Physical Science
WEEK 1

The Scientific Method

NA-06-SN-EN-SE-V1-03

Scientific Inquiry

"Mom! There are maggots on the meat again!"

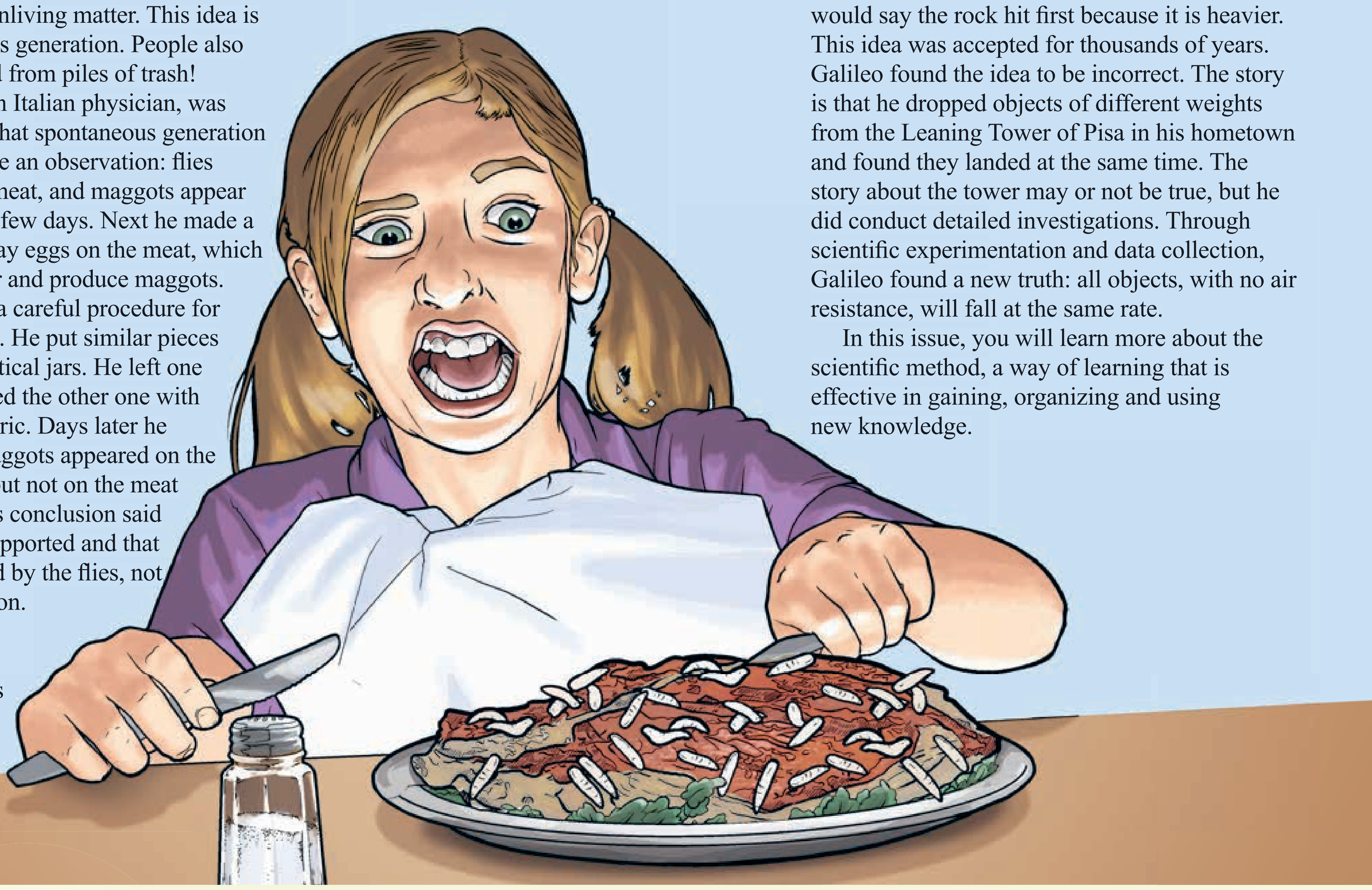
Let's hope you never have this experience. But before we had refrigerators and ways to preserve food, food would often spoil and become covered with fly larvae. In fact, this was common enough that many people believed maggots appearing on meat was evidence that life can arise from nonliving matter. This idea is known as spontaneous generation. People also believed mice formed from piles of trash!

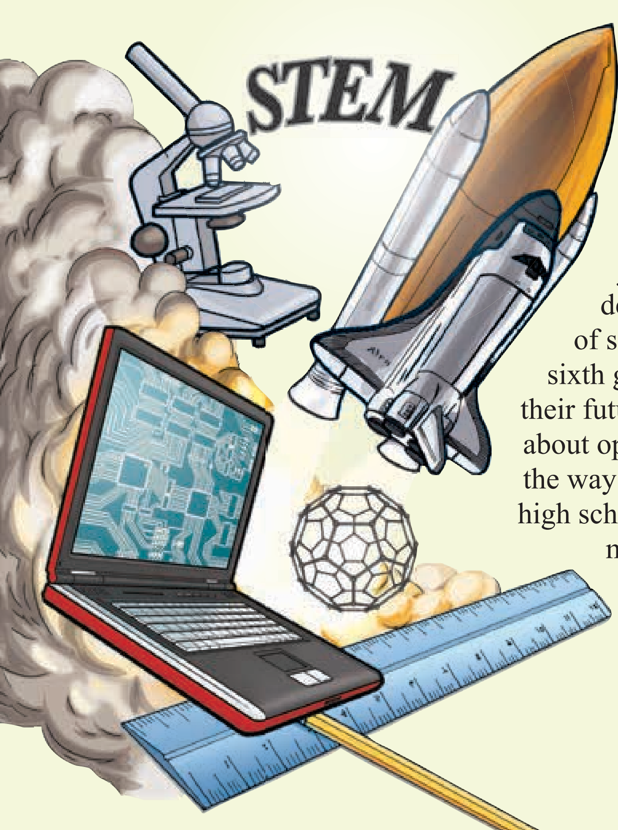
Francesco Redi, an Italian physician, was determined to prove that spontaneous generation did not exist. He made an observation: flies swarm around fresh meat, and maggots appear on meat left out for a few days. Next he made a hypothesis: the flies lay eggs on the meat, which hatch a few days later and produce maggots. Redi then developed a careful procedure for testing his hypothesis. He put similar pieces of meat into two identical jars. He left one uncovered and covered the other one with gauze, a very thin fabric. Days later he collected his data: maggots appeared on the meat in the open jar but not on the meat in the covered jar. His conclusion said his hypothesis was supported and that maggots are produced by the flies, not spontaneous generation.

Redi achieved his results through the scientific method. His experiment is still famous more than 300 years later because he took great care to construct an experiment that would produce accurate results. He recorded his data very carefully so he could clearly communicate his findings to others. His work was also remarkable because the study of science had only started 50 years earlier and was used by very few people.

Galileo Galilei of Italy is often credited with the founding of science. Before Galileo, scholars learned about the world through simple observation and reason. For example, they might drop a rock and a wad of paper at the same time and see that the rock hits the ground first. Reason would say the rock hit first because it is heavier. This idea was accepted for thousands of years. Galileo found the idea to be incorrect. The story is that he dropped objects of different weights from the Leaning Tower of Pisa in his hometown and found they landed at the same time. The story about the tower may or not be true, but he did conduct detailed investigations. Through scientific experimentation and data collection, Galileo found a new truth: all objects, with no air resistance, will fall at the same rate.

In this issue, you will learn more about the scientific method, a way of learning that is effective in gaining, organizing and using new knowledge.





Welcome to Another Year of Discovery!

Studies Weekly reporters are always on the job, looking for exciting developments in the world of science. We know that many sixth graders are thinking about their futures already. Some wonder about opportunities that will pave the way through middle school, high school and college. As a matter of fact, a few of you may already have your eye on a career. For those of you who love science as much as we do, you'll want to keep an eye on a trend we've seen all over the United States. School districts and community business leaders are teaming up to build STEM schools. STEM centers are dynamic institutions of learning that provide students opportunities to specialize in Science, Technology, Engineering and Math. Chances are there's a STEM center-based school in your community that is looking for hard-working students. Some STEM schools are designed to operate as freestanding schools. Others provide course work to supplement the general education at your home school, and many offer opportunities before school, after school or during vacation weeks. If you're interested, start by talking with your science teacher and parents; chances are they've got the scoop on STEM centers near you. Meanwhile, be sure to check back here in the coming weeks to see what's up—we'll bring you the news!

Step by Step with the Scientific Method

Question

The first step of any scientific investigation is a question or problem. A question often comes right after an observation. For example, you kick a soccer ball and notice it doesn't go very far. Your observation may lead you to the question, "Why didn't the soccer ball go very far?"

That's a good question, but for a scientific experiment, the question should be more specific. Making it a yes or no question is a good idea. Let's say you notice that the ball looks a little flat, so you rephrase your question, "Does the amount of air pressure in a soccer ball affect the distance it will travel when kicked?" This question includes a possible cause (air pressure) and a possible effect (the distance).

Hypothesis

Once you've come up with a good experimental question, think about the possible explanations for what you have observed. Previous knowledge can help you make an educated guess for the outcome of your experiment. This educated guess is called a hypothesis. A hypothesis is usually worded to include both the independent variable and the dependent variable (see "This Week's Question") and show the relationship between the two. Look at this example of an experimental question and the hypothesis formulated from it.

Question: "Does the amount of air pressure in a soccer ball affect the distance it will travel when kicked?"

Hypothesis: "If the air pressure in a soccer ball is increased, the distance it will travel when kicked will increase."

Procedure

Now you must figure out how to test your hypothesis. A procedure is a step-by-step list of instructions and materials needed to conduct your experiment. One purpose of your procedure is to show other scientists how you got your data so your results can be analyzed for accuracy and errors.

A procedure is a lot like a cookie recipe. To make cookies, you need a list of ingredients and directions, including measurements, times and temperatures. In the soccer ball experiment, your procedure must include directions for measuring the independent variable (air pressure), accounting for constant variables (such as kicking the ball the same way each time) and measuring the dependent variable (distance the ball travels). The procedure should also tell how many trials are necessary to get good results.

There must also be some way of comparing results. Scientists use a control variable that stays the same in each experiment. A control is the independent variable before it has been changed. For example, a soccer ball with no air could be a control.

Data

All that preparation comes down to the next step: collecting data. Your data are the results of your experiment. A data table will help you organize the results. It should have columns for the independent variable and the dependent variable. It should also have room for the appropriate number of trials. A data table should also have a title. Here is a sample:

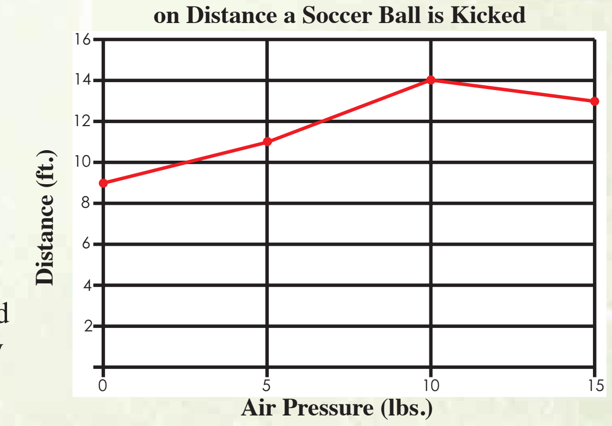
The Effect of Air Pressure on Distance a Soccer Ball Travels

Air Pressure	Trial 1	Trial 2	Trial 3	Average Distance (m)
0 lbs. (control)	8 m	9 m	10 m	9 m
5 lbs.	10 m	12 m	11 m	11 m
10 lbs.	14 m	12 m	16 m	14 m
15 lbs.	12 m	14 m	13 m	13 m

A graph is a good way to show your data. It makes a picture of your data that is easy to see and can be used to make predictions.

Conclusions

The Effect of Air Pressure on Distance a Soccer Ball is Kicked



The last step of the scientific method is to summarize what you learned. Tell if you answered your question and if the results supported your hypothesis.

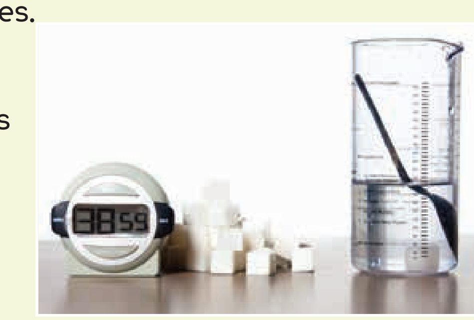
Experimenters should then evaluate the quality of their findings. Were there variables you couldn't control or problems you couldn't avoid? It is important to identify these limitations.

An experimenter might be surprised by the results of an experiment. They might find new questions to investigate. Scientists often suggest ways their findings could be used to help solve problems. For example, our graph shows the air pressure that is best for kicking a ball the greatest distance.

In the Lab

Variables

Variables are parts of an experiment that can change. Here is an investigation of variables that might affect how fast a sugar cube dissolves.



Materials:
- a box of sugar cubes
- water
- plastic spoons
- clear plastic cups
- stopwatch or clock

1. Pour 200 ml water into a cup.
2. Drop a sugar cube into the water and begin stirring.
3. Time how long it takes to dissolve the sugar cube. This will be your control.
4. With your partner develop a list of variables. A few examples include the temperature of the water and the speed of stirring.
5. Use a data table like the one shown. Enter your variables in the correct column. Two examples have been filled in.
6. Predict the effect changing each variable will have on the dissolving time.
7. Using the same size cups in the same amount of liquid, test each variable and record the dissolving time.

	Prediction	Dissolving Time
Control		
Variables		
Faster stirring		
Hotter water		

After you have tested each variable, think about the following questions:
1. What variables affect the time it takes for a sugar cube to dissolve?
2. For which variables was your prediction correct? Were there any surprises?
3. Did you make sure that only one variable was changed each time?

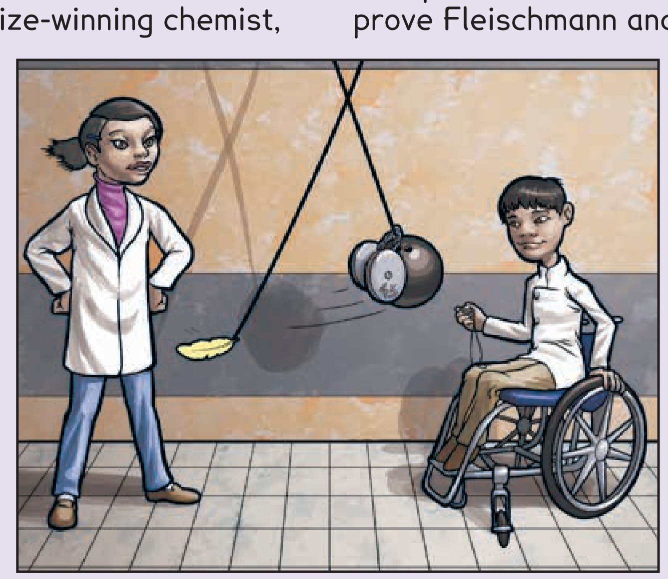
Bad Science

Nature of Science

Andy and Monique conducted a pendulum experiment. They had both noticed that heavier objects seemed to fall faster than lighter ones. So they both thought if they added weight to a pendulum, it would swing faster. After collecting data, they concluded that heavier pendulums do swing faster.

But their teacher showed them an article that said their results were wrong. Had they made a mistake?

Yes, and Irving Langmuir, a Nobel Prize-winning chemist, calls this mistake pathological science. This is when a scientist comes to the wrong conclusion after holding too hard to ideas he or she had before the experiment.



Consider the case of cold fusion. Fusion is the nuclear reaction occurring in the sun. Its potential to solve Earth's energy problems is enormous. Unfortunately, science has not taught us how to safely produce fusion reactions here on Earth. Wouldn't it be great if we could produce fusion reactions without all the pressure and heat normally required?

Scientists Martin Fleischmann and Stanley Pons thought so too. In 1989, they released results that said cold fusion can be produced in a jar on a laboratory table. What happened next is what makes science so successful—peer review. Other scientists studied their methods and tried to replicate their results. The scientists were not trying to prove Fleischmann and Pons wrong, they were simply looking for the truth. In the end, they didn't find any evidence that they could make cold fusion in a lab.

Were Fleischmann and Pons careless? Did they make false conclusions because they wanted to find energy solutions for the world? Did they simply want to be heroes?

Well, those are hard questions to answer. But it's clear that scientists must be very careful to analyze the results of their experiments with healthy skepticism, or doubt.

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What is a variable?

This Week's Question

A variable is part of an experiment that can change. The independent variable, or IV, is what the experimenter chooses to change. There should only be one IV in any experiment so you can be sure the result only has one cause. The dependent variable, or DV, is the outcome that you cannot control.

For example, a class is performing a rocket experiment. Students wonder if the number of fins would affect how far the rocket flies. Changing the number of fins (the IV) might affect the distance the rocket travels (the DV). The experimenter cannot control the distance in this experiment, but the IV can.

To conduct a fair test, students must make sure to keep all the variables the same except for the number of fins. The air pressure and angle of launch should be the same for every launch. These variables, which always stay the same, are constant variables, or CVs.

If the CVs are kept the same and the DV changes, the IV must be causing the change.

Galileo

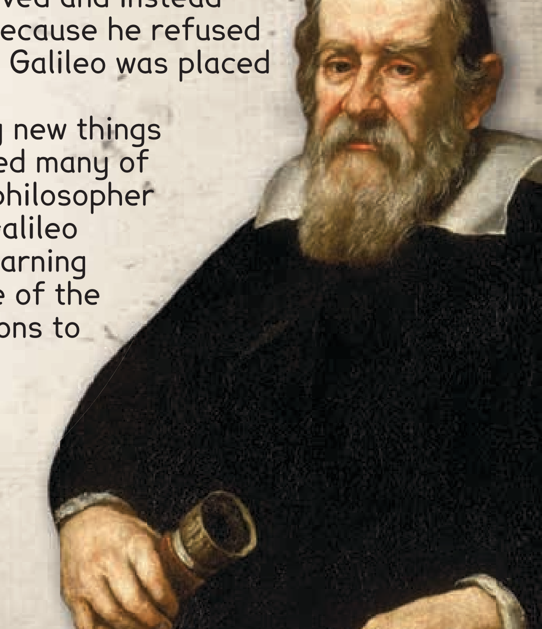
Spotlight

"All truths are easy to understand once they are discovered; the point is to discover them."

Galileo Galilei (1564-1642) was an Italian physicist often credited as the father of modern science. Galileo was interested in learning new things about the world.

Before Galileo, everyone believed the planets and the sun revolved around the Earth. Even the Catholic Church supported this belief. But Galileo found evidence that the sun was the center of our solar system. He was a religious man, but his discovery caused a conflict between science and the church. Galileo was unwilling to simply accept what others believed and instead depended on scientific evidence. Because he refused to go against what he had learned, Galileo was placed under house arrest.

Before Galileo, ways of learning new things were limited. Scholars had accepted many of the ideas proposed by the Greek philosopher Aristotle 1,500 year earlier. But Galileo opened doors with a new way of learning using measurable data. He was one of the first to use mathematical calculations to prove new discoveries.



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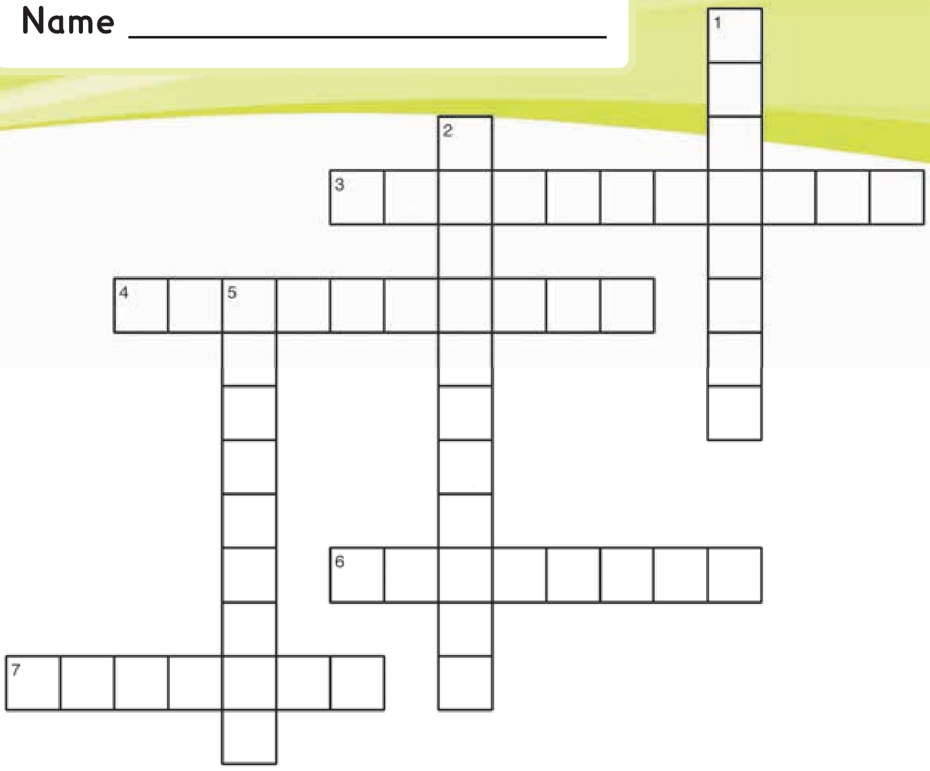

ACROSS

3. summaries of what was learned in a scientific experiment

4. an educated guess about an experimental question

6. the first step of any scientific investigation

7. unchanged independent variable used for comparison

DOWN

1. a part of an experiment that can change

2. the variable an experimenter chooses to change

5. step-by-step directions for conducting an experiment

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Connections Philanthropy and Values

Maybe you have heard the word "philanthropy" before. What does it mean? It describes actions that people make for the good of other people. What is a value? It's a way of behaving that people believe is good—like believing it's good to be honest.

One way you can practice philanthropy today is to help yourself and others learn good values. How do you learn good values? You can learn them from your parents, your teachers at school or church and other people.

You can also learn them from people that have been recognized for doing good things for society. An easy way to learn about people that have done good things is to visit values.com. Values.com has lots of stories and short videos that highlight the traits that make each of us better people. They even have billboards on the highway.

For example, you may have seen a billboard that looks like the one shown here.

This billboard is about Oral Lee Brown, who saved money from her job to send 19 kids to college. Isn't that cool? You can learn about lots of other people who practice philanthropy at values.com. Be sure to look for more of their "billboards" on Page 4 of Studies Weekly this year. We think they're so cool we want to check them out!

Let's Investigate

Jan Baptist van Helmont was a scientist in the early 17th century who was a careful observer of nature. He devised an experiment around the question, "Where do plants get their mass?" He grew a willow tree and replanted it in a pot. For five years he weighed the tree, the soil and the amount of water he added. In the end the tree had gained 164 pounds. Van Helmont deduced that the tree's weight gain had come from water alone.

Try this: place soil, water and seeds in a sealed jar and leave the jar for a period of time. Don't open it!

- What is your experimental question for this investigation?
- Using Van Helmont's result, make a hypothesis.
- Write a procedure that includes step-by-step directions and measurements.
- Collect your data and make observations.

As you read this week's lesson, circle or highlight all proper nouns with any color pen or highlighter. This will help you find some of the crossword answers and get ready for this week's test.

Mini-Lab

Hydrogen Peroxide and Plants

Have you ever put hydrogen peroxide on a cut? The reason your school nurse might do this is because hydrogen peroxide is a common disinfectant. It has even been approved as an ingredient in pesticides. So, does hydrogen peroxide affect the germination (sprouting) of seeds planted in the field? Let's see!

Materials:

- a packet of seeds (crop seeds would be best, such as broccoli, bean or corn)
- hydrogen peroxide
- paper towels
- resealable gallon-size plastic bags
- measuring spoons
- beakers
- water

Directions:

1. Pour 200 ml of water into each of four beakers.
2. Add 10 ml of hydrogen peroxide to one beaker, 30 ml to another and 50 ml to a third.
3. Fold paper towels so they fit into bags. Place one towel in each of four bags.
4. Label bags in the following way: 10 ml, 30 ml, 50 ml, control.
5. Pour all of the 10 ml solution into the bag marked 10 ml, making sure the paper towel is wet.
6. Repeat with the two other solutions and pour the plain water into the bag marked control.
7. Place 10 seeds on the paper towel in each bag. Seal and place on a tray out of direct sunlight.
8. Observe each day, looking for signs of germination.
9. After two weeks, count how many seeds in each bag have sprouted.
10. Make a data table to organize and display your results.

Write a conclusion that answers the following questions:

- What effect did the hydrogen peroxide have on the germination of the seeds?
- Do you think there is an acceptable concentration of hydrogen peroxide?
- What were some limitations of the experiment?
- How can the findings be used to solve problems?