GRAND COUNCIL TREATY #3

NUCLEAR 101

GUIDEBOOK

AS PRESENTED BY THE
TERRITORIAL PLANNING UNIT

Welcome!

January 28, 2022

Boozhoo,

Grand Council Treaty #3 (GCT#3) is the traditional government of the Anishinaabe Nation in Treaty #3. Grand Council represents 28 communities across the Territory. Grand Council's mandate is to protect the future of the Anishinaabe people by ensuring the protection, preservation and enhancement of inherent and treaty rights. The Territorial Planning Unit (TPU) is the department within Grand Council that works with the Treaty #3 Leadership to protect the lands, water and resources within the 55,000 square miles that make up Treaty #3 Territory. The TPU is guided by Anishinaabe Inakonigaawin (Anishinaabe Law), including Manito Aki Inakonigaawin (Great Earth Law) and the Treaty #3 Nibi (Water) Declaration.

In 2020, the Treaty #3 Chiefs in Assembly mandated the Territorial Planning Unit to work with the Nuclear Waste Management Organization (NWMO) in relation to the proposed Adaptive Phased Management project. This mandate lead the TPU to develop resources that educate on nuclear processes and ensure the respect and implementation of Manito Aki Inakonigaawin. This Nuclear 101 Guide is a direct result of the mandate set out from Treaty #3 leadership and is based on knowledge shared by the Elders and Knowledge Keepers in the Anishinaabe Nation in Treaty #3.

It is our hope that through the Nuclear 101 Guide, everyone in Treaty #3 Territory can have the opportunity to learn about nuclear energy, but also learn from our Treaty #3 Elders and Knowledge Keepers about the Anishinaabe Worldview.

We look forward to continuing to learn with you about our relationships to the land and water and hope you find this guide useful in further understanding Nuclear Energy. For more information please visit gct3.ca or email tpu@treaty3.ca

Miigwech,

Ogichidaa, Francis Kavanaugh

Ogichidaa Francis Kavanaugh
Grand Council Treaty #3

Acknowledgements

This guidebook was created through the wisdom and teachings of Treaty #3 Elders. The community stressed the importance of including traditional knowledge alongside western science, and especially highlighting the knowledge of Elders for our youth. This guidebook is a living document of those important teachings, and reflects how we can make decisions for a sustainable and resilient future. We are so grateful to all the Elders who came out to Anicinabe Park in Kenora, as well as Couchiching First Nation who hosted us in Fort Frances to share their teachings, thoughts and messages for the youth of Treaty #3. Your time and wisdom is beyond valuable to our communities.

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Introduction

BOOZHOO!

We welcome you to the Nuclear 101 guidebook. This guidebook can be used in combination with a workshop or on your own. You can find interactive materials on the Grand Council Treaty #3 website at: **https://gct3.ca/.**

This guidebook was commissioned by Grand Council Treaty #3 and created in partnership with Grand Council's Territorial Planning Unit and Narratives Inc. The Nuclear 101 Guidebook was created to help with decision making on future nuclear energy projects. It was built using scientific knowledge, traditional teachings, and the principles contained within the Treaty #3 Nibi Declaration. Additionally, the Guidebook was built with guidance from Anishinaabe Law and the Manito Aki Inakonigaawin. The Guidebook has been developed for all people in Treaty #3 Territory and can be adapted to fit different ages. There are interactive and self-reflective activities throughout the Guidebook which you can complete on your own or in a group.

Throughout all seven chapters we will be exploring each topic in relation to the lands, waters, soils and skies around us and how they relate to the Seven Sacred Teachings. While the guidebook is best used in order from **Chapter 1** to **Chapter 7**, feel free to flip around to concepts you want to learn about as they are mentioned. Each chapter has a list of terms, teachings and places where you can go to learn more about the topic. Questions for reflection will be noted with the symbol , activities with the symbol . Each chapter also includes a series of QR Codes that showcase the Elders' teachings, animations and learning videos to help you get through important lessons. Scan the QR codes with your camera on your phone to open up the videos! You can also find each video on Grand Council Treaty #3's website.

The end of each chapter has a list of sources as well as a glossary to help define the words used in this guidebook in more detail. You'll also see the symbol every time a teaching is specifically highlighted.

The purpose of this guidebook is to provide information and learning opportunities from a range of sources on Nuclear Energy processes and share teachings from our Treaty #3 knowledge keepers on these topics. We hope it will be used by anyone looking to increase their understanding of nuclear science as a whole and as assistance in informed decision making on major projects like the NWMO Deep Geological Repository. This guidebook is an example of how Anishinaabe principles, teachings and practices can guide our decision making, education and planning.

Chii miigwetch to the many Elders, Women, Men and Youth of Treaty #3 who shared with us their thoughts, feelings, concerns, questions and teachings to help build this program.

Zhaagimaa Waabo

Scan the QR Code for an Introductory Video!

Illustrations within this document are inspired by woodlands artists such as Norval Morrisseau.

What is Manito Aki Inakonigaawin?

Manito Aki Inakonigaawin has been an inherent law to Anishinaabe in Treaty #3 territory since time immemorial. The law governs relationships with the land and its inhabitants throughout daily life.

This includes:

- Respecting the lands and waters
- Giving offerings to spirits and the Creator when you benefit from Mother Earth's gifts such as hunting, fishing or transportation
- Knowing your rights as a Treaty #3 member, and
- Understanding the responsibility as a steward of the land

The spirit and intent of Manito Aki Inakonigaawin signifies the duty to respect and protect lands that may be effected from over-usage, degradation and un-ethical processes. In the context of this Guidebook, Manito Aki Inakonigaawin guides our decision-making on the land. This is especially important in how we decide what type of energy we use and how it affects our earthly systems.

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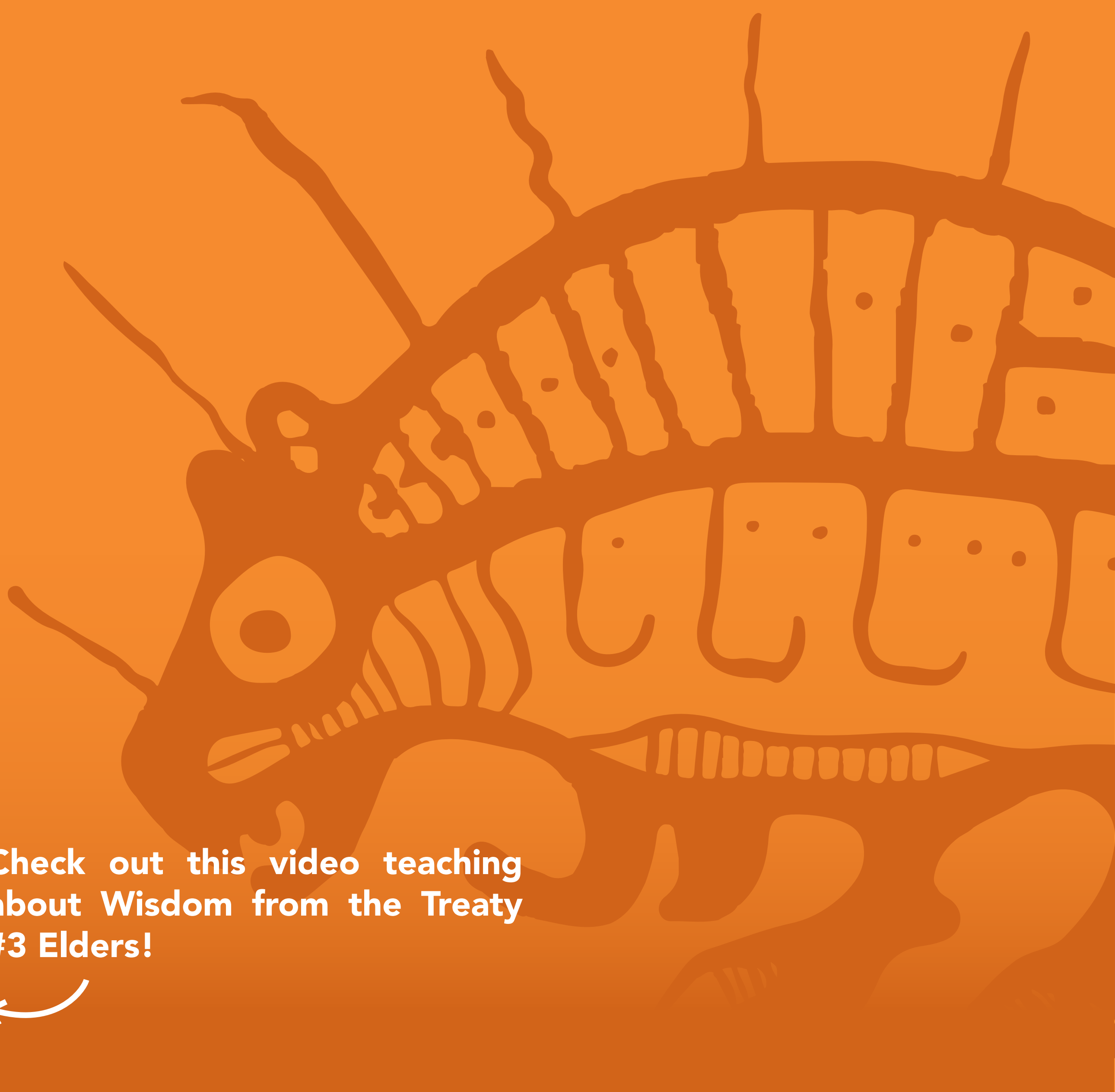
Chapter 1

The Atom (Wisdom)



Check out this video teaching about Wisdom from the Treaty #3 Elders!

Chapter 1
The Atom (Wisdom)

In this chapter :

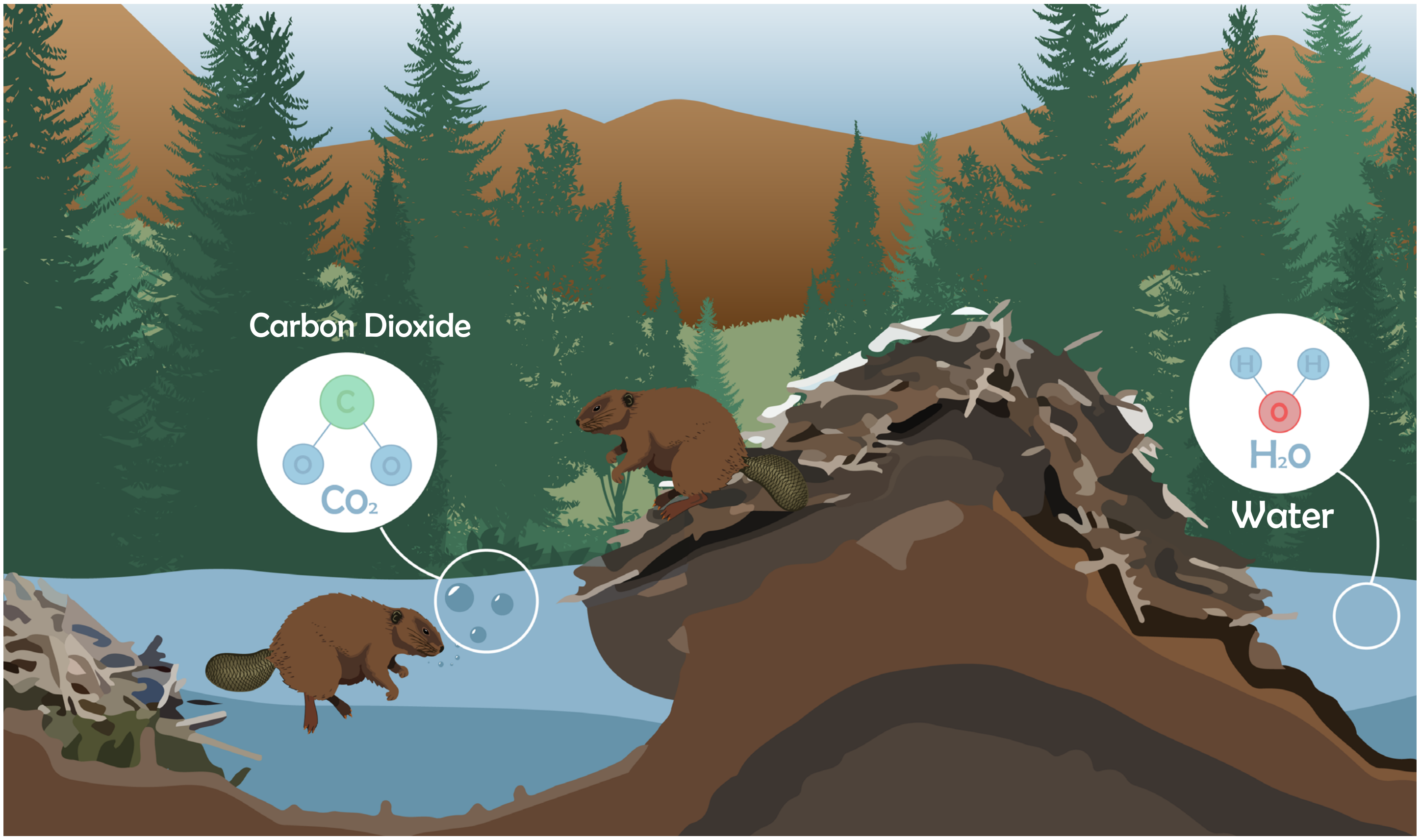
- Aki: Earth
- Amik: Beaver
- Atom
- Electron
- Element
- Energy
- Neutron
- Nibi: Water
- Nibwaakaawin: Wisdom
- Nucleus
- Nuclear Force
- Proton
- Subatomic particles

Nibwaakaawin (Wisdom) *is passed on and continual. If you don't tell someone something that they should know, then wisdom ends. Wisdom must be passed down to everyone. We seek out the wisdom of our Elders because they have the ability to draw on their knowledge and life skills to provide guidance. The Elders of Treaty #3 have graciously shared their teachings with us which you will find throughout this guidebook. We start our journey of knowledge with the atom. Atoms are the building blocks of a life on Aki (Earth). But what is an atom? How does it relate to the word "nuclear" and what does nuclear even mean? Together we will explore these questions, and their answers will help us in every chapter to follow.*

The Nibi Declaration of Treaty #3 states:

> *"All beings, including Anishinaabe, are born of nibi. We depend on nibi to live and our bodies are made of it. Nibi is the source of our wellbeing. It nourishes us, spiritually, physically, mentally and emotionally and provides cleansing and healing."*
>
> -Nibi Declaration of Treaty #3, May 2020

Nibi (Water) is sacred and a part of every living thing on **Aki (Earth)**. Nibi is made of **elements**, in fact, everything on Aki is made up of elements; the air, the rocks, the trees and the animals. Nibi is made up of the elements hydrogen (H) and oxygen (O).

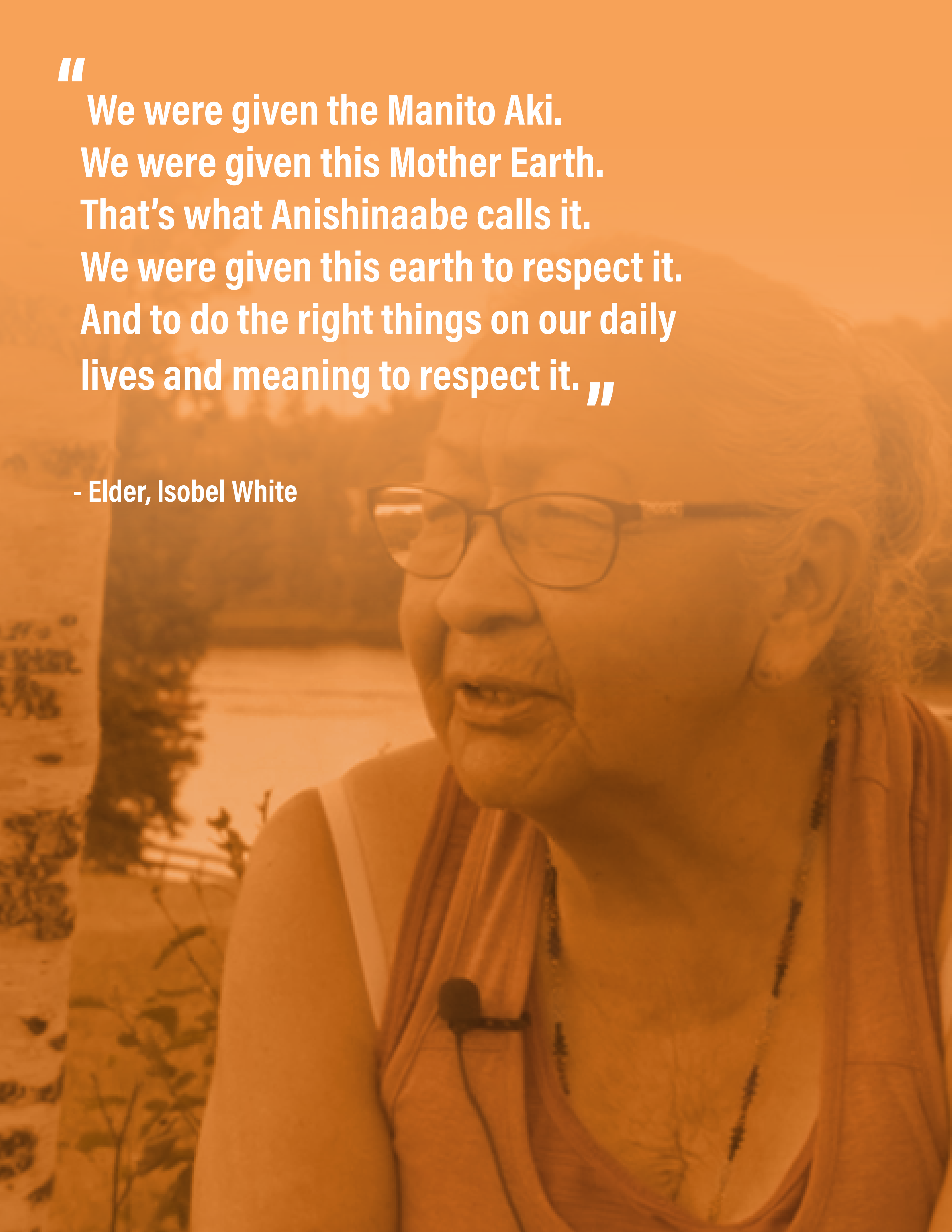


Common elements you might have heard of are:

- oxygen (key element in air and water)
- carbon (important part of all living things from people to the smallest leaf on a tree)
- potassium (a mineral found in bananas and potatoes)
- metals like nickel, gold, iron or copper.

Elements are made up of **atoms**. Just like the **amik (beaver)** builds its lodge out of sticks, every element is built out of atoms. **Atoms** are the building blocks of life.

Atoms can mix and match with each other to make new compounds, the natural things we interact with every day. For example, one oxygen atom comes together with two hydrogen atoms to make H_2O (water). Two oxygen atoms come together with one carbon atom to make CO_2, what we breathe out of our bodies with every breath.

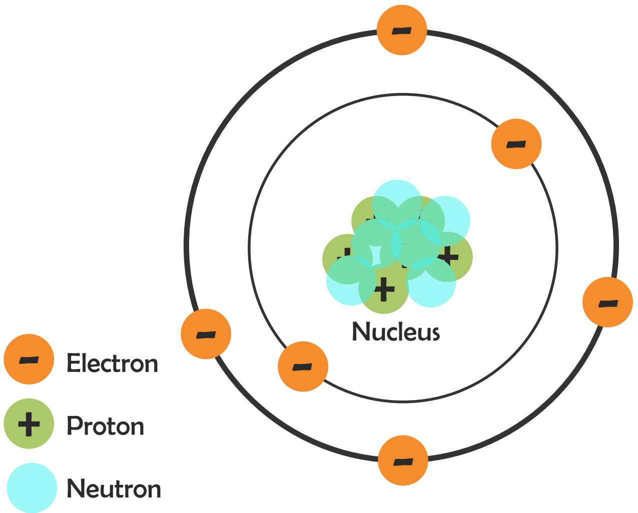


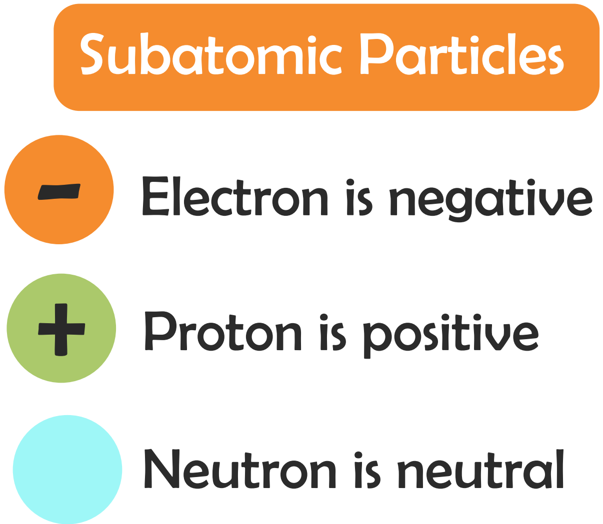
"We were given the Manito Aki.
We were given this Mother Earth.
That's what Anishinaabe calls it.
We were given this earth to respect it.
And to do the right things on our daily
lives and meaning to respect it."

- Elder, Isobel White

Just like every person is different, every atom is different and has different characteristics. How different atoms mix and match and come together or break apart depends on the nature of each atom and the parts of each atom.

Parts of an atom





An atom is made up of **electrons**, **neutrons** and **protons (subatomic particles)**.

Protons and neutrons exist in a tight clump together at the center of the atom called the nucleus. That word may sound familiar as it's the reason for the name "nuclear" in nuclear energy. We will go over nuclear energy in more detail in **Chapter 4: Uranium (Respect)**.

Outside the nucleus are electrons, which are whizzing around the nucleus constantly in a kind of cloud. The number of protons and electrons an atom has determines what kind of atom it is. For example, a hydrogen atom has 1 proton and 1 electron while an oxygen atom has 8 protons and 8 electrons. Changes in the number of electrons, protons or neutrons can change the nature of the atom.

Electrons move around the nucleus—sometimes closer to it, sometimes farther out. Electrons have a negative charge, while protons have a positive charge. Neutrons have a neutral charge. That old saying "opposites attract" is true for electrons and protons, the electrons are attracted to the positive charge of the protons and that is what causes them to stay moving around the nucleus.

If one atom is slightly different charge than another, the electrons of any atom close to it may jump over. Electrons jump and move between atoms often. When they move from atom to atom, they transfer energy. We will talk more about energy in **Chapter 2: Energy (Love)**.

There is energy in the movement of electrons and their attraction to protons but there is also a much stronger source of energy in the nucleus, the energy holding the protons and neutrons together. This is the **nuclear force** that is used in nuclear power.

Atoms are very small and can't be seen without a really powerful microscope, the kind that costs hundreds of thousands of dollars and takes up half a room. It's difficult to think about something so small that we need really complicated tools to see it. How small is an atom compared to the rest of the world?

If the average beaver is about 1 meter across, that's about a trillion times larger than an atom. If we made an atom bigger, even only to the size of a grain of sand, a beaver a trillion times larger than an atom would be 1 million kilometres across. That's as big as the sun!

That's how much bigger living things are when compared to an atom.

While an atom is so small, it still connects everything around us. The atoms of hydrogen and oxygen come together to form nibi which is part of every living thing on Aki. Whether or not two atoms come together can have a big effect. The difference between carbon dioxide (CO_2) and carbon monoxide (CO) is only one single oxygen atom but carbon monoxide is deadly and carbon dioxide is not. You might have a carbon monoxide detector in your home right now. The reason it doesn't start beeping with every breath of CO_2 you breathe out is only one single, tiny, atomic difference.

Small changes can add up to big changes. That's why it is so important to gather knowledge from many sources before making a change or difficult decision. Wisdom is essential to decision making.

"Wisdom is part of making the right decision that you think is right. Doesn't necessarily mean that somebody else might think it's right, but you got to stand for what you believe in."

-Treaty #3 Elder, Sherry Ann Roseborough

Reflection Question

How do you use Wisdom when making decisions?

What sources of knowledge do you trust? Is there someone you go to for advice or guidance? Feel free to reflect to yourself or write below.

Reflection Question

How do you relate to something as small as an atom? How do you relate to nibi (water)?

What does the word “atomic” mean to you?

What surprised you the most about atoms and their relationship to life?

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Chapter 2

Energy (Love)

Check out this video teaching about Love from the Treaty #3 Elders!

Chapter 2

Energy (Love)

In this chapter :

- Biomass
- Clean energy
- Climate change
- Energy
- Electricity
- Electrons
- Free Electrons
- Fossil Fuels
- Greenhouse gases
- Ion
- Migizi: Eagle
- Non-renewable energy
- Renewable energy
- Turbine
- Zaagi'idiwin: Love
- Free electrons

The Grandfather Teaching of **Zaagi'idiwin (Love)** *is represented by* **Migizi (the Eagle)**. *Love is many things, the love of water, the love of children, the love of life. To love something, regardless of what is it is, makes it better. To love somebody or something other than yourself is unselfish. Just as love flows freely, so does energy. We will explore energy in this chapter. The energy from freely flowing electrons is called electricity which is what we use to power our lights, homes and electronic devices. We get energy from many different sources, some which we have to dig out of the ground like coal, oil and uranium for nuclear power, and some that come from above ground like wind, solar and water. In this chapter we will explore where gets its energy from and where it is used as well as what makes certain sources of energy "cleaner" than others.*

> *"[Love] is kind of grounding for me, yeah. And how I feel and how I radiate is how somebody reacts to me. "*
>
> -Treaty #3 Elder, Sherry Ann Roseborough

Energy is all around us. Energy from the food we eat is turned into fuel that we use to think and walk and move. Energy is also the heat we feel when we rub our hands together on a cold morning, the power of an eagle's wings or the force of water rushing over a waterfall.

We usually know energy in the form of heat and light; things to cook food with, keep us warm in the winter and allow us to see what we're doing. Fire has been very useful for this reason since time immemorial. Nowadays, electricity allows us to have heat and light very quickly and easily in our own homes.

The word electricity comes from the word electron. **Electrons** are parts of an atom that zip around the nucleus in the center and have a negative charge. Electrons move around a lot, sometimes closer to the center of the atom, sometimes farther away, and sometimes they even jump over to another atom. Those that jump are called **free electrons** because they freely move from atom to atom. The movement of electrons is called electricity.

As we learned in **Chapter 1**, the number of protons, neutrons and electrons an atom has can change the nature of that atom, think of it like the "personality" of that atom. If an atom has slightly more of one kind over another, it is called an **ion**. **Ions** can have a negative charge (too many electrons) or a positive charge (too many protons).

Negatively charged ions are attracted to positively charge ions because electrons and protons are attracted to each other ("opposites attract"). You can see this in rainstorms when lightning jumps from between a cloud and the ground. The negative ions in the cloud are attracted to the positive ions in the ground. They want to come together so the ions stream up from the ground and down from the cloud in a bolt of lightning.

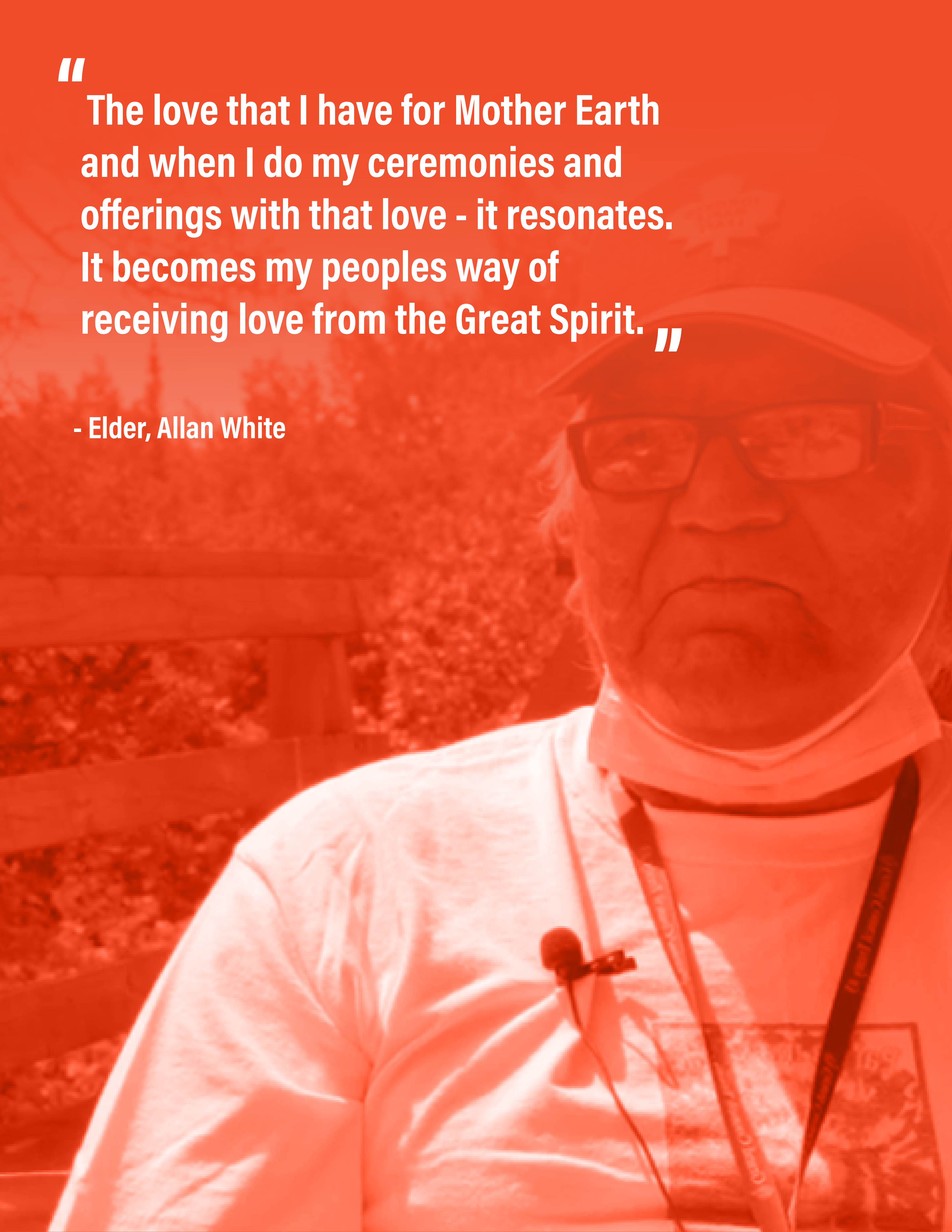
You often hear words like "flow", "stream" or "current" related to electricity because people used to believe that electricity flowed like water. Now we know that electricity is less like water flowing and more like a game of tag between electrons. Electrons bump into each other and transfer energy. Humans have learned to direct this bumping to transfer energy inside thick cables in one long line all the way from the generating station to your home.

"I love it when it storms... Especially at a camp sitting on the deck, in the rain, watching the lightning and, it's just power. Just beautiful. Just thinking "Oh, I can, you know, I think I can change it". And Mother Nature goes, "Yeah, well here. Hold my water and show us." ...Yeah. The power, the thunder, just lightning. Just one of her ways of showing us, like, we're nothing. We're here because she lets us."

-Treaty #3 Elder

> "The love that I have for Mother Earth and when I do my ceremonies and offerings with that love - it resonates. It becomes my peoples way of receiving love from the Great Spirit."

- Elder, Allan White



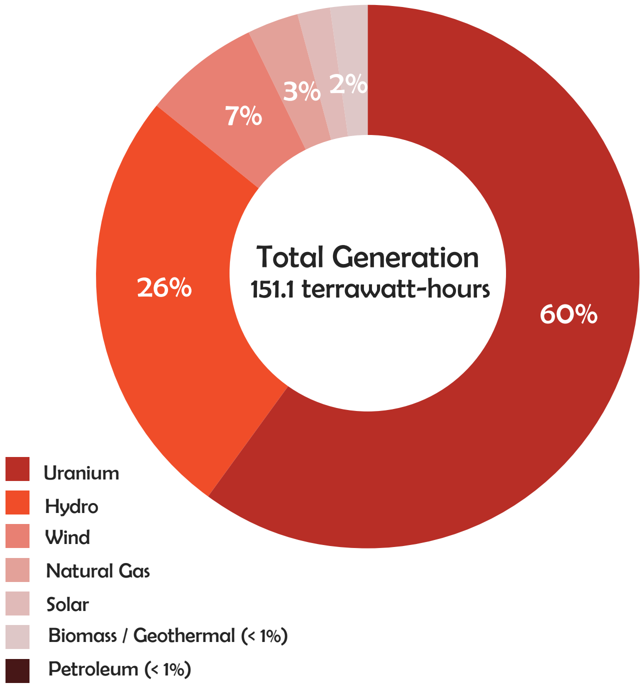
Electricity is produced in many ways from many different sources. Nuclear power, water, wind, sun, and **fossil fuels** (oil, coal and natural gas) are all used to produce electricity. The energy contained in these different sources is used to create a force that spins a large wheel called a **turbine**. Within this turbine are magnets inside coils of copper, when the turbines rotate these magnets the electric field of the magnets pulls electrons along the copper wires, making electricity.

There are different ways to make the turbine spin. Sources such as flowing water or wind push against these turbines and make them spin. Energy sources such as coal, natural gas, or biomass are burned to produce heat. (Nuclear power produces heat from splitting a uranium atom). This heat is used to boil water, creating steam which then spins the turbines to produce electricity.

Electricity is an important part of daily life, everything from light bulbs, to smartphones, to factories requires electricity. Industrial activities like manufacturing or mining use the most electricity in Canada- they eat up over 40 percent of the country's electricity. Household electricity use is about 30 percent. Ontario alone uses almost a third of all of Canada's electricity.

The image below shows the many different sources of electricity in Ontario. All these different sources produce 15.1 terawatt-hours of electricity per year- that's enough to power a simple 100-watt light bulb for 17 million years!

Nuclear power plants, which use uranium as fuel, produce about 60% of Ontario's electricity. Hydroelectric dams, which dam rivers and then use the natural flow of water to spin turbines to generate electricity, make 26% of the electricity in Ontario. The rest of Ontario's electricity is from a few sources including wind, natural gas, solar, and biomass. **Biomass** is plant or animal material, like wood, yard waste or manure that is burned. Energy from that fire is used to heat water and produce steam, which then creates electricity by spinning a turbine.



With three nuclear power plants, Ontario is a Canadian and global leader in the operation of nuclear power plants. Outside of Ontario, there is only one other nuclear power plant in Canada, in New Brunswick. In these plants, energy from the nuclear force holding the uranium atom together is used to heat water, producing steam to spin a turbine and generate electricity. Nuclear energy is very efficient, requiring only a small amount of fuel to produce a large amount of electricity. The average nuclear fuel pellet is about the size of a fingertip and can power a home for over six weeks. This is the same as using 807 kilograms of coal (that's a pile of coal the same weight as 124 eagles!).

Unlike coal, nuclear power doesn't release any greenhouse gases. Just like oxygen and nitrogen, greenhouses gases like carbon dioxide and methane are normal parts of air. These gases are released from burning any kind of carbon like coal or oil. The problem is, when too much is burned, extra gas ends up in the atmosphere that wasn't there before. Greenhouse gases tend to stay in our atmosphere longer than they should and stop extra heat from leaving the Earth, just like how sun heats up a greenhouse when it's trapped by the glass. Because this extra heat is trapped by greenhouse gasses and can't leave the Earth's atmosphere, temperatures increase worldwide. This rise in global temperature has created changes in climate, ocean currents and weather like extreme storms. This overall pattern of global change is called **climate change** and is causing serious problems for life on Aki (Earth).

Power sources that give off lots of greenhouse gases, like gas engines in cars, are sometimes called "dirty energy". Sources of energy that do not release any greenhouse gases are called "**clean energy**" or "green energy". The term green energy is also used for energy that is from renewable resource. An energy source is considered renewable when it can be used over and over again without running out. Sources like wind, water, sunlight and heat from Aki's core are considered renewable because no matter how much energy is made from them, the source is not used up. Some sources like wood and other plants are also considered renewable as new ones grow back after harvesting, but they must be carefully managed to make sure they are not used faster than they can be naturally replaced.

While the nuclear force holding atoms together is infinite and will never run out, nuclear power plants themselves are not considered renewable because they have to use uranium which has been mined from the ground. There is only set amount of uranium in the ground that while it is a big amount, once it's gone, it's gone. Some the nuclear fuel can be recycled and reused but not every country does this.

While nuclear power is non-renewable, it is sometimes lumped in as a "clean energy" source because it doesn't produce any greenhouse gases. But nuclear energy is not without its impacts as it does produce waste from the used fuel that needs to be disposed of properly.

Climate change is an immediate threat to all of us. Changing patterns of weather and climate will impact how Aki functions, which will impact how people can live. Climate change is responsible for raising sea levels, bringing more damaging storms, longer droughts, wildfires and many other negative impacts on people. Energy is responsible for 78% of global greenhouse gas emissions that are leading to climate change. Developing and using more clean energy technologies is a very important step in preventing climate change from becoming disastrous. Canada is considered a world leader in clean energy. Over 80% of Canada's energy comes from green sources, 15% of that being nuclear power. Globally, nuclear energy is the second largest source of green energy.

How we choose to move away from greenhouse gas heavy power sources and which sources we switch to is an important decision. Hydroelectricity, nuclear power and wind power may not produce greenhouse gases, but they do have their own impacts which can affect water flow, human health, animal health and animal migrations. Being fully informed of positive and negative impacts of these options is important when making decisions like these.

Self Reflection

When you think of the earth, skies, soil and water, which energy do you think is most beneficial for the planet? Feel free to reflect to yourself or write below.

The principles of the Nibi Declaration include that water is sacred and that it has a spirit and agency that cannot be controlled or owned. Do these statements make you think differently about how we use water for electricity?

INTERACTIVE ACTIVITY:

https://www.calacademy.org/educators/lesson-plans/nuclear-energy-whats-your-reaction

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Chapter 3

Radiation (Bravery)

Check out this video teaching about Bravery from the Treaty #3 Elders!

Chapter 3

Radiation (Bravery)

In this chapter :

- Aki: Earth
- Alpha particles
- Beta particles
- Dose
- Electromagnetic spectrum
- Frequency
- Gamma rays
- Geiger-Müller counter
- Giizis: Sun
- Ionizing
- Isotope
- Makwa: Bear
- Nuclear decay
- Radiation
- Radiation Sickness
- Radioactive
- Radioisotope
- Wavelength
- Zoongide'ewin: Bravery/Courage

Zoongide'ewin (Bravery) *is having the strength to do things in the way that you feel is right, even when you face opposition. Bravery is also about having the courage to open your mind and listen to others who might have different opinions. It takes Bravery to face the unknown or the dangerous. Radiation is a word with a lot of feelings behind it that may bring up some emotions or images to your mind. You might think of something dangerous, a chemical or toxin that could harm people or transform them into superheroes in comic books. Or you might think it's helpful, for example in treating cancer. What exactly is radiation and where does it come from? What are safe or unsafe levels of radiation? How do you measure radiation? How long does it last?*

We'll answer these important questions in this topic.

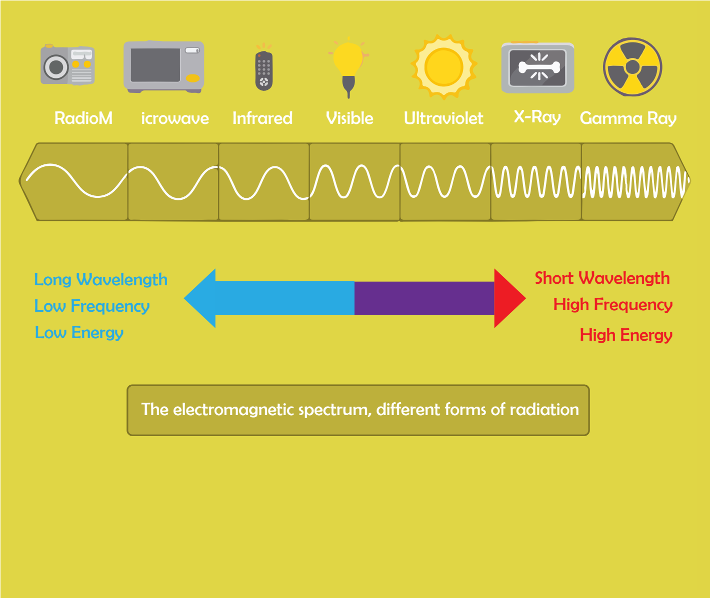
Radiation is just another word for carrying and passing on energy. We know from **Chapter 2** that energy can be in the form of heat or light -but it can also be forms invisible to our eyes.

Radiation is all around us, even if we don't know it. Many natural things in the universe give off radiation like certain plants, rocks and the stars in space.

Giizis (the sun) gives off radiation in the form of light, heat, UV rays and others. This energy comes in waves, just like waves in a lake or ocean. Different types of radiation have different **wavelengths**, with different amounts of peaks or crests.

Really long waves with less peaks have less energy and really short waves with lots of peaks have higher energy. The number of peaks is called **frequency**. You tune into these waves every day when you switch channels on your car radio or alarm clock. Station names are often numbers like 89.5 or 104, which actually represent the frequency of the radio waves. Radio waves are a very common form of radiation that exists in the world every day and are completely harmless to humans.

The **electromagnetic spectrum**, types of radiation and their wavelengths



Another common form of radiation you might use everyday are microwaves. Using a microwave to heat a meal makes the water molecules in the food release energy in the form of heat, which cooks the food. This is also completely harmless to humans. As we go up in energy of the wave, radiation gets less safe for humans. For example, ultra-violet (UV) radiation can cause sun burns and over time, damage to the skin cells which can cause skin cancer. We see here in the image to the left, X-rays are higher in energy than UV rays. X-rays are helpful for looking at your bones or teeth but too much of them without protection can be harmful to your cells, just like UV. That's why the dentist makes you wear that heavy lead vest to protect the rest of your body while they take x-rays of your teeth.

As we learned in **Chapter 1**, the number of protons, neutrons and electrons an atom has can change the nature of that atom. If you change the number of neutrons in an atom, that is called an isotope. **Isotopes** are different forms of the same atom with slightly different characteristics. Think of it like variations on chocolate ice cream. One type of chocolate ice cream might have chocolate chips, or brownie pieces or nuts but each type is still chocolate ice cream.

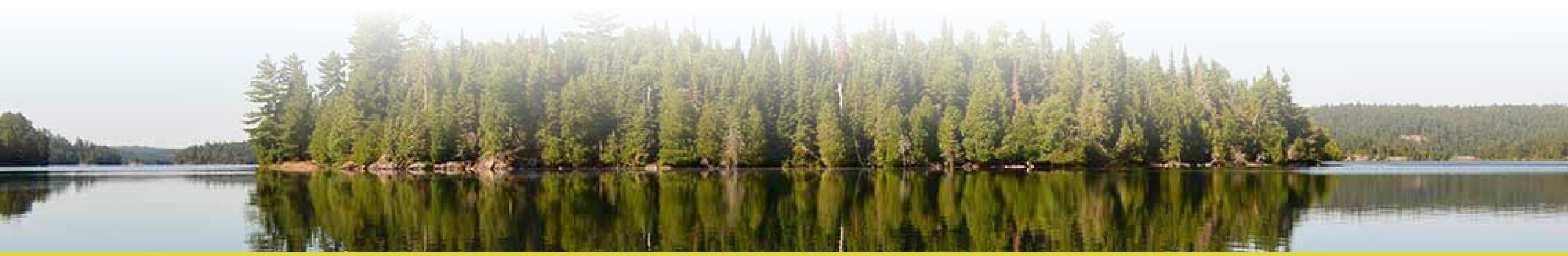
Oxygen has 8 protons and 8 electrons. It also has 8 neutrons. Scientists call this isotope, oxygen-16 (8 protons + 8 neutrons), which is the most common form of oxygen. Other isotopes of oxygen are oxygen-18 (8 protons + 10 neutrons) and oxygen-17 (8 protons + 9 neutrons).

Imagine if adding more or less chocolate chips would affect how fast the ice cream melts. That's how it works for atoms. Generally, if you have an isotope with less neutrons than normal, the nucleus of that atom is less stable. That nucleus will then try and get more stable by getting rid of excess particles or by radiating energy. This is called being **radioactive**, and the process is **radioactivity**.

An isotope that is radioactive is sometimes called an unstable isotope or **radioisotope**. Some elements live mostly as stable isotopes (like oxygen-16) while some elements have no stable isotopes at all. The element uranium is one of those. We will talk about uranium more in **Chapter 4: Uranium**.

Lots of things are naturally radioactive and "unstable" without causing any harm to humans. Potassium-40, naturally occurring in foods like salt and bananas, is an unstable isotope. When an isotope tries to be more stable by losing some particles, it changes over time. That process is called **nuclear decay**.

Imagine we have an ice cream with cookie pieces in it and when we take off the cookies, it causes the ice cream to melt. When that ice cream melts and falls off the cone, what flavour is left over? We now have something completely different—just a cone. Over time, an unstable atom of one element will decay and change into a different element. For example, postassium-40 in bananas will decay into argon-40. Nuclear decay is a very slow process and takes a long time; the time it takes for half of all the potassium atoms in a banana to change to argon atoms is over 1.25 billion years! Scientists use this knowledge of decaying isotopes to date fossils and archaeological remains.



Nuclear decay involves the movement of particles to and from the nucleus. We know that when particles move around or change, they radiate energy. When an atom goes through nuclear decay it releases radiation in a couple of different forms. These are **alpha particles**, **beta particles** and **gamma rays**. Alpha, beta and gamma radiation are called **ionizing radiation** because they create ions when they interact with other atoms. Learn more about ions in **Chapter 2: Energy (Love)**.

Gamma rays are the most dangerous to living things because they are a very high energy form of ionizing radiation. Unlike alpha and beta particles which can be blocked by sheets of paper or thin sheets of metal (like aluminum foil), gamma rays can only be blocked by a thick layer of lead.

A large amount of gamma radiation can damage sensitive cells in your body, like those in your blood, bones and intestines and cause **radiation sickness**. Symptoms of radiation sickness include stomach pain and vomiting, hair loss and cancer. Without treatment, radiation sickness can be severe and even deadly. Depending on the dose (amount) of radiation, radiation sickness can be treated by removing contaminated clothing, receiving a blood donation, taking special proteins to increase growth of white blood cells or taking medicines to bind to the radiation and safely pass it through your body.

"Sometimes, everybody has fear. Everybody has fear, for whatever that may be. I'm afraid of reptiles, snakes, frogs, anything in the water. It looks kind of eerie to me, dinosauric or Jurassic, haha but that's what my lodge is. Fear, I had to be brave. To that part of who we are... But if the more you follow your way, then you make it stronger, then the more it's easier for you. That's the way I look at bravery. I'm going to stay brave for my people, for my grandkids, my great grandkids. And for other people that are suffering here, I'll pray for them. That's what I say bravery is about."

-Treaty #3 Chief of Washagamis Bay, Vernon Copenace

How Humans Use Radiation

While radiation can be harmful, it can also be helpful. Humans have created many different types of medicines and medical tools using radioactive materials. Some radioactive isotopes like yttrium-90 and actinium-225 are used to kill cancer cells, while others like calcium-47 and carbon-11 are used to diagnose cancer. X-rays, CAT scans and PET scans use radiation to see within the body to find broken bones, tumours and disease. Around the world, about 400 million people are treated or diagnosed using nuclear medicine each year. In Canada between 2019 and 2020, just over 9 million people were diagnosed using nuclear imaging.

Radiation is used to keep us safe by killing germs in certain food products like meat, dried vegetables and spices before they go on the shelf. In our homes, the isotope americium-241 is used in smoke detectors to detect fires.

Even our own bodies are radioactive, containing carbon-14 (which is that isotope used in dating fossils!) and our old friend from the banana, potassium-40.

Radiation is a natural part of life, the trick is to reduce your exposure as much as possible to sources you can control, like wearing sunscreen to prevent damage to your cells from UV rays.

What is a safe level of radiation?

Just like ice cream is measured in litres and chocolate chips are measure in grams, radiation is measured in **Sieverts (Sv)**, or sometimes in **Roentgens (R)**, named after famous scientists who studied radiation. Living at sea level, you're likely to be exposed to natural forms of radiation from Aki (the Earth) and from space at about 0.088 R per year. This is very low amount—if R were dollars, then you wouldn't even get one penny a year in radiation. The Canadian Nuclear Safety Commission says you can be exposed to up 25 times more radiation a year before you would see any health problems. Radiation can be measured using a Geiger-Müller Counter, a handheld device you might have seen in movies that clicks or beeps whenever it finds radioactive materials.

Because nuclear decay happens so slowly, it's products can be around for a long time. For example, the heat and electricity from nuclear decay is used to power satellites and spaceships, like the Voyager spacecraft, that travel out to the furthest reaches of our solar system. On the flip side, the negative effects of nuclear decay are also around for a long time; this is why the storage of radioactive materials is a big problem society is facing. The storage of radioactive materials from nuclear power waste is an issue currently being faced by Treaty #3 with the Nuclear Waste Management Organization's Deep Geological Repository project. We will be touching on the issue in depth in future chapters.

"Being brave is standing up. Listening to what somebody else has to say, but then being brave enough to say, I don't agree with you."

- Elder, Sherry Ann Roseborough

Reflection Question

How do you use bravery when making decisions? Why do you think using bravery is important?

Reflection Question

Which kinds of radiation have you used or experienced? Check off the ones you have used or experienced in the table below.

✓	Type of Radiation	Sources
○	Light	• The sun • Fire • Candles • Light bulbs • Electronics • Stars
○	Heat	• The sun • The earth • Body heat • Fire • Friction • Appliances • Electronics
○	Radiowaves	• Radio • Television • Cell phones • WiFi • Astronomy • Radars
○	Microwaves	• Microwave ovens • Radars • Satellite communication • Astronomy • Garage door openers • Lane and collision detection systems in cars
○	Infrared	• The Sun • Fire • Baseboard radiators • Night vision goggles • Night vision camera

Reflection Question

TABLE CONTINUED.

	Ultraviolet	• The Sun • Tanning booths • Water purification • Gel or acrylic nail curing • Forensic and crime science • Black lights at glow bowling
	X-Rays	• Dentist, Doctor, Physiotherapist or Chiroporatcor's office • Airport security • CT/CAT scans • Radiotherapy for cancer • Astronomy
	Alpha Particles	• Smoke detectors • Cancer treatments • Smoking tobacco
	Beta Particles	• Industrial testing (ex. Testing paper thickness) • Cancer treatment
	Gamma Rays	• Cancer treatment • Nuclear reactors • Astronomy • Sterilization of medical equipment • Bacterial removal from food • PET scans

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Chapter 4

Uranium (Respect)

Check out this video teaching about Respect from the Treaty #3 Elders!

Chapter 4

Uranium (Respect)

In this chapter :

- Aki: Earth
- Asin: rock
- Biiwaabikokaan/Moona'igan: a mine
- Decay
- Gimishoomisinaanig: our grandfathers
- Half-life
- Madoodiswan: sweat lodge
- Bizhiki: Buffalo/Bison
- Mikinaak Minis: Turtle Island, "North America"
- Minaadendamowin/manaaji'idiwin: Respect/Mutual Respect
- Nuclear Fission
- Nuclear Power
- Nuclear Waste
- Open-pit mining
- Opwaaganag: pipe
- Pellet
- Rod
- Underground mining
- Casks
- Fuel Rod
- Uranium
- Yellowcake

The Grandfather Teaching of Minaadendamowin/ Manaaji'idiwin (Respect/Mutual Respect) is represented by Mashkode-bishiki (the Bison). Respect takes time. It is a cycle that can be built up in many different ways from respecting yourself, to the land you walk on, to the skies above you, to the animals around you or the people you meet. When removing something from the Earth, you must respect where it came from. In this chapter we explore where uranium comes from and how it is used.

Treaty 3 is home to a very large area of rock called the Canadian Shield, the ancient geological core of **Mikinaak Minis (Turtle Island)**, once huge mountains (some even bigger than Mount Everest!) that have been broken down through the ages by rain, winds, and ice. The Canadian shield is over 8 million square kilometres across and up to 4 billion years old. It has many important rocks, metals and minerals that have played an important role in our lives. The Elders have said that the **asiniig (rocks)** of **Aki (Earth)** are alive, they have spirit and knowledge, and should be respected.

Assinig play an important part in **opwaaganag (pipe)** and **madoodiswan (sweat lodge)** ceremonies where we call them gimishoomisinaanig (our grandfathers).

Gimishoomisnaanig have been here since time immemorial and have interacted with many living creatures. **Bizhikiwag (bison)** would use large stones to rub off excess fur or scratch an itch eventually rubbing the stone smooth. Plants, animals, fungi and other small creatures use assiniig for their homes. The Anishinaabeg have used asiniig for ceremony, guidance, art and wayfinding.

Uranium, the raw material for today's nuclear fuel, is a natural substance found in the earth in certain types of assiniig. The universe's uranium formed over 6.6 billion years ago in huge exploding stars. Uranium is all over our planet; in fact, uranium is about 500 times more common than gold! Uranium can be found in all three major types of rocks (**igneous**, **metamorphic** and **sedimentary rocks**). These types of rocks with veins of uranium are found most often in Australia, Canada, and Kazakhstan.

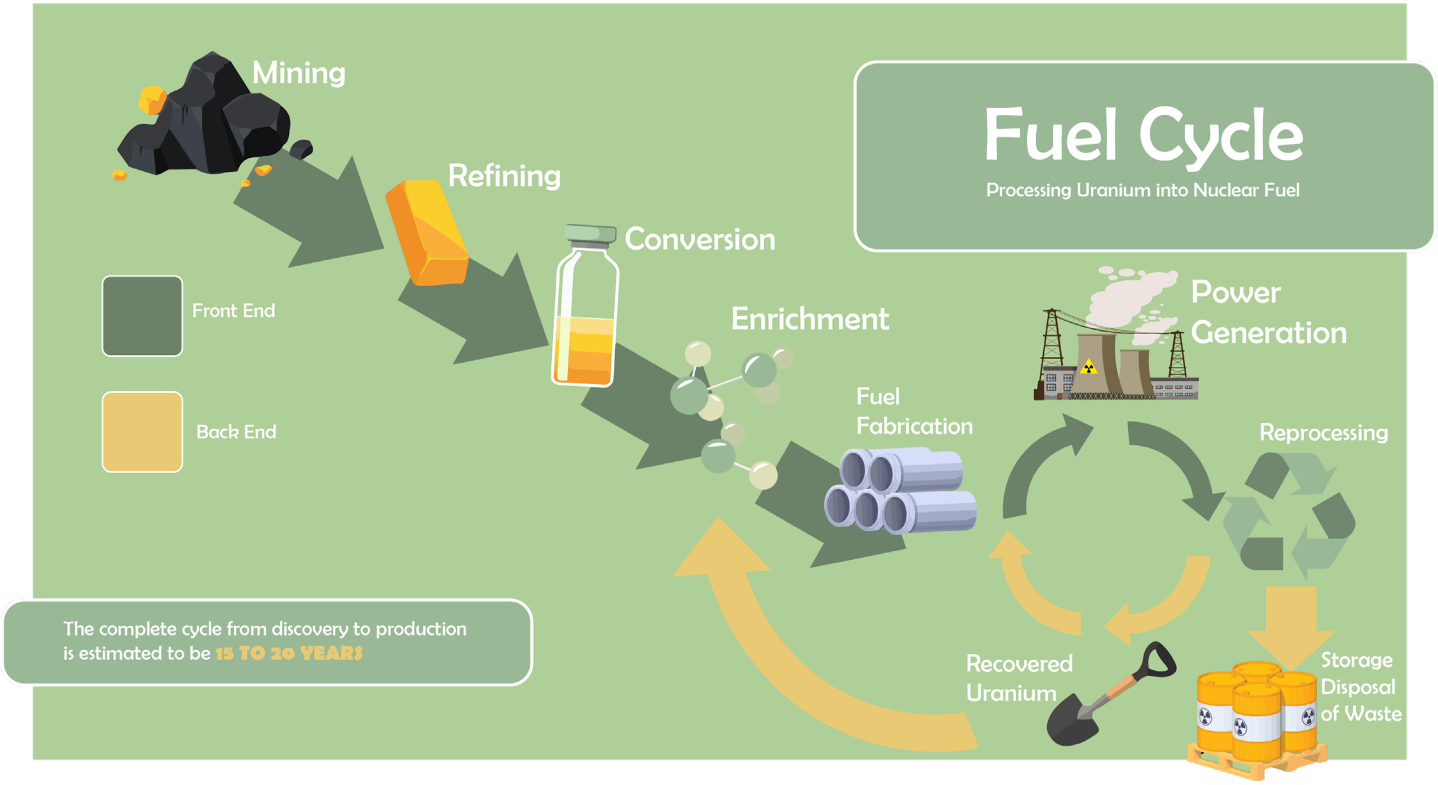
As we learned in **Chapter 3: Radiation**, uranium has no stable isotopes. That means it is naturally radioactive, always releasing energy or particles just like potassium-40 does in bananas.

Uranium has to be processed through a series of steps to safely produce efficient fuel for generating electricity.

In this chapter, we'll be taking a deeper dive into how uranium is mined and processed into nuclear fuel!

Did you know?

The largest source of electricity generation in Ontario is nuclear energy? Nuclear energy accounts for approximately 60% of Ontario's energy.



The Mining Process:

Uranium normally exists as uranium-238, uranium-235 or uranium-234, naturally found in the earth's crust. There are two ways that have been identified to harvest uranium:

Biiwaabikokaan/Moona'igan: a mine or mining: When uranium is near the surface, miners will dig the rock out of open pits – just like limestone or granite. Open pit mining involves stripping away the soil and rock that live above the uranium ore and then recovering the uranium from there. When the uranium is found deeper underground, miners must dig underground to reach it. The rock is then removed through underground tunnels.

In Situ Leaching: Another process to recover uranium is called In Situ Leaching. "In Situ" comes from the Latin words "in place". This is the preferred method to extract uranium since it's much a much cheaper way to get the ores out of the ground and is considered more environmentally friendly than traditional underground or open pit mining. Rather than disturbing the soil and sedimentary rock, miners will instead pump water mixed with oxidants such as oxygen gas and sodium bicarbonate (baking soda) through injections wells that lead to groundwater under the earth's crust. This will dissolve uranium in porous rocks and make the uranium into a liquid. The waters are then pumped up into new wells (away from the injection wells), where the water is filtered to access the uranium.

In Canada, uranium is extracted in northern Saskatchewan. This includes a total of five mills and mines: Cigar Lake Mine, Key Lake Mill, McArthur River Mine, McClean Lake Mine, and Rabbit Lake Mine and Mill.

> *"You've got to respect who you are. And if you don't respect who you are, then how do you expect somebody else to respect you? And you got to respect people, like other people, like everybody has an opinion. Everybody has their own idea of what way things should be. And I think respect is listening and saying, "Okay, well let's try it that way, maybe it is better. Or next time we'll do it your way, and we'll do it my way this time." But I think respect is like respecting everybody. Like, doesn't matter who they are, white, black, green, purple."*
>
> -Treaty #3 Elder

Milling Process: Once uranium has been extracted through either the Mining or In Situ Leaching process, it is then brought into a mill where the uranium ore is grounded into a very fine material, like sand. The very fine material then goes into a series of chemical processes to get out any last remaining rock from the uranium itself. Once the uranium is dissolved from the rest of the rock, it needs to be extracted from the chemical liquids again. After removing any left over liquids, the uranium is turned into a concentrate made up of uranium oxides – this mixture is called yellowcake. **Yellowcake** looks like a fine yellow powder that is packaged and sealed in special steel containers made for safe shipping.

Fuel Fabrication: After the yellowcake is prepared, it is then brought into fuel fabrication to make nuclear fuel. In this process, the yellowcake is processed further to create enriched uranium (which converts the uranium oxide into a more useable form called uranium-235). The enriched uranium is made into ceramic fuel pellets that are only the size of a quarter and have the ability to produce a lot of energy.

Did you know?

Did you know that one fuel pellet is equal to the same amount of energy as 410 litres of oil. That’s 9 full gas tanks for a small car! Did you also know that if you had just seven fuel pellets, you would be able to power your home for 1 year?

The fuel pellets are then put together into tubes called **fuel rods**. These fuel rods are then assembled into bundles of rods, just like a bundle of firewood. Once the fuel bundles have been assembled, trucks transport them to the reactor sites in safety containers. These containers are tested regularly throughout the transport trip to ensure the safety of the drivers, the public, and the environment. Once ready, the fuel bundles are placed into the reactor core and filled with water. Once the water is added, the nuclear reaction is started, generating heat and energy.

Nuclear Power

When the uranium has been processed to this level, it is more likely to produce energy and will enter a state of **nuclear fission**. The way nuclear fission works is when a free neutron bumps into the atom of the uranium, it splits the nucleus and throws off additional neutrons which zips around and bumps into more atoms – this process will naturally create heat! In a nuclear power plant, this heat is used to boil water, creating steam that turns a turbine within the power plant to generate power. Just like water and wind rotate turbines through movement, the uranium generates enough steam to move the turbine.

Neutron? Nucleus? What do these words even mean? Check out **Chapter 1: The Atom** if you need a refresher.

"We are Anishinaabe, and we have teachings and ways of life that we have to start to understand and respect once again."

- Elder, Willie Yerxa

Transporting Radioactive Materials

Most radioactive material is shipped on the highway. This is because those organizing the shipment (such as routing and charting managers) have more opportunities to create safety during transportation, which may include escorting the delivery, minimizing traffic on shipping routes, and tracking the delivery itself.

Very high-level radioactive materials, such as spent nuclear fuel bundles are shipped in specifically designed containers called casks. These casks are designed to contain the high-level radioactive material, even when there's an accident. Casks undergo a series of extreme tests before they are used. This include:

- Collisions with objects that can't move, like being dropped on the ground or into a steel spike
- Burned in a gasoline fire for 30 minutes
- Submersion in water for eight hours

Uranium used in Ontario usually comes from Northern Sasquatchewan and travels all the way to power plants in Clarington and Pickering, Ontario.

The fuel bundles are stored onsite in fresh fuel storage bins which protects them until the operators need them. At this stage, the uranium is only mildly radioactive, and almost all radiation is contained within the metal tubes. Typically, reactor operators change out about one-third of the reactor core (40-90 fuel bundles) every 1-2 years.

Life and Decay Cycle

While uranium is highly associated with radioactivity, its rate of decay is so low that we don't usually see its effects. The time it takes the isotope uranium-238 to break down into new elements (its **half-life**) is 4.5 billion years. Uranium-235 has a half-life of just over 700 million years. And Uranium-234 has the shortest half-life of them all at 245,500 years.

Over time uranium decays in turns into a series of other elements like radium-226, which then decays into radon-222, which becomes polonium-210, and finally turns into a stable element lead. This happens over millions and billions of years. The materials in the **fuel rod** have only begun to go through this series of changes, and will still give off radiation for some time. That means nuclear waste from a power plant is still radioactive and needs to be stored in a way that won't make people or the environment sick.

In **Chapter 5**, we'll be taking a look at the history of nuclear energy and address the ways in which nuclear waste is processed and stored.

Reflection Question

What does it mean to respect the environment?

Are there any offerings, rituals or traditions that you perform when you take something from the land, waters or soils? Feel free to reflect to yourself or write below.

Do you think that nuclear energy respects the environment?

Reflection Question

What could be the pros and cons of shipping uranium across the country for use in energy facilities?

PROS (+)	CONS (-)

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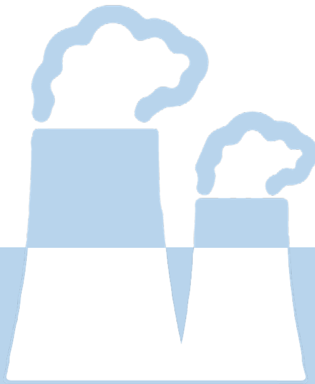
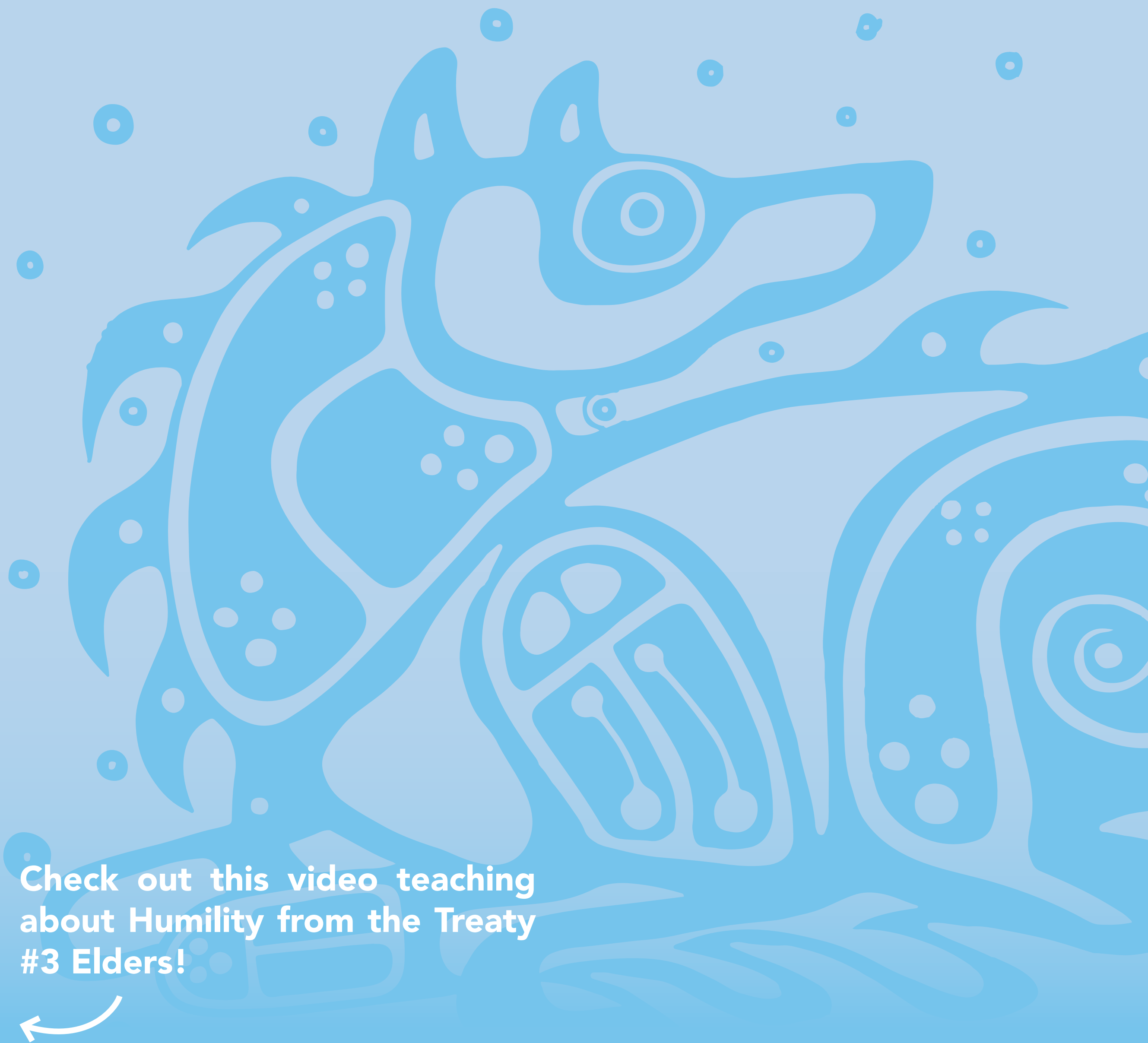


Chapter 5

Nuclear Waste (Humility)



Check out this video teaching about Humility from the Treaty #3 Elders!

Chapter 5
Nuclear Waste (Humility)

In this chapter :
- Atom
- Atomic bomb
- Bioremediation
- Dabaadendizowin "humility"
- Deep Geological Repository
- Hibakusha
- Fallout
- Ma'iingan "wolf",
- Manhattan Project
- Nuclear fission
- Nuclear force
- Nuclear fusion
- Nuclear meltdown
- Radiation
- Yellowcake

Dabaadendiziwin (Humility) *is to know our role within creation. We must respect our place and praise the accomplishments of others. It is important to be aware of the balance and equality of all of life.*

People create waste all the time in their daily lives. Not only do our bodies produce waste, but our activities like cooking, cleaning or working produce waste too. The same is true for nuclear energy. When uranium, coolants, and other material involved in the production of nuclear energy are used up, damaged or unusable, they have to be stored away from where they could harm living things. We will explore the topic of nuclear waste in this chapter including the beginnings of nuclear technology and the dangers of past nuclear accidents.

As we learned in **Chapter 1**, all living things, including us, are made of atoms. The nuclear force holds different parts of the atom together. The **nuclear force** is very strong and contains a lot of energy, when an atom is split apart, large amounts of energy are released. **Nuclear fusion** (adding atoms together instead of splitting them apart) also creates a lot of energy but it's much harder to control.

The discovery of splitting the atom, or **nuclear fission**, using uranium happened in the 1930s. In the 1940s scientists realized that nuclear fission actually produced energy. With the right conditions and enough uranium, a chain reaction of fission could be created to make energy that could be converted into electricity. (Check out **Chapter 2** and **Chapter 4** for more information on how nuclear fission produces electricity.)

Unfortunately, this early research happened at the same time as World War II and was not inspired by the goal of sustainable energy for the world, but for the development of new kinds of weapons. **The Manhattan Project** was an effort by the United States and the Allied Forces during World War II to develop nuclear weapons. The United States government recruited researchers from around the world to perfect nuclear fission to build an atomic bomb.

The atomic bomb (or A-bomb) used the energy released from nuclear fission and multiplied it many times. By putting lots of uranium into one container, the atomic bomb set off many nuclear fission reactions at once using an explosive. Because there were so many nuclear fission reactions, it made a massive explosive blast, along with radiation and nuclear fallout that were very damaging.

Chapter 5

Nuclear Waste (Humility)

As we learned in Chapter 2, Radiation is a wave of energy that comes from many sources, including the sun, the soil, water, rocks, and plants. In small doses radiation is safe and does no harm. However, in large doses, like in an atomic bomb blast, it can be very damaging to human health.

Nuclear fallout is left-over radioactive material from a nuclear explosion that falls to the ground after exploding out into the air. These pieces of material can be radioactive and dangerous to human health.

Nuclear weapons have only been used twice. Both times the United States used them against Japan during World War II. The first atomic bomb was dropped on Hiroshima, Japan on August 6th, 1945. The second was dropped on August 9th, 1945, in Nagasaki, Japan. These bombs killed around 135,000 people and injured thousands of others including giving long lasting health effects to survivors.

Today, the world generally agrees that nuclear weapons are dangerous and wrong and that they are not the proper way to use nuclear technology. The Treaty on the Non-Proliferation of Nuclear Weapons promotes peaceful uses of nuclear technology, like generation of clean energy or use in medicine, and works to lower the number of nuclear weapons worldwide.

While nuclear science was born during a time of war, and produced horrible effects, society has learned from the past and have redirected nuclear science towards positive outcomes.

In fact, nuclear generating stations are one of the most common and popular ways to generate electricity. The first nuclear power stations started operations in the 1950s after the Second World War. Thirty-two countries use nuclear energy, including Canada, the United States, Germany, France, China, Sweden and many more. In total, nuclear power stations provide about 10% of the world's electricity.

Nuclear power may increase in the world as more and more people demand cleaner energy sources than oil and coal.

Hibakusha is a Japanese word meaning *"atomic bomb survivor"*. As survivors, the hibakusha had to deal with health problems, grief, societal changes, fear and discrimination after the war. Survivors and their families, as well as concerned citizens, continue to promote peace and advocate for a reduction in nuclear weapons. You can meet and speak with an atomic bomb survivor on Zoom through the Hiroshima Peace Memorial Museum. With at least a month's notice, groups of 10 or more can sign-up. For a free 60-minute session weekdays from 9am-4pm Japan time. For more information see: http://hpmmuseum.jp/modules/info/index.php?action=PageView&page_id=177&lang=eng

Unfortunately, some countries have had accidents at nuclear power plants in the past. Most recently, the Fukushima Daiichi accident in Fukushima, Japan released large amounts of radioactive material into the environment. In 2011, a large earthquake and the resulting tsunami flooded the nuclear plants in Fukushima. The flood disabled a lot of the plant's electrical systems, including several back-up generators used to cool the nuclear cores. Without the cooling system, the reactors began to go into meltdown.

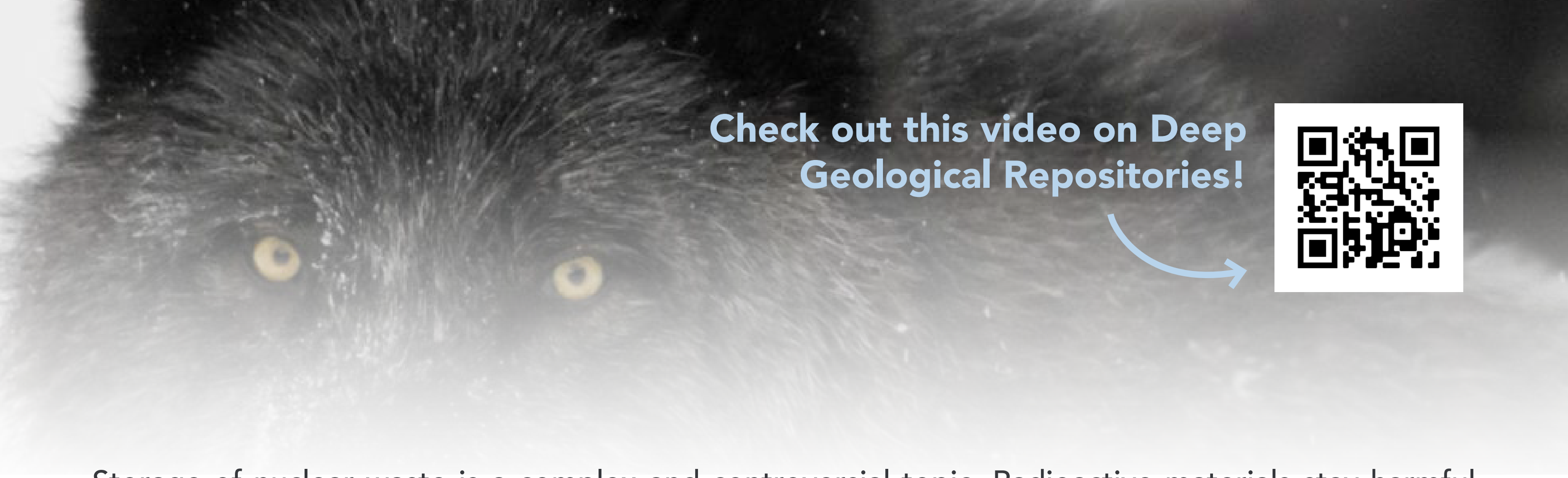
A **nuclear meltdown** is when temperatures within the reactor get so high that the nuclear fuel (ex. uranium) starts to melt. When this happens, large amounts of heat and steam can create explosions that release radiation in an uncontrolled way. This occurred in Fukushima, and there were several explosions and the release of large amounts of radiation. As a result, over 100,000 people were evacuated, and towns had to be permanently sealed off due to the radiation.

Nuclear accidents are difficult to clean up, given the danger of high amounts of radiation. Clean up of nuclear materials, especially of the water used to clean and isolate radioactive material from the air, is very difficult and is still going on today. While clean up is slow, there is progress. In 2021, the United Nations found that those who were living in Fukushima now had no risk to their health, or any health-related impacts from the accident.

In Canada, we've had nuclear accidents too. The most severe was the NRX accident which happened in 1952 in Chalk River, Ontario. It was the first major nuclear accident in the world. A combination of human errors, miscommunication, and mechanical failures led to a failure of the cooling system and partial meltdown. Several explosions occurred in the reactor building, damaging the reactor. To cool the reactor during the meltdown fresh water was pumped through the reactor system. But the explosion had cracked the pipes, leaking over 4000 m3 of radioactive water into the basement of the building (that's about a million 4 L jugs of milk worth!)

Luckily no one was injured and no one had to be evacuated, but there was significant radioactive contamination on the site from the radioactive water and the damaged building. Hundreds of military personnel were sent to dispose of this waste over two years. The water was filtered and pumped into a sandpit away from the Ottawa River to filter into the ground. The damaged reactors and other waste were buried in rock at a disposal site.

The Chalk River facility, its decommissioning and future waste disposal, remains a hot button issue for the area, especially as it is located on the Ottawa River, in the traditional territories of the Algonquin and Anishinabek Nations.



Check out this video on Deep Geological Repositories!

Storage of nuclear waste is a complex and controversial topic. Radioactive materials stay harmful for many years after they have been used – sometimes for more than 25,000 years! To safely store this waste in a way that protects people and the environment, it has to be separated from the environment using water, metal, concrete or rock.

Low-level waste, like protective clothing or laboratory equipment, is stored separately from regular waste for a few years until it is no longer radioactive, then disposed of in a landfill with regular garbage. Just as nibi (water) is used in healing ceremonies, it is also used to help "heal" nuclear waste. For used nuclear fuel, some of the most dangerous nuclear waste, it is first placed in a pool of water for 10 years to cool. This helps remove the danger of excess heat. Then it is placed into concrete and metal containers called casks, which prevent radiation from escaping into the environment. The water and mud from the bottom of the cooling pools also has to be healed, it needs to be stored or made safe at a water treatment plant. New studies are looking at using **bioremediation** (breaking down contaminants using bacteria) to change radioactive materials into less dangerous forms so there is less waste that has to be stored.

Another way to store more dangerous radioactive waste is in a **deep geological repository (DGR)**. A DGR is an underground facility, hundreds of meters below the surface built in stable rock. DGRs use natural rock formations that have been very stable for millions of years and will continue to be stable. Human-made barriers are also added to further ensure that radioactive materials are kept away from people and the environment.

DGRs have been used in the past for various types of other toxic waste that cannot be recycled or cleaned. The only radioactive waste DGR that is operating right now in **North America** is the Waste Isolation Pilot Plant in New Mexico, United States. This DGR houses contaminated materials like clothing, tools and other equipment. DGR for storage of highly radioactive nuclear waste from used fuel have been proposed by several nations including Canada, France, Germany, the United States, and Finland. The Onakalo Spent Nuclear Fuel Repository in Finland is now in the construction phase, set to be ready for waste in 2023. In Canada, the Nuclear Waste Management Organization is currently assessing potential sites for creation of a DGR. **Chapter 6: The NWMO Project** explores a possible Canadian DGR in more detail.

Reusing and reducing nuclear fuel is another way to reduce the amounts of nuclear waste generated from energy production. Some fuels used in nuclear reactors can be refined or recycled. Plutonium can be pretty easily reprocessed to get enough material to use as fuel again. Uranium is more difficult to recycle for fuel but can be reprocessed into material for medical uses.

> “The hardest thing in life, he said, that we’ll ever do, that we’ll ever face, or try and live your life that way, is humility.”

- Chief Perrault, Couchiching First Nation

Reflection Question

What does humility and being humble mean to you?

How does humility relate to how we interact with the Earth? Feel free to reflect to yourself or write below.

What are your feelings about nuclear waste?

Reflection Question

How easy or hard was it to find credible information about nuclear energy?

What plans should be in place to protect people from nuclear waste?

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Chapter 6

The NWMO Project (Honesty)

Check out this video teaching about Honesty from the Treaty #3 Elders!

Chapter 6

The NWMO Project (Honesty)

In this chapter :

- Adaptive Phase Management Plan
- Canadian Shield
- Deep Geological Repository
- Dry storage
- Gwayakwaadiziwin/ Kawakaatiziwin: Honesty
- Impact Assessment
- Impact Benefit Agreement
- Radiation Sickness
- Revenue Sharing Agreement
- Saabe: Bigfoot
- Semaa: Tobacco
- Wet storage

Gwayakwaadizin (Honesty) *is extremely important in meeting with others, especially when discussing serious issues or decisions. Treaty #3 is potentially facing a big decision with the Nuclear Waste Management Organization's proposed deep geological repository project. You might have already gotten information in the mail or gone or a community event about it. This chapter explores the project, including any potential positive and negative impacts.*

So far, we've learned that 15% of Canada's electricity comes from nuclear power, made from steam powered turbines heated by the energy that comes out of a uranium atom when it is split. The nuclear waste from the plant gives off other forms of energy as it decays, like alpha, beta and gamma radiation. We know that these forms of radiation can be very harmful to living things for thousands of years. So here's the problem- what to do with that nuclear waste?

In Canada, nuclear power plants have been operating for decades. There are currently 18 nuclear reactors inside 5 plants in operation right now, plus a dozen or so decommissioned plants and research reactors. Even if we never built any new plants and closed all the current plants in Canada, we'd still have to figure out what to do with the nuclear waste that has already been produced.

How is waste stored right now

Right now radioactive waste is stored across the country in different ways. Who is responsible for the storage depends on the material and how radioactive it is? For example, the uranium mining companies are responsible for the storage of uranium mine tailings.

Wet storage means the used fuel rods go into pools of water on site to cool down. This takes about 6-10 years.

Dry storage means the fuel rods are removed from the water and stored in large containers made of concrete. The dry storage facility is usually on the same site as the reactor and wet storage but in a different building.

When the nuclear plant site is built they include space for all of the waste that will be produced during the plant's lifetime. But this can present a problem if there is an accident at the plant or a natural disaster that damages the building. **Chapter 5: Nuclear Waste** explores some past nuclear accidents.

Many people in Canada were concerned about this issue including the Canadian government, scientists, and power generation companies. This led to the Nuclear Fuel Waste Act which was established in 2002 by the Canadian government. The Act was put in place to make the owners of used fuel responsible for the development of long-term waste management. These companies and research facilities that had used nuclear fuel came together and agreed that it would be best to have a separate, non-biased, organization to deal with nuclear waste management.

The result was the Nuclear Waste Management Organization (NWMO). NWMO was founded by, and is funded by, the following companies that have or have had nuclear reactors: Ontario Power Generation, New Brunswick Power Corporation, Hydro-Quebec, and Atomic Energy of Canada Limited. companies that have or had nuclear reactors. Instead of each company being individually responsible for their own waste, NWMO is now responsible for all of Canada's long-term used nuclear fuel management.

To tackle the problem of used nuclear fuel, NWMO has made a multi-year plan to find a system to transport used nuclear fuel from different facilities and then store it in a **deep geological repository (DGR)**. We first explored the idea of a DGR in **Chapter 5: Nuclear Waste (Humility)**. A deep geological repository is a place to store waste under the earth at levels deeper than humans usually dig (500m or half a km deep).

NWMO made the Adaptive Phased Management (APM) plan in 2010 after three-years of discussion with specialists and the public to understand best management approaches.

The first phase of the APM involves a multi-year process to find a host for the DGR. This involves a lot of meetings and conversations with communities and stakeholders.

Right now, NWMO is in the process of choosing potential sites for deep geological repository. This involves looking at rocks and the geology of areas across Canada to find the right type of rock for a DGR. When they find an area that has suitable geology, NWMO comes into the communities to talk about the DGR and used nuclear fuel.

NWMO has already looked at and ruled out 18 areas that won't work for the DGR either because the rocks weren't right or because the community was not interested in the project. Both First Nations and non-First Nations communities have been looked at. It's important to note that the DGR will not go ahead without community approval!

Right now, the towns being considered for the DGR are the towns of **Ignace** and **South Bruce**. Both towns are undergoing studies to explore the suitability of their geology while the community learns more about the DGR.

The town of Ignace is close to Wabigoon Lake Ojibway Nation and is in the traditional territory of the Anishinaabeg. As a lead community on the site selection process, Wabigoon asked Grand Council Treaty 3 for help, to lead dialogue with all Treaty 3 Nations. Grand Council Treaty 3 has entered into a Learn More Agreement with NWMO to learn more about them and the DGR. If South Bruce or Ignace are not chosen, NWMO might continue looking in other places in Treaty 3. It is very important to note- the Learn More Agreement does not equal consent to the DGR! No one has said yes to this project, and no one is currently putting any waste into the ground.

"Honesty... I think when you lie, you have to keep the lie up and you have to remember what you said and who you said it to and why you said it. And I believe that if I tell the truth, then I don't have to worry. And I tried to teach my son that and working with the kids... If you're honest, the chances are that you'll get a better response than if you lie."

-Treaty #3 Elder, Sherry Ann Roseborough

History of Deep Geological Repositories

Underground disposal of waste is not a new idea, countries around the world have stored different types of waste underground since the 1950s. Some were simple wells where liquid waste was injected into the earth, other times the waste was put into an old mine since the space was already dug out. Using an old mine can be for short-term or long-term storage. In a mine like this in Germany, officials realized that the radioactive waste stored there couldn't actually stay long term and it will have to be moved to a deeper, more secure structure.

Long-term deep geological repositories for intermediate level waste have been made in the U.S. and Korea. The Wolseong Disposal Center in Korea has space 130m deep to hold 100, 000 drums of waste. NWMO would like to build a facility with the same kind of capacity but for high level waste. The proposed Canadian DGR would house 4.6 million fuel bundles inside 100,000 containers.

What kind of waste?

Low level waste: has low radioactivity, short half-lives and doesn't produce any heat. For example, Contaminated soil or rubble from decommissioning a nuclear power plant.

Intermediate level waste: has low to medium level radioactivity, short to long half-lives and produces either no heat or a small amount. For example, Contaminated clothing and tools from working with radioactive materials, waste from mining or fuel reprocessing.

High level waste: has high radioactivity, short to long half-lives and produces heat. For example, Used nuclear fuel from nuclear power plants.

The first ever high-level radioactive waste DGR is being built in Finland, set to open in 2023. The types of waste that would go into a GDR like this would be those with high radioactivity or long half-lives, such as spent nuclear fuel. These kinds of radioactive materials can produce radiation in the form of alpha, beta and gamma radiation as well as heat. To learn more about radiation, please see **Chapter 3: Radiation (Bravery)**.

The Finland facility is close in design to the proposed NWMO facility, fuel rods inside cannisters, surrounded by bentonite clay, buried in rock about 500 metres below the surface. The area where Finland's DGR is being built was chosen because of how stable the rock is there.

Scan the QR code above or visit: https://www.youtube.com/watch?v=aoy_WJ3mE50 to watch a video exploring the Onakalo Spent Nuclear Fuel Repository in Finland.

What exactly do people look for when they want to build a DGR? Why is the NWMO looking in certain areas and not others?

NWMO is looking for really old rock that has low permeability- that doesn't let a lot of water through it. There's two types of rocks they are looking for- sedimentary (layers and layers of rock squished together) or crystalline (made of crystal-like minerals but no glass). An example of crystalline rock is granite, which is used in fancy kitchen countertops.

The sedimentary rock suitable for a DGR is over 450 million years old and is at a depth of over 500 meters. It has been found that this type of rock is the safest to contain and isolate used nuclear fuel bundles. Northern Ontario (in the Canadian Shield) is actually one of the prime areas to finding this type of geology.

As important as what is in the rock is what is not in the rock. NWMO looks for areas that don't have any valuable (according to them) minerals in them. They don't want to bury waste in a place that future humans may want to dig to start a mine.

NWMO also looks for areas that don't have a lot of earthquake activity, erosion or characteristics in the soil that might break down the containers. The rock must also be able to stand up to future stresses like shifting land or glaciers on top of it.

Right now, the design for the DGR is a large space with different rooms for storing the waste. The DGR would be at about 500 m below ground and would have enough room for 4.6 million used fuel rods. The actual size of the DGR would depend on the rock it goes into, but we can assume the whole DGR might be about 4 km long and 3km wide. The fuel rods would go inside containers made of carbon steel, coated in copper (to resist rusting and erosion) and then into a box filled with clay. These boxes would be lowered into the DGR by an elevator shaft and then stacked in rows in the placement rooms. Clay pellets would be pumped in to go between any gaps or spaces. This kind of clay, called bentonite, is used in all sorts of industries including home basement repair because it's very good at absorbing water. In the event of failure in the walls of the DGR or the containers, this clay is supposed to absorb water to prevent the nuclear waste from coming into contact with groundwater.

Preparing the site and completing construction could take about 10 years. NWMO's DGR is expected to be used for about 40 years and then it will be monitored another 70 years before being decommissioned. Fully sealing all tunnels and removing any buildings above ground is expected to take about 30 years. So that is about 150 years from start to finish. After that, what happens to the site would be up to future generations of people. The NWMO's Postclosure Safety Assessment Reports assume that there would be some kind of control or monitoring or at least memory of the location of the DGR for about 300 years post closure. This kind of long-term scale is hard to think about. There have already been so many changes the past 300 years, it's difficult to think about how things might change in another 300 years. **Chapter 7: The Future** explores this idea further as well as any emergency scenarios that could happen to a DGR.

Scan the QR code to see a model of the potential deep geologic repository as shown in Chapter 5.

Where would the waste come from?

Another big question asked about the DGR project is where the waste would come from. If a DGR were to be made in Canada, nuclear waste would be shipped from the existing plants in Ontario and New Brunswick as well as from decommissioned reactors.

When nuclear waste has to be transported, it is only shipped by certain companies that are licenced and trained in safe handling of nuclear material. Rules about who can transport and how it is transported are determined by Transport Canada and the Canadian Nuclear Safety Commission. Each employee has to be trained on transport, emergency planning and security measures.

Before modern regulations came into effect there was contamination from uranium ore along the Northern Transportation Route from the Northwest Territories to Alberta. In the 1990s officials found contamination at boat docks and launches from transporting this ore back in 1930s. The Canadian Nuclear Safety Commission claims that there has never been an accident or spill involving transported nuclear materials in modern times, despite over one million containers of radioactive material being transported in Canada every year.

The weakest link in the transport chain isn't the driver, pilot, navigator or even the vehicle used to transport, but the container. Making the container safe and secure in the event of an accident is the number one priority of rules and regulations. Making sure the nuclear waste is safely transported is naturally a big concern to community members.

Potential Negative Impacts

We know from learning about nuclear power accidents and radiation fallout in **Chapter 5** that radiation not contained safely can be deadly.

Radiation sickness from exposure to unnatural levels of radiation can cause vomiting, dizziness and headache immediately or a few hours after exposure. Long term exposure to high levels of radiation can cause serious side effects like internal bleeding, cancer and death.

In 1986 there was a nuclear meltdown at Lenin Atomic Power Station in Chernobyl, U.S.S.R. (now Ukraine), which caused radioactive gas and debris to explode out into the air. Many first responders and workers at the plant died shortly after. One month later, 10,000 had been hospitalized. 336, 000 people from nearby towns were evacuated and weren't allowed to return. The total area contaminated ended up being about 4300 square kilometres, a little less than the size of the province of Prince Edward Island. It's difficult to know how many people died due to this accident and its fallout because of politics surrounding the breakup of the U.S.S.R. at the time, but experts estimate the total deaths 50 years after the accident will be about 16,000.

While a nuclear meltdown is very different than slow radioactive leak, high radiation levels in the environment over time could have long term effects. If any radioactive materials escaped into water under the ground, they could be accidentally ingested by animals, absorbed by plants or drunk by humans. Sometimes, the thought or idea that there could be contaminated food or water can be just as harmful for people mentally. After Chernobyl, the people of the nearby country of Belarus suffered a lot of worry and stress because of fear of contamination for themselves or their children. Whether or not there actually was contamination there, the fear was enough to effect people's actions and attitudes.

Environmental changes, damages or even digging into rock can be distressing for community members as the Anishinaabeg are stewards of the land. Even if the DGR is deemed completely safe by experts, the cultural, social and mental impacts may be too much for people to accept having it in their area. In Chapter 7: The Future (Truth) we will explore your feelings on the project and allow space to share positive and negative thoughts.

What is radiation? What is a safe or unsafe amount?

Check out Chapter 3: Radiation (Bravery) for a refresher.

"If you don't listen, you are not going to follow the right path. You're going to fall off. You're going to go off in your own direction, and you're going to lose your way, because you won't have that respect for yourself. You won't have that honesty for yourself, and you won't have that wisdom. You won't carry that wisdom, because you've walked off the path. And that's what they meant about that, being honest to yourself."

- Elder, Hilda Boy

What are the alternatives?

Like any garbage, the solution is reduce, reuse, recycle. As we learned in **Chapter 5**, some nuclear fuel can be reused again either for nuclear fuel or recycled for medical purposes like imaging, testing and treatment. If we lower the amount of waste produced, that means less waste has to be stored. Some people argue for a reduction in nuclear power all together, but this can be hard during this time of climate change when the alternatives are fossil fuels. Hydroelectricity using dams produces no waste but can create a lot of negative impacts including fluctuating water levels impacting wild rice crops, animal habitat, traditional hunting and trapping grounds or even displacing communities all together. Investing in many different types of clean energy sources like wind and solar may help in the change from oil, gas or nuclear.

Right now, radioactive waste is being stored above ground which is leaves it vulnerable to natural disasters or human error. As we talked about in the beginning of the chapter, even if we were to close all of the nuclear power plants in Canada right now, the old waste would still be there. The goal of a deep geological repository was to move the waste somewhere away from potential emergencies that could affect it. The problem of nuclear waste and what to do with it, still exists.

Potential Positive Impacts

As with any industry development, communities can leverage consent to enter their territory for economic, social and infrastructure opportunities like roads, transmission lines, internet access and employment.

A DGR would be staffed and monitored for 150 years which could be 150 years of employment for the community and opportunities for community members to go into the clean energy or scientific research fields. Monitoring could be tied into an Indigenous Guardians program, with community members leading the monitoring process based on cultural and traditional protocols. Ceremonial plans could be written to ensure that the proper ceremonies are completed if rocks or other environmental features have to be disturbed.

Communities can negotiate relationship agreements, process agreements, impact benefit agreement and revenue sharing agreements. These are all different ways to ensure participation in the process, revenue from any profits or compensation for any potential impacts.

The **Impact Assessment** process can help communities determine any positive or negative impacts that may come out of any project in their territory. These can be led by industry, provincial or federal governments, qualified specialists and by communities themselves. Impact Assessments are important tools in informed decision making.

You can search up any active federal impact assessments on the Government of Canada's website including those involving NWMO: https://iaac-aeic.gc.ca/050/evaluations/index?culture=en-CA

Reflection Question

What does honesty mean to you? How can you tell if someone is honest?

How much trust do you have in individual people or organizations to be honest? Feel free to reflect to yourself or write below.

What do you think of NWMO and the Deep Geological Repository project?

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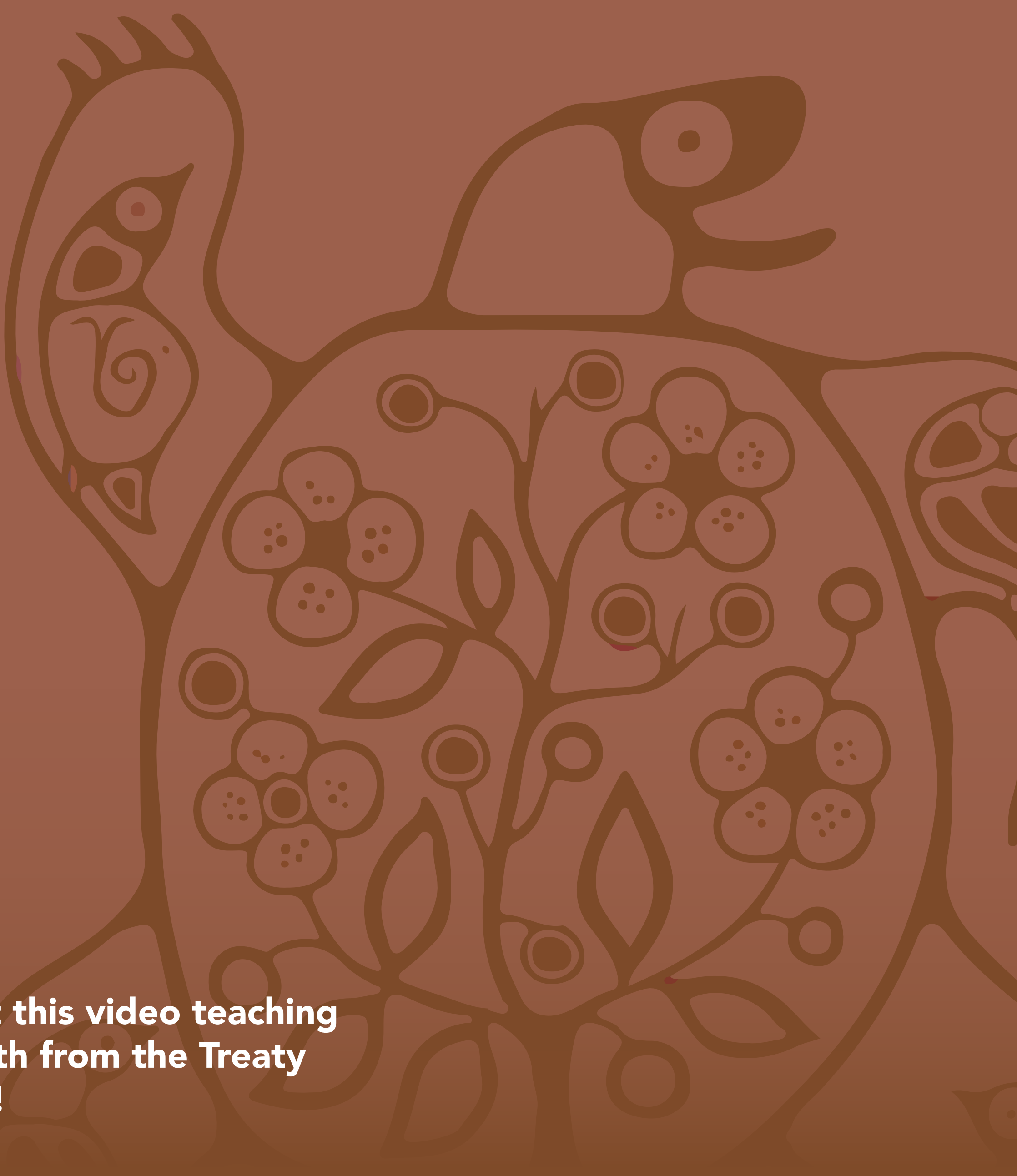
Chapter 7

The Future (Truth)



Check out this video teaching about Truth from the Treaty #3 Elders!

Chapter 7
The Future (Truth)

In this chapter :

- Aki: Earth, land
- Asin: Stone, rock
- Debewin: Truth
- Deep Geological Repository
- Manito Aki Inakonigaawin
- Mikinaak: Turtle
- Mikinaak Minis: Turtle Island
- Natural analogues
- The Seven Generations Value
- Tectonic Plates

The teaching of ***Debewin (Truth)*** *is necessary to know all of the other teachings. Truth is important in making long-term decisions. Whatever decisions we make affect the future generations. In this chapter we will explore potential long-term impacts of the Deep Geological Repository. How would it be affected by future events like natural disasters or shifting tectonic plates? This chapter's special focus will be on sharing your current thoughts and feelings on the project. With the interactive activity, The* ***Danger is Still Present****, we will review symbols and messaging proposed to warn future generations about nuclear waste.*

For some, the past may be hard to see. In many cases it has been deliberately destroyed by the powers of colonialism. Stories, photographs and heirlooms have survived and been passed along but it can be hard to imagine the person behind the object or story. What was their favourite colour, favourite food? Did they love the mornings or the nighttime? What were they feeling when they made an important decision? We may never know these details about ancestors from seven generations ago, but their actions and decisions still affect the world just as our decisions will affect our future descendants.

The **Seventh Generations Value** of the Haudenosaunee Confederacy has been adopted by many groups as a principle for decision making. The main question to ask when making decisions is *"How will this affect future generations?"* not just someone's immediate children or grandchildren but seven generations in the future.

Manito Aki Inakonigaawin: The Great Earth Law

Grand Council Treaty 3 adopted Manito Aki Inakonigaawin in 1997 as an official law of the Nation and over the years it has become the main framework through which consultation must occur with any Treaty 3 communities. The written MAI is only a portion of the oral laws as passed down since time immemorial by the Creator. How it can be fully implemented and what that will mean for the future of the Anishinaabe people is being explored today by Elders and community leaders.

"Manito Aki Inakonigaawin, to me, reflects how we as a nation are building a future for our children. Our children, and our children, our grandchildren. For the next seven generations and beyond, we are building ownership and relationships and reconnecting with our land, our water, and our air, and the resources that are above and below. We're starting to understand our creation story and tying that into our way of life, and our way of being is so important."

-Treaty 3 Elder, Theresa Jamieson

Treaty 3 potentially faces a big decision with the Nuclear Waste Management Organization's Deep Geological Repository for nuclear waste. This project could bring impacts, both positive and negative, to the area. **Chapter 6: The NWMO Project (Honesty)** gave us an overview, but we will explore this project in more detail in this chapter.

Safety Planning and Regulations

One of the major questions from community members is safety. How would people, plants, animals and waters be protected in the event of an emergency?

Standards and regulations for nuclear safety are set by different official groups around the world such as the International Atomic Energy Agency (IAEA). There are rules and requirements for the running of the nuclear plants and waste disposal. Especially important are rules about not using nuclear technology to make weapons ("the Non-Proliferation Treaty").

While the IAEA sets the standard for nuclear safety around the world, some say they don't go far enough. The IAEA has been criticized in the past for not being involved enough in emergencies such as the 2011 Fukashima Daiichi nuclear disaster in Japan. Testing and assessment of the damage right away by IAEA as a review separate from the Japanese government's tests would have helped back up big decisions like evacuating the area around the plant. In fact, in 2014, the Japanese government reached out to the IAEA to ask them to double check their research and monitoring of post disaster radioactivity levels in the sea. These back-up systems are important in ensuring the truth. Being open and transparent with radioactivity levels will help keep people safe.

Regular monitoring and testing of facilities is important both before, during and after a crisis even up to the decommissioning and closure of the plant. Once you have a lifetime's worth of data, it's easy to learn what are the safety standards, what can be done better and what needs to be changed. But how do you get a lifetime's worth of data for a something with a lifespan of hundreds of thousands of years?

There are currently only a handful of DGRs in the world, in the world, and none are close to the end of their planned lifespan. How can we know that a DGR structure will be safe to last all that time?

There is a lot that can be tested in scientific laboratories both above ground and in special underground labs that mimic the conditions of a real DGR. Scientists can use math and specialized computers to try and model what will happen in the future.

But Aki (the Earth) is alive and always changing and each asin (stone) is different from each other deep underground. This difference between perfectly modelled stone in the lab and a complex, changing system could cause slightly different results in the real DGR than expected from the lab. That's why people look to natural analogues for proof that a Deep Geological Repository will be safe.

A **natural analogue** is a natural system that is very similar to a proposed repository. It might be at the same depth or have the same type of rocks, water, soil and other materials. How that system has changed over time tells researchers how a repository will change over time. In Chapter 4 we learned how uranium ore is naturally present on and under Aki. A body of naturally occurring radioactive materials underground like uranium ore can be used as an analogue for used radioactive fuel pellets placed underground in a DGR. How and why did the ore form in those places? How has it changed over time? Does the material move around to different places as the earth shifts? How does it interact with water under ground? The answers to those questions help model how a Deep Geological Repository would act.

Natural analogues do have their limitations. Some ore bodies are not as deep underground as a DGR would be and have very complicated interactions with groundwater. The Natural Analogue Working Group continues to research natural analogues and how they could be used to solve big problems like nuclear waste disposal and carbon emissions.

Natural Disasters and Natural Changes

Aki has changed slowly over millions of years since it was first formed, and it will continue to change as we move into the future. In the past 500 million years, the continents of Aki have shifted and moved, mountains have been worn down by water and wind and large sheets of ice have scraped up the land. How will natural changes affect a deep geological repository 500 metres below ground?

NWMO says each used nuclear fuel container, made of carbon steel, is strong enough to stand up to the pressures of the rock above it, even if glaciers 3-kilometres-tall were to move on top of the DGR.

What is carbon steel?

Carbon steel is used for everything from kitchen knives to car parts, it's strength and flexibility depends on exactly how much carbon is in it. The hardest type is high-carbon steel (0.6-2% carbon) which is about two times the strength of low-carbon steel at 84 000 psi yield strength (hitting it until it breaks) and 140 000 psi tensile strength (applying pressure or bending it until it breaks).

psi = "pounds per square inch", a unit used to measure pressure
The pressure of the atmosphere above us is 14.7 psi.
Under 500m of ocean, the pressure would be 693 psi.
Under 500m of sand, the pressure would be 1301 psi.

High-carbon steel of 0.8% carbon can stand up to 140 000 psi of pressure.

When buried underground, carbon steel will break down slowly over time because of natural chemical processes like corrosion and oxidation (rusting). How fast and how much will break down depends on what the soil is like including the temperature, how acidic it is or how much oxygen is in the soil.

The corrosion rate for steel can be anywhere from 0.2 to 20 micrometres per year (a very tiny amount, 1000 times smaller than a millimetre). NWMO's fuel containers have an extra layer of protection with a copper coating on top of the steel, since carbon is resistant to corrosion.

Since the fuel containers are 0.5 metres thick, that means without corrosion protection they would break down to the inner part anywhere from 100,000 to 10 million years.

If we check back in **Chapter 4: Uranium**, we know that uranium decays, going under a series of changes into other isotopes of itself or other elements, releasing radiation. (Check out **Chapter 3: Radiation** to learn about nuclear decay). This happens over a very long long time, over millions and billions of years.

About 50% of the uranium-238 will have decayed in 4.5 billion years while the other uranium isotope used in nuclear fuel, uranium-235, takes 700 million years for 50% to decay.

This decaying uranium inside the fuel containers is protected by more layers, of clay and concrete. The type of clay used is really good at absorbing water. When water reaches the bentonite clay, the clay actually swells, filling in any small cracks or pores, blocking any water from coming in. If applied perfectly, it can block all water movement.

If the decaying uranium were to stay protected in its casing and series of barriers of the Deep Geological Repository, what would happen if the earth itself were to move?

The Earth's crust and upper mantle make up the tectonic plates, moving pieces on top of the molten core of the Earth, kind of like crunchy cheese on top of a casserole. These plates move around at the same rate your fingernails grow, at around 1.5-5 cm per year. Sometimes they bump up against each other creating earthquakes or volcanoes.

Luckily for us, there are no major tectonic plates bumping together through mainland Canada, so we don't usually have many earthquakes or volcanic eruptions. All of Mikinaak Minis (Turtle Island) is actually part of one large tectonic plate called the North American plate. Treaty 3 has very little earthquake activity, having only a couple of earthquakes that registered more than 2.5 on the Richter scale in a 30-year period. You generally have to have an earthquake of greater than 3 to be noticed by people.

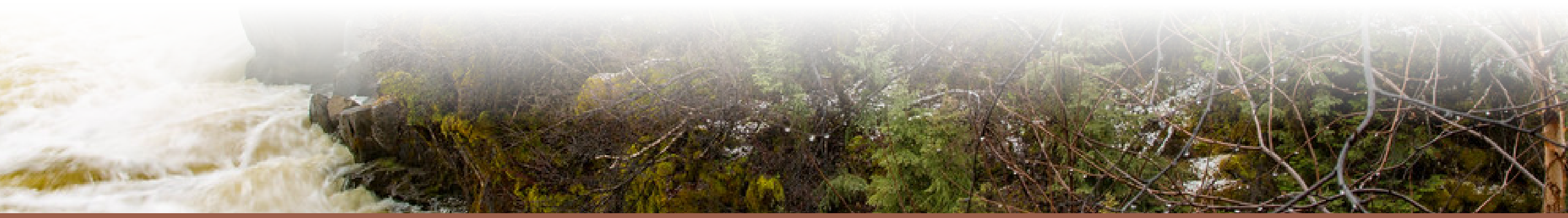
Since there is not much movement in tectonic plates in the area, scientists look at natural analogues to see how earthquake activity and moving tectonic plates in similar types of rock would expose or carry radioactive materials in the future.
If there is an ice age in a million years from now, some earthquakes could occur when the glaciers retreat but they would have to be really big earthquakes to damage the structure of the DGR and surrounding rock.

You can calculate your area's risk of earthquakes and even read the seismic waveforms (movements of the earth) on Earthquake Canada's website at: https://www.seismescanada.rncan.gc.ca/resources-en.php

NWMO assessment reports go over several "what if" situations like this, such as:

- What would happen if 10, 50 or 1000 containers were to fail (i.e., breakdown) over 10,000 years?
- What would happen if all the containers were to fail by 60, 000 years?
- What would happen if 10% of used fuel escaped all at once?
- What if the bentonite clay doesn't absorb at the rate it's supposed to?
- What would happen if humans accidentally drilled into the DGR?
- What would happen if the DGR isn't sealed properly?
- And many other questions.

The graphic on the next page explores some of these scenarios and their resulting radiation doses to the surrounding area.

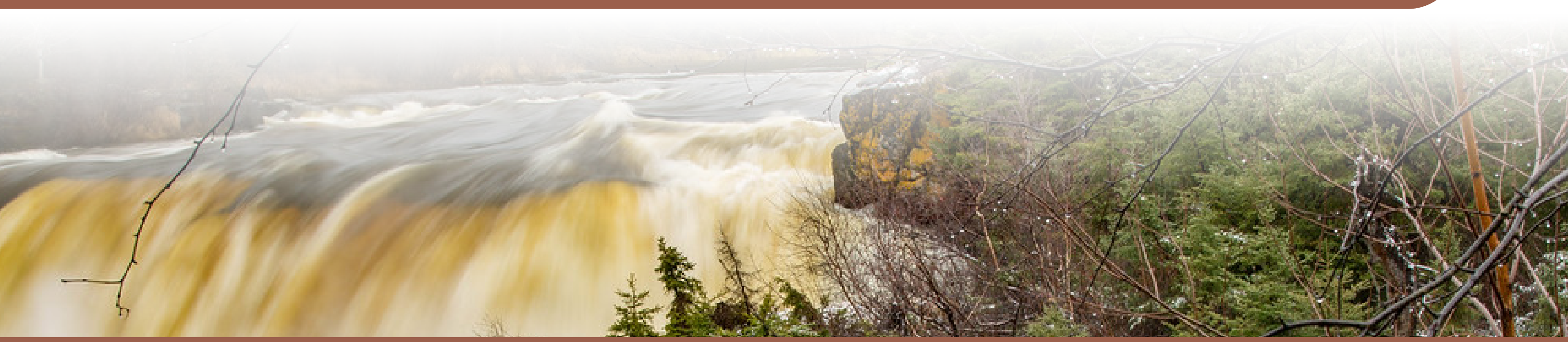


The table below explores some of these scenarios and their resulting radiation doses to the surrounding area.

Average Canadian background radiation: 1.8 millisieverts (mSv) per year
Safety limits (public): 1 mSv per year, exposure to man made radiation
Safety limits (nuclear worker): no more than 50 mSv per year

What would happen if?

Event	Radiation Exposure per year	Comparison
Baseline Case (some containers fail)	0.00025 mSv	Eating 2 and a half bananas
10 containers fail at 1000 years	0.0025 mSv	Eating 25 bananas or getting half of a dental x-ray
All containers fail at 10, 000 years	0.81 mSv	162 dental x-rays
All containers fail at 60, 000 years	0.63 mSv	126 dental x-rays
Humans accidentally drill directly into the DGR at 300 years	580 mSv residents living near-by drill site	116, 000 dental x-rays or almost four years living on the space station
Humans accidentally drill directly into the DGR at 100, 000 years	10-20 mSv residents living nearby drill site	2000-4000 dental x-rays



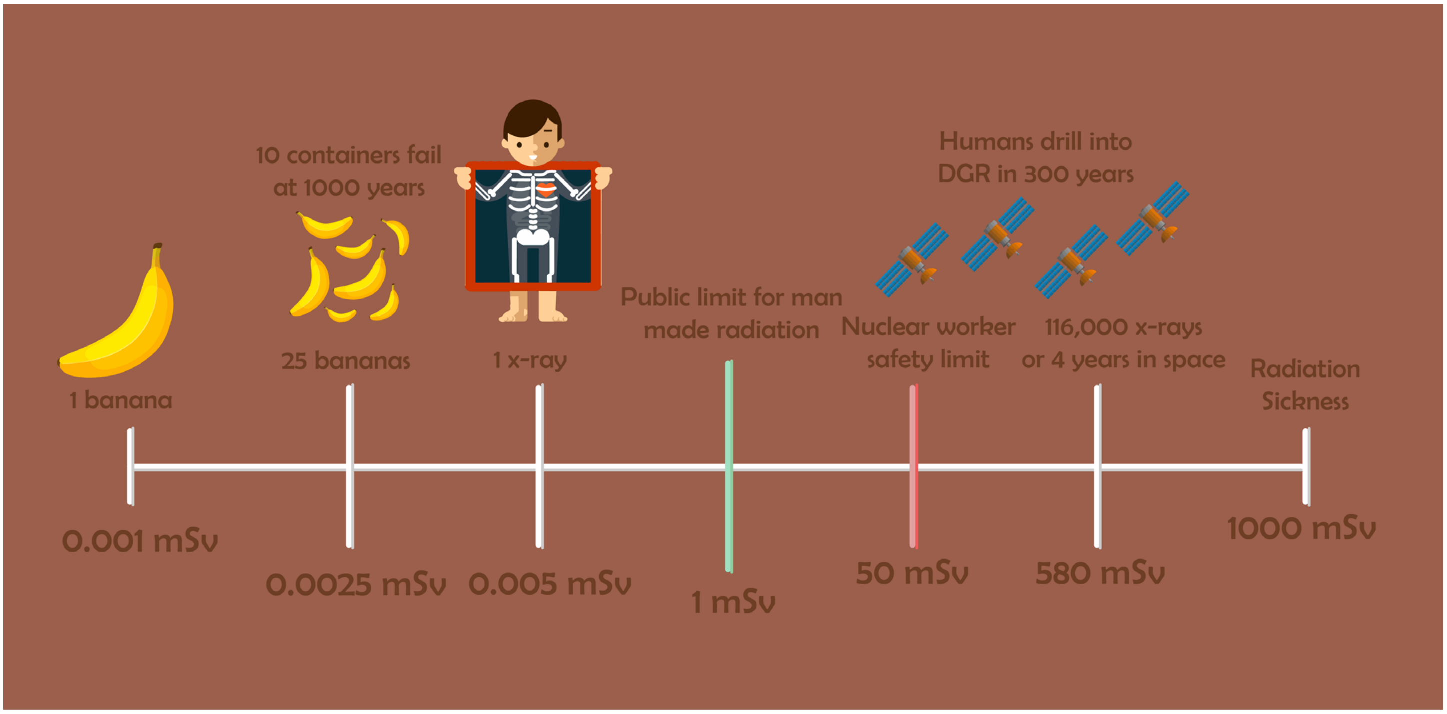


Diagram spaces not to scale.

While the DGR can be planned and built based on known science and safety standards, the biggest "what if" for safety is not the structure or operation but humans ourselves. Postclosure monitoring of the Deep Geological Repository is set to finish 100 years after the operation of the DGR. That is less than five generations of people that may come and go before monitoring finishes.

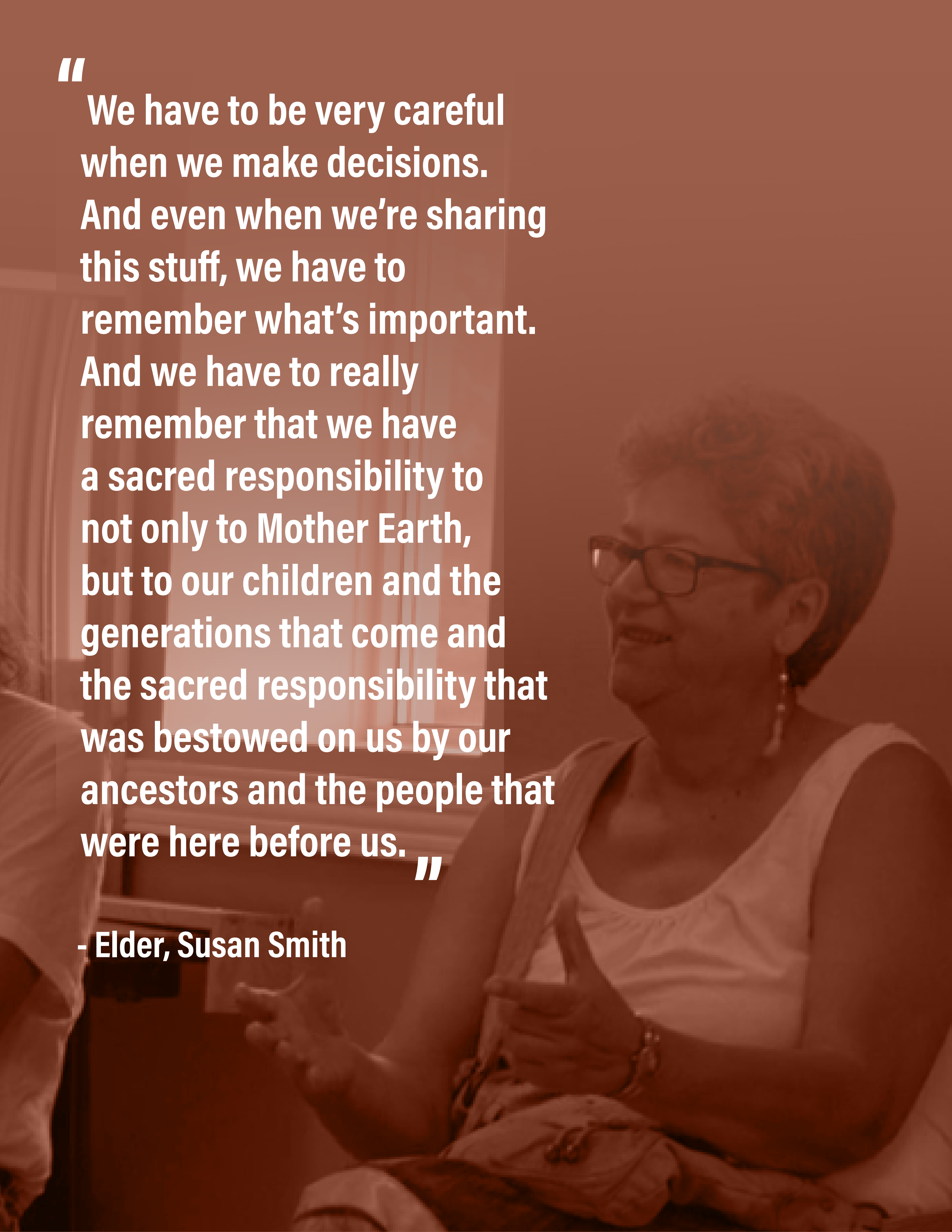
What systems will be in place after 100 years? In 200 years will signs and records be lost?

In 300 years will people even know the DGR is there? Just as it is difficult to see into the past, it's difficult to see into the future. What will the world look like then? What language will people be speaking? Can we assume future residents will be able to read or understand warning signs? If they do accidentally drill into the DGR, will they understand what it is?

Now would be a good time to explore these ideas by yourself or with a group in the interactive activity **The Danger is still Present on page 69**.

Forgiveness

While there are seven main Sacred Teachings, Elders often talk about an eighth teaching- the teaching of forgiveness. How important do you feel the concept of "forgiveness" is when thinking about the future? What about the past?



"We have to be very careful when we make decisions. And even when we're sharing this stuff, we have to remember what's important. And we have to really remember that we have a sacred responsibility to not only to Mother Earth, but to our children and the generations that come and the sacred responsibility that was bestowed on us by our ancestors and the people that were here before us."

- Elder, Susan Smith

The Danger is Still Present

We review symbols and messaging proposed to warn future generations about nuclear waste. What symbols, words, sounds or textures would you use to warn people of radioactive waste?

What do you think of when you see this image? What emotions do you feel?

Do you know what this is? If not, what do you think it's for?

This symbol is commonly called the "trefoil" or nuclear warning symbol. It is designed to warn people that there are radioactive materials nearby.

The Danger is Still Present

If you never knew it was a nuclear symbol, what other things could it be a symbol of? Ex. flower

What about this symbol? What do you think it's trying to say? What emotions do you feel when you look at it?

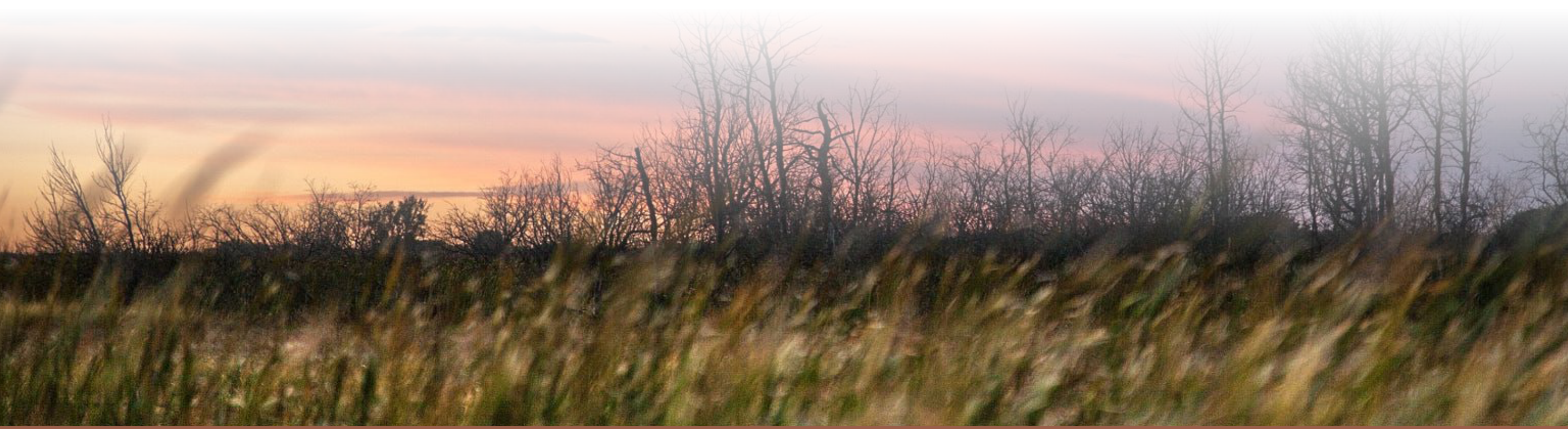
Do you think this picture says "danger!" much better than the other symbol? Or is it more confusing?

The Danger is Still Present

Scientists, governments and concerned public have been trying to find a way to leave future generations a message about the dangers of nuclear waste for decades. Future generations may not speak the same language or be able to read and write the same language that we do now. You might have your own experience of trying to understand someone else or trying to be understood. The children's game of telephone is an easy way to show how quickly messages can change over time.

Sandia National Laboratories in New Mexico tried to come up with images that would speak to certain feelings and go along with a written warning at a long-term nuclear waste site. They tried to find images that spoke to the dangers of what would be buried, both physically and mentally.

What emotions do you feel when you look at these images?



The Danger is Still Present

The group of people who come up with these suggestions wanted any images at the site to act as a visual representation of certain warnings and feelings. The words they said the images represent, almost look like a poem.

This place is a message...and part of a
system of messages ...pay attention to it!

Sending this message was important to us.
We considered ourselves to be a powerful culture.

This place is not a place of honor...no highly esteemed deed is commemorated here
. . .nothing valued is here.

What is here was dangerous and repulsive to us.
This message is a warning about danger.

The danger is in a particular location...
it increases towards a center...the
center of danger is here... of a
particular size and shape, and below us.

The danger is still present, in your time, as
it was in ours.

The danger is to the body, and it can kill.

The form of the danger is an emanation
of energy.

The danger is unleashed only if you
substantially disturb this place physically.
This place is best shunned and left uninhabited.

What feelings do you feel when you read this “poem”?
Do you think it get its message across?

The Danger is Still Present

Nuclear waste can remain a danger to humans for thousands to hundreds of thousands of years. That is a very long time in the future to keep a location safe and to warn people not to disturb it.

What would you use to warn people about the dangers of nuclear waste? Would you use visual or non-visual tools (ex. a drawing versus a sound recording). Feel free to use the space below to outline what your nuclear waste warning images or system would look like.

Final Reflection Questions

Feel free to reflect to yourself or write below. What was one thing you learned or were surprised about? What was one thing you still want to know about?

After having gone through all seven chapters, do you feel like this guidebook will help you make an informed decision on a Deep Geological Repository or other future major projects in your area? What would you choose to do if this project came to your territory?

Check out this video from the Treaty #3 Elders sending a message to future generations

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Glossary

A

Aki: Anishinaabemowin word for the Earth, earth or land in general.

Adaptive Phase Management Plan: plan for long term storage of used nuclear fuel. Involves multi-year site selection process including dialogue with potential host communities. Established and enacted by the Nuclear Waste Management Organization.

Alpha particles: a form of ionizing radiation. Made of two protons and two neutrons stuck together. Released from the nucleus during nuclear decay. Can be blocked by a sheet of paper.

Amik: Anishinaabemowin word for Beaver.

Anishinaabemowin: living language of the Anishinaabeg, also know as Ojibwe/Ojibway.

Asemaa: Anishinaabemowin word for tobacco, alternatively “Semaa”.

Asin: Anishinaabemowin word for stone, rock.

Atom: basic building block of life. All matter is made up of atoms. Not visible with the naked eye or regular microscopes, extremely small and numerous. There are trillions of atoms in one drop of water.

Atomic bomb: sometimes called “A-bomb” or “nuclear weapon”. Powerful explosive created by splitting apart an atom of uranium. Two atomic bombs were dropped by the United States on Japan in 1945 during World War II. Atomic bombs produce a large explosion and extreme amounts of radiation.

B

Beta particles: a form of ionizing radiation with high energy. Beta particles are released from the nucleus during nuclear decay. Can be electrons or positrons. Can be blocked by thick layers of plastic or thin sheets of metal.

Biomass: biological material like plants, wood, compost, yard waste or material that is burned to make heat or produce steam to power turbines.

Bioremediation: using bacteria to break down contamination in soil.

Bizhiki: Anishinaabemowin word for buffalo (Bison bison), alternatively “Mashkode-bizhiki

Biiwaabikokaan: Anishinaabemowin word for a mine, alternatively “Moona’igan”

C

Canadian Shield: ancient geological area of rock running through the center of Canada, prominent in Treaty 3. Were once huge mountains that have been ground down by wind, rain and glaciers moving across them. Total area is over 8 million square kilometres across. Estimated to be 4 billion years old. Sometimes called “Precambrian shield”.

Clean energy: energy production or use that doesn’t involve fossil fuels (coal, oil, natural gas).

Climate change: global pattern of systematic change in climate. May result in higher or lower temperatures than average, changing weather patterns, changing sea levels, ice melt and ocean currents. Caused by human burning of carbon-based fuels (coal, oil, natural gas) and the production of other greenhouse gases (ex. Methane gas from livestock).

D

Dabaadendizowin: Anishinaabemowin word for Humility.
Debewin: Anishinaabemowin word for Truth.
Decay: change within the atom of an element that results in the release of energy in the form of heat, light and radioactive particles. Having lost subatomic particles, the atom will have changed from one element into another. Ex. potassium-40 into argon-40. Decay happens at different speeds depending on what element is decaying. Also called "nuclear decay".
Deep Geological Repository: Deep = 500m, Geological= of rocks, Repository= room or container. A place to store waste under the earth at levels deeper than humans usually dig.
Dose: amount of radiation. Can differ between absorbed dose (how much was absorbed by the body) and equivalent dose (effect on the body based on type of radiation).
Dry storage: Nuclear fuel rods stored in large containers made of concrete, usually on the same site as the reactor and wet storage but in a different building. Dry storage happens after the fuel has cooled down in wet storage for multiple years.

E

Electricity: transfer of energy from the movement of electrons.
Electromagnetic spectrum: the range of different types of radiation. In fact, they are all one force of electromagnetic waves. The energy and frequency of the waves creates the difference between something like visible light and radio waves. The electromagnetic spectrum uses Hertz to measure frequency.
Electron: a particle smaller than an atom which has a negative charge. Electrons move around the nucleus in the centre of the atom. Electrons are repelled by each other and attracted to protons because of their positive charges. Electrons may move over to nearby atoms (these are called "free electrons"). Some atoms are more willing to lose electrons than others.
Element: something that only contains one type of atom. Elements are organized on a chart called the Periodic Table of Elements based on the number of protons in each atom (its "atomic number"). Oxygen has the number 8 in its square on the Periodic Table because the most common type of oxygen has 8 protons.
Energy: something that has to be transferred in order to perform work on it. Ex. Energy used to exercise, energy used to heat dinner.

F

Fallout: resulting nuclear contamination from a nuclear weapons blast or accident.
Fossil Fuels: things made from ancient life that living long ago, ex. Dinosaurs, trees that has been flattened and changed by the Earth, squished into a liquid or solid form. Oil, coal, and natural gas are fossil fuels. Humans burn them for heat, electricity production or transportation.
Frequency: the number of peaks in a wave of radiation. Measured in the unit Hertz.
Gamma rays: a very powerful form of ionizing radiation. Created from nuclear decay. Can only be blocked by thick layers of lead. Can be damaging to the human body.

G

Geiger-Müller Counter: device used for measuring amount of ionizing radiation in an object or surrounding area. Can measure alpha, beta, gamma or x-ray radiation. Uses a Geiger-Müller or GM Tube which detects electronic pulses from ionization.
Giizis: Anishinaabemowin word for Sun.
Gimishoomisinaanig: Anishinaabemowin for "our grandfathers".
Greenhouse gases: gases that contribute to the greenhouse effect. They block heat from leaving the Earth's atmosphere and cause the Earth to warm abnormally which cause global effects on climate ("climate change"). Greenhouses gases are things like carbon dioxide, methane, ozone, nitrous oxide and fluorocarbons.
Gwayakwaadiziwin: Anishinaabemowin word for Honesty, alternative spelling "Kawakaatiziwin".

H

Half-life: the time to takes for half of all the atoms present to decay into a new type of atom. Example, if you have 100 atoms at a half life of 50 years, in 50 years you will have 50 atoms. However, in 50 more years you won't have 0 atoms, you will have 25 because 25 is half of 50. After 150 years you will have 12.5 atoms etc. etc.
Hibakusha: Japanese word for someone who has survived an atomic bomb and its after-effects.
Impact Assessment: the process of identifying the future consequences of a current or proposed action on environmental, social, historical, or cultural components. More comprehensive and holistic than an environmental assessment.
Impact Benefit Agreement: An agreement between a group affected by development (ex. An Indigenous community) and the proponent causing the development (ex. Industry, government etc.). These agreements outline that where communities are impacted, they will receive some sort of benefit from the proponent, such as compensation.

I

Ion: an atom with a charge, ex. Having more electrons will give it a negative charge, having more protons will give it a positive charge.
Ionizing: the ability to create ions by taking or giving an electron. Ionizing radiation is radiation that has the ability to remove electrons from atoms.
Isotope: Different forms of the same atom. They have the same number of protons but differ in the number of neutrons. Ex. Carbon-13 (6 protons, 7 neutrons) versus carbon-14 (6 protons, 8 neutrons).

K

Kawakaatiziwin: Anishinaabemowin word for Honesty, alternative spelling "Gwayakwaadiziwin".

M

Madoodiswan: Anishinaabemowin word for sweat lodge.

Ma'iingan: Anishinaabemowin word for wolf.
Makwa: Anishinaabemowin word for bear.
Manaaji'idiwin: Anishinaabemowin word for Mutual Respect.
Manhattan Project: formerly top secret American military project to develop nuclear weapons during the Second World War. Named because of the New York location of their first headquarters.
Manito Aki Inakonigaawin: The Great Earth Law of the Anishinaabeg. Oral guideline from time immemorial. Adopted by Grand Council Treaty 3.
Mashkode-bizhiki: Anishinaabemowin word for buffalo (Bison bison), alternatively "Bizhiki".
Migizi: Anishinaabemowin word for eagle.
Mikinaak Minis: Anishinaabemowin for Turtle Island, also known as the continent of North America.
Mikinaak: Anishinaabemowin word for turtle.
Moona'igan: Anishinaabemowin word for a mine, alternatively "Biiwaabikokaan".
Natural analogues: natural systems that have similar conditions to a human-made structure. Ex. Uranium ore deposits are similar to burying uranium deep underground.

N

Neutron: a particle smaller than an atom which has a neutral charge. Neutrons exist, along with protons, in a tight clump at the centre of the atom called the nucleus.
Nibi: Anishinaabemowin word for water.
Nibwaakaawin: Anishinaabemowin word for Wisdom.
Non-renewable energy: sources used to create energy which can't be used again once used. Ex. Oil, coal, natural gas. Once completely consumed, you can't make any more of them.
Nuclear decay: see "decay"
Nuclear fission: the act of splitting the nucleus of an atom.
Nuclear force: the force holding the nucleus together. Since the nucleus is made up partly of protons which have the same charge as each other, the nuclear force is very strong at close range to hold them together as normally, like charges repel each other. The nuclear force acts on both the protons and the neutrons. Sometimes referred to as the "strong nuclear force" or "residual strong force".
Nuclear fusion: the act of combing two or more nuclei from multiple atoms.
Nuclear meltdown: when temperatures within a nuclear reactor get so high, that the nuclear fuel starts to melt. When this occurs, large amounts of heat and steam can create explosions that release radiation in an uncontrolled way.
Nuclear power: using the energy from splitting a uranium atom to heat water, creating steam which spins a turbine, creating electricity.
Nuclear waste: by-products of using radioactive materials for power or for weapons.
Nuclear Waste Management Organization: An organization with a mandate to develop a plan for long-term storage of used nuclear fuel. NWMO was founded by and is funded by Ontario Power Generation, New Brunswick Power Corporation, Hydro-Quebec and Atomic Energy of Canada Limited. Known as NWMO for short.
Nucleus: a tight bundle of protons and neutrons at the centre of an atom. Electrons revolve around the nucleus in a kind of cloud. From a Latin word meaning nut or kernel in centre of a fruit (like a pit in a peach).

O

Open-pit mining: mining in a large open hole rather than in tunnels. Used when the mineral is found close to the surface.
Opwaaganag: Anishinaabemowin word for pipe

P

Pellet: a small piece of uranium used as fuel for nuclear power.
Proton: particle smaller than an atom with a positive charge. Protons exist in a clump with neutrons in the center of the atom called the nucleus.

R

Radiation: transmission of energy. Can be in the form of heat, light, radio waves, microwaves, alpha particles etc.
Radiation Sickness: damage to human cells caused by high levels of dangerous radiation. Causes symptoms of nausea, vomiting and hair loss. If not treated can cause cancer and death.
Radioactive: giving off radiation in the form of particles from the nucleus as part of nuclear decay.
Radioisotope: an isotope that is radioactive. Ex. Carbon-12 is a stable (nonradioactive) isotope while carbon-11 is unstable (radioactive) and is therefore called a radioisotope.
Renewable energy: energy source that can be used over and over again or regrown after use. Ex. Plant materials, wind, water, solar.
Revenue Sharing Agreement: an agreement to share any revenue from industry or development with the communities that will be affected by that development. Ex. Tolls from new bridges, revenue from hydroelectric projects.
Rod: uranium fuel pellets are put together into one tube called a rod. These rods are then bundled together to go into the nuclear reactor to create power.

S

Saabe: Anishinaabemowin for Bigfoot, forest creature representing the Teaching of Honesty.
Semaa: Anishinaabemowin word for tobacco, alternatively "Asemaa".
Subatomic particles: particles that are smaller than atoms. Ex. Neutrons, electrons and protons. There are many particles that are even smaller than this such as gluons, quarks and Higgs-Bosons. These types of particles don't aren't explored in this Guidebook.

T

Tectonic Plates: large pieces of the upper level of the Earth's crust and upper mantle. These plates are the size of continents and moved slowly at the rate of 1.5-5 cm a year. Interactions between tectonic plates can cause volcanoes,

earthquakes and tsunamis.
The Seven Generations Value: A core value of the Haudenosaunee Confederacy, adopted by many groups as a principle for decision making. The idea is to make decisions based on what will affect not just someone's immediate children or grandchildren but seven generations in the future.
Turbine: a large wheel like structure spun by water or steam to produce electricity. Within this turbine are magnets inside coils of copper, when the turbines rotate these magnets the electric field of the magnets pulls electrons along the copper wires, making electricity.

U

Underground mining: mining in a series of tunnels or spaces not exposed to the surface. Opposite of open-pit mining.
Uranium: a chemical element with the atomic number 92 (has 92 protons). A metallic substance usually found as an ore in rock. Natural substance formed in explosions of stars over 6.6 billion years ago. Has no stable isotopes so is naturally radioactive.

W

Wavelength: distance between peaks of a wave. Waves with high frequencies (lots of peaks) then to have a short distance between them, therefore a short wavelength.
Wet storage: the storage of used nuclear fuel rods in pools of water to reduce the temperature and allow radiation to dissipate. Wet storage happens on site where the fuel rods were used. Wet storage happens for 6-10 years.

Y

Yellowcake: fine yellow powder which is a concentration of uranium oxide. Yellowcake is further processed to create enriched uranium for fuel pellets.

Z

Zaagi'idiwin: Anishinaabemowin word for Love.
Zoongide'ewin: Anishinaabemowin word for Bravery or Courage.

Notes

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Zhaagimaa Waabo

narratives