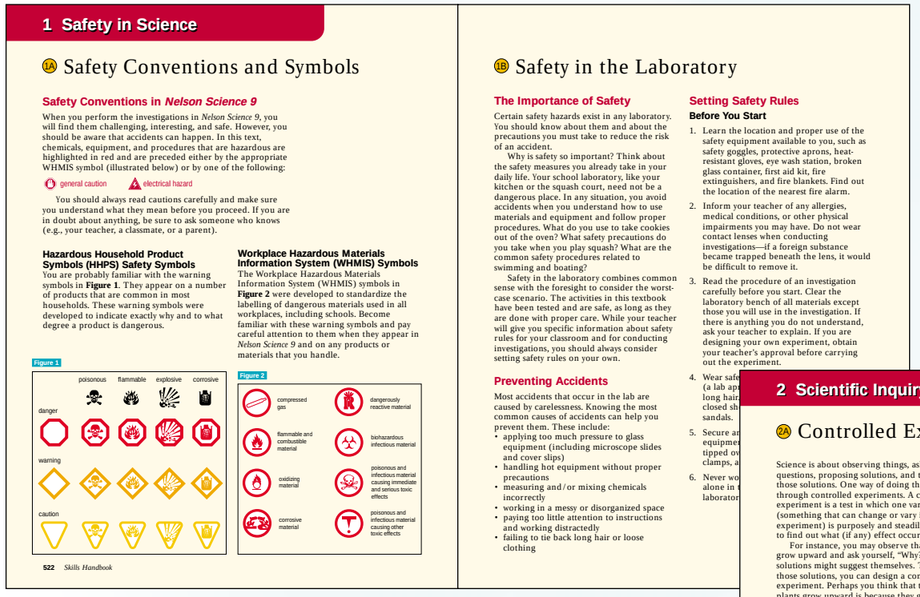
Skills Handbook

The *Skills Handbook* section of the text is a student reference that provides background and practical activities to support skill development. The handbook emphasizes inquiry and design skills, communication skills, and skills related to the use of tools, materials, and equipment, as outlined in the curriculum expectations.



1 Safety in Science

1A Safety Conventions and Symbols

Safety Conventions in *Nelson Science 9*

When you perform the investigations in *Nelson Science* 9, you will find them challenging, interesting, and safe. However, you should be aware that accidents can happen. In this text, chemicals, equipment, and procedures that are hazardous are highlighted in red and are preceded either by the appropriate WHMIS symbol (illustrated below) or by one of the following:

general caution electrical hazard

You should always read cautions carefully and make sure you understand what they mean before you proceed. If you are in doubt about anything, be sure to ask someone who knows (e.g., your teacher, a classmate, or a parent).

Hazardous Household Product Symbols (HHPS) Safety Symbols

You are probably familiar with the warning symbols in **Figure 1**. They appear on a number of products that are common in most households. These warning symbols were developed to indicate exactly why and to what degree a product is dangerous.

Workplace Hazardous Materials Information System (WHMIS) Symbols

The Workplace Hazardous Materials Information System (WHMIS) symbols in **Figure 2** were developed to standardize the labelling of dangerous materials used in all workplaces, including schools. Become familiar with these warning symbols and pay careful attention to them when they appear in *Nelson Science* 9 and on any products or materials that you handle.

Figure 1

Figure 2

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1B Safety in the Laboratory

The Importance of Safety

Certain safety hazards exist in any laboratory. You should know about them and about the precautions you must take to reduce the risk of an accident.

Why is safety so important? Think about the safety measures you already take in your daily life. Your school laboratory, like your kitchen or the squash court, need not be a dangerous place. In any situation, you avoid accidents when you understand how to use materials and equipment and follow proper procedures. What do you use to take cookies out of the oven? What safety precautions do you take when you play squash? What are the common safety procedures related to swimming and boating?

Safety in the laboratory combines common sense with the foresight to consider the worst-case scenario. The activities in this textbook have been tested and are safe, as long as they are done with proper care. While your teacher will give you specific information about safety rules for your classroom and for conducting investigations, you should always consider setting safety rules on your own.

Preventing Accidents

Most accidents that occur in the lab are caused by carelessness. Knowing the most common causes of accidents can help you prevent them. These include:

- applying too much pressure to glass equipment (including microscope slides and cover slips)
- handling hot equipment without proper precautions
- measuring and/or mixing chemicals incorrectly
- working in a messy or disorganized space
- paying too little attention to instructions and working distractedly
- failing to tie back long hair or loose clothing

Setting Safety Rules

Before You Start

1. Learn the location and proper use of the safety equipment available to you, such as safety goggles, protective aprons, heat-resistant gloves, eye wash station, broken glass container, first aid kit, fire extinguishers, and fire blankets. Find out the location of the nearest fire alarm.
2. Inform your teacher of any allergies, medical conditions, or other physical impairments you may have. Do not wear contact lenses when conducting investigations—if a foreign substance became trapped beneath the lens, it would be difficult to remove it.
3. Read the procedure of an investigation carefully before you start. Clear the laboratory bench of all materials except those you will use in the investigation. If there is anything you do not understand, ask your teacher to explain. If you are designing your own experiment, obtain your teacher's approval before carrying out the experiment.
4. Wear safe… (a lab ap… long hair… closed sh… sandals.
5. Secure ar… equipme… tipped ov… clamps, a…
6. Never wo… alone in … laborator…

2 Scientific Inquiry

2A Controlled Experiments

Science is about observing things, asking questions, proposing solutions, and testing those solutions. One way of doing this is through controlled experiments. A controlled experiment is a test in which one variable (something that can change or vary in your experiment) is purposely and steadily changed to find out what (if any) effect occurs.

For instance, you may observe that plants grow upward and ask yourself, "Why?" Various solutions might suggest themselves. To test those solutions, you can design a controlled experiment. Perhaps you think that the reason plants grow upward is because they grow toward the light. This is your hypothesis. From your hypothesis, you can make a prediction that you can test through experimentation, for instance: "As the angle of light shining on plants steadily increases, the angle of the plants' growth should steadily increase."

To design a controlled experiment to test this hypothesis, you need to control, or keep constant, as many of the variables, or possible causes of the effect, as possible. You might conduct an experiment on five identical plants, ensuring that all growing conditions—water, nutrients, temperature, kind of light, etc.—are the same. You would then change one variable, the angle of light shone on the plant, and measure the results.

You can use a control group as well (**Figure 1**). In the plant experiment, you could have a plant that has sunlight shining on it from directly above. If the hypothesis is correct, this plant will not grow at an angle. It is the control for the experiment, and the other plants are the test cases. The control is set up exactly like the test cases, but no variable is changed.

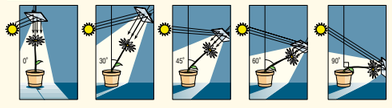
Unfortunately, scientists can never be sure that they have controlled all possible causes of the effects. Because of this, they can never be absolutely sure that the conclusions they make are true. However, the more the results match the prediction, the more confident the scientists can be about their hypotheses.

The Process of Scientific Inquiry in Controlled Experiments

Scientists use an inquiry process to find answers to their questions. This process is also referred to as the Scientific Method. There are common components for an inquiry that allow scientists to duplicate experiments so results can be validated and communicated. These components are outlined in the flow chart in **Figure 2**.

It is important that you follow this process and use the related skills whenever you are asked to design and conduct an experiment, if you expect to find reliable answers to the questions you pose. You can use the flow chart as an overall checklist. You can also refer to the more detailed sections in this Skills Handbook that deal with each of the specific skills necessary for each part of the process.

Figure 1



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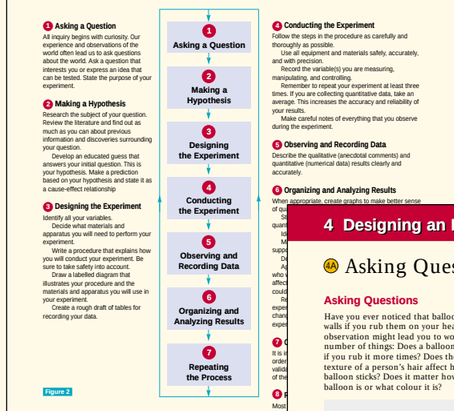
1 Asking a Question
2 Making a Hypothesis
3 Designing the Experiment
4 Conducting the Experiment
5 Observing and Recording Data
6 Organizing and Analyzing Results
7 Repeating the Process

Figure 2

Try This Getting It Right

Research two famous Canadian scientists, Dr. F. G. Banting and C. H. Best, then answer the following questions:

1. How many days, months, or years did it take Banting and Best to discover insulin?
2. Did they problem… once? If … how man… experim…



1 Asking a Question
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1 Asking a Question
All inquiry begins with curiosity. Our experience and observations of the world often lead us to ask questions about the world. Ask a question that interests you or express an idea that can be tested. State the purpose of your experiment.

2 Making a Hypothesis
Research the subject of your question. Review the literature and find out as much as you can about previous information and discoveries surrounding your question.
Develop an educated guess that answers your initial question. This is your hypothesis. Make a prediction based on your hypothesis and state it as a cause-effect relationship

3 Designing the Experiment
Identify all your variables.
Decide what materials and apparatus you will need to perform your experiment.
Write a procedure that explains how you will conduct your experiment. Be sure to take safety into account.
Draw a labelled diagram that illustrates your procedure and the materials and apparatus you will use in your experiment.
Create a rough draft of tables for recording your data.

4 Conducting the Experiment
Follow the steps in the procedure as carefully and thoroughly as possible.
Use all equipment and materials safely, accurately, and with precision.
Record the variable(s) you are measuring, manipulating, and controlling.
Remember to repeat your experiment at least three times. If you are collecting quantitative data, take an average. This increases the accuracy and reliability of your results.
Make careful notes of everything that you observe during the experiment.

5 Observing and Recording Data
Describe the qualitative (anecdotal comments) and quantitative (numerical data) results clearly and accurately.

6 Organizing and Analyzing Results
When appropriate, create graphs to make better sense

Figure 2

Try This Can You Test It?

Decide whether each of the questions in **Table 1** would be testable or impossible to test. Then make up some testable questions of your own.

Table 1

Question	Testable		Not Testable
	Independent (Cause) variable	Dependent (Effect) variable	
What is the effect of increasing the number of times that a balloon is rubbed on a person's head on the length of time that the balloon stays stuck to a wall?	balloon rubbed on a person's head	the length of time the balloon stays stuck to a wall	?
Does listening to loud music affect a teenager's ability to hear?	?	?	
Does a rock think?	?	?	
Do tennis balls bounce differently when wet?	?	?	
Is there extra-terrestrial life in our universe?	?	?	

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4 Designing an Experiment

4A Asking Questions and Hypothesizing

Asking Questions

Have you ever noticed that balloons stick to walls if you rub them on your head? This observation might lead you to wonder about a number of things: Does a balloon stick better if you rub it more times? Does the length or texture of a person's hair affect how well a balloon sticks? Does it matter how inflated the balloon is or what colour it is?

[Catch art SH.4.1: photo: balloon being rubbed in hair, then being stuck on wall]

Each of these questions is the basis for a sound scientific investigation. With a little rewording, it will become clear how these questions can be tested. Not every question that you will want an answer for can be tested: some are too general, or too vague. Learning to ask questions that can be tested takes time and is a fundamental skill in scientific inquiry.

The first balloon-related question could be stated more usefully: "What is the effect of increasing the number of times that a balloon is rubbed on a person's head on the length of time that the balloon stays stuck to a wall?" You can probably already begin to plan an experiment that would answer this question. A testable question is often about cause-effect relationships. These questions often take the form: "What *causes* the change in variables?" and "What are the *effects* on a variable if we change another variable?" As you know, a variable is something that can change or vary in an investigation.

Scientists call the cause variable the independent variable. This is the one thing in the experiment that you purposely change. For instance, increasing the number of times that a balloon is rubbed on a person's head is something you control: you are changing the independent variable. The effect variable is called the dependent variable. This is what you measure in your experiment (e.g., time, distance) and it "depends" on the variable you purposely change (independent variable). The amount of time the balloon stays on the wall is the dependent variable.

A scientific question that asks what happens to a dependent variable when we change the independent variable is a question you can test.

Hypothesizing

A suggested answer or reason why one variable affects another in a certain way is called a hypothesis. Often you have some idea about this even as you ask your question. Having noticed, for instance, that a balloon sticks to the wall after you rub it in your hair, you might predict that rubbing it more will make it stick longer. You might be wrong, of course, but your prediction is probably based on past observations, on logic, and on bits of scientific theory you may remember. If you're really interested, you may even do some research based on what you already know. If you then pull everything you know together and express it, you would have a hypothesis. For instance, you might predict that the balloon sticks to the wall because it is attracted by static electricity, and that rubbing the balloon more produces a greater static electric charge on the balloon.

Predictions and hypotheses go hand in hand (**Table 2**). The hypothesis is how you can explain a prediction. The prediction is what you test through your experiment. And, if the experiment confirms the prediction, you can have more confidence that your hypothesis is correct.

Table 2 Sample Hypotheses and Predictions

Hypothesis (possible reason for cause–effect relationship)	Prediction	
	Possible cause (independent variable)	Possible effect (dependent variable)
Candy contains sugar that is used for energy by germs in the mouth. And these germs produce an acid that decays the teeth.	As the amount of candy that a person eats increases…	…the number of tooth cavities increases.
A larger sail traps more air, which then provides a greater force to a boat.	As the size of the sail increases…	…the top speed of the sailboat increases.
Salt helps oxygen in the air combine with iron in the metal of the bicycle to form rust.	As the amount of salt on a road increases…	…the amount of rusting of the metal parts of a bicycle increases.

Try This Hypothesize

Now it's your turn. With a partner, think of a few hypotheses and predictions that could be tested. Use a chart similar to **Table 3** to record your thoughts.

Table 3 Hypotheses and Predictions of Cause-Effect Relationships

Hypothesis (possible reason for cause–effect relationship an educated guess)	Possible cause (independent variable)	Possible effect (dependent variable)
?	?	?
?	?	?

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Try This Activity

At least one *Try This* activity is included in each section of the handbook to offer students the opportunity for hands-on skill development.