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 that was here a while ago? 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." If you did, you would be making 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.


Beginning your observations of water puddles

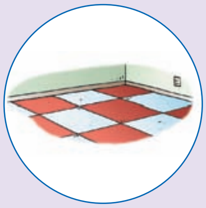

Concluding your observations of water puddles

Instant Practice—Making Qualitative and Quantitative Observations

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

(a) Food colouring made the water blue.
Adding 3 mL of food colouring turned 250 mL of water blue.

(b) The water became warmer.
The water's temperature increased by 5°C.



(c) We needed just over a dozen floor tiles for our model room.
We needed 14 floor tiles for our model room.

(d) The liquid boiled in 5 min.
The liquid took only a few minutes to boil.

(e) The mass of this solid is 5 g more than that one.
This solid is heavier than that one.

(f) He drinks eight glasses of water each day.
He drinks 2 L of water each day.

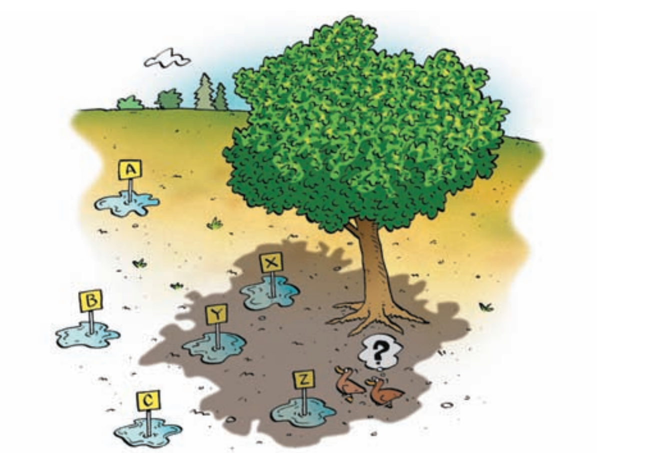
You probably already know that evaporation is the reason that the puddles are disappearing, but there are still lots of questions you can ask about evaporation. Although the two puddles were the same size, one evaporated much more quickly than the other one did. Your quantitative observations tell you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

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.

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.



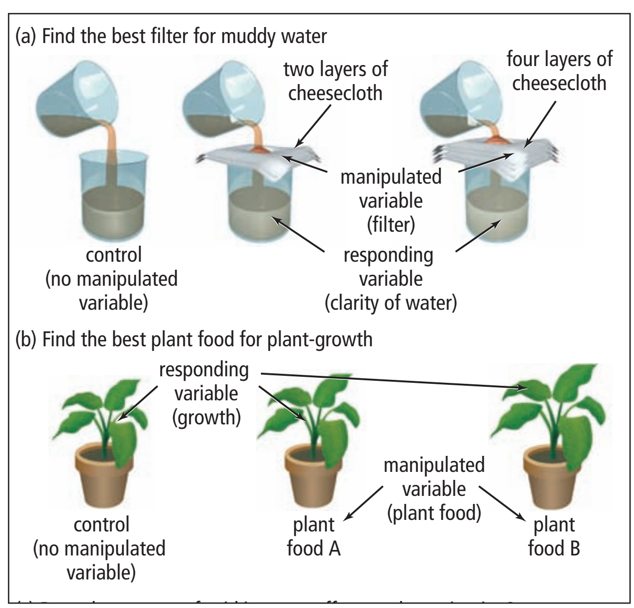
Identifying Variables

"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 always important to test only one variable at a time.

You need to control your variables. This means that you change only one 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 illustration below to see some examples of variables.



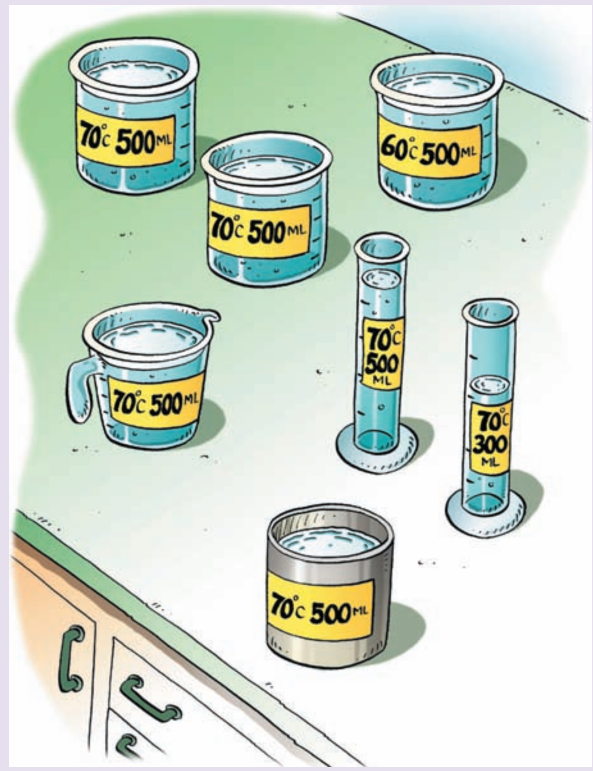
Designing a Fair Test

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 tell you anything 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—Doing a Fair Test

1. With a partner, examine the following illustration. In your notebook, write the letters of the "puddles" you would not use to set up a fair test. Explain why you would not use them.



2. Now, you can carry out your experiment. How many times will you do it in order to be sure that you have truly tested your hypothesis?

3. What kinds of errors can creep into a test such as the one described above? Use your sense of humour, and work with a partner to draw some sketches that illustrate some errors. (Make sure they are errors that could actually occur!)

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 collected all your data, you are ready to analyze it 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 a 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