TOPIC
2.1

How and why do we study matter?

Key Concepts

- Matter and its interactions make up our world.
- Safety is key when working with matter.

Curricular Competencies

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal interest.
- Ensure that safety and ethical guidelines are followed in your investigations.
- Critically analyze the validity of information in secondary sources and evaluate the approaches used to solve problems.

According to the B.C. government, about 2000 wildfires occur in the province each year. One strategy to prevent wildfires or to fight existing ones is to carry out planned, or prescribed, burns. The firefighter shown here is working at a prescribed burn, which was started on purpose and is carefully kept within planned boundaries. The fuel used to start the fires is highly flammable. In contrast, the firefighter's clothing and safety equipment resist burning. The different properties of different substances and materials determine how they can be used and how we can work with them safely.

Starting Points

Choose one, some, or all of the following to start your exploration of this Topic.

1. **Identifying Preconceptions** What is matter? In your own words, define the term. Use your definition to explain whether each of these terms related to the introduction is an example of matter: wood, smoke, oxygen, fuel, plan, firefighter, fire, heat, gloves, crackling sound.
2. **Questioning and Predicting** Wildfires can occur naturally, but today most are started by human activities. It is not just the burning that causes harm but the smoke. What compounds are released into the air when wood burns? What are the chemical and physical properties of these compounds? How are they dangerous to human and animal life?
3. **Communicating** First Peoples in B.C. have used controlled burning techniques as part of their traditional practices. Invite an Elder or traditional knowledge keeper to share how and why controlled burns may be used and how they are done safely.

Key Terms

There are six key terms that are highlighted in bold type in this Topic:

- matter
- mixture
- compound
- pure substance
- element
- chemical reaction

Flip through the pages of this Topic to find these terms. Add them to your class Word Wall along with their meaning. Add other terms that you think are important and want to remember.

CONCEPT 1

Matter and its interactions make up our world.

Activity

Describe It, Separate It

Your teacher will provide your group with a mixture. You will have access to equipment such as magnets, filters, and sieves. Before starting, examine Figure 2.1 below.

1. Is your mixture heterogeneous or homogeneous (a solution)? How do you know?
2. Can you separate your mixture into parts? Try to do so.
3. Are the parts of your sample mixtures or pure substances? Explain.
4. What further tests would you like to conduct to gather more information about the components of your sample?

matter anything that has mass and takes up space

pure substance matter that has a definite composition and cannot be separated by physical means

mixture a blend of two or more pure substances in which each substance retains its individual properties; can be separated by physical means

You are surrounded by **matter**, and chemistry is the science of matter and its interactions. By studying chemistry, we can better understand the properties and behaviour of matter on Earth and beyond. Matter can be classified as either a **pure substance** or a **mixture**. Pure substances are made up of one type of particle. Mixtures are made up of two or more pure substances, and therefore two or more types of particles. Figure 2.1 summarizes the classification of matter.

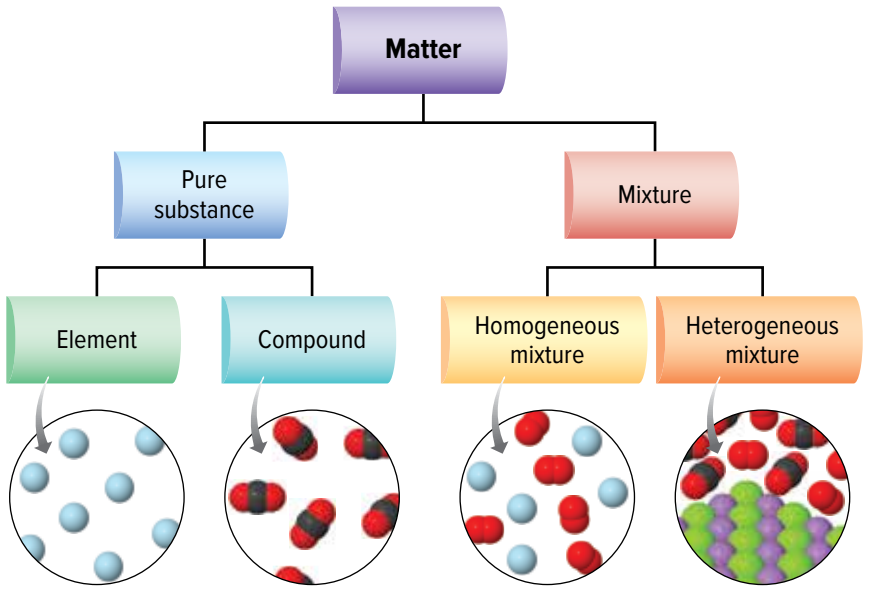

Figure 2.1 Matter is either a mixture or a pure substance. A mixture can be homogeneous or heterogeneous. A pure substance can be an element or a compound. **Give one example of each of these: a mixture, an element, and a compound.**

This train runs on diesel fuel. Diesel is a mixture of chemical compounds made of the elements hydrogen and carbon.

The metal used to make the bridge is steel. Steel is a very strong solid mixture—an alloy—composed of iron and small amounts of other elements, such as carbon.

The rock of the hillside is a mixture that includes quartz, which is a compound made of the elements silicon and oxygen.

This river water is a mixture made up of the compound water, a variety of compounds and elements dissolved in the water, and suspended bits of rock.

Figure 2.2 This pair of railway bridges, called the Cisco bridges, is found at Siska, B.C. **Make a table to list the mixtures, compounds, and elements mentioned. Add one example not mentioned.**

Mixtures, Compounds, and Elements

Most of the materials we interact with each day are mixtures. Figure 2.2 shows and describes some examples of solid, liquid, and gas mixtures. Some—such as air and steel—are homogeneous mixtures, or *solutions*. They are mixed uniformly throughout, and you cannot see their components, even with a microscope. Others, such as rock, have different parts that you can see. These are *heterogeneous mixtures*. But all are made up of two or more different pure substances.

Pure substances can be elements or compounds. **Elements** are made up of just one type of atom and cannot be broken down into simpler substances by chemical means. **Compounds** are made up of atoms of two or more elements.

element a pure substance that cannot be broken down into simpler substances by physical or chemical means

compound a pure substance made up of two or more elements; can be broken down into elements by chemical means

Properties of Matter

The steel of the railway tracks in Figure 2.2 is a strong, hard, shiny solid. Rock is also a hard solid, but it is brittle. Air is a clear, colourless gas. These descriptions all use *physical properties*. These are characteristics of matter that can be observed or measured without changing its chemical identity. In contrast, *chemical properties* describe the ability of matter to react with another substance to form one or more different substances. Table 2.1 gives further examples.

Table 2.1 Physical and Chemical Properties

Physical Properties		Chemical Properties
• colour • malleability • texture • viscosity • ability to conduct heat and electricity	• state of matter • melting point • boiling point • hardness • solubility	• combustibility • reactivity with acids • reactivity with oxygen • lack of reactivity

Chemical Reactions

chemical reaction a process in which the atoms of one or more pure substances are rearranged to form a different substance or substances.

An important part of studying matter is carrying out and observing chemical reactions. In a **chemical reaction**, one or more pure substances interact to form a different substance or substances. For example, elements can react to form compounds, compounds and elements can react to form different compounds, and compounds can break apart to form elements and simpler compounds.

A fire is a common example of a chemical reaction. In a forest fire, compounds in plants react with oxygen in the air to form many compounds, including carbon dioxide, carbon monoxide, and water, as well as the element carbon. You cannot see or smell carbon dioxide or carbon monoxide, but water is a visible part of smoke as it cools and forms droplets in the air. You can see the carbon as the black charcoal left behind by the fire. Energy is also released in the form of light and heat. **Figure 2.3** shows other examples of chemical reactions.

Figure 2.3 A Explosive chemical reactions are used in mining to break apart rock and soil. B In a sparkler, metals react with air and release energy in the form of light and sound. C Exposing food to heat results in chemical reactions that change its taste and appearance. D The chemical reaction between substances in this tablet and water produces gas, which you can see as bubbles in the water.

Before you leave this page . . .

1. What is the difference between a pure substance and a mixture? Use diagrams in your answer.
2. List three physical properties of water at room temperature.
3. Give one example of an element and one example of a compound. Explain how they are different.
4. What happens in a chemical reaction?

CONCEPT 2

Safety is key when working with matter.

Activity

Be Prepared; Be Safe

Figure 2.4 shows two students carrying out Investigation 2A. How have they ensured that they are doing their investigation safely? First do the following:

- Read Safety in Your Science Classroom on page xiv–xvii.
- Review the safety guidelines in **Figure 2.5** on the next page.
- Read Investigation 2A on pages 96–97.

Then answer these questions.

1. What is the meaning of each safety symbol in Investigation 2A?
2. Why should the test tube be angled away from you and your partner?
3. What would you do if some hydrochloric acid spilled on the lab bench?
4. Where are the fire extinguishers in your classroom and how are they used?

Making sure that you know how to handle materials safely in the laboratory is an essential part of studying chemistry. **Figure 2.4** shows some of the blue safety icons that you will see attached to investigations in this unit. You will also see Workplace Hazardous Materials Information System (WHMIS 2015) symbols, which alert you to potential hazards when working with specific substances in the lab. As part of the WHMIS 2015 system, Safety Data Sheets (SDS) are available for each chemical you will handle.

Connect to Investigation 2A on pages 96–97

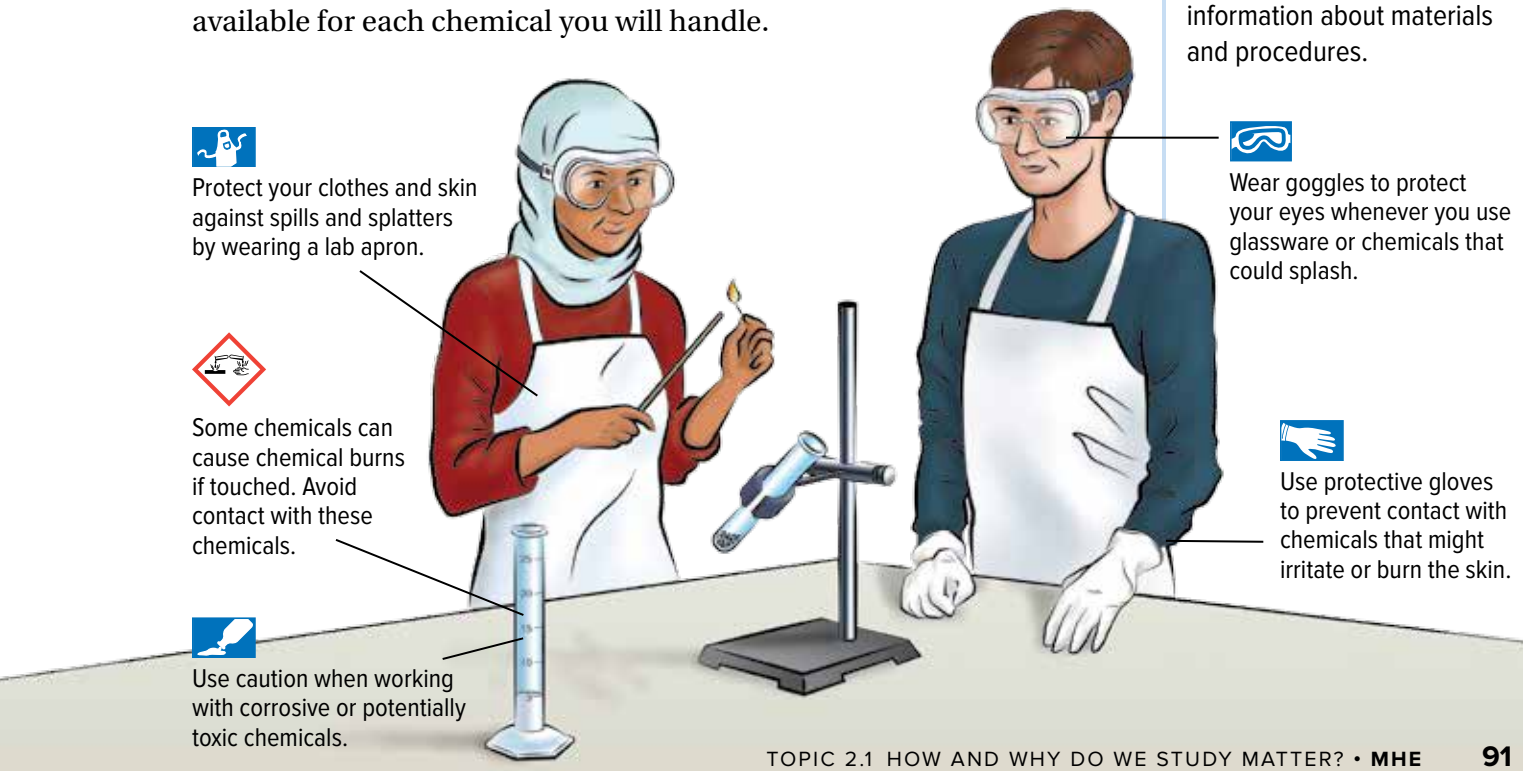

Figure 2.4 Safety icons (blue and white) and WHMIS symbols (black and red) communicate important information about materials and procedures.

Staying Safe in Your School Laboratory

1. Before you begin

- Inform your teacher if you have any allergies or medical conditions, or if there are other factors that could affect your work in the chemistry lab.
- Know the location of the nearest fire alarm, fire extinguisher, fire blanket, first-aid kit, safety shower (if there is one), and eye wash station. Know how to use them.
- Study your activity, investigation, or other lab assignment carefully before you start. Ask for help if you have questions.
- Be sure you understand the safety icons.

2. Dressing the part

- Wear protective clothing as appropriate and as directed, such as a lab apron, gloves, and safety glasses.
- Tie back long hair, and secure or remove scarves, caps, ties, or long necklaces.
- Wear footwear that covers your entire foot, including toes.

3. Acting responsibly

- Never chew gum, eat, or drink in the lab.
- Work carefully with your partner or group and make sure you keep your work area clear.
- Stay focused on what you are doing. Acting irresponsibly is dangerous in the lab.

Staying Safe; Being Aware

Before you start any activity or investigation in the lab, read the procedure carefully. Be sure you understand what is involved in each step, including safety precautions. Be aware of what you are doing and what others are doing at all times. Know where safety equipment such as fire extinguishers and eyewash stations are, and how to use them. By following safety guidelines such as the ones listed in **Figure 2.5**, and by staying alert, you and your classmates create an environment in which you can confidently explore the properties and interactions of matter.

4. Using equipment

- When carrying equipment for an activity or investigation, hold it carefully. Carry only one object at a time.
- When working with electrical equipment, make sure your hands are dry, especially when touching electrical cords, plugs, or sockets. Pull the plug, not the cord.
- Report damaged equipment to your teacher immediately.
- Place electrical cords where people will not trip over them.

5. Working with heat

- If you use a laboratory burner, be sure you understand how to light and use it safely.
- Point the open end of a container being heated away from yourself and others.
- Do not allow a container to boil dry.
- Handle hot objects carefully. Remember that glassware and equipment looks the same hot as it does cold.
- Inform your teacher if you receive a burn. Apply cold water to the burned area immediately.

6. Working with chemicals

- Read and understand all safety labels, including WHMIS symbols.
- Never taste any substances you use in the lab.
- If any part of your body contacts a substance in the lab, inform your teacher. Immediately wash the area thoroughly with cold water. If you get anything in your eyes, wash them immediately and continuously for 15 minutes.
- Handle substances carefully. If you are asked to smell a substance, never smell it directly. Hold the container slightly in front of and beneath your nose, and waft the fumes toward your nostrils.

7. Cleaning up

- Clean up any spills according to your teacher's instruction.
- Clean equipment and glassware before you put it away.
- Dispose of all materials as directed by your teacher. Never discard materials in the sink or garbage unless your teacher directs you to.
- Wash your hands thoroughly after doing an activity or investigation.

Figure 2.5 These are just some of the safety rules to follow in your school laboratory.

Connect to Investigation 2B on pages 98–99

Before you leave this page . . .

1. What is an SDS?
2. List three things you should do before beginning any investigation in the lab.
3. What are the locations of the eyewash stations and fire extinguisher in your classroom?

AT ISSUE

Should we use flame-retardant substances?

What's the Issue?

In Canada, many, many household products—from upholstered furniture, electronics, and children's toys to kettles, chairs, and carpet backing—and even our cars contain polybrominated diphenyl ethers (PBDEs). The purpose of these chemicals is to slow or stop fires, and so protect the consumer.

But are we really protected by these chemicals, or do they pose a health risk to us? The David Suzuki Foundation warns that exposure to these chemicals can damage our immune systems, reproductive systems, neurological systems, and more. It's a bit ironic: the very chemicals that are included in products in order to keep us safe from the effects of fire actually expose us to harm when they burn. And scientists are concerned that we're exposed to them at other times too. For example, they are released into the air while they are being manufactured. And when products containing them disintegrate, the toxic chemicals accumulate in household dust. Recently, the Canadian government agreed that PBDEs do pose a risk to people and the environment. It has put in place regulations to prevent their manufacture in Canada and to restrict their use.

Dig Deeper

Collaborate with your classmates to explore one or more of these questions—or generate your own questions to explore.

1. Canada has recently restricted the use of PBDEs in new Canadian-made products, but there are still many existing products in Canadian households, including carpets and toys, which contain these PBDEs. Do you think these might pose an ongoing health risk to the public? If so, which part of the population might be most at risk? Explain your answer. Research to find suggestions about what families can do to minimize their exposure.
2. The flammability of children's sleepware has been regulated in Canada since 1971. How have the regulations changed since then? Are the regulations successful in protecting children?
3. What materials might First Peoples have used that have flame-retarding properties? A local Elder or Knowledge Keeper could assist with answers to this question.

Check Your Understanding of **Topic 2.1**

QP Questioning and Predicting PC Planning and Conducting PA Processing and Analyzing E Evaluating
AI Applying and Innovating C Communicating

Understanding Key Ideas

1. State whether each of the following is an example of matter. Explain your answer in each case. PA C

a) a brick
b) sunlight
c) the sound of a train
d) air
e) the colour red
f) a text message

2. Classify each of the following as an element, a compound, or a mixture. PA C

a) ocean water
b) gold
c) carbon dioxide
d) a pencil

3. List at least two physical properties of each of the following pure substances. PA C

a) oxygen
b) copper
c) carbon (diamond)
d) carbon (coal)

4. When you cook food, its appearance and taste changes. Why does this indicate a chemical reaction is occurring? PA E C

5. What is each of these safety icons telling you? PA C

a)  Eye Safety

b)  Fire Safety

c)  Chemical Safety

d)  Disposal Alert

Connecting Ideas

6. Which WHMIS 2015 symbols would you expect to see on a cylinder of oxygen like the one shown here? Explain your answer. (Refer to Safety in Your Science Classroom on pages xiv–xvii.) AI

7. You are about to carry out an investigation involving a laboratory burner. AI

a) Which safety icons would you expect to see in the instructions?
b) What precautions would you take?

Making New Connections

8. Physical and chemical properties define both the uses and hazards associated with materials. PA E AI

a) What does the chemical property of combustibility refer to?
b) List three combustible materials.
c) List three materials that are not combustible.
c) List one application in which a combustible material is needed.
d) List one application in which a material that is not combustible is needed.

9. Early chemists would taste the substances they were working with as a way to identify and describe them. PA E AI C

a) Would you characterize taste as a physical or chemical property? Explain.
b) Why is it essential not to eat or drink anything, even chewing gum, when working in the laboratory?

INVESTIGATION
2-A

STRUCTURED INQUIRY

Skills and Strategies

- Processing and Analyzing
- Evaluating
- Communicating

Safety

- 1 mol/L hydrochloric acid can cause burns. Inform your teacher immediately of any spills. If any hydrochloric acid contacts your skin, flush the area with cold water for 15 minutes.

What You Need

- 2.5 g mossy zinc
- large test tube
- 50 mL beaker
- test tube clamp
- 5 mL 1 mol/L hydrochloric acid
- graduated cylinder
- 2 wooden splints
- matches
- ring stand

Safely Observing a Chemical Reaction

An important part of investigating matter involves observing what happens when different substances interact. In order to perform lab activities safely, including those that involve potential hazards such as splint tests and acids, it is essential to read and understand the procedure and safety precautions before you start.

One technique for identifying substances is to observe the effect on the substance of a flame or glowing ember. For example, when a flame is brought close to a source of hydrogen, the flame will ignite the hydrogen and produce a loud "pop" sound.

Question

How can a burning splint test be carried out safely to help you identify the element produced when zinc and hydrochloric acid are mixed?

Procedure

1. Work in pairs. Place 2.5 g of mossy zinc in a large test tube.
2. Place the test tube in a clamp and attach the clamp to a ring stand so that the mouth of the test tube is angled up and away from you. Attach the clamp about halfway down the tube.
3. Measure 5 mL of 1 mol/L hydrochloric acid in a graduated cylinder. CAUTION: 1 mol/L hydrochloric acid could cause burns and produce hazardous fumes.
4. Light a wooden splint with a match. Dispose of the match as directed by your teacher. CAUTION: If you are using gloves, do not wear them for this step.
5. Place the burning splint at the mouth of the test tube, then move the burning splint to the mouth of the graduated cylinder. Record your observations.

6. Extinguish the flame and dispose of the splint as directed by your teacher.
7. Carefully pour the hydrochloric acid into the test tube.
8. Wait 2 minutes. Then invert the small beaker over the top of the test tube.
9. Wait 90 seconds. Then repeat step 4.
10. Remove the beaker from the test tube. Then place the burning splint at the mouth of the test tube. Record your observations.

Evaluate and Communicate

1. Describe any changes you observed during the test.
2. What caused the bubbles to form when you added the hydrochloric acid to the zinc metal?
3. Why did you test the zinc metal and hydrochloric acid with the burning splint before mixing them?
4. What happened to the burning splint in step 10? Compare this to what happened in step 5. How do you explain the differences in what you observed?

INVESTIGATION
2-B

STRUCTURED INQUIRY

Skills and Strategies

- Processing and Analyzing
- Evaluating
- Communicating

What You Need

- Safety in Your Science Classroom on pages xiv–xvii
- Internet access
- several copies of an SDS

Explore Safety Data Sheets

Under the WHMIS 2015 system, each chemical has a Safety Data Sheet (SDS). The SDS lists information about the properties of the chemical, as well as instructions about how to handle and store it safely. For example, your teacher may use a concentrated hydrochloric acid, such as 37% hydrochloric acid, to make the solutions you use in class. Because it is reactive and corrosive, this acid has many safety precautions associated with its use. A portion of an SDS for concentrated hydrochloric acid is shown below.

A1 Chemical Company

A1 Chemical Company
Safety Data Sheet (SDS)
Version 5.4
Revision Date 05/17/2016
Print Date 07/20/2016

1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	Hydrochloric acid 37%
Brand:	A1
Product use:	For research purposes
Supplier:	A1 Chemical Company
Manufacturer:	Acme Chemical Manufacturer
Telephone:	(555) 555-5555

2. HAZARDS IDENTIFICATION

Emergency Overview

WHMIS Classification
E Corrosive Material Corrosive

GHS Classification
Corrosive to metals (Category 1)
Skin corrosion (Category 1B)
Serious eye damage (Category 1)
Specific target organ toxicity – single exposure (Category 3), Respiratory system

GHS Label elements, including precautionary statements

Pictogram: 

Signal word: Danger

Question

What is an SDS and how is it meant to be interpreted and used?

Procedure

1. Work in small groups. Each group will be given several copies of the SDS of a particular hazardous material. (If possible, your teacher will also provide a sample of the material for your reference.)
2. Read the procedure and divide up tasks among group members.
3. Research and answer the following questions about SDSs in general.
   - What are the purposes of an SDS?
   - What types of materials are required to have an SDS?
   - How is the information on an SDS categorized?
4. Research and answer the following questions about your SDS.
   - What is the name of your material?
   - Where and how is the material used?
   - What are the chemical and physical properties of your material?
   - What first-aid measures are recommended if one of the following occurs:
     - inhalation
     - skin contact
     - eye contact
     - ingestion
   - What precautions are listed for safe handling and storage?
5. Each member of the group must come up with at least one additional question about your assigned material or about SDSs in general that arose from the research. Do additional research to answer your questions.

Process and Analyze

1. Within your group, share the results of your research. How do the chemical and physical properties of your material affect the safety measures listed on the SDS?
2. Which sections on the SDS are most relevant to you as a student in a high school science classroom?

Communicate

3. Give each member of your group a number. For a group of five, for example, give each person a unique number from one to five. Have all the like numbers in the classroom gather in groups. Be sure there is one person from each of the original groups in each new group.
4. In the new groups, take turns sharing what you learned about your assigned material and its SDS.
5. From a First Peoples perspective, safe interactions with the natural world may be seen as part of our reciprocal relationships with the universe. How does understanding and following safety procedures show respect for the interconnectedness of life?