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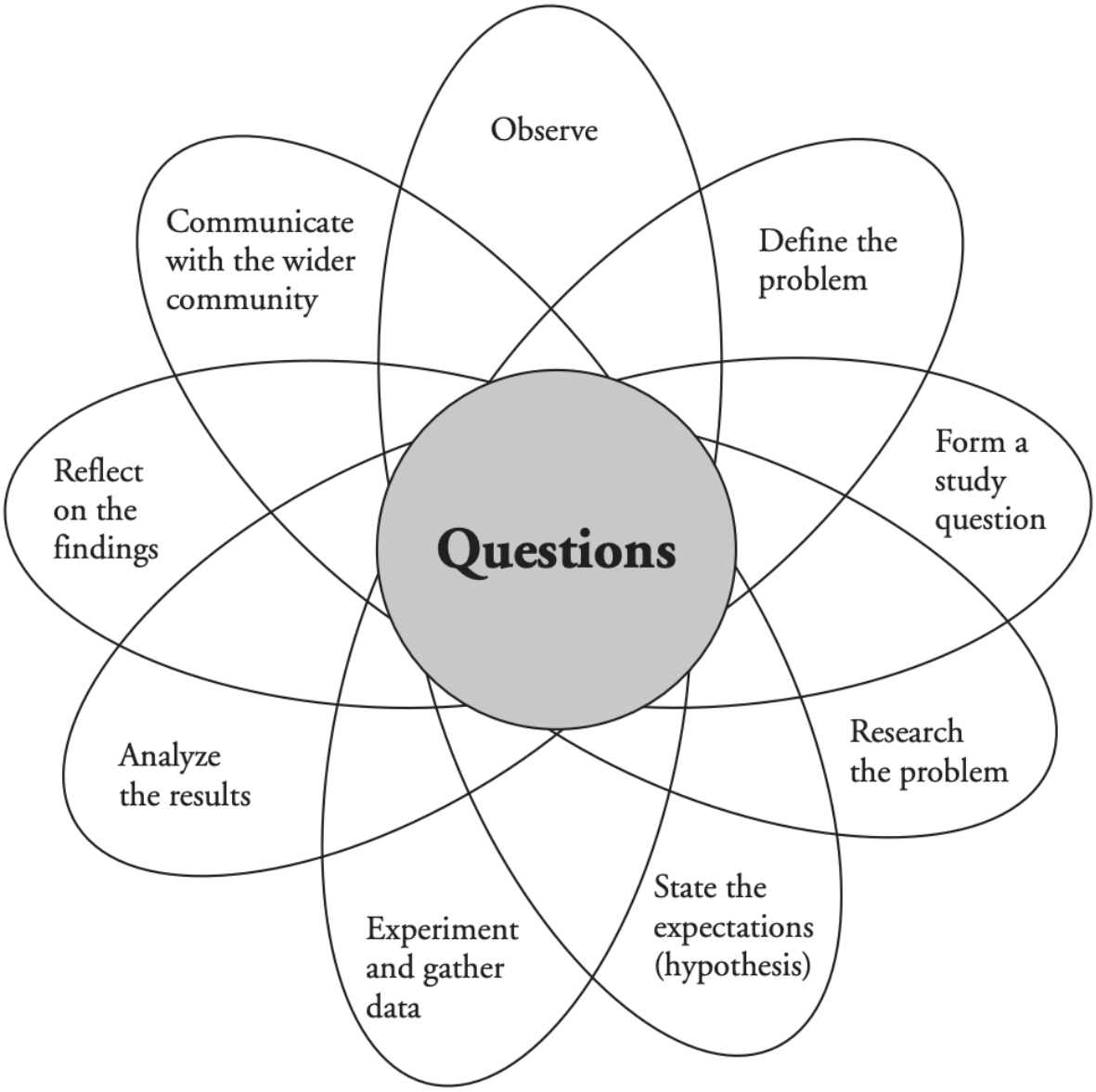
Scientific Inquiry

What do scientists do?

Why?

Science is a unique way of learning about the natural world. Scientists work hard to explain events, living organisms, and changes we see around us everyday. Model 1 depicts typical activities or stages scientists engage in when conducting their work. The design of the model shows how various steps in scientific inquiry are connected to one another. None of the activities stands alone- they are all interdependent.

Model 1 – Scientific Inquiry



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1. What is the central theme of all scientific inquiry as shown in **Model 1**?

2. What are the nine activities that scientists engage in as part of scientific inquiry?

3. Which of the activities would require a scientist to make some observations?

4. Which of the steps would require a scientist to gather data?

5. Considering the activity described "communicating with the wider community," in what ways might a scientist communicate?

6. Remembering that scientists often work in teams, which activities would require a scientist to communicate with others?

7. Given your responses to Questions 1–6, do you think these activities must be carried out in a specific order or can multiple activities be carried out at the same time? Justify your response by giving examples to support your answer.

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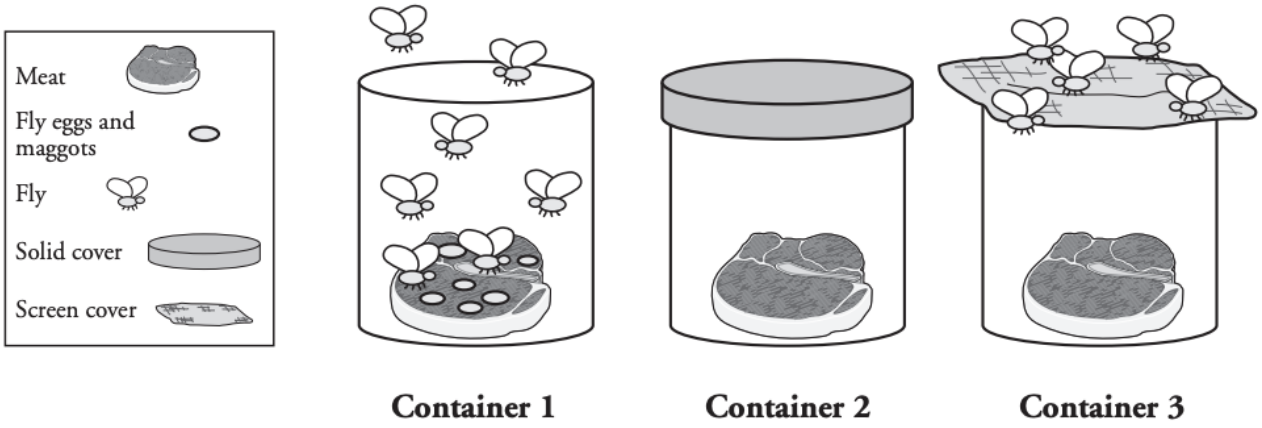
Model 2 – Redi's Experiment



The table below represents the ideas the Italian scientist Francesco Redi (1626–1698) might have had as he was carrying out his experiments. The questions that follow the table relate to the process Redi may have used.

Using the nine activities from Model 1, complete the table in Model 2 for each of the processes Redi completed in his investigation.

Discovery of flies and maggots on a piece of meat.	**Scientific Inquiry**
Where did the flies and maggots come from?	
Are the maggots and flies "related"?	
Gather information about the origins of flies and maggots. The year is 1668 and no scientific studies are available, but the common belief is that living things such as flies can be generated from nonliving things, such as rotting meat. This belief is known as spontaneous generation.	
Does meat spontaneously generate flies and maggots?	
If I leave a container of meat open and seal another container, then both should create flies and maggots.	
Set up two containers with meat; one will be open and one will be covered. Leave them for several days.	
Flies and maggots are found in the jar with no cover (1) but not in the covered jar (2).	
Was the reason for no flies in the second jar due to the "bad air" being sealed in the jar, which stopped the flies and maggots from being generated by the meat?	
Run the experiment again adding a third jar with a fine mesh cover. Flies and maggots are only found in the open jar.	
Flies lay eggs on the meat, which hatch into maggots, which become flies.	

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8. What year did Redi carry out his experiment?

9. Describe the accepted theory during Redi's time explaining the origin of the flies.

10. What was this theory called?

11. How many experiments/jars did Redi set up the first time?

12. What was the purpose of having one jar left open and the other one sealed?

13. Why did Redi carry out another experiment with three jars?

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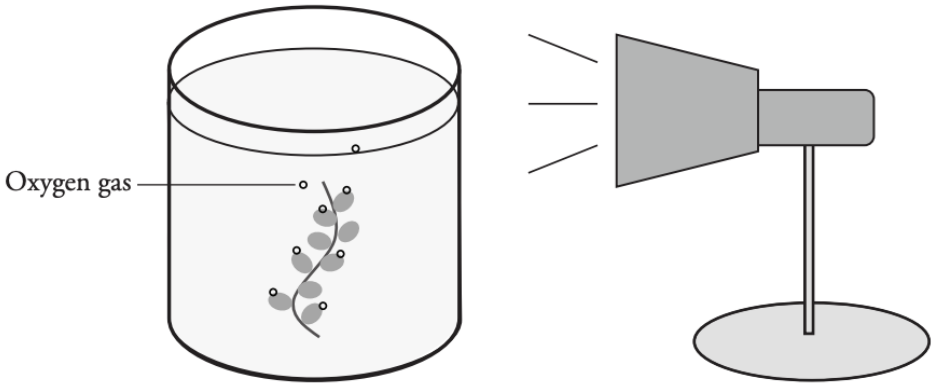
Experimental Variables

What is measured during a controlled experiment?

Why?

When scientists set out to do an experiment, they first think about the variables that may affect the outcome of the experiment. A variable is any condition that may cause a change in the system being studied. Some variables are measured quantitatively, like temperature, mass or height. Other variables are recorded in a qualitative manner, like color, texture or species. The most important factor is that the scientist runs a controlled experiment. In a controlled experiment, only one variable is changed to ensure that the effect of only that one variable can be measured.

Model 1 – Photosynthesis in an Aquatic Plant



1. The diagram in **Model 1** illustrates a clipping of an aquatic plant in water.
    a. What process is occurring in the plant's cells to produce the gas in the bubbles that appear?

    b. What gas is the plant producing?

    c. What source of energy is the plant using to conduct the process recorded in part a?

2. Depending on the environment the plant is in, more or less gas may be produced. Suggest a method for measuring the rate of gas production from the aquatic plant in **Model 1**.

3. Create a list of environmental factors that may affect the rate of gas production in the aquatic plant in **Model 1**. These factors could become variables in an experiment.

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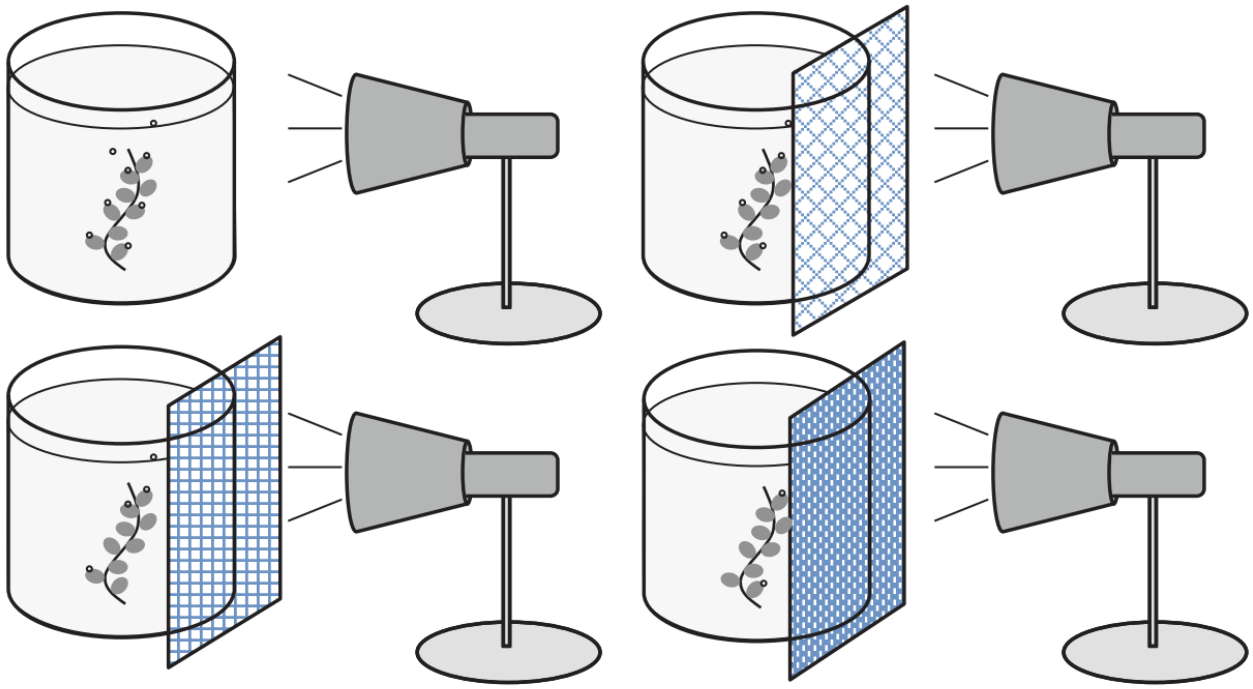
Model 2 – Aquatic Plant Experiment



4. Examine the four trials shown in **Model 2**. Identify several conditions in the experiment that are the same in each trial.

5. Describe the one condition that has been varied among the four trials in **Model 2**.

6. How does the condition described in Question 5 appear to affect the rate of gas production by the aquatic plant? ***Provide specific evidence from Model 2 to support your answer.***

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Model 3 – Aquatic Plant Data

	Length of clipping (cm)	Number of leaves on clipping	Lamp power (watts)	Percentage of light from lamp that reaches the plant	Number of oxygen bubbles formed in 10 minutes
A	12		40	100%	
B	12		40	75%	
C	12		40	50%	
D	12		40	25%	

7. ***Refer to the diagrams in Model 2 to complete the data table in Model 3.***

8. The column headings in Model 3 each describe a variable in the experiment.
   a. What variable was purposely changed in the experiment?

   b. What variable changed as a result of changing the variable listed in part a?

   c. What variable(s) in the Model 3 data table remained constant among all the trials?

Read This!

When designing an experiment, you need to consider three types of variables. The independent variable is changed by the experimenter in the design of the experiment. This variable is sometimes called the "manipulated variable." The dependent variable is what changes as a result of the change in the independent variable. This variable is sometimes called the "responding variable." In some cases more than one dependent variable is considered. The third category of variables is controlled variables. These are variables that you think may change the outcome of the experiment, but since they are not being studied, they need to be kept constant in each trial.

9. Identify the independent, dependent, and controlled variables for the experiment that produced the data in Model 3.

   Independent

   Dependent

   Controlled

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Read This!

A well-written research question states the independent and dependent variables in the experiment. For example, a student investigated the effect of soil pH on the number of strawberries produced by a strawberry plant. Her research question was "How does the pH of soil affect the number of strawberries produced by a strawberry plant?"

10. Write a research question, using the format suggested in the Read This!, for the experiment in **Model 2**.

11. A student wonders, "Does the moisture content in soil affect how far a worm can dig?" Identify the variables that are being considered in this experiment and the variables that need to be controlled.

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Analyzing and Interpreting Scientific Data

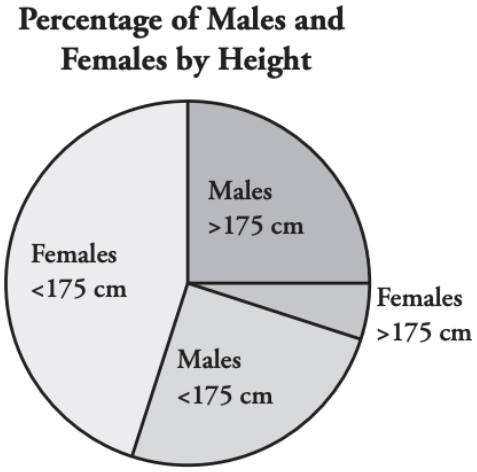
How can analyzing and interpreting scientific data allow scientists to make informed decisions?

Why?

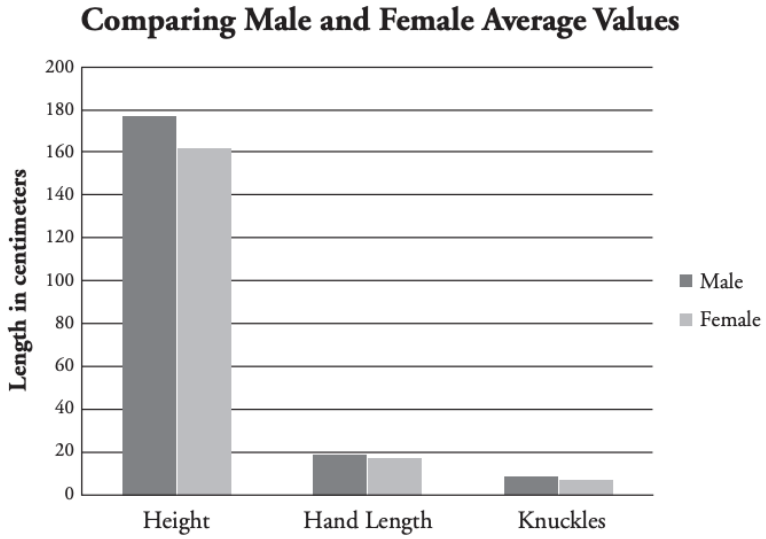
During scientific investigations, scientists gather data and present it in the form of charts, tables or graphs. The data must be properly collected, analyzed, and interpreted to allow scientists to make informed decisions regarding the validity of their study and any further work that may be necessary to achieve their objectives. The ability to present and use data charts, tables, and graphs correctly is essential for good scientific practice and also prevents unnecessary or inappropriate work and misinterpretation of the data.

Model 1 – Graphs and Charts of Classroom Measurement Data

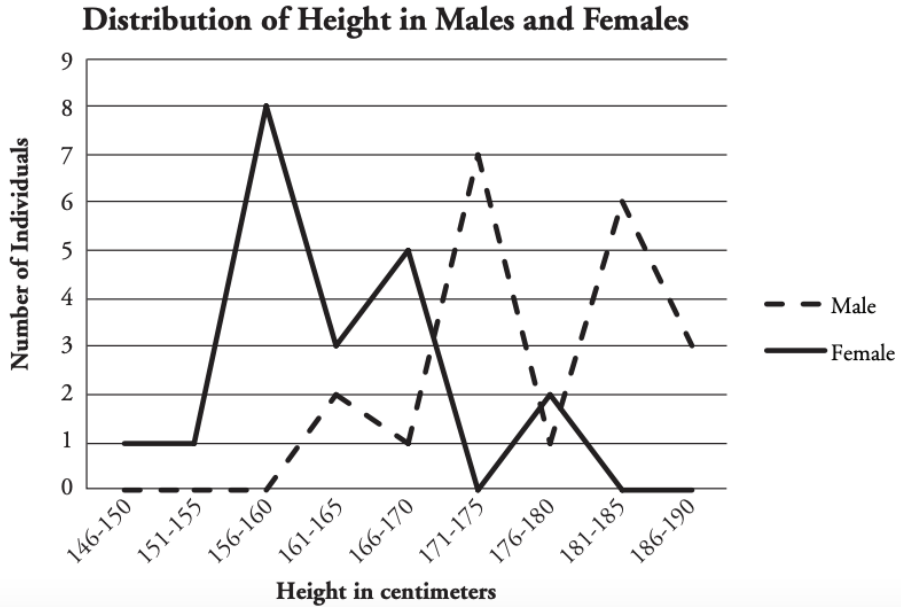
Pie Chart



Bar Graph



Line Graph



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1. According to the data in **Model 1**, how many females fall within the range 146–155 cm tall?

2. According to the data in **Model 1**, how many males are 181 cm or above in height?

3. Using the graph(s) in **Model 1**, determine the approximate average height of males and of females.

4. Refer to the data in **Model 1**.
   a. How many males are taller than 175 cm and approximately what percentage of the total is that?

   b. Which graph(s)/chart(s) illustrate the answer to the previous question?

5. Which type of graph or chart in **Model 1** shows a side by side comparison of data?

6. Which type of graph or chart in Model 1 shows trends in data across an entire data set?

7. Describe two trends in male and female height using the line graph.

8. Use complete sentences to compare the presentation of height data in the three graphs. Discuss any information that is located on more than one graph, and any unique information that is available on each.

9. If you wanted to see if a correlation exists between the height of an individual and his/her hand length, what would be the best type of graph/chart to make? ***Explain your reasoning.***

10. What conclusions can you draw comparing the height, hand length, and knuckle width of males and females? ***State your conclusions in complete sentences.***

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Model 2 – Foot Width in a High School Classroom

Female foot width (cm)	Male foot width (cm)
7.8	10
8	10.5
8	9
5	9.3
17	13
7.5	7.5
7.5	10
7	9.2
7.8	9
7	4.5

Mean = $\frac{\text{sum of all data values}}{\text{number of data values}}$

Median = Middle value of an ordered set of data.

Mode = Most frequently occurring value in a set of data.

11. Refer to the data in **Model 2**.
    a. What value for foot width is most frequent in males?

    b. What is this value called?

12. Determine the median value for foot width for males and for females. Describe in complete sentences the method you used to determine the median values.

13. Determine the mean for each data group, and describe in a complete sentence how you calculated them.

Read This!

Within a data set there may be individual values that seem uncharacteristic or do not fit the general trend. These data points may be referred to as outliers or anomalous data. In most samples, a small number of outliers are to be expected, due to the variation inherent in any naturally-occurring population. Outliers can also result from errors in measurement or in the recording of data. Normal variation can often be distinguished from error by repeating the measurements to see if the same range is obtained. Scientists also use statistical calculations to determine the expected range of data, so that judgments can be made about the authenticity of individual data points. Outliers should not be ignored, however, as many interesting scientific discoveries have resulted from the study of such unexpected findings.

14. Which data point(s) in the foot width values in **Model 2** might be considered outliers? Explain your choice(s).