Scientific Inquiry

The rain has stopped, and the Sun is out. You notice that a puddle has disappeared from the sidewalk. What happened to that puddle of water? You could probably quickly answer that question, but how would you prove your answer? You would need to make observations and record data.

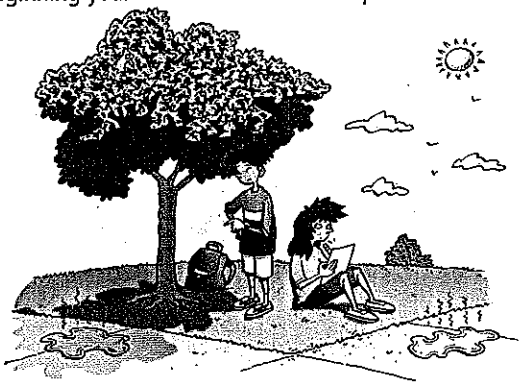
Making Observations

First, you might observe what happens to some other puddles. You would watch them closely until they disappeared and record what you observed.

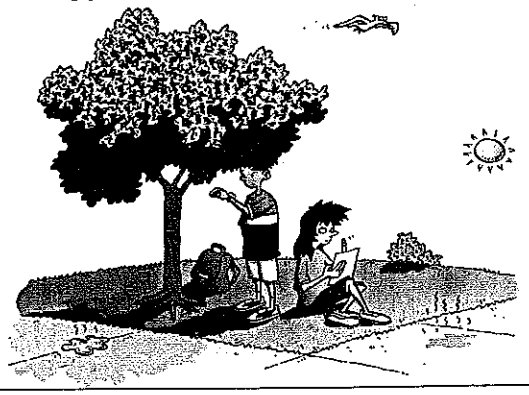
One observation you might make is "The puddle is almost all gone." That would be a qualitative observation, an observation in which numbers are not used. A little later, you might also say, "It took five hours for the puddle to disappear completely." You have made a quantitative observation, an observation that uses numbers.

You probably already know that evaporation is the reason that the puddles are disappearing, but there are still lots of questions you can ask about evaporation. Although the two puddles were the same size, one evaporated much more quickly than the other one did. Your quantitative observations tell you that one evaporated in 4 h, whereas the other one took 5 h. Your qualitative observations tell you that the one that evaporated more quickly was in the Sun. The one that evaporated more slowly was in the shade. You now have a question to ask: Does water always evaporate more quickly in the Sun than in the shade?

Beginning your observations of water puddles



Concluding your observations of water puddles



Instant Practice—Making Qualitative and Quantitative Observations

Copy the observations below in your notebook. Beside each write "Qual" if you think it is a qualitative observation and "Quan" if you think it is a quantitative observation.

1. (a) The bowling ball is heavier than the basketball.
   (b) The red ball weighs 5 g more than the blue ball.
2. (a) The temperature increased by several degrees.
   (b) The temperature increased by 2°C.
3. (a) The water was lukewarm.
   (b) The water was cooler than the oil.
4. (a) The colour changed from blue to green.
   (b) The sound became louder as the vibrations increased.
5. (a) The second light bulb was the brightest.
   (b) The 60 W bulb was brighter than the 40 W bulb.
6. (a) The flight lasted nine minutes.
   (b) The flight lasted 2 h.

Stating an Hypothesis

Now you are ready to make an **hypothesis**, a statement about an idea that you can test, based on your observations. Your test will involve comparing two things to find the relationship between them. You know that the Sun is a source of thermal energy, so you might use that knowledge to make this hypothesis: Evaporation from natural pools of water is faster for pools in sunlight than for pools in shade.

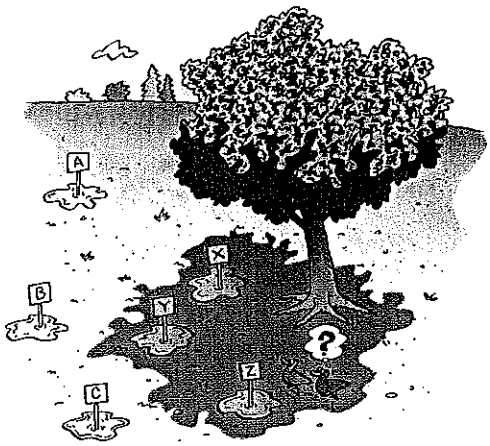
Instant Practice—Stating an Hypothesis

Write an hypothesis for each of the following situations. You may wish to use an "If...then..." format. For example: *If* temperature affects bacterial growth, *then* bacterial culture plates at a higher temperature will have more bacterial colonies than those at a lower temperature.

1. The relationship between studying and your score on quizzes
2. The relationship between types of atmospheric gases and global warming
3. Do batteries last the same amount of time in different devices?
4. Does the colour of flowers influence honeybee visitations?

Making a Prediction

As you prepare to make your observations, you can make a **prediction**, a forecast about what you expect to observe. In this case, you might predict that pools A, B, and C will dry up more quickly than pools X, Y, and Z.



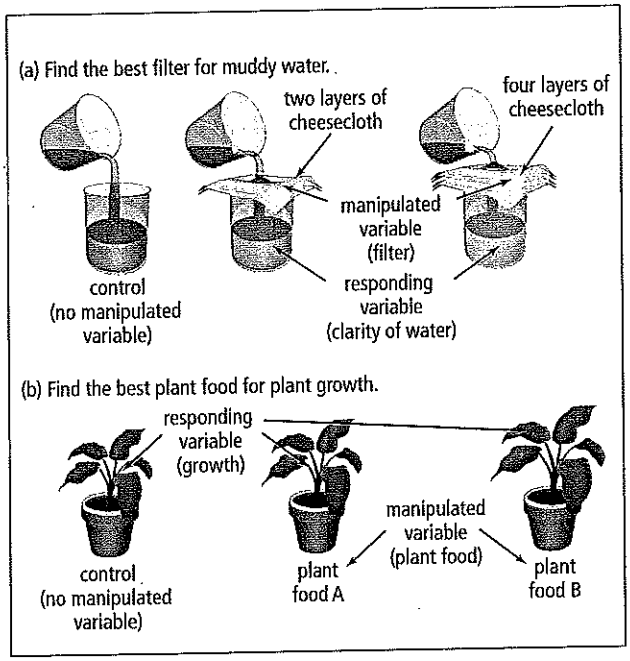
Identifying Variables

"But wait a minute," you think, as you look again at your recorded observations. "There was a strong breeze blowing today. What effect might that have had?" The breeze is one factor that could affect evaporation. The Sun is another factor that could affect evaporation. Scientists think about every possible factor that could affect tests they conduct. These factors are called **variables**. It is important to test only one variable at a time.

You need to control your variables. This means that you change only one variable at a time. The variable that you change is called the **manipulated variable**. In this case, the manipulated variable is the condition under which you observe the puddle (one variable would be adding thermal energy; another would be moving air across it).

According to your hypothesis, adding thermal energy will change the time it takes for the puddle to evaporate. The time in this case is called the **responding variable.**

Often, experiments have a **control**. This is a test that you carry out with no variables, so that you can observe whether your manipulated variable does indeed cause a change. Look at the illustrations on the next page to see some examples of variables.



Designing a Fair Test

If you consider more than one variable in a test, you are not conducting a **fair test** (one that is valid and unbiased), and your results will not be useful. You will not know whether the breeze or the Sun made the water evaporate.

As you have been reading, a question may have occurred to you: How is it possible to do a fair test on puddles? How can you be sure that they are the same size? In situations such as this one, scientists often use **models**. A model can be a mental picture, a diagram, a working model, or even a mathematical expression. To make sure your test is fair, you can prepare model "puddles" that you know are all exactly the same. **Science Skill 8** gives you more information on using models.

Instant Practice—Identifying Variables

For each of the following questions, state your control, your manipulated variable, and your responding variable.

1. Does light travel the same way through different substances?
2. Does the addition of compost to soil promote vegetable growth?
3. How effective are various kinds of mosquito repellent?

Forming a Conclusion

Many investigations are much more complex than the one described here, and there are many more possibilities for error. That is why it is so important to keep careful qualitative and quantitative observations.

After you have completed all your observations, you are ready to analyze your data and draw a **conclusion**. A conclusion is a statement that indicates whether your results support or do not support your hypothesis. If you had hypothesized that the addition of thermal energy would have no effect on the evaporation of water, your results would not support your hypothesis. An hypothesis gives you a place to start and helps you design your experiment. If your results do not support your hypothesis, you use what you have learned in the experiment to come up with a new hypothesis to test.

Scientists often set up experiments without knowing what will happen. Sometimes they deliberately set out to prove that something will not happen.

Eventually, when an hypothesis has been thoroughly tested and nearly all scientists agree that the results support the hypothesis, it becomes a **theory**.

A Process for Scientific Inquiry

One model of the scientific inquiry process is shown in the concept map below.

The Scientific Inquiry Process