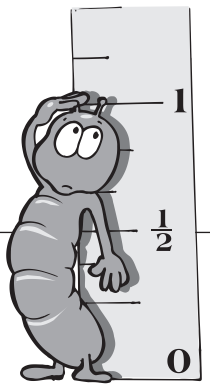
Equipment, Procedures, and Safety

Section 1.1
Length and Measurement



Pre-View 1.1

- **Ruler** or **meter stick** – equipment used in the laboratory to measure length in millimeters, centimeters, or meters
- **Meter** – metric unit for length
- **Accuracy** – the correctness of a measurement or how close the measurement is to the actual value
- **Precision** – the exactness of a measurement in terms of how many decimal places are used; determined by the smallness of the increments used in the measurement; can also be a measure of how reproducible or repeatable the data is

In general, biology is the scientific study of living things. Various types of equipment are used when studying biology, especially when conducting laboratory experiments. Biologists often use this equipment to make measurements. In your study of biology, it is important to know the names of some basic equipment and glassware and to understand when and how they are used. It is also important for you to know how to make meaningful measurements.

Measuring Length in a Laboratory

One of the most basic laboratory measurements is length. Just about everyone knows how to use a ruler to measure the length of an object, but scientists must measure length using metric units instead of feet and inches. A **ruler** or **meter stick** with metric units usually has several types of marks. The smallest marks indicate millimeters (mm). By the way, these marks are also called graduation marks or graduations. Graduation marks are found on many types of scientific equipment, so you will see this term again.

The centimeter ruler shown in figure 1-1 is drawn to scale. There are 1000 mm in one **meter**. The longer marks that are numbered show centimeters — 10 mm = 1 cm, and there are 100 cm in one meter. A man who is six feet tall is around 1.8 meters tall (or 1 meter, 80 centimeters). The ".8" means eight-tenths, and eight-tenths of a meter is 80 centimeters.

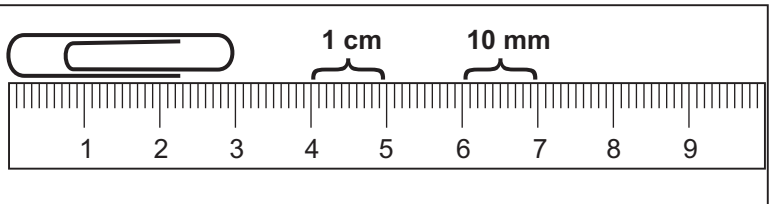


Fig. 1-1 Centimeter Ruler (To Scale)
A large paperclip is approximately 3 cm long.

Much longer lengths or distances are measured in kilometers (km), which are 1000 meters. One mile is about 1.6 kilometers.

Some scientific equipment is digital and gives a number on a readout. Other pieces of equipment, like rulers and meter sticks, require you to determine the measurement by manually reading a scale. In the real world, measurements rarely fall exactly at a graduation mark. Most of the time, the reading falls between two graduation marks. To get the reading, you simply estimate between the marks. Look at an example.

Performing Scientific Experiments

Section 2.2
Setting Up Experiments

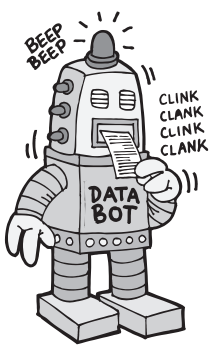
Pre-View 2.2

- **Experiment** – a set of steps used to test a hypothesis
- **Data** – observations, measurements, and other information gathered in an experiment
- **Quantitative data** – measured data; data associated with numbers or specific amounts
- **Qualitative data** – descriptive data; data not associated with numbers or amounts
- **Control group** – the group that is used for comparison; it does not receive the tested element
- **Experimental group** – a group that receives one element being tested
- **Bias** – a belief or opinion that may affect experimental results
- **Unbiased** – having no opinion or being impartial
- **Placebo** – a substance given to a control group that has no effect on the experiment but is used to eliminate bias
- **Constants** – factors that remain the same for all groups during an experiment
- **Variable** – a factor that is changed during an experiment in order to test its effect
- **Independent variable** – the variable used to produce an effect
- **Dependent variable** – the measurable change that occurs because of the independent variable

An **experiment** is a set of steps that are performed to collect data. The data can then be used either to prove or to disprove the hypothesis. The experiment must be designed carefully so that the data collected gives meaningful information. The following questions should be considered when designing an experiment.

Designing an Experiment

- What data should be collected and how?
- How many groups will be used?
- How many subjects per group should be used?
- What will be the control group?
- Will there be a placebo used?
- What are the important constants?
- What is the independent variable?
- What is the dependent variable?

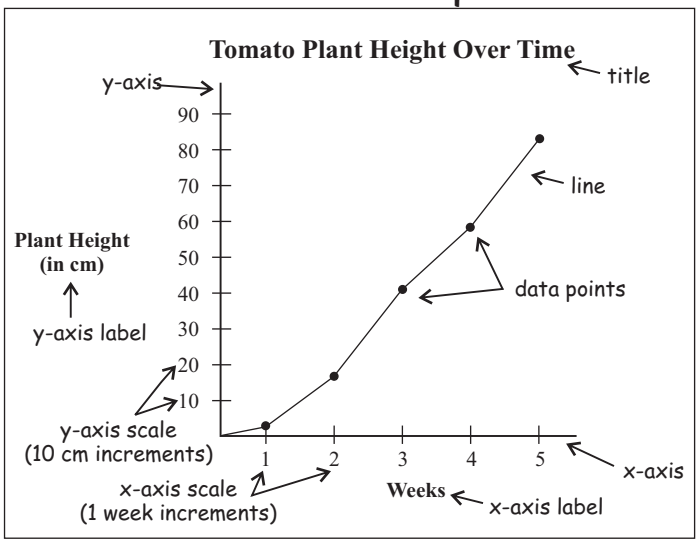


Data

Data is any information gathered during an experiment. Measured data, such as length, mass, pH, temperature, or time of day is called **quantitative data**. Remember, a quantity is an amount of something, so quantitative data deals with numbers or amounts. The data recorded in most experiments is quantitative. Descriptive data, on the other hand, is called **qualitative data**. Color, odor, taste, feel, or any other described quality is considered qualitative data.

Many kinds of information can be recorded during an experiment. However, the only data that should be collected in an experiment is the information that can be used to prove or disprove the hypothesis. The scientist must decide which information is important to record and which isn't.

Well-Constructed Graph



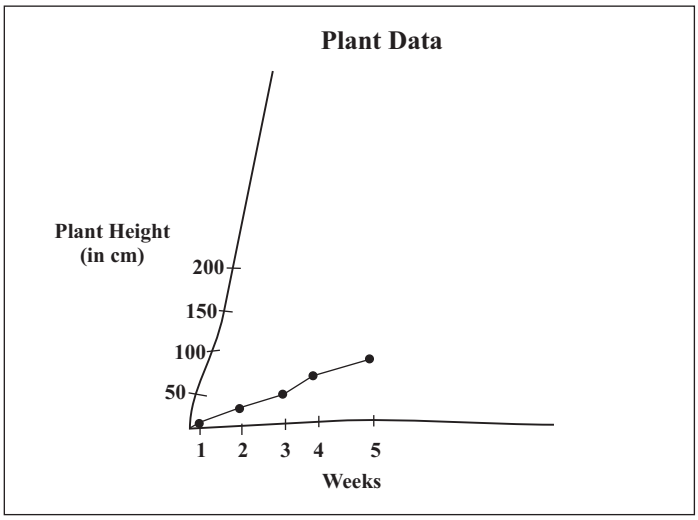
The graph on the left is a good example of how a line graph should be drawn.

Title: The title of a graph should give a general explanation of the data shown by the graph. In this example, the title is "Tomato Plant Height Over Time."

Axes and Labels: The x and y axes should be labeled to show what kind of data is being given. In this case, the x-axis represents "weeks" and the y-axis represents "plant height in centimeters."

Scale: The scale is shown by the numbers that are labeled on the x and y axes. In this example, the x-axis has a scale of one week per increment. The y-axis has a scale that is marked in 10-centimeter increments.

Poorly-Constructed Graph



Do you recognize all the reasons this graph is poorly constructed?

Title: Although this graph does have a title, it is not very descriptive of the data represented. For example, it doesn't tell what kind of plant.

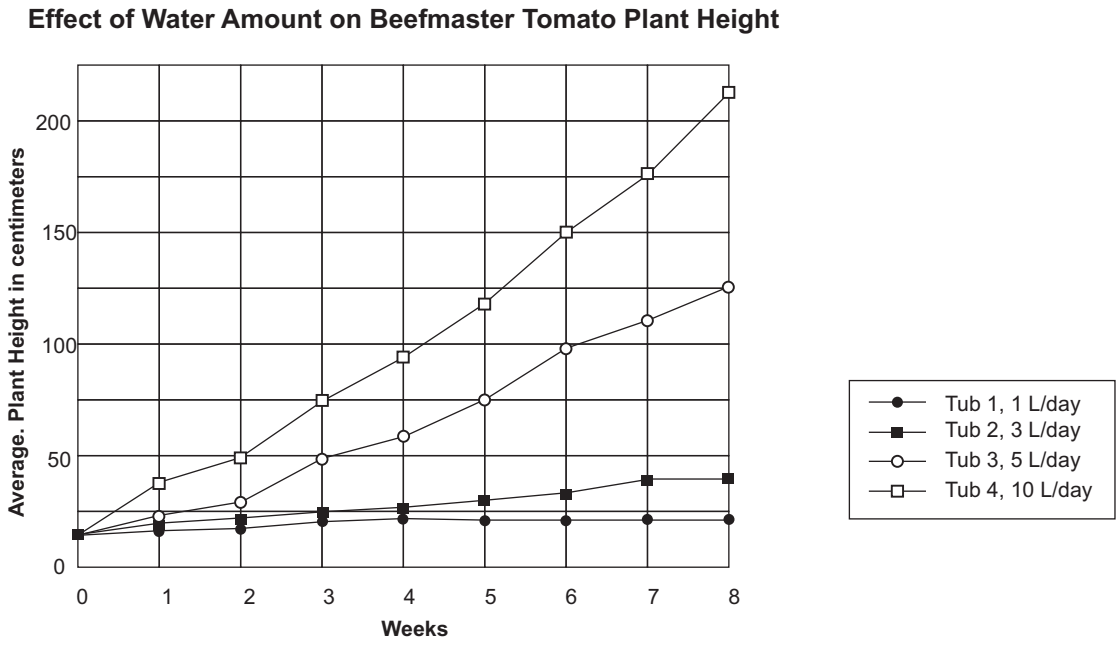
Axes and Labels: The x-axis and the y-axis are correctly labeled, but they are crooked. Be sure that you use a straight edge when drawing graphs by hand, and you will probably want to use graph paper as well.

Scale: When constructing a graph, choose a scale so that your data fills the space. In this example, the poorly chosen scale causes the data to fill only a small corner of the graph. Also, increments should be equally spaced. Notice that the spacing between the weeks is not equal.

When constructing line graphs, remember the following: Use a descriptive title that explains the data. Label the x and y axes and give the units. In the examples above, labeling the y-axis as "Plant Height" is useless unless you also give the units. Likewise, labeling the x-axis as "Time" would not be an appropriate label. No one would know what the 1, 2, 3, 4, or 5 represented — days, weeks, months, etc. Use an appropriate scale so that your data is spread out over the length and width of the graph. And of course, be very neat by drawing straight lines to represent your axes.

Read about the following experiment, study the graph, and answer the questions that follow.

The Beefmaster tomato plant is a variety that produces large tomatoes ideal for slicing and using on sandwiches. An experiment is performed to determine how the amount of rain, or watering, affects the height of Beefmaster tomato plants. Seedlings of equal height were planted in four large tubs. Each tub contained three plants, and all plants received the same amount of sunlight and fertilizer. The only difference was the amount of water that each tub received. The data from the experiment is summarized in the graph below.



6. Which of the following conclusions is supported by the graph?

F Rain helps tomato plants produce healthy, firm tomatoes.
G Beefmaster tomato plants grow taller than other varieties.
H Beefmaster tomato plants die when they are over-watered.
J Beefmaster tomato plants grow taller when they receive more water.

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7. Based on the graphed data, which of the following would be a logical prediction?

A Beefmaster tomato plants will thrive in gardens that are consistently watered.
B Beefmaster tomato plants will grow taller when they are planted in tubs.
C Beefmaster tomato plants will need more sunlight and fertilizer when planted in a garden.
D Beefmaster tomato plants will grow well during a drought.

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