Chapter 7 • Designing Experiments

Designing Experiments

In experiments, you collect information under certain controlled conditions. The purpose of an experiment is to answer a question or test a possible answer to a question. After you do an experiment, you analyze your results. For example, you might be asked to design an experiment to find the best flour to use for chocolate chip cookies. Or, you might be asked to design an experiment to test whether a ping pong ball bounces higher than a golf ball. In both of these cases, you need to follow these basic steps:

- state a hypothesis
- identify variables
- develop a procedure
- gather data
- analyze results
- draw conclusions

This chapter will deal with the first three steps. These are the steps involved in designing an experiment.

State a Hypothesis

A hypothesis is a possible solution to the problem you want to solve or a possible answer to a question about the problem. Write out your hypothesis. This will keep you focused on the problem and help you decide what to test. A set of hypotheses that have held up under testing by many scientists is called a theory.

Example If you are testing chocolate chip cookies, you might write down this hypothesis:

Chocolate chip cookies made with whole wheat flour are better than chocolate chip cookies made with white flour.

However, what do you mean by the word better? Do the cookies taste better? Are they cheaper or easier to make? Are they less likely to burn in the oven? Are they more nutritious? You need to make your hypothesis specific. A more testable hypothesis would be:

Chocolate chip cookies made with whole wheat flour taste better than chocolate chip cookies made with white flour.

Test Tip

The Grade 8 Intermediate-Level Science Test may ask you to design an experiment. If you follow a certain procedure for doing experiments all the time, the question will not seem so difficult, no matter what the subject of the experiment is.

Content Clue

These steps are part of the process many scientists refer to as the scientific method.

Content Clue

In an experiment, test only one thing, or variable, at a time.
Example  In the case of the ping pong ball and the golf ball, stating the hypothesis might seem very simple:

A ping pong ball bounces higher than a golf ball does.

However, do you mean that this ping pong ball bounces higher than that golf ball? Do you mean that all ping pong balls bounce higher than all golf balls? Or do you mean that, in general, ping pong balls bounce higher than golf balls?

The experiment you do will be a bit different for each case. If you want to know whether a certain ping pong ball bounces higher than a certain golf ball, you need to test only those two balls. If you want to know whether all ping pong balls bounce higher than all golf balls, you need to test a huge sample, including different brands of balls. If you want to know whether, in general, ping pong balls bounce higher than golf balls, you still need to test a large number of balls but not as many as for the second experiment.

**Identify Variables**

A variable is anything that can affect the outcome of the experiment. One of the variables in an experiment is the particular factor you are testing. This is the factor you will change during the experiment. Every variable that is not being tested needs to remain the same. A constant is a factor that does not change. If you don’t have these constants, you will not be sure why you get the results you do.

Example  In the cookie example, the factor being tested is the type of flour used. Suppose one batch of chocolate chip cookies uses white flour and butter. Another batch uses whole wheat flour and margarine. You think the first batch tastes better. Is the difference caused by the different flour or by the different fat? You have no way of knowing.

Suppose you make both batches using butter. However, in one batch you use 2 cups of whole wheat flour. In the other batch, you use 1 \( \frac{1}{2} \) cups of white flour. This time the second batch tastes better. Is it because of the different types of flour or the different amounts of flour?
You must also make sure all the other ingredients are the same. For both batches, you need to use the same brand and type of sugar, the same grade of eggs, and the same brand of chocolate chips. In addition, you need to use the same amount of each for each of the different batches. The different batches need to be baked under the same conditions, at the same oven temperature, and for the same length of time. Everything about baking the two batches of cookies needs to be the same except the kind of flour used.

**Example** In the case of the bouncing balls, the factor to be varied is the type of ball—ping pong balls versus golf balls.

What are the variables that need to stay the same? Certainly the surface the balls are bounced on needs to be the same, as does the height from which the balls are dropped. Other factors may not be so obvious. Will the room temperature affect the way the balls bounce? What about humidity? What about time of day?

When you design an experiment, you need to take all the possible variables into account. If you decide not to ensure that a particular variable will remain constant, you need to have some idea of what effect this will have on the outcome of the experiment.

As much as possible, you want to control even the variables you think will have no effect on the outcome of the experiment. You may think that room temperature has no effect on the way balls bounce. However, most materials are affected by temperature. Extreme temperatures might change the results of this experiment. In this case, it is fairly easy to make sure the room temperature remains constant.

Identifying the variables that are not being tested and keeping them constant is one of the hardest parts of designing an experiment. When you design your experiment, write down all the possible variables. Then you will more easily see which factors you have to hold constant and which ones you will vary.

**Develop a Procedure**

Before you can do your experiment, you need to come up with a procedure. The best way to do this is to write down what you intend to do. What steps will you take that will allow you to vary the factor you are testing while keeping all the others constant?

**Test Tip**

Use scrap paper to write down your thoughts on a procedure. Brainstorm all the possible steps. Then organize and eliminate.
The procedure must also provide a way to get meaningful results. For example, you may need to have measurements so you can compare things. In other cases, an experiment is testing to see only whether something happens or does not happen. In this case, measurements are not needed.

**Example** The procedure for testing the cookies needs to describe how you are going to make the two sets of cookies, keeping the variables other than flour type constant.

The procedure also needs to describe how you are going to measure your results. Once you have made your cookies, how are you going to decide which ones taste better? You could taste them yourself. However, that would be only one opinion. To get a scientifically meaningful result, you would need to ask many people to taste the cookies. In this case, you could ask ten of your friends to try both kinds of cookies and record which one they preferred.

**Example** The procedure for testing ping pong balls versus golf balls needs to define the surface on which the balls are being dropped and the height from which they are being dropped. The procedure should state the number of balls to be tested. The more balls you test, the better your results will be. However, ten ping pong balls and ten golf balls should probably give you meaningful results.

The procedure also needs to specify how you are going to measure the height each ball bounces. One possibility would be to place a meter stick behind each ball and have someone record the height on the meter stick to which each ball bounces.

**Write It Down**

As you practice designing experiments, get used to writing down every step of your plan. Write down your hypothesis. Write down the variables in your experiment. Write down a step-by-step procedure for performing your experiment.

Writing down everything makes it easier to actually do the experiment and keep track of what you have done. It helps you analyze your data. It also allows someone else to repeat your experiment and check your results. Finally, it will make it easier for you to successfully complete this part of the Grade 8 Intermediate-Level Science Test.
**Practice**

**Living and Nonliving Things**

Kevin knows that he breathes faster after he runs. He guesses that the length of time he runs has an effect on how fast he breathes.

Design an experiment to see whether Kevin's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: ______________________________________

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Factor to be varied: ________________________________

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Two factors to be held constant:

1. ________________________________

2. ________________________________

Procedure: ______________________________________

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**Content Clue**

Regular exercise strengthens the heart and lungs. A stronger heart pumps more blood with each beat. This lets the heart beat less often, which means the body doesn’t need to breathe as fast.

**Test Tip**

If your experiment seems to need it, be sure to include a way to measure something. Here, you would need to measure how fast Kevin breathes. Also, remember to include the unit of measurement, such as breaths per minute.
Practice

Genetic Information

Devon notices that his garden has more red carnations than white carnations. He guesses that red is a dominant trait in carnations and white is recessive.

Design an experiment to see whether Devon's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: ______________________________________

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Factor to be varied: _____________________________

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Two factors to be held constant:

1. _____________________________

2. _____________________________

Procedure: __________________________________

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Test Tip

Write down a step-by-step plan for the procedure. Number your steps, and make sure they follow a logical order. Picture someone else trying to follow your directions. This will help you be clear and provide all the needed information.

Content Clue

If red is a dominant trait in carnations and white is a recessive trait, the chances are greater that the offspring of crossed red and white carnations will have red flowers rather than white flowers.
Practice

Change Over Time

Marcia planted two different varieties of tomatoes in her garden. She planted all the Zing tomatoes together in one patch. All the Berry Red tomatoes were planted together in another patch. The Zing tomatoes grew taller and produced more tomatoes than the Berry Red plants. She guessed that this was because the Zing tomatoes were better adapted to growing in her area, which had a warmer climate, and that the Berry Red tomatoes were better adapted to growing in a colder climate.

Design an experiment to see whether Marcia's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: ____________________________
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Factor to be varied: __________________
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Two factors to be held constant:

1 __________________________________

2 __________________________________

Procedure: __________________________
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Test Tip

You do not need to prove a hypothesis right or wrong. You need only to see whether your findings support or fail to support your hypothesis.
Practice

Reproduction and Development

One day Jeremy was observing the caterpillars in his yard. He saw that fifteen of them had formed cocoons. He guessed that the cocoons would develop faster if they were kept warmer.

Design an experiment to see whether Jeremy’s guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: __________________________________________

Factor to be varied: ____________________________________

Two factors to be held constant:
1 __________________________________________
2 __________________________________________

Procedure: __________________________________________

Test Tip
It can be difficult to think of all possible factors. Think of the environment as one group of factors. When doing experiments with living things, an organism’s internal conditions are also factors.

Content Clue
Jeremy will need to collect caterpillars so he can find out the time at which each one develops and makes its cocoon. He will also need to be able to tell the cocoons apart, so he will need to mark them somehow.
Practice

Meeting Daily Needs

Sarah grew lilies in her garden. She had read about three different kinds of fertilizers. She had an idea about which would be best to use on her flowers. She thought that "Type 1" would be the best fertilizer.

Design an experiment to see whether Sarah's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: _____________________________________________

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Factor to be varied: _____________________________________________

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Two factors to be held constant:
1 _____________________________________________

2 _____________________________________________

Procedure: _____________________________________________

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Content Clue

Fertilizers are natural or artificial substances added to soil. They contain chemicals to improve plant growth.

Test Tip

There may be many variables that need to be held constant. If the question only asks for two, pick the two you think are the most important.

Test Tip

Make sure the plants to be tested are about the same size when you start.
Practice

Energy in Ecosystems

Patrick got a terrarium as a birthday present from his friend Josh, who already had one. Patrick noticed that his terrarium did not last as long as Josh's. The plants inside it died. He wondered if this was because his terrarium did not have any animals.

Design an experiment to see whether Patrick's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: ______________________________________________________
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___________________________________________________________
___________________________________________________________

Factor to be varied: ____________________________________________
___________________________________________________________

Two factors to be held constant:
1 __________________________________________________________
2 __________________________________________________________

Procedure: ______________________________________________________
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Test Tips
Your procedure will need to include a way to record data.
Also, be sure to note what each plant looks like at the beginning of the experiment so its growth can be compared with the growth of the other plants.

Content Clue
In an ecosystem, producers and consumers depend on each other. Producers give off oxygen that consumers breathe in. Consumers give off carbon dioxide that plants use for photosynthesis.
Practice

Humans and the Environment

Jason noticed that the pond near his house had developed a thick covering of algae. The growth seemed to have developed only after the golf course had been built. He thought that the fertilizer used on the grass at the golf course might have caused the algae growth in the pond.

**Design an experiment to see whether Jason’s guess was correct. Write your answers in the spaces provided. Include these elements in your response:**

**Hypothesis:**

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**Factor to be varied:**

________________________________________________________________________
________________________________________________________________________

**Two factors to be held constant:**

1. __________________________

2. __________________________

**Procedure:**

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**Test Tip**

Don’t forget that observation is an important part of most scientific procedures.

Fertilizer used on grass usually contains nitrogen and phosphorus, two things algae need to live and grow.

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The Living Environment: Key Idea 7  119
Practice

The Earth and Space

One day Tony noticed that in his town, the shortest shadows of the day occurred at 11:30 a.m. rather than at 12:00 noon. This told him that in his town, noon in solar time was different from noon on his clock. He guessed that the difference between what the clock showed as noon and what the Sun showed as noon was the same all year round.

**Design an experiment to see whether Tony’s guess was correct. Write your answers in the spaces provided. Include these elements in your response:**

- **Hypothesis:**
- **Factor to be varied:**
- **Two factors to be held constant:**
  1.
  2.
- **Procedure:**

**Content Clue**

In ancient times, people used the Sun and the shadows that it created to tell time. This is called **solar time.** Because of the Earth’s **rotation,** the Sun changes position in the sky as the day goes on. Normally, the shortest shadows occur at 12:00 noon, solar time.

**Test Tip**

You do not need to always follow the steps of the **scientific method** exactly in designing your **experiment.** You may skip some or repeat some others. It all depends on the problem you are trying to solve. However, don’t eliminate any step without giving it careful thought.

**Test Tip**

Although checking the shadows every day would be ideal for this experiment, doing it once a week is probably often enough.
Practice

The Interaction of Air, Land, and Water

Selena noticed that the sand at the beach seemed much warmer than the water. She wondered whether that was because water took more energy to heat up than land.

Design an experiment to see whether Selena’s guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: 

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Factor to be varied: 

________________________________________________________________________

________________________________________________________________________

Two factors to be held constant:

1  

2  

Procedure: 

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Content Clue

Sunlight is a form of radiation. Radiation is the transfer of energy in the form of waves. Different substances absorb radiation at different rates.

Test Tip

Be sure to always put your hypothesis in a form that can be tested by your experiment.
Practice
Physical Properties of Matter

Frances took swimming lessons in a swimming pool. Then her family went to the beach, and she swam in the ocean. She noticed that her body seemed lighter in the ocean than it had seemed in the pool, which made it easier for her to swim. She thought that the salt in the ocean water might have had something to do with her feeling.

**Design an experiment to see whether Frances’s guess was correct. Write your answers in the spaces provided. Include these elements in your response:**

**Hypothesis:**

**Factor to be varied:**

**Two factors to be held constant:**

1

2

**Procedure:**

**Test Tip**

Scientists can be influenced by what they already believe and by the opinions of others. Be aware of these factors when you write your hypothesis and design your experiment.

**Content Clue**

The factor being tested here is buoyancy. If Frances felt lighter in the ocean, it was because she was more buoyant. The buoyancy of an object changes as the substance in which it is located changes.
Practice

Forms of Energy

Eric bought a pair of sunglasses that didn't seem to work well. Other pairs lying around his house seemed to work better. He wondered whether certain types of lenses blocked out more sunlight than other types.

Design an experiment to see whether Eric's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: _____________________________

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Factor to be varied: ______________________

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Two factors to be held constant:

1 ______________________

2 ______________________

Procedure: _____________________________

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Test Tip

Be careful to test for only one variable.

Content Clue

Lenses are all convex in shape but are made of different materials and different thicknesses. They may also have different types of coatings.
Practice

Forces and Motion

One day while Joyce's bicycle was being fixed, she borrowed her friend Mary's bicycle. As she rode Mary's bicycle, it seemed to her that it coasted better than her own bicycle did. She thought the reason might be that Mary's bicycle had smoother tires.

Design an experiment to see whether Joyce's guess was correct. Write your answers in the spaces provided. Include these elements in your response:

Hypothesis: ____________________________________________________________

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______________________________________________________________________

Factor to be varied: ____________________________________________________

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Two factors to be held constant:
1 ___________________________________________________________________
2 ___________________________________________________________________

Procedure: ____________________________________________________________

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Test Tip

Coasting better might mean coasting farther, coasting faster, or both. You need to decide which of these two variables you are testing and provide a way to measure it.