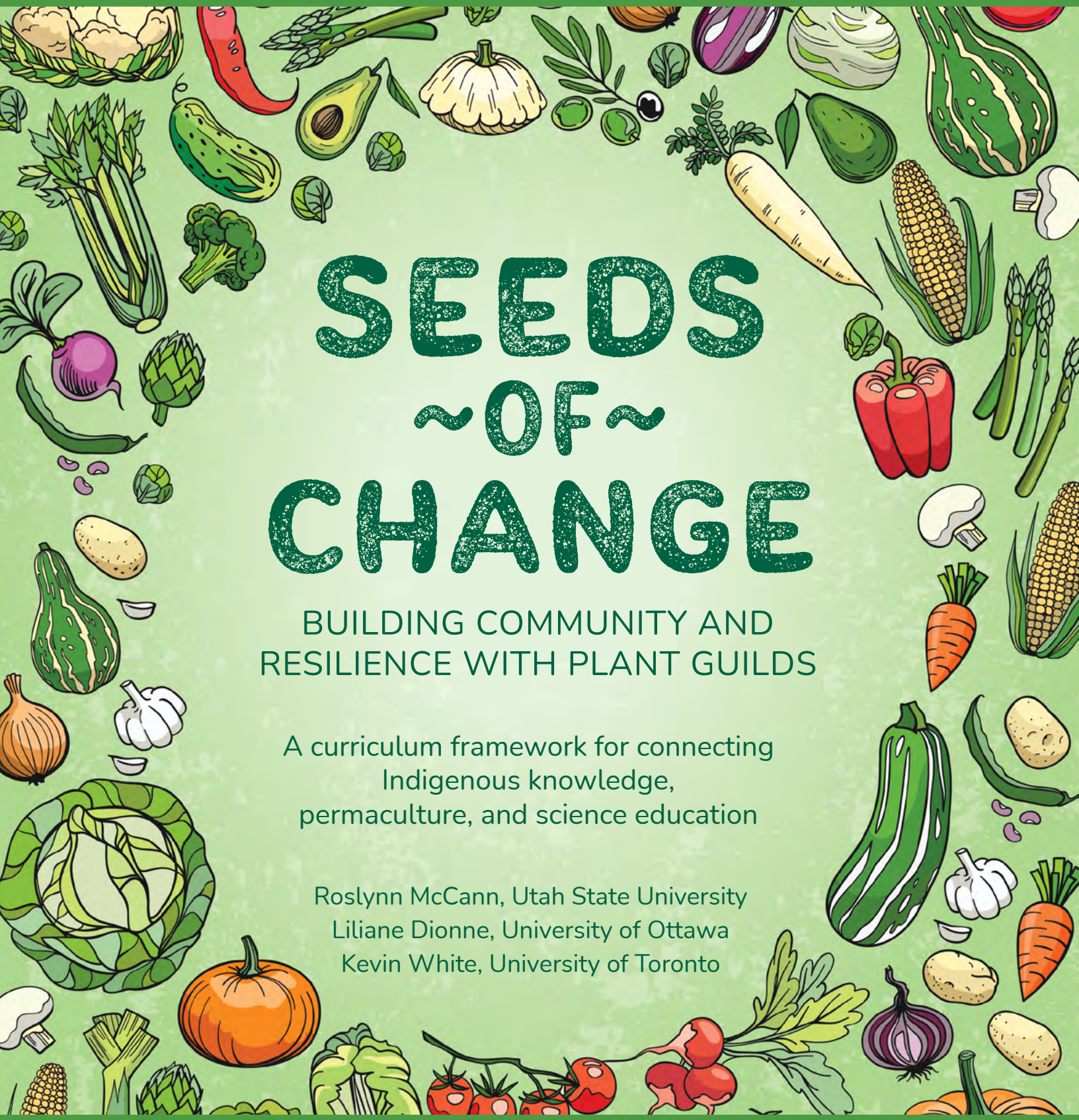

SEEDS ~OF~ CHANGE

BUILDING COMMUNITY AND RESILIENCE WITH PLANT GUILDS

A curriculum framework for connecting Indigenous knowledge, permaculture, and science education

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Designed for Grade 6 – Living Systems/Biodiversity

Extension
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TABLE OF CONTENTS

PEDAGOGY

Goal: Highlight Indigenous (First Nations, Métis, and Inuit) contributions to science, technology, and sustainable agriculture, with a focus on relational worldviews, permaculture practices, and respect for Mother Earth.

Teaching objectives: Students will:

- Explore the history of ongoing Indigenous agricultural practices in the territory where they live through stories, local examples, and where possible, community knowledge keepers.
- Understand the characteristics and uses of native and culturally significant food plants.
- Describe the interdependence between plants, humans, water, soils, and nutrients.
- Examine and taste the benefits of cultivating and eating plants to keep the body and mind healthy.
- Emphasize the importance of plants to society and the environment from a variety of perspectives.
- Suggest personal and collective actions to optimize the positive effects of human activities on plants and to minimize the negative effects.
- Harness student creativity through incorporating art and permaculture.
- Recognize Indigenous innovations (e.g., companion planting, seed saving, polycultures, water management) that align with modern permaculture design.
- Reflect on the ethical dimensions of learning from Indigenous knowledge: respect, reciprocity, and responsibility.

Curriculum in French: Perte biodiversité (Pb), Tableau STE, connected to the overarching Ontario Science and Technology Curriculum.

Learning and teaching approaches: Storytelling, with incorporated guest speakers, Elders, or Knowledge Keepers, if possible (even via video or stories if in-person isn't possible), two-eyed seeing (the Mi'kmaq concept of integrating Indigenous and Western knowledge systems), inquiry-based learning and teaching, place-based learning, pedagogy in nature, experiential learning, and interdisciplinarity.

Location: School grounds and classroom, and community gardens or grounds.

Duration: 50 minutes for each activity (with some activities split into a few class periods due to tasks taking longer, such as germinating seeds). Consider one weekly class over a 2–3 month period.

Materials: Handouts, internet links.

Activity 1: Bean seeds and microscopes or magnifiers.

Activity 2: A few bags of soil, organic seeds (ideally Native seeds), mulch, 2-gallon watering can, a few bags of compost or manure, rocks or other material for garden edge, gardening tools.

Activity 3: Seeds from the school garden, clean containers for seed conservation, labels.

Activity 4: 10–25 corn cobs with husks or corn husks, bowl with hot water for husk softening, elastic band.

Activity 5: Soup ingredients (see recipe in Appendix F).

Working modalities: Plenary, group work, individual work.

Concepts and vocabulary: Permaculture, gardening, plant names, plant anatomy, plant physiology, photosynthesis, nutrients, soil organisms, water conservation, weather, Haudenosaunee legends, traditions and vocabulary, Anishinaabemowin/Ojibwe tradition and vocabulary, Indigenous holistic vision of the world, sustainability, relation to Mother Earth, food security, food sovereignty.

Evaluation options: Learning journals or sketchbooks (draw plants, reflect on stories), group presentations (i.e., on a specific Indigenous agricultural innovation), creative expression (artwork, songs, corn husk dolls, poems), practical demonstration (design a plant guild, cook together).

Overview

Drawing on the Three Sisters Indigenous story, students will explore the importance of plants and the reciprocal relationships that exist between plants, soils, living organisms, and human beings on Earth. Students will also learn about the importance of passing on cultural teachings, including plant sources, seed sources, and sustainable agricultural practices through the oral traditions (stories) of Indigenous communities.

INTRODUCTORY ENGAGEMENT, STORYTELLING, AND QUESTIONING

Step 1. Ask the students about their familiarity with gardening. Do they have a garden at home, or can they think of relatives or friends with one? What kind of plants are typically grown in their region? Their own garden? What do they know about growing plants? Can they think of any ways to keep the soil fertile so that plants can grow to their full potential?

Step 2. Read the Three Sisters story to the students (see Appendix A), and/or ask a few students to each read a paragraph (if possible, invite Elders or Indigenous representatives to tell the story, or show a video of an Elder telling the story). Encourage students to think about the story overnight, and to draw on a paper what the story is telling them.

Step 3. Engage the group in a discussion with the following questions:

1. What did you find that was beautiful in the Haudenasonee story?
2. Why can corn, bean, and squash ensure the survival of Haudenosaunee people and potentially all of humanity?
3. Why do you think Indigenous peoples specifically chose corn, bean, and squash to grow in their gardens? How might these plants interact with each other?
4. How can Western science and traditional ecological knowledge coexist? How can this combined knowledge provide new perspectives for human societies to fight against climate change and live in greater harmony with nature?
5. How can you contribute to the sustainability of the natural world as a student, individually? How might you do this collaboratively with the school and community?

ACTIVITY 1: WHAT IS THE SCIENTIFIC KNOWLEDGE BEHIND THE THREE SISTERS STORY?

(Time required: two to three periods over 3 weeks due to germinating time.)

This activity aims to help students understand the relationship between the nitrogen-fixing roots of beans with corn and squash growth. The activity also teaches germination and basic methods to germinate seeds.

Step 1. In a scrapbook, ask students to illustrate how the Three Sisters interact with each other and the soil as they grow. Students can work in teams of three (like the plant team of three in the Three Sisters).

Step 2. Invite students to present their sketches to the class. A discussion will help students to learn more about the symbiotic relationships that exist.

Step 3. In groups of three, students participate in a germination experiment with bean seeds (Appendix B).

Step 4. When the beans have a well-developed root system, students take the plant out from the jar and use a microscope or a magnifier to try to see the rhizobium on the roots. They sketch in their scrapbook what they see through the magnifier.

Closing Questions

1. What are the names of the bean sprout's different parts?
2. What organisms can be found in the bean roots?
3. Why are these organisms growing in bean roots but not in corn or squash roots?
4. What are the soil and plant benefits from these nitrogen-fixing bacteria located in the bean roots?

ACTIVITY 2: PLANNING A PERMACULTURE PLANT GUILD

(Time required: one to two periods, or more, depending on whether you will plant a school garden with the students.)

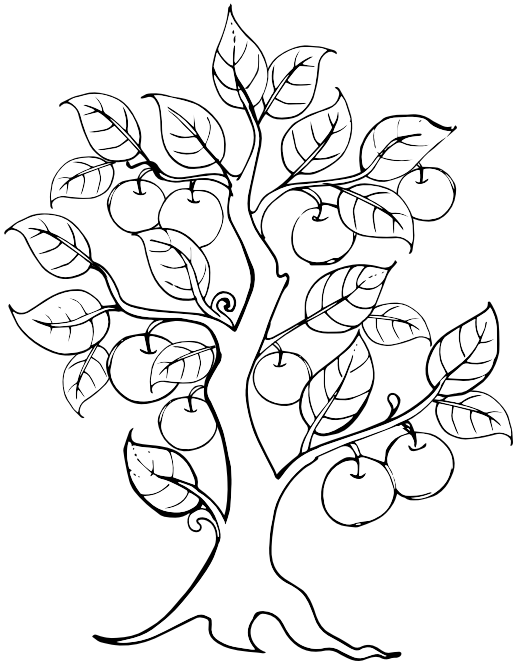
This lesson introduces students to the concept of a **plant guild**. In permaculture, a guild is a group of plants chosen and arranged to support one another—sharing nutrients, offering protection, and creating physical structure—much like the relationships found in a healthy forest ecosystem (see Appendix C). Guilds provide a model for selecting and placing plants in ways that mimic nature's patterns and promote regenerative growth.

Step 1. Draw a basic apple tree* on a white board/flip chart, including the roots.

*For communities in very cold climates, we suggest using the haskap berry (or honeyberry) bush instead.

Ask the class: "What does this tree/bush provide for us?" (answers: oxygen, fruit, shade, soil stabilization, wind

block…let them brainstorm creative answers). Then ask, "What does this tree/bush need to survive?" (answers: carbon dioxide, microbes, water, nitrogen [and other key nutrients such as phosphorus, potassium, magnesium etc. – "happy soil"], sunlight, care [pruning, keeping an eye out for nutrient deficiencies, etc.]).



Alternatively, you can have them work in teams with flipcharts to draw their own trees, provide their thoughts in the creative outlet of their choice, then share with the class. Mention that there are ways we can meet the tree's soil needs through plant communities or "guilds" (see Appendix C for further information about plant guilds, apple trees, and haskap berry bushes). For example, there are what we call **nitrogen-fixing plants**, such as:

- Beans (fava, alfalfa, green, runner, field, sweet, peanuts , soybeans, cream, black-eyed or purple-hulled, lupins, lentils, cowpeas, chickpeas),
- Clovers (white, red, crimson, Silver River), and
- Vetches (hairy, American, wood, tufted).

Step 2. As a class, assign each student a potential plant in an apple tree/haskap berry bush guild (see Appendix C for more information). Here are some examples:

- Overstory: apple tree/haskap berry bush.
- Pollinator attractor: fennel, lavender.
- Nutrient accumulator: comfrey, rhubarb.
- Nitrogen fixer: lupine, false indigo.
- Pest repellant: perennial garlic, marigold.
- Living mulch: strawberries, woolly thyme.

Ask the students to research their assigned plant and discover some of its benefits. Then, have them consider what a specific benefit could look like if acted out. Once the class is ready, stand the student representing the apple tree/haskap berry bush on a chair in the middle of the room, and ask the student to act out the function selected (i.e., spreading arms wide to provide shade). Then ask who would like to be nearest to the apple tree/haskap berry bush and why and continue to situate students around and out from the apple tree/haskap berry bush, each acting out their selected function. The class should be fun and chaotic by the end. Once all students return to their seats, discuss the beauty that occurred in such diversity added to the guild.

Step 3. Recap the story of the three sisters. Have students reflect on the functions of the three plants and how they work together in synergy. Then, have students complete their own apple tree/haskap berry bush drawing by selecting some plants that could be in their guild, based on the many layers and functions they could incorporate into one apple guild, allowing them to apply their creative energies.

Step 4. If you have the space and resources, plan and build your own guild or school garden. Each group can take care of an area of the guild based on their sketches.

ACTIVITY 3: SEED SAVING AND FOOD SOVEREIGNTY

(Time required: one to two periods, depending on the amount of seeds.)

This lesson aims to help students learn about the concepts of seed saving (for ancient seeds) and food security, as well as food sovereignty. The goal is to develop students' empathy by linking the classroom with the community.

Step 1. Show the class photos of different types of native seeds and have them guess what kind of plants grow from those seeds (see Appendix D). You may wish to cut out the seeds and plants in Appendix D, and challenge students to try to match them. Discuss the necessity of saving native seeds as opposed to buying the same few varieties from large multinational companies.

Step 2. In groups of three, students research the terms "food security" and "food sovereignty." Find similarities and differences between the terms, and a definition for food sovereignty that resonates the most with the group. The groups will then present their discoveries to the class. Emphasize the connection between seeds, seed saving, food security, and food sovereignty.

If doing the activity during harvest season:

Step 3. Clean and dry seeds from the school garden (if the school does not have a garden, the seeds can come from the students' home gardens). Label and store the seeds in a safe place, noting the date of storage and the approximate planting date.

Step 4. Research local organizations serving food to those in need and/or growing food organically or using Indigenous methods, and vote on one as a class to donate surplus harvest and/or seed. Share surplus seed and harvest with community organizations in need.

ACTIVITY 4: MAKE A CORN HUSK DOLL

(Time required: one period.)

The aim of this activity is to understand the use of all the resources in Indigenous communities, such as corn husks. Other plants are used to create baskets and other crafts. It aims to show students how to create a doll with corn husks, which they can either keep for themselves or give as a gift to a kindergartner.

It is best to do this activity during the corn harvesting season. Have one corn with husk for each student. You can ask for parents to contribute corn for their child to bring for the activity. You can also ask grocery stores to keep corn husks for you. If there is not enough corn, students can make the doll in teams.

Note: Keep the unused corn for Activity 5 (making a soup or a salad).

Steps for making a doll with corn husk:

Step 1. Read the story in Appendix E.

Step 2. Follow the directions on how to make the doll (also in Appendix E).

Step 3. Each student presents their doll to the class (or teams of students present their doll as a group).

Step 4. Reflect on what the students learned by asking any or all of the following questions (organized into themes).

Personal Connection

- What was it like to make a doll out of corn husks?
- Which part of making the doll was the most challenging or the most fun for you?

Cultural Meaning

- Why do you think Indigenous communities used corn husks (instead of other materials) to make dolls?
- What can we learn about a culture by looking at the objects people create with natural materials?
- How does the story in Appendix E connect to the dolls we made?

Environmental Values

- What does this activity teach us about using *all parts* of a plant, not just the part we eat?
- How is making a doll from husks an example of reducing waste and respecting nature?
- Can you think of other everyday items we could make from natural or reused materials instead of throwing away?

Community Connection

- How might giving your doll as a gift build kindness and connection between people?
- Why is it important to share traditions like corn husk dolls across generations and cultures?
- If you could teach someone else to make a corn husk doll, who would you share this tradition with and why?

ACTIVITY 5: HEALTHY EATING HABITS WITH THE THREE SISTERS

(Time required: two periods.)

Obesity is among the leading causes of health problems in North America. Diabetes is one of the diseases that affects the most members of Indigenous communities in North America. Developing children's taste for eating vegetables is an excellent way to help them develop healthy eating habits, including a varied diet. This activity involves developing a soup recipe using crops grown in a "Three Sisters" garden, and then preparing and enjoying the soup (see Appendix F). Complete Steps 1 and 2 in the first 50-minute period. Complete Step 3 in the second period. If soup is not suitable for your context, you can also use the Three Sisters Salad recipe (see Appendix G).

Note: Ensure you are aware of any food allergies in the class.

Activity Materials

Hot plate, large pot, big wooden spoon, water, condiments (chicken-flavor bouillon or any chicken or vegetable stock), onions, thyme, pepper, salt, and any other ingredients of your choice.

Step 1. Have some students share about their dream soup. Discuss with students the different types of nutrients necessary to maintain health. Ask students to identify some ingredients we can put in a soup, divided into three categories: protein sources (meat, beans, tofu, chicken stock), vitamin sources (vegetables, fresh herbs), and condiments (pepper, dry herbs, spices, salt). Clarify that each soup will contain the "three sisters" (corn, beans, and squash) as the main ingredients.

Step 2. The students invent a soup recipe in teams of three, then vote for the best one. (Alternatively, Appendix F includes the Three Sisters Harvest Vegetable Soup recipe that you can make together as a class.)

Step 3. Have the students participate in cutting the vegetables and putting them in a large pot. The teacher is then responsible for cooking the soup. When ready, all students share the soup. Remaining portions can be brought home by the students, left at the school cafeteria, or donated to a local food pantry for families in need.

Step 4. Reflect on what the students learned by asking any or all of the following questions (organized into themes).

Personal Connection and Nutrition

- What did you notice about the taste of the Three Sisters Harvest Vegetable Soup (or salad)?
- How was this recipe similar to or different from the foods you normally eat at home?
- What was your favorite part about making the soup together?
- What role do beans, corn, and squash each play in keeping our bodies healthy?

Culture and Community

- Why do you think Indigenous communities developed and passed down recipes like the Three Sisters Harvest Vegetable Soup?
- How does cooking and sharing food together help build community in a classroom, family, or culture?

Action and Habits

- How could you include more vegetables like beans, corn, or squash in your meals at home?
- What is one healthy eating habit you might try after this activity?
- If you were to teach someone else about the Three Sisters, what would you share?

CONCLUSION

This curriculum invites students to see themselves as part of the living systems that sustain us. By weaving together Indigenous knowledge, permaculture design, and science education, students not only learn about plants and ecosystems but also explore values of respect, reciprocity, and responsibility toward the Earth. Through stories, hands-on activities, and shared meals, students gain an appreciation for biodiversity, food sovereignty, and the creative resilience of Indigenous agricultural practices.

At the heart of this learning is the idea of relationship—between plants, soil, water, and people; between generations who pass on knowledge; and between students and the communities to which they belong. As students reflect on the lessons of the Three Sisters, plant guilds, seed saving, and shared traditions, they can see how small acts of care, such as planting, cooking, creating, and giving, contribute to a more resilient and hopeful future.

This framework aims to empower students to recognize the importance of Indigenous innovations and modern permaculture in addressing today's challenges. More importantly, it calls them to imagine their role in building communities of care, where food, culture, and ecological health are nurtured together.

OVERALL REFLECTION QUESTIONS

Connections to Knowledge and Story

- What part of the Three Sisters story stood out to you the most, and why?
- How do Indigenous stories help us understand science, nature, and community differently?
- What similarities do you see between Indigenous agricultural knowledge and modern science?

Plants, Ecosystems, and Permaculture

- What did you learn about how plants help each other grow?
- Why is biodiversity (having many kinds of plants, animals, and microorganisms) important for a healthy garden and planet?
- How is a plant guild like a community of people?

Culture, Community, and Responsibility

- How do food traditions—like seed saving, making corn husk dolls, or cooking soup together—help connect people to each other and to the land?
- What responsibilities do we have when learning from Indigenous knowledge?
- How can sharing food, stories, or handmade gifts strengthen our classroom and community?

Action and Hope

- What is one way you could help take care of the Earth at school, at home, or in your community?
- How might you design a "guild" in your own life—not just with plants, but with people, places, and actions that help each other thrive?
- What gives you hope after learning about the resilience of plants, people, and communities?

Appendix A: The Three Sisters Story

BACKGROUND AND LEGENDS

The "Three Sisters" traditional gardening technique—planting corn, beans, and squash in the same spot of the garden—originated with the Haudenosaunee (hah-dee-no-shownee), or "People of the Longhouse." This community is part of the large Iroquoian family. This Three Sisters gardening technique has been used by traditional Native American gardeners in many different regions of North America.

SUSTAINERS OF LIFE

To Native Americans, however, the meaning of the Three Sisters runs deep into the physical and spiritual well-being of their people. Known as the "sustainers of life," the Iroquois consider corn, beans, and squash to be special gifts from the Creator. The well-being of each crop is believed to be protected by one of the Three Sister Spirits. Many legends have been woven around the Three Sisters—sisters who would never be apart from one another, sisters who should be planted, enjoyed, and celebrated together.

There is an abundance of folklore, stories, and history surrounding Three Sisters gardening, but they all shared the understanding of these plants as women, sisters.

Some stories tell of a long winter when the people were dropping from hunger. Three beautiful women came to their dwellings on a snowy night. One was a tall woman dressed all in yellow, with long flowing hair. The second wore green, and the third was robed in orange. The three came inside to shelter by the fire. Food was scarce but the visiting strangers were fed generously, sharing in the little that the people had left. In gratitude for their generosity, the three sisters revealed their true identities—corn, beans, and squash—and gave themselves to the people in a bundle of seeds so that they might never go hungry again.

SKY WOMAN AND NORTH AMERICA

In the Iroquois creation myth, it was said that the earth began when "Sky Woman" who lived in the upper world peered through a hole in the sky and fell through to an endless sea. The animals saw her coming, so they took the soil from the bottom of the sea and spread it onto the back of a giant turtle to provide a safe place for her to land. This "Turtle Island" is now what we call North America. Sky Woman had become pregnant before she fell. When she landed, she gave birth to a daughter. When the daughter grew into a young woman, she also became pregnant (by the West wind). She died while giving birth to twin boys. Sky Woman buried her daughter in the "new earth." From her grave grew three sacred plants: corn, beans, and squash. These plants provided food for her sons, and later, for all of humanity. These special gifts ensured the survival of the Iroquois people.

For millennia, from Mexico to Montana, women have mounted up the earth and laid these three seeds in the ground, all in the same square foot of soil. When the colonists on the Massachusetts shore first saw Indigenous gardens, they inferred that the savages did not know how to farm. To their minds, a garden meant straight rows of single species, not a three-dimensional sprawl of abundance. And yet they ate their fill and asked for more, and more again.

Corn

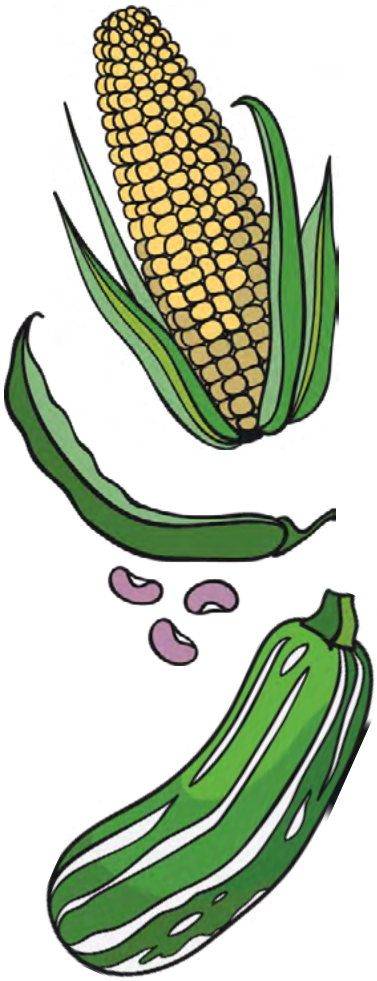
Once planted in the May-moist earth, the corn seed takes on water quickly, its seed coat thin and its starchy contents, the endosperm, drawing water to it. The moisture triggers enzymes under the skin that cleave the starch into sugars, fueling the growth of the corn embryo that is nestled in the point of the seed. Thus, corn is the first to emerge from the ground, a slender white spike that greens within hours of finding the light. A single leaf unfurls, and then another. Corn is all alone at first, while the others are getting ready.

Beans

Drinking in soil water, the bean seed swells and bursts its speckled coat and sends a rootling down deep into the ground. Only after the root is secure does the stem bend to the shape of a hook and elbow its way aboveground. Beans can take their time in finding the light because they are well provisioned: their first leaves were already packaged in the two halves of the bean seed. This pair of fleshy leaves now breaks the soil surface to join the corn, which is already 6 inches tall.

Squash

Pumpkins and squash take their time—they are the slow sisters. It may be weeks before the first stems poke up, still caught in their seed coat until the leaves split, its seams and break free. I'm told that our ancestors would put the squash seeds in a deerskin bag with a little water or urine a week before planting to try to hurry them along. But each plant has its own pace, and the sequence of their germination, their birth order, is important to their relationship and to the success of the crop.



WORKING TOGETHER

The corn is the firstborn and grows straight and stiff; it is a stem with a leafy goal. Laddering upward, leaf by long-ribbed leaf, it must grow tall quickly. Making a strong stem is its highest priority at first. It needs to be there for its younger sister, the bean. Beans put out a pair of heart-shaped leaves on just a stub of a stem, then another pair, and another, all low to the ground. The bean focuses on leaf growth while the corn concentrates on height. Just about the time that the corn is knee-high, the bean shoot changes its mind, as middle children are wont to do. Instead of making leaves, it extends itself into a long vine, a slender green string with a mission. In this teenage phase, hormones set the shoot tip wandering, inscribing a circle in the air, a process known as circumnutation. The tip can travel a meter in a day, pirouetting in a loopy circle dance until it finds what it's looking for: a corn stem or some other vertical support. Touch receptors along the vine guide it to wrap itself around the corn in a graceful upward spiral. For now, it holds back on making leaves, giving itself over to embracing the corn, keeping pace with its height growth. Had the corn not started early, the bean vine would strangle it, but if the timing is right, the corn can easily carry the bean.

Meanwhile, the squash, the late bloomer of the family, is steadily extending herself over the ground, moving away from the corn and beans, setting up broad-lobed leaves, like a stand of umbrellas waving at the ends of hollow petioles. The leaves and vines are distinctly bristly, giving second thoughts to nibbling caterpillars. As the leaves grow wider, they shelter the soil at the base of the corn and beans, keeping moisture in, and other plants out.

SOURCES

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Northeastern State University. (n.d.). *Three sisters legend.* https://www.nsuok.edu/heritage/three-sisters-legend.aspx

Appendix B: Germination Experiment Instructions

For this science project, students can use kidney beans, white beans, or any variety of native beans. Inside a glass jar or a reusable transparent plastic container, wet paper towels and fold them in the jar. Then, place three seeds in between the glass (or plastic) and the paper towel. The paper needs to stay moist (but not soaking wet) during the full germination time. The students should take photos and measurements of their germinating seed once a week, drawing and noting these and any other observations in their scrapbook. When the beans have sprouted, it is time to plant the shoots in the soil for the roots to develop nodules full of bacteria. Students take out the paper towels and put some soil and a small amount of *Rhizobium* inoculants in their glass or transparent plastic container. If you do not have inoculant, outdoor soil where beans have been planted previously is good too. Each student will plant their two or three small bean plants and water them regularly, being careful not to overwater and drown the seeds. They can continue to check the glass for roots as their bean plants grow, then place their plant roots under a microscope to see the rhizobium on the roots.

Appendix C: What Is a Plant Guild?

How can we make healthy soil through a plant community, also known as a *plant guild*? Interplanting combines crops that minimize competition for sun and nutrients. Companion planting, a step above interplanting, intentionally blends varieties that enhance each other. If the main plant in a guild is an apple tree, other plants can support the apple tree in numerous ways "by luring beneficial insects for pollination and pest control, boosting soil tilth and fertility, reducing root competition, conserving water, balancing fungal populations to counter diseases such as scab, diversifying the yield of food, creating habitat, and several other functions. The result is a healthier apple tree and a varied ecology" (Hemenway, 2001, p. 186).

Why a guild instead of monoplanted grasses surrounding the apple tree? Grasses are surface feeders and compete for nutrients with trees, whose principal feeding roots are also near the surface. As a result, instead of complementing each other in their functions, the grass and apple tree compete for nutrients.

Some plants, like yarrow, chicory, daylily, Indian rice grass, and plantain, are nutrient accumulators, drawing minerals from deep in the soil and making them available to the rest of the guild. Others, such as comfrey and artichoke, act as living mulch; they cover the soil, add fertility, and suppress unwanted plants. Certain species—dill, fennel, bee balm, lavender, Russian sage, anise (European hyssop), native penstemon, and culinary sage—attract beneficial insects by providing food and shelter, which in turn supports the tree through pollination and natural pest control. Still others, like daffodils and garlic chives, help by suppressing grass and weeds with their bulbs.

THE THREE SISTERS GARDEN GUILD

Planting corn, beans, and squash or pumpkins together, interconnecting these plants for the benefit of each other, has been a traditional agricultural practice for Indigenous communities in North America from time immemorial. In fact, all the corn, beans, and squash found anywhere around the world originated from seeds coming from the Indigenous traditional gardens in South and North America (referred to by Indigenous peoples as Turtle Island).

The Hadenosaunee people grew food using the traditional Three Sisters garden, creating beneficial community relationships. The three plants help each other grow within a supportive ecosystem of plants, animals and microorganisms. This is a form of companion planting: the corn stalks support the beans as they climb around them, allowing them to receive plenty of light and support. The beans are nitrogen fixers. They are special plants that have a *symbiotic* relationship with a kind of bacteria called *rhizobia* on its roots. Bean plants help the growth of the other plants, especially in responding to the high nitrogen needs of corn, by releasing nitrogen dioxide absorbed from the air into the soil (Figure 1). The third sister, squash or pumpkin, provides an efficient ground cover that helps to keep the soil moist and weed-free (Ngapo et al., 2021).

With the rhizobia living in their roots, it is possible for the beans to convert nitrogen to help it grow and then to share the surplus with other plants in the soil. To better understand the process of nitrogen-fixing bacteria, the so-called "rhizobia" are one of several groups of bacteria capable of "fixing" nitrogen, i.e., converting nitrogen dioxide gas into ammonia and then into organic molecules, such as amino acids. Because of this ability, nitrogen-fixing bacteria are significant conduits between an extremely large pool of nitrogen in the atmosphere and living things who otherwise could only obtain nitrogen by recycling it from existing pools of organic nitrogen (e.g., amino acids, ammonia, nitrate, and nitrite). Unlike many nitrogen-fixing bacteria that can fix nitrogen when "free-living" (i.e., when not living inside a host plant), rhizobia can only fix nitrogen when associated with a plant that provides it with carbohydrates. The carbohydrates provide energy for a process that requires substantial inputs of energy (both adenosine triphosphate [ATP] and the reducing power of nicotinamide adenine dinucleotide [NADH]).

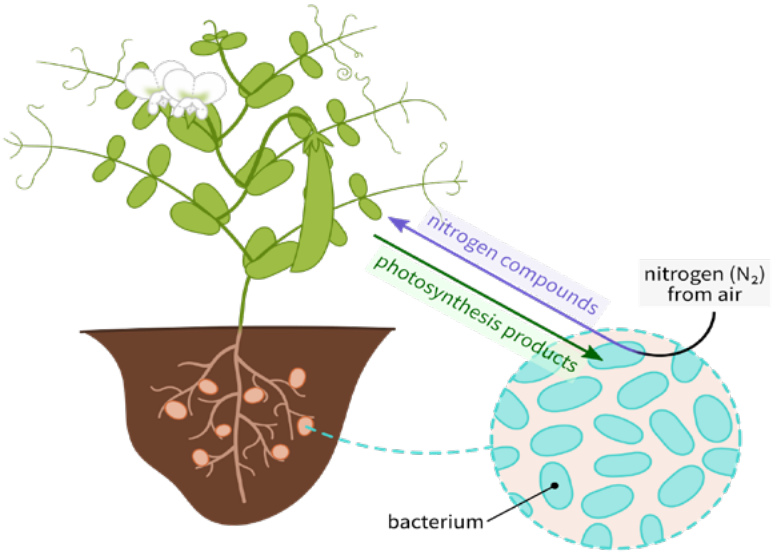

Figure 1. Rhizobium: Nitrgen Fixing Bacteria
Source: Briggs, 2021

In summary, rhizobia is only associated with legumes, members of the pea family. Other nitrogen-fixing plants include plants in the legume family, such as lupine, Apache plume, clover, and alfalfa. However, not all legumes are associated with rhizobia, and some that have nitrogen-fixing capability may have bacteria other than rhizobia.

APPLE TREES

Figure 2 shows an apple tree guild example from Toby Hemenway's *Gaia's Garden*.

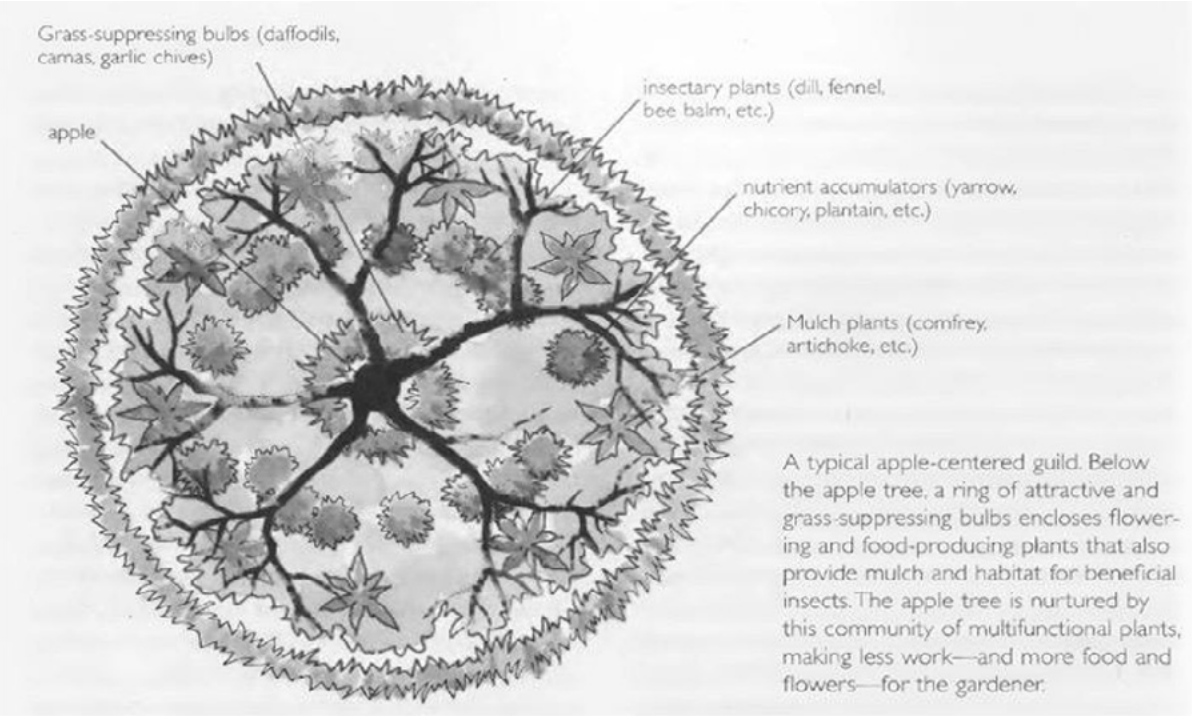

Figure 2. *Apple Tree Guild*
Source: Hemenway, 2001

Features

There are over 7,500 varieties of apple trees around the world, but the basic characteristics of apple trees are the same (Beddes et al., 2012). Apple trees are deciduous with alternate, toothed, oval leaves 1 to 2-1/2 inches long and 3/4 to 2 inches wide. The trees generally remain somewhat small, between 10 and 39 feet, and while they can grow taller, they are usually pruned to make harvesting easier (Garden Guides, 2022). Apple blossoms, perhaps the most beautiful and fragrant characteristic of apple trees, bloom in the spring and are white with a slight pink coloring. Almost all apple trees require cross-pollination to produce fruit (Beddes et al. 2012). Mature apples are ready for harvesting in the fall.

Identification

The overall appearance of apple trees is one of the most noticeable characteristics of apple trees to many casual observers, even when they're not in bloom. Apple trees, when grown in full sun, divide into many large branches low on the trunk, resulting in a canopy of branches and leaves that is usually wider than the tree is tall.

Climate

One of the most important characteristics for home gardeners to consider when selecting apple trees is the climate for which their trees are best suited. While apple trees can tolerate warm temperatures, they have a winter chilling requirement that varies by apple variety. The chilling requirement, common in fruit and nut trees, is simply the amount of hours between 32 degrees Fahrenheit and 45 degrees Fahrenheit that the tree receives each winter. While apple trees can survive freezing temperatures, it is important that they receive between 300 and 1,200 hours (depending on the variety) of the chilling requirement to ensure even blooming and normal growth (Garden Guides, 2022).

Cultivation

Apple trees perform best in loamy, deep, well-drained soils. Loam combines sand, silt, and clay; it retains moisture but still allows drainage. The ideal soil pH for apples is slightly acidic to near neutral, often around 6.0 to 7.0, yet apples are grown on a diverse array of soils. They are also adaptable and can be grown in a wide range of climates. They especially thrive in temperate and cool temperate climates. Because the apple is extremely hardy in cold weather and blooms comparatively late, many cultivars are suitable for northern and colder regions. The late bloom helps reduce damage from late frosts in spring.

Consideration

Home gardeners who want to grow apple trees should know that planting seeds from an apple will not always result in an apple tree of the same variety as the fruit from which the seeds came. Instead, the seeds are a mixture of the tree it was grown on and the tree that served as the cross-pollinator. Instead, apple trees are most often grown from grafts designed to produce the desired variety of apple. Apple tree grafts are readily available from gardening centers and online retailers.

HASKAP BERRIES (HONEYBERRIES)

Haskap berries (also called *honeyberries*) resemble blueberries in color but are shaped more like small olives (Figure 3). Even though they resemble these fruits, they actually come from a type of honeysuckle bush that grows naturally in North America, Europe, and northern Asia (Figure 4). In Japan, people have enjoyed wild haskap berries for centuries, calling them the "berry of long life and good vision" (Salisbury Greenhouse, n.d.).

In North America, haskaps weren't very popular at first because the wild berries were often too bitter. That changed when plant breeders at the University of Saskatchewan developed new varieties that are sweeter and better for eating. Today, these improved Canadian cultivars are grown in gardens worldwide.

Unlike raspberries that spread or saskatoon berries that can grow wild, haskap bushes stay neat and compact. They usually grow no taller than 2 meters (about 6 feet) and form tidy, rounded shrubs that fit well even in small yards or townhome gardens. Two bushes take up about the same space as one apple tree!

In spring, they bloom with yellow, trumpet-shaped flowers that attract bees and other pollinators. Since haskaps need cross-pollination to make fruit, you'll need at least two different varieties planted near each other.

The flavor of haskap berries is often described as a mix of blueberry and raspberry, though some say it tastes a bit like grapes or black currants. The berries are juicy, sweet-tart, and very nutritious. They are high in vitamin C and full of antioxidants, which help keep our bodies healthy.

You can eat them fresh, dried, or blended into smoothies. They're delicious in jams, jellies, baked goods, and even ice cream.

Haskap plants are tough because they come from cold northern regions. They grow best with at least 6 hours of sunlight, rich soil, and regular watering while young. Once established, they are hardy and even tolerate wetter soils better than many other fruiting plants.

To keep them healthy, feed with fertilizer once a month from May through early August. Stop fertilizing after mid-August so the plants can get ready for winter.

One important thing to remember: Haskaps don't like to grow alone. To get berries, you need at least **two** different varieties planted together so their pollen lines up. Think of them as "garden partners" that help each other thrive!

Figure 3. *Haskap Berries*
Source: Salisbury Greenhouse, n.d.

Figure 4. *Haskap Berries Grow on a Bush*
Source: Salisbury Greenhouse, n.d.

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Beddes, T., Pace, M., Black, B., & Ashcroft, M. (2012, March). *Apple production and variety recommendations for the Utah home garden*. Utah State University Extension. https://extension.usu.edu/yardandgarden/research/apple-production-and-variety-recommendations-for-the-utah-home-garden

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Appendix D: What Seed Is It?

Consider each picture on this page and guess what plant the seed produces. Correlating answers are on the following page.

Picture 1

Source: American Meadows

Picture 2

Source: American Meadows

Picture 3

Source: Minnesota Wild Flowers

Picture 4

Source: Pinelands Nursery & Supply

Picture 5

Source: Pixabay

Picture 6

Source: American Meadows

Picture 7

Source: Pixabay

Picture 8

Source: Pexels

Picture 9

Source: Pexels

Appendix D Answers

Picture 1 : Black-Eyed Susan

Source: Pexels

Picture 2: Lupine

Source: American Meadows

Picture 3: Wild Geranium

Source: Pexels

Picture 4: Blue Lobelia

Source: American Meadows

Picture 5: Common Milkweed

Source: Pixabay

Picture 6: Blazing Stars

Source: Pixabay

Picture 7: Indigenous Corn

Source: Pexels

Picture 8: Squash

Source: Pexels

Picture 9: Pinto Beans

Source: Wild Rose Heritage Seed Company

Appendix E: Corn Husk Doll

BACKGROUND STORY: THE LEGEND OF THE NO-FACE DOLL

The doll made with corn husk is a traditional craft from many different Indigenous communities in America. Children used the doll for play. Here is the story, coming from Haudenosaunee people (from the Oneida Indian Nation website).

"The Haudenosaunee people respect what they call the sustainers of life, the Three Sisters – Corn, Beans and Squash. The Corn Spirit was so thrilled to be one of the sustainers of life that she asked the Great Spirit if there was anything more that she could do for her people. The Great Spirit told her that a doll could be formed from her husk. So she made the doll from her husk and gave the doll a beautiful face. Then, the doll went from village to village and played with the children.

Everywhere she went everyone kept telling her how beautiful she was. So, it wasn't long before she became conceited. The Great Spirit called to her. But, before she went into the Great Spirit's lodge she looked into a pool of water to admire herself. The Great Spirit talked to her and told her that if she kept thinking that she was better than everyone else a terrible punishment would come upon her, but he wouldn't tell her what it would be. So, again the doll went from village to village playing with the children and again everyone kept telling her how beautiful she was.

It wasn't long before she became conceited again. The Great Spirit called her and once again she looked into the pool of water to admire herself before going into the lodge. Upon entering, the Great Spirit said to her: 'I have given you one warning, now a great punishment will come upon you.' But he still wouldn't tell her what it was. When she left the lodge, she again looked into the pool of water to admire herself, but this time she didn't have a face. The Great Spirit had taken it away.

Since that time, the Haudenosaunee people do not make a face on their corn husk dolls. This is to remind people, never to think that they are better than anyone else or a great punishment will fall upon them."

MAKING A CORN HUSK DOLL

Here is how to make a doll from corn husks:

Step 1. Prior to the activity, peel fresh corn and put the husk in the refrigerator for a week until the husk turns pale yellow.

Step 2. From the refrigerator or any storage location, place the husk in warm water to soften. Each student takes the husk of one corn. Additional leaves can be used for string.

Step 3. Take the end of the husk (the thinner parts) and tie them up with an elastic band. Then turn the node upside down to create the doll head and tie a string made of husk for the neck.

Step 4. With three thin slices of husk, make a braided string for the doll arms. Try to form a hand at the hand. Then, have the arms inserted under the neck in the middle of the layers of the corn husk. Tie another string made of a thin husk for the doll waist.

Step 5. Depending on the clothes, if pants are wanted, then divide the husk in two parts and tie them at the ankle. If you want a dress, then leave the husk in one piece. If you want, use some of the corn silk to make the doll's hair.

SOURCES

Oneida Indian Nation. (2025). *The legend of the no face doll.* https://www.oneidaindiannation.com/the-legend-of-the-no-face-doll https://www.oneidaindiannation.com/the-legend-of-the-no-face-doll/

Appendix F: Time to Make Soup!

Do you know soup recipes combining corn/maize, beans/peas, and squash? In teams of three, you will develop a soup that you would love to eat with those three main ingredients. You will then present your recipe to the rest of the class and vote for the best one. The chosen recipe will be prepared and cooked for the group.

SOUP NAME:

Ingredients and proportions:

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Directions:

(Write the steps to prepare the soup below.)

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Alternatively, you can make the following delicious vegetable soup recipe from Ganondagon (2024) together as a class!

THREE SISTERS HARVEST VEGETABLE SOUP

Ingredients

- 2 cups hulled white corn, cooked/prepared ahead
- 15-ounce can of kidney or pinto beans
- 32 ounces vegetable broth
- Two 15-ounce cans diced tomatoes
- 2 tablespoons olive oil
- 1 cup onion, chopped
- 2 celery stalks, chopped
- 2 cloves garlic, minced
- 1 teaspoon basil
- 1 teaspoon cumin
- 2 cups winter squash, peeled and cubed
- 1/2 cup carrots, diced
- 1 cup parsnips, cubed
- Salt and pepper to taste

Directions

- Rehydrate hulled white corn (see directions below).
- Warm the oil in a large soup pot on medium heat. Add onions, celery and garlic. Sauté 10 minutes on low heat.
- Add basil and cumin, salt, and pepper to taste. Add squash, carrots, parsnips and tomatoes. Simmer until tender. Add beans and corn and simmer for another 10 minutes. Add vegetable broth. Simmer on low for 10–15 minutes.

HOW TO REHYDRATE HULLED WHITE CORN

Cooktop Method

Soak hulled white corn in water over night. Drain and rinse.

Place in stockpot and add water to cover corn by 3 inches.

Bring to a boil. Reduce heat to low and cook for 3 hours. Cook longer if you prefer the texture tender or softer.

Crock-pot Method

Place hulled white corn in a Crock-Pot. Add water to cover by 3 inches.

Cook 6 ½ hours on the high setting or 10 hours on low. Drain and rinse.

SOURCE

Ganondagan. (2024). *3 sisters harvest vegetable soup*. Friends of Ganondagan. https://www.ganondagan.org/hulled-corn-recipes-1/3-sisters-harvest-vegetable-soup

Appendix G: Time to Make Salad!

THREE SISTERS SALAD

Corn, beans, and squash—the three sisters are better grown together. The three also provide nutrients for each other and are delectable in this Three Sisters Salad! You can watch this video on how to prepare the salad.

Preparation time: 10 minutes

Cook time: 25 minutes

Servings: 12

Author: Chef Kirk Ermine

Ingredients

- 4 cups of ½ inch cubed, peeled butternut squash (about 1 small)
- 2 tablespoon canola oil
- 2 cups cooked or canned corn kernels
- 19-ounce can black beans, drained and rinsed
- 1/2 cup canola oil
- 1/4 cup white wine vinegar
- 1 tablespoon honey
- 1/4 cup chopped fresh parsley
- 1/4 teaspoon salt
- 1/4 teaspoon freshly ground black pepper

Instructions

1. In a large bowl, toss squash with the 2 tablespoons of canola oil. Place in a single layer on a parchment-lined, large-rimmed baking sheet. Bake in 400 °F oven for 20 to 25 minutes or until tender. Set aside to cool.

2. In a large bowl, whisk together the 1/2 cup of canola oil, vinegar, honey, parsley, salt, and pepper. Add squash, corn, and beans; toss well. (Salad can be covered and refrigerated for up to 1 day.)

SOURCES

Canadian Food Focus. (2022, December 21). *Three sisters salad* [Video]. YouTube. https://www.youtube.com/watch?v=Dv1m4QqdD78

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