Yucca as a Bridge Between STEM and Diné Cultural Knowledge

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“Several scientific bodies have elevated the critical importance of Indigenous Traditional Ecological Knowledge (ITEK) traditions that recognize the intersections between ecological systems and environmental and climatic conditions as central to an interdisciplinary approach to climate adaptation. In many cases, considerable restoration projects and opportunities have, indeed, been informed by ITEK(s) and practices” (Hill et al., 2024, p. 2).

Topic and Context

This interdisciplinary STEM unit explores Indigenous plants through the lenses of STEM and Indigenous knowledge, also known as Traditional Ecological Knowledge (TEK). Traditionally, the Diné (Navajo) people approach plants with respect and intention. For them, the relationship with plants is deeply spiritual, reciprocal, and rooted in the concept of Hózhó: living in balance, beauty, and harmony with the natural world; where plants are not just resources, they are relatives and teachers. Each plant carries a purpose and a story, often tied to ceremony, healing, and survival.

Throughout the multi-week unit, students will learn about a native plant (*yucca, family Asparagaceae, subfamily Agavoideae*) that grows in many areas throughout the Southwest United States, including in Dinétah on the Navajo Nation. Each and every part of the plant's structure is useful from the flowers to the stems and the roots. As a resilient desert plant, it offers many rich opportunities for students to examine adaptations, investigate biomimicry, soil health, water retention, chemistry, and environmental stewardship while incorporating Indigenous knowledge, particularly Diné agricultural and medicinal practices. The Diné word for yucca is Ts'áászi' and the Diné people hold the yucca plant in high regard. They incorporate it into their traditions and beliefs in various ways that could be considered sacred or, at the very least, spiritually significant (Gallo, 2019).

The yucca plant provides a strong interdisciplinary foundation for activities that align with STEM principles for exploring science, engineering, sustainability, and cultural traditions. The major learning objectives include: investigating yucca plant adaptations for survival in desert ecosystems; exploring biomimicry in engineering inspired by yucca fibers and structure; analyzing the yucca plant's role in Indigenous traditions, especially Navajo agricultural and medicinal uses; and designing hands-on experiments and simulations related to yucca plant sustainability. Each lesson allows learners the opportunity to investigate the yucca plant's ecological functions, medicinal uses, symbolic roles in ceremonies and other parts of Diné life.

These hands-on activities and experiments will touch upon several areas of science: life and physical (biology, chemistry, and environmental science) and they will be inter-woven with Diné lessons on cultural knowledge, bilingual vocabulary, storytelling, and creative expression. By bridging the two content areas: science and Diné standards, students will discover how the yucca plant embodies resilience, purification, and sustainability for Indigenous groups. This curriculum blends Indigenous ways of learning and knowing with modern science and aims to inspire innovation and build self-worth by developing an understanding of Diné way of life (Diné Content Standards, n.d.). By integrating Diné storytelling, students will connect ecological concepts to Indigenous sustainability practices, reinforcing the importance of land stewardship and traditional wisdom (Jessen et al., 2022).

This unit promotes scientific literacy, cultural relevance, and creative problem-solving. It supports equity by validating Indigenous ways of knowing and providing all students with access to

meaningful, hands-on STEM experiences. Through this unit, students learn to see their ancestors as scientists, engineers, and storytellers capable of making connections between tradition, innovation, and community care. It was written for 4th and 5th grade students in a STEM classroom and aligns to both Next Generation Science Standards (NGSS) and the Diné Content Standards. The lessons were developed and piloted in a STEM classroom in a public K-5 school in rural Tonopah, Arizona. While the school is not located on tribal lands, it serves some Native American students and their families. It weaves Diné perspectives with 'Western science' and explores the yucca plant as a cultural and ecological cornerstone, blending life science, chemistry, engineering, storytelling and cultural arts connecting scientific inquiry with ancestral knowledge, honoring the plant not only as a source of healing and fiber, but as a symbol of resilience and identity. The unit has been developed for Indigenous students by honoring traditional uses of yucca as food, fiber, and medicine while engaging in STEM related activities that deepen their understanding of yucca's role in both ecological systems and cultural practices.

Timing: The unit is best suited for the fall season, aligning with harvest time and traditional teachings about plant use and stewardship. It fits naturally into an early-year schedule when science practices such as asking questions, developing models, and planning investigations are introduced. This timing also allows students to connect yucca's healing properties to broader themes of wellness, resilience, and community care as they build classroom culture.

Land Acknowledgement: Winters' Well Elementary School sits in the Tonopah Desert, west of the Hassayampa River on homelands that were sacred to Hohokam, Tohono O'odham and Yavapai Nations who live, resist, and thrive. May we honor the past, present and future generations who have and will forever call this place home. Let this land acknowledgement be a call to actively resist colonizing systems and support the resilience of Native communities and our relation to Mother Earth.

Rationale

In 1896, in an article published in the "Botanical Gazette" titled *The Purposes of Ethno-Botany,* J. W. Harshberger wrote "The study of ethno-botany aids in elucidating the cultural position of the tribes who used the plants for food, shelter or clothing" (Harshberger, 1896, p. 146). This quote exemplifies Harshbeger's belief that through the knowledge of plants, we can get a glimpse into the innovations and cultural values of Indigenous people. He was inspired by the way that Native peoples used plant materials with ingenuity and, hence, introduced the term as a formal field of study. Ethnobotany is the scientific study of the traditional knowledge and customs of a people concerning plants and their medical, religious, and other uses (Ethno Botany, n.d.). Harshberger posited that through ethnobotany, we could begin to see how Indigenous and traditional groups used plants in innovative ways to survive, in terms of food, shelter, medicine, and tools. For many of these groups, plants became part of their cultural development. Harshberger saw Indigenous plant knowledge as an

anthropological key to understanding how societies evolved. Most importantly, he saw value in preserving that wisdom. (Harshberger, 1896).

Today, many people are focused on the principles of food sovereignty and land stewardship, as they push to integrate Indigenous farming practices (Integrating Indigenous Farming Into Sustainable Agriculture, 2025). “Agriculture is not just about growing food; it’s about sustaining life, cultures, and communities. As climate change, land degradation, and food insecurity become increasingly urgent issues, it’s clear we need farming methods that are not only sustainable but also respectful of local traditions,” (Integrating Indigenous Farming into Sustainable Agriculture, 2025). Harshberger saw ethnobotany as a bridge between botany, anthropology, and archaeology, and a way to honor the deep knowledge embedded in traditional lifeways.

For generations, many Indigenous people faced systemic efforts to erase their language, traditions, and ecological knowledge, particularly through forced assimilation policies, boarding schools, and land displacement. “(T)he average forced migration that many Tribes were forced to undertake was 239 km, with a maximum forced migration distance of 2774 km” (Farrell, J et al., as cited in Hill et al., 2024, p. 2). These historical disruptions have led to a decline in Diné Bizaad (Navajo language) fluency and the loss of traditional environmental practices that once guided sustainable living in the Southwest. “Despite the historical imposition of Settler-colonialism to cultural, spiritual, and traditional kinship practices to territorial homelands and lifeways, Indigenous communities continue to resist acculturation by actively asserting sovereign stewardship of cultural and traditional lifeways, languages, kinship practices, and land-based pedagogies” (Hill et al., 2024, p. 2). In this spirit of sovereign stewardship, this curriculum becomes a reclamation. It is a braid of science and story, rooted in the soil of ancestral memory and reaching toward futures our students will shape. The Diné believe that plants are part of a larger web of relationships that include animals, water, mountains, and ancestors. As one Diné writer put it, “We don’t just use plants—we walk with them.” Through the yucca’s fibers, they trace the wisdom of their grandmothers; through watercolor, they echo the landscapes that raised them; through inquiry and design, they learn that knowledge is not confined to textbooks, it lives in the land, the language, the hands.

To teach ethnobotany is to remind our children that they are not just learners of science, they are inheritors of it. Their questions carry the weight of generations. Their models reflect both tradition and innovation. Their investigations are acts of cultural continuity, braided with purpose and pride. We have been given a unique opportunity to honor and restore Indigenous knowledge by integrating STEM education with Diné ecological wisdom, ensuring that students see their culture, language, and ancestral science reflected in their learning. My goal is to validate and elevate Indigenous science by showing that cultural wisdom and science are not separate, but complementary. I designed this curriculum unit to introduce 4th and 5th grade students to ethnobotany through a lens that honors their cultural heritage, ecological knowledge, and lived experiences. My hope is that they see ethnobotany as not just a science. It is also the story of survival and stewardship. It offers a meaningful way to connect academic content to the wisdom of their families, communities, and

ancestors. By exploring plants, students learn about traditional uses for food, fiber, medicine, and ceremony. While these lessons are deeply rooted in Diné cultural teachings and seasonal cycles, they also reinforce the universal values of respect, reciprocity, and sustainability. In combining storytelling, biomimicry, chemistry, and engineering, students actively engage with both: scientific concepts and Diné ecological traditions. The unit also builds essential science and engineering practices aligned with the Next Generation Science Standards. Students ask questions, develop models, plan investigations, and design solutions. My intentions are to bridge traditional culture and Indigenous knowledge within the modern STEM frameworks. This interdisciplinary approach supports academic rigor while promoting equity, relevance, and engagement.

Why yucca?

The yucca plant is more than just a plant. It has played a vital role in Diné survival, serving as a source of food, medicine, fiber, and livestock care for generations. It is featured in the Diné creation story, and it is used in rituals and traditional ceremonies where it symbolizes protection and purification. The yucca plant has also been used as a clan symbol, as it is associated with resilience, adaptability, balance, and self-sufficiency, values that are deeply embedded in their families and community. By focusing on yucca plants, students can connect ancestral knowledge and hands-on learning. They have an opportunity to see their own culture reflected in STEM, reinforcing that their ancestors were scientists, engineers, and innovators. This approach fosters pride, empowerment, and curiosity, ensuring that Diné students see their knowledge, identity, and future in the curriculum.

By building a STEM unit around yucca, I can promote cultural awareness, scientific inquiry, and real-world applications, empowering students to think critically about conservation and Indigenous knowledge in modern contexts. I am creating something that doesn't just meet standards, it honors stories, uplifts identity, and plants seeds for lifelong curiosity.

As a 28-year veteran educator, I bring to the classroom a deep commitment to inquiry, creativity, and cultural relevance. My funds of knowledge include expertise in bicultural education, STEM curriculum design and phenomena-based learning, as well as a strong foundation in ecological knowledge, storytelling, and language. While I am not Diné, I have made an attempt to weave these threads together to create interdisciplinary experiences that honor Indigenous ways of knowing while building scientific literacy and critical thinking.

I approach teaching as a relational practice that is rooted in respect, reciprocity, and wonder. I am passionate about engaging students in hands-on learning that is both rigorous and joyful. I also draw from my experience as a creative up-cycler and visual designer to make learning tactile, beautiful, and accessible. At the same time, I recognize that my knowledge is not complete. I am continually learning about the diverse histories, languages, and cultural practices of the students and families I serve, especially those from tribes and communities beyond my milieu. I may be limited in my understanding of specific ceremonial protocols, linguistic nuances, or regional traditions, and I rely

on students, families, and community members as co-teachers and cultural guides. Their stories, lived experiences, and ancestral wisdom are essential to shaping a classroom that is truly responsive and sustaining. By listening deeply, inviting collaboration, and creating space for cultural expression, I strive to elevate Indigenous knowledge not as an add-on, but as a foundation for STEM learning. My goal is to ensure that every student sees their identity reflected in the curriculum and feels empowered to shape the world through both tradition and innovation.

Students will explore how Diné ancestors understood plant chemistry, sustainability, and land stewardship, knowledge that was historically suppressed but remains deeply relevant today. This approach validates Indigenous science, reinforcing that Diné knowledge is not separate from STEM but an integral part of it. By weaving language, history, and STEM together, this unit empowers Diné students to reclaim their heritage, strengthen their identity, and see themselves as scientists, engineers, and innovators, just as their ancestors were scientists and chemists out in the field 'doing' STEM. In addition, I hope that by teaching ethnobotany empowers students to once again become the knowledge keepers. I want them to understand that their culture is not separate from science—it *is* science. By grounding STEM learning in place-based, culturally responsive content, we cultivate curiosity, resilience, and a sense of belonging that extends far beyond the classroom.

Instructional Guide

This unit centers on the yucca plant as a culturally significant and scientifically rich anchor for interdisciplinary STEM education. My intention is three-fold. I aim to design a curriculum that honors Indigenous ecological knowledge, fosters inquiry-based learning, and engages students through hands-on exploration. The yucca plant offers a unique opportunity to meet these goals while aligning with Next Generation Science Standards (NGSS) and promoting culturally responsive pedagogy. I've chosen to focus on the yucca plant, not just as a botanical specimen, but as a living story. Yucca is more than a plant; it is a teacher, a healer, a fiber artist, and a quiet guardian of the land.

In building this unit I tried to braid together science, culture, and storytelling in ways that honor both ancestral wisdom and modern scientific inquiry. Yucca is deeply rooted in Diné/Navajo tradition. It has been used for generations as food, medicine, fiber, and ceremonial cleansing. By exploring yucca's many roles, students can engage with plant science through a culturally responsive lens. They learn that plants are not just passive organisms, but they are active participants in our ecosystems and our lives. This unit invites students to see yucca as a protagonist in a larger ecological narrative, one that includes erosion, adaptation, and resilience.

From a scientific standpoint, yucca offers rich opportunities to explore structure and function, chemical properties, and energy transfer. Its saponins foam when mixed with water, making it a perfect entry point into chemistry and the concept of chemical reactions. Its fibrous leaves can be

tested for tensile strength, woven into classroom engineering challenges, or used to model natural materials in design thinking. Its edible parts allow for lessons in nutrition, digestion, and sustainable harvesting. The unit is designed to integrate life science, physical science, and engineering practices. Students will investigate how yucca transforms sunlight, air, and water into healing compounds, test its cleansing properties through simple chemistry experiments, and engineer solutions using its fibrous leaves. In short, yucca is a gateway to multiple NGSS standards across life science, physical science, and Earth systems.

Yucca is a cornerstone of Diné/Navajo tradition, used for generations as food, medicine, fiber, and ceremonial cleansing. By focusing on yucca, students gain access to a living example of how plants serve multiple roles in ecosystems and human communities. This unit invites learners to explore yucca's biological structure and function, its chemical properties, and its role in traditional ecological stewardship.

The heart of this unit lies in its storytelling. I needed to tell the story of the yucca while maintaining a level of decorum that communicated my respect for the culture and its foundations. "Along with an aesthetic application not easily recognized by outsiders, the Navajo creation story has social and religious applications even more difficult for us to apprehend, and its importance transcends the arcane artistic value that an academic literary critic might assign to an established text," (Zolbrod, 1984, p. 23). To meet the need to teach about the creation story while not interfering with the cultural implications of telling the story during the time of year that is held sacred, I found myself writing and paraphrasing, almost *creating* legends I could use in the instructional capacity (Carey, 2011). For example, *Yucca Who Held the Mountain* is one legend I wrote to anchor the unit in narrative. In this story, a humble yucca plant uses memory and fiber instead of strength, to keep a mountain from crumbling. The tale reflects themes of quiet resilience, ecological balance, and the power of ancestral knowledge.

The unit is divided into three phases or twelve lessons. During phase 1 (p. 13) of the unit, students learn about the yucca as a strong, resilient plant. In accordance with the NGSS expectations for 5th grade, students learn about the yucca plant as a macroscale system that can survive in arid environments and during strong wind storms (Next Generation Science Standards, n.d.). They design a system model of the plant while also learning about the importance of the yucca plant as a part of the Diné creation story (Gallo, 2019). During phase 2 (p. 30), students begin to see the plant in terms of the structure and function of the parts within the plant. They engage in scientific investigations around the yucca plant and its adaptations for survival in desert ecosystems. The specialized adaptations (deep roots and fiber strength) further illustrate the strength of the plant. They investigate the mutualistic relationship between the yucca moth and the flowering plant (Little Seeds, n.d.). They also discover that the plant contains saponins that serve two purposes: making soap and calming the stomachs of livestock (Rathod et al., 2024). During phase 3 (p. 34) students braid yucca leaves into cord to create a strong tool used in farming. During the final phase of the unit (p. 37), students engage with a performance-based task as the evaluative component or assessment. They will learn how to

extract the saponin from the yucca root (Rathod et al., 2024); how to use a coding platform to design a simulation of the life cycle of the yucca moth (Little Seeds, n.d.) and how to use stop motion animation to create scenes that illustrate their own healing legends around the healing properties of yucca. The unit responds to a practical challenge: how to teach STEM in ways that are inclusive, hands-on, and deeply engaging.

Through this lens, students develop scientific literacy while deepening their understanding of Indigenous science and sustainability. This unit also addresses equity and access. Yucca is a plant that students can observe, touch, and understand through lived experience and community knowledge. By incorporating upcycled materials, differentiated instruction, and phenomena-based learning, the unit ensures that all students can participate meaningfully, regardless of background or ability.

In summary, this unit positions the yucca plant as a bridge between tradition and innovation, science and story, inquiry and identity. It reflects my commitment to creating learning experiences that are rigorous, inclusive, and rooted in place. With support from the Institute for Native-serving Educators (INE), I have been able to expand my knowledge about Indigenous education. I have developed materials, and received professional development to help me integrate culturally grounded STEM into my classroom. Ultimately, I chose yucca because it holds the mountain—and it holds the potential to connect my students to science, story, and self. Through this unit, I hope they'll learn not only how plants work, but how knowledge is woven across generations, how healing can come from the land, and how even the quietest things can be powerful.

Teaching Plan

*NOTE: Understanding the background of the students is important to teaching this unit of study. For this teaching plan, lessons were created for mostly non-Indigenous students living off of a reservation with some Native American classmates. In order to successfully implement the unit, the teacher will need to provide some background knowledge around Diné Cultural Considerations & Guidance.

Concept 1: PO 1: I will develop my cultural knowledge to build self-worth. (4th-6th grade) **Diné be'é'ool'įįł bóhoosh'aahgo binahjį' ádił nishdlįį dooleeł.**

- Emphasize respect and curiosity—this is a window into a living tradition, not a reenactment.
- Frame the lessons as celebrations of Indigenous science and resilience. Avoid tokenizing by tying everything back to student agency and land stewardship.
- K'é: This concept refers to kinship and the bonds of respect, responsibility, and love among members.
- Spiritual Identity: Each clan carries teachings and responsibilities that guide members through life. This structure is not just a formality, it's a way of establishing relationships, showing respect, and understanding kinship ties.
    - Students will write their kinship statements in accordance with Dine Standards: Diné Culture Standards: Concept 2, PO 2: I will express appropriate kinship terms. Shił ílįigo K'é nisdzin dooleeł.

Script to help students create their kinship statements:

- "Yá'át'ééh. Shí éí [Name] yinishyé. I am called [Name].
- [Mother's Clan] nishłį. I am born to the [Mother's Clan].Tódích'íi'nii (Bitter Water)
- [Father's Clan] báshishchíin. I am born for the [Father's Clan] Kinyaa'áanii (Towering House)
- [Maternal Grandfather's Clan] dashicheii. My maternal grandfather is from the Táchii'nii (Red Running Into the Water)
- [Paternal Grandfather's Clan] dashinalí. My paternal grandfather is from the Naakai dine'é (Mexican People)
- Diné nishłį. I am Navajo."

Their statement might sound like:

- **"Yá'át'ééh. Shí éí Ashkii Yazhi yinishyé.** I am called Ashkii Yazhi.
- **Tódích'íi'nii nishłį.** I am born to the Bitter Water Clan.
- **Kinyaa'áanii báshishchíin.** I am born for the Towering House Clan.
- **Táchii'nii dashicheii.** My maternal grandfather is from the Red Running into the Water Clan.
- **Naakai dine'é dashinalí.** My paternal grandfather is from the Mexican People Clan.
- **Diné nishłį."** I am Navajo."
- Students learn that a deeply meaningful introduction reflects a person's identity, heritage & place within the community.
    1. **Mother** – "I am born to…"
    2. **Father** – "I am born for…"
    3. **Maternal Grandfather** – "My maternal grandfather is…"
    4. **Paternal Grandfather**– "My paternal grandfather is…"

ANCHOR PHENOMENON Yucca		Lesson #1

The anchoring phenomenon will serve as the real-world event that anchors the learning and engages students as they construct an explanation. Students will learn that yucca plants have specialized adaptations (deep roots, fiber strength, saponins) that help them survive in arid environments and learn about the role the yucca plant serves in the Diné creation story.

Learning Objectives: Students will learn about how the cow's digestive process contributes to the creation of methane gas which contributes to global warming.

Materials

Science Engineering Notebooks/Field Journals

Adhesive illustrations of the cow (created using labels #5164)

large anchor chart of the cow

Resources

VIDEO(s): Cow Burps Are Warming the Planet: PBS video focuses on the role of methane emissions from cow digestion, explaining how this potent

NGSS (Science) Standard: LS1.A: *Structure and Function* – Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.
Diné Culture Standards: Concept 3, PO 2: I will classify the Land and Water beings in my environment. ***Shinaagóó kéyah dóó naaldlooshii dóó Tó ádaat'éhhígíí shił béédzin dooleeł.***
Diné Bizaad Vocabulary Wall: *béégashii* is the Diné word for cow. Challenge students to begin using the Diné vocabulary.
Need to know: Cow manure affects the climate. Enteric Fermentation: Ruminant animals like cows have specialized digestive systems that break down food through fermentation, releasing methane as a byproduct. This methane is then released, mainly through burping. Why is methane a concern? Methane is a potent greenhouse gas, meaning it traps heat in the atmosphere, warming the planet. While it stays in the atmosphere for a shorter period than carbon dioxide (about 12 years), it has a significantly higher warming potential over a shorter timescale. Manure Management: When manure from livestock is stored, it decomposes and releases methane.
Why is this important? Understanding how methane contributes to greenhouse gas emissions means students can design solutions to reduce methane output (e.g., feed additives, waste management systems) **Related STEM career fields:** Environmental scientist; Agricultural ecologist or engineer; Climate analyst; Animal nutritionist; Sustainability consultant; Biotechnologist

greenhouse gas contributes to climate change. [2:48]; How cattle impact climate change [2:27] explores the complex relationship between cattle farming and climate change, including the impact of methane emissions from cow digestion and manure, as well as the potential for carbon sequestration through pasture management. https://www.youtube.com/watch?v=5yMzdDI0OBo; Vox https://www.youtube.com/watch?v=oRUjKZOhV6E Start at 1:03-2:02

TEXT:

Article: Antimicrobial and Digestive Effects of Yucca schidigera Extracts Related to Production and Environment Implications of Ruminant and Non-Ruminant Animals: A Review:https://www.mdpi.com/2077-0472/12/8/1198

Introduce project

- Provide background knowledge of the Navajo people and the reservation in northern Arizona that spreads into Utah and New Mexico. Students need to understand that the Land Acknowledgement means that for those of us who are not Native Americans, we are all living on land that did not belong to our ancestors. Read the Land Acknowledgement:
    - *Winters Well Elementary School sits in the Tonopah Desert, west of the Hassayampa River on homelands that were sacred to Hohokam, Tohono O'odham and Yavapai Nations who live, resist, and thrive. May we honor the past, present and future generations who have and will forever call this place home. Let this land acknowledgement be a call to actively resist colonizing systems and support the resilience of Native communities and our relation to Mother Earth.*
- **Say:** We are going to learn about how our Navajo ancestors were doing STEM science many years ago by combining what they know to solve a problem. We will work for the next few weeks to combine Western science with the Indigenous ways of knowing. Ask: Can we combine ancestral knowledge and modern science, technology and engineering in STEM?

Engage

- Ask students if they know about ways that cows are harmful to our environment.
- **VIDEO:** Show video Cow Burps Are Warming the Planet: This PBS video focuses on the role of methane emissions from cow digestion, explaining how this potent greenhouse gas contributes to climate change. https://www.pbs.org/video/cow-burps-are-warming-the-planet-ggezvc/ [2:48]

Explore: Manure & Methane Management

- **Ask:** How many stomachs does the cow have? Included in the 4 stomach-system: rumen, reticulum, omasum, & abomasum. Digestive processes like fermentation, absorption, and enzymatic breakdown & microbial activity (occur especially in the rumen); with movement of ingesta between compartments.
- **Ask:** Did you know a desert plant could help cows burp less methane into the atmosphere? yucca

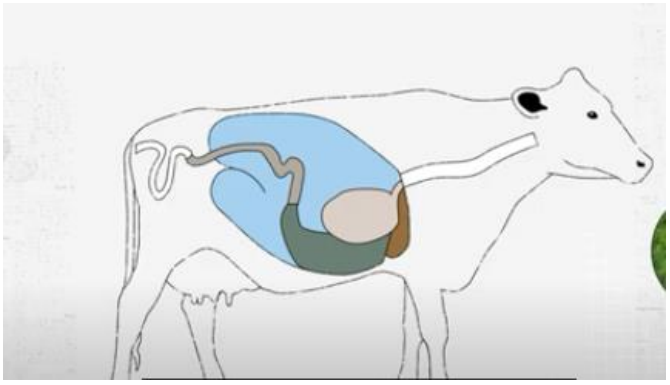
Explain: System Models

Systems and System Models

- **Ask:** How could we develop a model to describe the digestive system of the cow?
- On page 2 of the Science Engineering Notebook/Field Journals, place the sticker of the cow. Label cow in Diné Bizaad Vocabulary: béégashii is the word for cow.
- Develop a model to describe the digestive system of the cow on page 2 of the Science Engineering Notebook. Label cow in Diné and label internal parts we will address in this unit: rumen.
- **System Boundaries** (These define what's inside the system and what's outside.) Include the system boundaries, components of the system, connections between those components, the "unseen" mechanisms at work, labels, and text boxes.
    - Included in the system:
        - The four stomach compartments: rumen, reticulum, omasum, and abomasum
        - Digestive processes like fermentation, absorption, and enzymatic breakdown
        - Microbial activity (especially in the rumen)
        - Movement of ingesta between compartments
    - Outside the system:
        - Mouth and esophagus (input pathway)

- Small and large intestines (output pathway)
- External factors like feed type, environment, and cow behavior

Think of the system as starting at the entry to the rumen and ending at the exit from the abomasum.



Elaborate

- To support the concept of **Systems and System Models:** Internal and External Structures, explain how plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- **Ask:** Can we combine ancestral knowledge and modern science to design a tool, code, or process that honors yucca's role in both culture and sustainability?

Evaluate

- **Assessment Boundary:** NGSS stresses at this grade level that students should understand the macroscale systems and their function, not microscopic processes.

Phase 1: Students learn about the yucca as a strong, resilient plant.

Introduce Yucca & the DINÉ Creation Story		Lesson #2

During phase 1, students investigate the yucca plant and its adaptations for survival in desert ecosystems.

Learning Objectives: Students will learn about how the yucca plant is a part of the Diné creation story and that yucca plants have specialized adaptations (deep roots, fiber strength, saponins) that help them survive in arid environments.
NGSS (Science) Standard: LS1.A: *Structure and Function* – Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.
Diné Culture Standards: Character Building Standards: Concept 2, PO 1: I will listen to and apply Diné teachings. ***Iínísts'aa'go binahji bínashidi'neezta'igíí choosh'ii dooleeł.*** **History Standards: Concept 2, PO 2**: I will demonstrate my cultural knowledge gained from my immediate family. ***Bil k***éé***dahasht'iinii nihe'***é***'ool'iil doo bee dahinii'naanii shil b***éé***hozin dooleel.* PO 3.** I will interpret the purpose and meaning of the Navajo Nation symbols. ***Din***é ***bidahnaat'a'i doo bibee i'diidliid bee*** éé***dahozinigii baa nahashne' dooleel.***
Diné Bizaad Vocabulary Wall: *Ts'áászi'* is **yucca:** A desert plant used for food, fiber, and cleansing
Need to know: Yuccas are deep rooted and long lived, with individual plants living hundreds of years. Leaves stand out protectively and are armed with sharp points. Most have loose,thread-like fibers that curl from their edges. Flowers produced in May and June are highly palatable and used by livestock and wildlife.
Why is this important? Learning the Diné creation story is important because it's not just a myth, it's a living framework that shapes identity, values, and worldview for the Diné people. **Related STEM career fields:** plant biologist, ecologist, botanist, agricultural scientist, geneticist, horticulturalist, conservation biologist, climate scientist, biotechnologist

Culturally Responsive Teaching Consideration: *The Diné creation (Diné Bahane') story, often called the 'Emergence Story', is a sacred narrative that explains how the Diné people came into this world through a series of four worlds. It's deeply tied to identity, land, and spiritual understanding. Some parts of the story are considered ceremonial knowledge, traditionally shared by elders or medicine people at specific times of year (often winter). These elements may be inappropriate to teach casually or out of season.This is one version of the Diné creation story that has been shared publicly for educational purposes. It's important to know that for many Diné people, this story is sacred and passed down through family and ceremony.*

Materials

Science Engineering Notebook/Field Journal

adhesive illustrations of the First World *Nihodilhil:* Black World (created using labels #5164)

system model of a yucca plant

- adhesive illustrations of the yucca plant

Resources

TEXT: Navajo Creation Story: https://navajopeople.org/blog/navajo-creation-story-the-first-world-nihodilhil-black-world/ [use this version as it mentions yucca]; "Four Worlds: The Dine Story of Creation"

Time Among the Navajo by Kathy Eckles Hooker & Helen Lau Running

VIDEO: Yucca Plant
https://www.youtube.com/watch?v=2XusWoefuag
Start at [8:08]
https://www.youtube.com/watch?v=cvrUJOcx2eA

Navajo Nation Flag Song

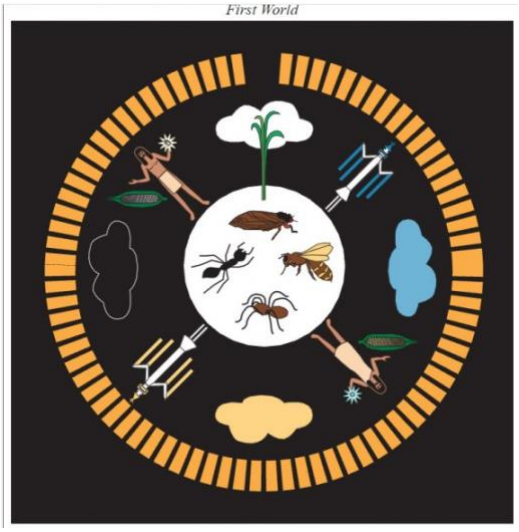
Navajo Nation Seal Lesson Power Point

Introduce project

- Provide background knowledge of the Navajo people. Explain the culturally sensitive understanding that we are talking about the creation story, we're not teaching it.
- The Creation Story: Yucca is featured in the Diné creation story, representing an element present with the First Woman and holding significance within their understanding of the world's origins. In the West of the First World, (which would later be called the Land of the Sunset), the Yellow Cloud and Blue Cloud met and created First Woman. With her was the perfect, yellow corn, just like the white corn. Except, First Woman also had the white shell, yucca, and turquoise stone with her.

Engage

- View poster of First World: Navajo Creation Story Provide some culturally sensitive understanding that we are talking about the creation story, we're not teaching it. Read to students the first world of the Creation Story.



Explore

- Share with students copies of Time Among the Navajo by Kathy Eckles Hooker & Helen Lau Running (While not solely about yucca, this book highlights traditional Navajo activities, including yucca shampoo-making, which connect to natural chemistry and Indigenous sustainability). Students can put the First World adhesive sticker onto page 3 of their field journals.

Explain System Models

Systems and System Models

- Include Navajo perspectives on yucca as a survival resource: Yucca plants have specialized adaptations (deep roots, fiber strength, saponins) that help them survive in arid environments. Students put the adhesive yucca model onto page 4 of their journals.


(Mayes & Lacy, 2012)

- Add the external structure that is below ground: roots. Label the model with the **Diné Bizaad Vocabulary:** Ts'áászi' and **yucca**: A desert plant used for food, fiber, and cleansing
- **Internal and External Structures:** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. Discuss with table groups how both the cow and the yucca plant have internal and external structures that function to support survival and growth.

Elaborate

- Ask students: How do you feel about the differences between Indigenous and Western Science? Explain.
- Today we will begin a class chart that we will add to with each lesson. Our first entry will be: **deep roots**

Feature	Function	Cultural Use
deep roots	water access	soil protection, resilience
long fibers	strength, flexibility	ropes, sandals, brushes
saponins	cleansing	soap; birth ceremonies

Evaluate

- How does the yucca plant use a system of internal & external structures to support survival and growth? Assessment Boundary: NGSS stresses at this grade level that students should understand the macroscale systems and their function, not microscopic processes.

Art Integration: Yucca		Lesson #3

Continuing phase 1, students closely observe the external structures of the yucca plant

Learning Objectives: Students will illustrate the yucca plant, paint with color and label: leaves, roots, flower.

NGSS (Science) Standard: LS1.A: *Structure and Function* – Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Diné Culture Standards (K-3): Concept 3, PO 3: I will name the various plants within my surroundings. ***Shinaagóó nanise' dahólónígíí dabízhi' shił bééhózin dooleeł.***

Diné Bizaad Vocabulary Wall: Students can label the yucca plant in Navajo: *Ts'áászi'*

Need to know: Yuccas are deep rooted and long lived, with individual plants living hundreds of years. Leaves stand out protectively and are armed with sharp points. Most have loose,thread-like fibers that curl from their edges. Flowers produced in May and June are highly palatable and used by livestock and wildlife.

Why is this important? Students engage in a layered, hands-on learning experience that blends observation, cultural respect, and scientific thinking when they use watercolors to paint the yucca plant.

Related STEM career fields: ethnobotanist, botanical illustrator, plant biologist

Materials

5"x7" water color paper (1 each)

colored pencils, pastels or water colors

yucca leaves (1 each)

Resources

VIDEO(s): How to Draw a Yucca with Ameen
Yucca Plant
https://www.youtube.com/watch?v=2XusWoefuag

Making a paintbrush from a yucca plant
https://www.youtube.com/watch?v=mhj603t9EfM

Introduce project

- Yucca is featured in the Diné creation story, representing an element present with the First Woman and holding significance within their understanding of the world's origins. In the West of the First World, (which would later be called the Land of the Sunset), the Yellow Cloud and Blue Cloud met and created First Woman. With her was the perfect, yellow corn, just like the white corn. Except, First Woman also had the white shell, yucca, and turquoise stone with her.

Engage

- Students watch the video describing how to create a paint brush from a yucca leaf. https://www.youtube.com/watch?v=mhj603t9EfM
- Students watch the video of Amreen drawing the yucca plant with a pencil. Teacher stops the video on the final scene where students can best see the plant. https://www.youtube.com/watch?v=vcCGyrCfaZI

Explore

- Distribute water color pages and ask students to write their name in the corner using a pencil.
- Students draw or sketch the yucca with a pencil.
- Use water colors to paint the picture of the plant.

Explain

- Include Navajo perspectives on yucca as a survival resource: Yucca plants have specialized adaptations (deep roots, fiber strength, saponins) that help them survive in arid environments.

The Yucca Plant Supports Biodiversity		Lesson #4

Introduce "The Yucca Who Held the Mountain"

- Revisit the Navajo seal and identify the yucca plant held by First Woman (the shell, yellow corn & turquoise).
- Tell the Yucca Legend Inspired by Indigenous Knowledge: Long ago, when the desert was young, the Four Sacred Mountains argued over who was strongest. Wind tossed their stones. Rains carved their faces. One by one, their soils began to slip away. The Holy People saw this & planted a gift at the mountains' feet, a plant with sword-like leaves & stubborn roots. "This is Yucca," they said. "Not loud like the wind. Not heavy like stone. But it holds the earth with quiet strength." Yucca sank her roots deep, holding soil that wanted to run. She soaked up water and shared it with thirsty kin. Even as the rains returned & winds howled, Yucca stood anchored & wise. From that day on, wherever Yucca grows, the land remembers how to stay.
- Introduce vocabulary: **erosion, fibrous roots, taproot, soil conservation**

Engage

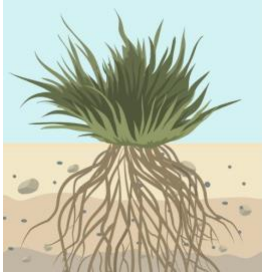
Show students a video of soil erosion: https://www.youtube.com/watch?v=BoSUEIkK_Y4

- **Ask:** What's happening to the land? What could help hold the soil in place?
- Soil erosion strips away topsoil, the nutrient-rich layer plants need to grow. Without it: Crops become less productive; Farmers rely more on fertilizers; Food security is threatened.
- Eroded soil often ends up in rivers and lakes, carrying **pollutants** and **sediment** that harm aquatic life, pollute drinking water, increase flood risks

Explore Root Race Erosion Experiment

- Students build two mini landscapes in trays: **Tray A:** Bare soil and **Tray B:** Soil with yarn or string "roots" (representing yucca)
- They simulate rain using watering cans or spray bottles and observe.
- **Ask:** Which tray erodes more? How do "roots" help?

Explain



- Add the yucca plant sticker to page 6 of the Science Engineering Notebook.

- Explain that the yucca plant is a desert survivor with deep roots and cultural significance. Add the roots to the system model that illustrates how yucca plants prevent erosion.

Elaborate

- How do roots protect the Earth? **Ask:** What did we observe? Why do roots matter?
- Create a chart comparing yucca to grass, discussing its role in erosion control to modern conservation techniques. **Ask:** How are yucca roots (Ts'áászi' biké tł'óół) different from grass or tree roots?

Plant	Root Type	Erosion Protection
grass	fibrous	moderate
yucca	deep tap root + fibers	strong

***Evaluate:** Root Reflections*

Students complete a gallery walk to see other group models of soil erosion.

- *"How do yucca roots (Ts'áászi') help the land?"*
- *"What have you learned about erosion?"*
- *"How can we protect the soil in our community?"*

Where Does Carbon Go? Yucca, Carbon & the Desert Code

Lesson #5

Students will learn about the yucca's role in soil conservation & carbon sequestration, which connects to sustainability & climate resilience.

Learning Objectives: Students will investigate how desert plants like yucca contribute to carbon sequestration and ecosystem resilience. They'll connect plant structure to function by creating an interactive simulation where a yucca plant absorbs carbon from the atmosphere through photosynthesis.

NGSS (Science) Standard: LS1.A: Structure and function; LS2.A: Interdependent relationships in ecosystems; LS2.B: Cycles of Matter and Energy Transfer in Ecosystems: Investigate soil health and how yucca plants contribute to desert ecosystems; ESS3.C: Human Impacts on Earth Systems: Indigenous agricultural practices with yucca highlight land stewardship and sustainable farming; LS2.C:

Materials

2 clear containers (jars or beakers)

2 sponges of the same size

1 scoop of healthy, biologically active soil (e.g., compost or soil from a rich garden)

1 scoop of degraded, sandy soil

Food coloring (green or red works well for visibility)

A measuring cup

Water

Ecosystem Dynamics, Functioning, and Resilience: Yucca's role in soil conservation and carbon sequestration connects to sustainability and climate resilience.
Diné Character Building Standards: Concept 3, PO 3. I will cooperate with my peers. ***Bił da'íníshta'ígíí bich'į́ shá áhwwiint'įį dooleeł.***
Diné Bizaad Vocabulary Wall:
Need to know: Carbon sequestration is the process of capturing & storing carbon dioxide (CO_2) from the atmosphere to help reduce the effects of climate change. All plants store carbon as part of the **photosynthesis process**, where they absorb carbon dioxide (CO_2) from the atmosphere & convert it into sugars to build their tissues. This carbon becomes part of the plant's **biomass**: its leaves, stems, roots & the organic matter it contributes to the soil when it dies & decomposes. However **not all plants store carbon equally**: **Trees** are especially powerful carbon sinks because of their large size, wide leaves & long lifespan. **Grasses & shrubs** store less above ground (narrow leaves collect less sunlight) but can contribute significantly to **soil carbon**, especially in healthy grasslands. **Plants with mycorrhizal fungi** (like many native desert species) can transfer *more* carbon to the soil, up to 15% more, thanks to their underground partnerships. Biological Carbon Sequestration happens naturally when plants, trees & soils absorb CO_2 during photosynthesis. For example: **Forests & grasslands** store carbon in their biomass & roots. Healthy soils, especially those managed with regenerative practices, can lock carbon underground. Oceans also absorb CO_2, storing it in marine plants & sediments.
Why is this important? Helps slow global warming by reducing greenhouse gases in the atmosphere. Supports soil health & biodiversity when done through regenerative agriculture, which plays a key role in climate change mitigation strategies worldwide.

Resources

VIDEO: Carbon Sequestration in Plants:
The Carbon Cycle:
https://www.youtube.com/watch?v=p3R-dB9K4ss [3:23]

How trees capture & store carbon:
https://www.youtube.com/watch?v=vJY3DTaE0sI&pp=0gcJCfwAo7VqN5tD [2:38]

Introduce project

- Remind students that they have previously been taught about photo synthesis
- Introduce the idea that plants absorb carbon dioxide **(CO_2)** and store it in their roots, stems, and leaves.

Engage

- Show students a sealed jar with a plant inside (or a photo of a terrarium).
- **Ask:** How does this plant survive? What happens to the air inside?
- **Ask:** What is sequestration? the process of capturing and storing a substance, often to prevent it from causing harm. In environmental science, it most commonly refers to carbon sequestration, the act of removing carbon dioxide (CO_2) from the atmosphere and storing it in a stable form

- Show a video on Carbon Sequestration in Plants:
    - The Carbon Cycle: https://www.youtube.com/watch?v=p3R-dB9K4ss [3:23]
    - How trees capture & store carbon: https://www.youtube.com/watch?v=vJY3DTaE0sI&pp=0gcJCfwAo7VqN5tD [2:38]

Explore

Activity: **Carbon Sequestration Simulation**

- Demonstrate the concept of carbon sequestration. The sponge illustrates the porous, absorbent nature of healthy soil and root systems that allow for the storage of carbon. Sponge represents how plant roots absorb carbon dioxide. While plants primarily absorb CO2 from the atmosphere through their leaves during photosynthesis, their roots play a crucial role in transferring and storing that carbon in the soil.
- Set up the “healthy soil system”
    1. Place the soil: Put the healthy, dark, compost-rich soil into the bottom of one of the clear containers.
    2. Add the sponge: Place one of the sponges on top of the soil. This sponge represents the intricate root system of a plant, and the soil itself represents the "soil carbon sponge"—the porous, living material that holds carbon.
    3. Pour the "carbon": Mix a few drops of food coloring into a cup of water. Explain that the colored water represents the carbon CO2 that plants pull from the atmosphere and transfer to the soil.
    4. Observe absorption: Slowly pour the colored water onto the sponge. The water will soak into the sponge and be absorbed by the healthy soil below. You will see the water holding capacity of the soil is very high.
- Setup the "degraded soil" system
    1. Place the soil: Put the degraded, sandy soil into the second clear container. Explain that this soil has lost its structure and biological life due to tilling or erosion.
    2. Add the sponge: Place the second sponge on top of the sandy soil.
    3. Pour the "carbon": Pour the same amount of colored water from the same food-coloring mixture onto this sponge.
    4. Observe runoff: The water will likely run through the sponge and into the soil, but much of it will either pool on top or run down the sides, failing to be absorbed. The sandy, degraded soil cannot effectively hold the water (or carbon).

Explain

What Is Carbon Sequestration?

- After the demonstration, explain the following concepts to connect the model to carbon sequestration:

- *Sponge as roots:* The sponges represent the expansive network of plant roots, which actively transport carbon compounds into the soil.
- Colored water as carbon: The colored water symbolizes the CO2 that plants capture from the atmosphere through photosynthesis.

- *Healthy soil as a carbon sink:* The healthy, compost-rich soil acts like a carbon sink, storing the carbon-rich compounds delivered by the roots. The living organisms in healthy soil, like bacteria and fungi, create a porous structure that holds carbon and water like a sponge.

- *Degraded soil as a weak sink:* The sandy, degraded soil cannot absorb and hold the "carbon" effectively. This shows that when soil is unhealthy, it releases more carbon than it stores, contributing to atmospheric CO2

- *Sequestration in the soil:* When the plant's roots and the living soil effectively "trap" the carbon, this represents successful carbon sequestration. The carbon becomes part of the soil's organic matter, keeping it out of the atmosphere.

- *Create a class model:*
    - Sunlight + CO_2 → plant growth
    - Carbon stored in roots, stems, leaves
    - Some carbon returns to soil when plants die

Elaborate

Create a class Anchor chart: How Yucca Helps or Yucca Helps the Soil and the Sky Include:

- **Prevents erosion** → Deep roots hold soil in place during wind and rain (erosion control)
- **Shares water** → Roots absorb moisture and help nearby plants survive in dry environments
- **Protects other plants** → Acts as a wind barrier and creates microhabitats in harsh environments
- **Breaks up hard soil** → Taproots loosen compacted layers, making space for water and air
- **Feeds the soil** → Fallen leaves and fibers add organic matter when they decompose
- Yucca plants contribute to carbon sequestration. As hardy, drought-tolerant perennials with deep root systems and long lifespans, they absorb atmospheric CO_2 through photosynthesis and store it in their biomass and root structures. Their ability to survive in arid environments also makes them valuable in restoring degraded soils and promoting long-term soil health, which indirectly supports carbon storage.

Evaluate

- Exit ticket: “How does yucca help the Earth?”

The Yucca Moth	Lesson #6

Learning Objectives: Students will learn that the yucca moth plays a crucial role in pollination, demonstrating mutualistic relationships in ecosystems. They will examine deep root systems, water retention, pollination with the yucca moth, and fiber strength. Students will learn about the mutualistic relationship between the yucca moth and the flowering plant.

NGSS (Science) Standard: LS1.D: *Information Processing* – Different sense receptors are specialized for particular kinds of information; Animals use their perceptions and memories to guide their actions. **5-LS2-1**: *Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.* Model nutrient cycles or pollination systems.

Diné Culture Standards: Concept 3, PO 3: I will recognize the edible plants in my environment. ***Nihinaagóó nanise' daadanígíí shił bééhózin dooleeł.***

Diné Bizaad Vocabulary Wall: *Ts'aaszi' bi lich'ąhii* is literally yucca + moth and *Ts'áászi' at'ééd* is **yucca flower:** Edible blossom, used in cooking and ceremonies

Need to know: Yucca adaptations (deep roots, drought resistance, and pollination by yucca moths). The yucca moth is a non-descript, small, whitish moth that blends well with the color of the yucca blossoms where it spends most of its brief adult life. The relationship (mutualism) can be found in NGSS Life Science standards for middle school. **Prepare:** Cut specimens of yucca flowers to observe. Cut specimens of yucca and prepare adhesives for the specimen models.

Why is this important? Mutualism helps students understand that organisms don't live in isolation. They begin to see ecosystems as dynamic networks where yucca moths rely on yucca plants, bees rely on flowers and humans rely on microbes. They are ready to move beyond simple food chains and start exploring the complex relationships that shape ecosystems. Mutualism introduces them to the idea that nature isn't just about competition it's also about cooperation and interdependence.

Related STEM career fields: From conservation biology to agricultural science, mutualism is central to solving global challenges. Understanding it early helps students see how science applies to food systems, climate resilience, and biodiversity.

Materials

colored pencils

Science Engineering Notebook/Field Journal

BOOK: *Night Life of the Yucca: The Story of a Flower and a Moth* by **Katherine B. Hauth**

Resources

PDF: Pollinator Pal:Yucca Moth https://kidsgardening.org/wp-content/uploads/2022/01/Pollinator-Pal-Yucca-moth-1.pdf

VIDEOS: Included for reference only:

Yucca rupicola and Moth Pollination This video highlights the pollination process in Travis County, Texas, focusing on *Yucca rupicola*. It offers close-up visuals of the moth interacting with the flower and emphasizes the ecological importance of this relationship.[6:28]
***INAPPROPRIATE LANGUAGE** play with audio muted

Yucca Rostrata Moth Pollenation This clip explains how the moth's specialized mouthparts are adapted for collecting and depositing pollen. It's a clear example of mutualism: the moth pollinates the flower while laying eggs inside it. **POOR AUDIO**

How Are Yucca And Yucca Moth Adapted To Each Other ... This educational video breaks down the adaptations that make this partnership work—from the moth's pollen pockets to the flower's

structure. Great for modeling structure-function relationships. **AI generated audio**

The Yucca & its Moth Around 00:03:19 and 00:03:39, you'll see detailed footage of the moth inside the flower. It also discusses other insects that interact with yucca, offering a broader ecological context. **Not engaging to children**

Introduce project

- **Inquiry-based prompt: Ask:** "Can you think of two living things that help each other survive or thrive? What do they each give and get in return?" Encourage systems thinking, open the door to examples like bees and flowers, clownfish and sea anemones, or even humans and gut bacteria.
- Explain a symbiotic relationship. Key concept: **mutualization**. Name one mutualistic relationship you've heard of. What do both organisms get out of it?

Engage

- Show Videos That Demonstrate Yucca Moth Pollination:
    1. Yucca Moth Around the 0:58 mark, this video zooms in on the actual pollination behavior. It's a great resource for showing students how the moth deliberately transfers pollen—unlike most accidental pollinators. [2:32]
    2. MOTH MAKES HOUSE OUT OF A FLOWER (The Yucca Moth) A charming field-based video that explores the moth's life cycle and its symbiotic relationship with the yucca plant. It's ideal for sparking student curiosity and storytelling. [4:21]

Explore

- Read or summarize a traditional Navajo story about plants and survival (consult local educators or texts). Night Life of the Yucca: The Story of a Flower and a Moth by **Katherine B. Hauth.** This book explores the **symbiotic relationship** between the yucca plant and the yucca moth.

Explain

yucca moth (English) Tegeticula yuccasella (Scientific)

- The yucca flower can only be pollinated by the yucca moth Ts'áászi' bí lich' ąhii (literally "yucca moth,")
- Use the 'Pollinator Pal – Yucca Moth' (PDF): A kid-friendly, printable diagram to clearly

show the pollination steps.https://kidsgardening.org/wp-content/uploads/2022/01/Pollinator-Pal-Yucca-moth-1.pdf Print page 2 for labeling.

- **Discuss Botanical sketches:** a detailed drawing of a plant that captures its structure, form, and key features, often used for scientific observation, education, or artistic exploration. It's the intersection of art and science, where close visual study helps deepen understanding of plant anatomy and adaptations

Elaborate

- Follow this process to draw the yucca moth on page in the Science Notebook.
    - Guide students to sketch the yucca plant by helping them notice its adaptive traits (like narrow leaves and fibrous texture), while also honoring its cultural significance.
    - **Focus on Accuracy:** Unlike decorative flower art, botanical sketches aim to show the plant's true proportions, leaf arrangement, stem texture, and reproductive parts.
    - **Minimal Color:** Often done in pencil, ink, or light watercolor washes to emphasize form over aesthetics.
    - **Scientific Purpose:** Used by botanists, ecologists, and educators to document species, compare traits, or illustrate field guides.
    - **Observation-Based:** Artists often work from live specimens, herbarium samples, or field photos to ensure precision.

The Secret Life of the Yucca Moth	Lesson #7

The yucca moth plays a vital role in desert ecosystems through its unique life cycle and nocturnal pollination behavior, demonstrating mutualism and adaptation.

Learning Objective: Students will describe the life cycle of the yucca moth, explain how the moth's nocturnal behavior helps it survive, model the mutualistic relationship between the yucca moth and yucca plant, connect the moth's role to energy flow in ecosystems
NGSS (Science) Standard: 5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water. 5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. 5-PS3-1 Use models to describe that energy in animals' food was once energy from the sun. 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet criteria and constraints.
Diné Culture Standards: Concept 1, PO 4: I will identify the specific phases of the day/night. ***Jį dóó tł'éé' bił hoolzhishígíí bitaa íníshíi dooleeł.***

Materials

large pizza circles

Lifecycle diagram handouts

Paper flowers + cotton balls (pollination simulation)

Flashlights (nocturnal activity demo)

Construction paper, glue, scissors

corn meal

A Handful of Dirt by Raymond Bial

Resources

VIDEO: Optional: desert ecosystem

Diné Bizaad Vocabulary Wall: *Ts'aaszi' bi lich'ąhii* is literally yucca + moth and *Ts'áászi' at'ééd* is yucca flower**. Review these terms previously taught.**
Need to know: The yucca moth is a non-descript, small, whitish moth that blends well with the color of the yucca blossoms where it spends most of its brief adult life and pollinates at night.
Why is this important? Most pollination studies focus on daytime insects like bees. But moths, bats, and beetles do critical work at night. Moths may be more efficient pollinators than bees in some cases. Nocturnal pollinators face threats like light pollution (disrupts their behavior) and habitat loss due to climate change.

video clip
Yucca Moth at Night:
https://www.youtube.com/shorts/RjgTXgr9NY4

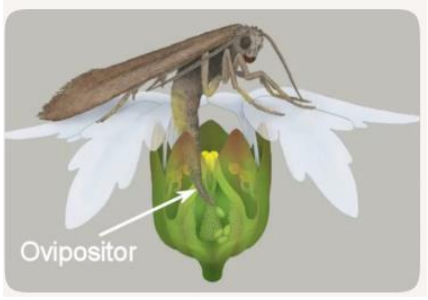
PDF: Pollinator Pal:Yucca Moth
https://kidsgardening.org/wp-content/uploads/2022/01/Pollinator-Pal-Yucca-moth-1.pdf

Introduce project

- Today we will add the system model of the yucca moth and the flower to science notebooks. Ask students to explain to table mates how the: Internal and External Structures of plants and animals' function to support survival, growth, behavior, and reproduction. **(Systems and System Models)**

Engage

- **Ask:** "What do you do at night? What animals are awake while you sleep?"
- Show a short video or image of a yucca moth and yucca plant: https://www.youtube.com/shorts/RjgTXgr9NY4



- Introduce the concept of nocturnal animals pollinating at night and review mutualism taught in the prior lesson.

Explore

- **Lifecycle Activity:** Students build a paper wheel story board showing:
  - *egg → larva → pupa → adult*
  - A yucca flower blooming at night
  - A moth pollinating the flower and laying eggs

- Larvae feeding on seeds, but not all which ensures the plant survives
- **Pollination Simulation:** Use cotton balls & corn meal to mimic moths transferring pollen between paper flowers

Explain

- Yucca plants rely on moths for pollination, which enables seed production and growth. Discuss how the moth lays eggs in the flower and how larvae feed on seeds.
- The yucca moth and yucca plant demonstrate mutualism and energy flow—larvae feed on seeds, moths pollinate flowers. Students trace energy from sunlight → yucca plant → moth larvae
- Highlight how these benefits both the moth and the plant

Elaborate

- Yucca moths and yucca plants have a one-of-a-kind relationship:
  - The moth pollinates the flower at night.
  - Then she lays her eggs inside it.
  - Her larvae feed on some seeds, but not all, so the plant still reproduces. This is an example of mutualism, where both species depend entirely on each other to survive.
- **Nocturnal Adaptation Demo:** Turn off lights, use flashlights to simulate how moths navigate at night
- Discuss camouflage, predator avoidance and other nocturnal pollinators

Evaluate

- Observation during activities as students complete a lifecycle wheel
- ***Exit ticket drawing and sentence in the reflection journal:*** Why is it important to learn about the nocturnal pollination behavior of yucca moths?

Phase 2: Explore **biomimicry** in engineering inspired by yucca fibers and structure.

Braiding with Yucca		Lesson #8

Learning Objectives: Students will learn that yucca fibers have unique chemical properties that make them strong and flexible & they can be tested for tensile strength, linking to engineering and biomimicry.
NGSS (Science) Standard: PS1.A: *Structure of Matter* –Design a biodegradable fiber project inspired by yucca's use in weaving and rope-making. PS3.C: *Relationship Between Energy and Forces* – Students design biodegradable fiber prototypes inspired by yucca & refine yucca-based engineering projects, applying biomimicry principles. Examine fiber strength.
Diné Character Building Standards: Concept 4, PO 4: I will practice life-skills from my relatives. ***Shik'éí bits'áádóó iiná ó'ool'įįł bóhoosh'ááh dooleeł.***
Diné Bizaad Vocabulary Wall: ***Ts'áászi' yishtł'óh*** (literally: I am braiding yucca), the yucca leaf is called ***bit'áá*****:** Used to make rope, baskets, and tools.
Need to Know: Yucca has diverse uses. Leaf fibers can be used as cordage, weaving material, and to make sandals. Discuss yucca's role in medicine, fiber production, and animal care. Yucca fiber is used for rope & tools. The strong fibers from yucca leaves were historically used to make ropes, harnesses, and other tools for managing livestock. The strong fibers of yucca were used in basket weaving and clothing, connecting craftsmanship to sustainability.
Why is this important? This is a tactile, cultural, and scientific experience that connects students to ancestral knowledge, ecological stewardship, and engineering design. Braiding yucca is a living tradition among Diné and other Indigenous communities. They engage in a practice passed down through generations. They honor the ingenuity of their ancestors. They build pride in their cultural identity through hands-on experience. Braiding yucca teaches: Material science: Students observe fiber strength, flexibility, and durability. Engineering principles: They learn tension, patterning, and structural integrity. Design thinking: They adapt techniques for different uses—rope, baskets, sandals, tools.

Materials

yucca leaves
metal spoons/rock scrapers
pony beads

Resources

VIDEO*: "Yucca Cord Made Easy"*
https://www.youtube.com/watch?v=XdlNpZOx2D8

Introduce project

Today we will be making yucca cordage:

Engage: "What Can a Leaf Do?"

- Show students a photo or video of a braided yucca rope or sandal.
- **Ask:** What do you think this is made of? How could a plant become something strong enough to carry weight?
- Read a short version of "The Yucca Who Held the Mountain" to ground the lesson in story and stewardship:

> *Long ago, when the Four Sacred Mountains still whispered to the stars, the People lived in harmony with the land. But one summer, the winds grew restless, and the rains forgot their way home. The mountain called Dził Ná'oodiłii began to crumble, its roots drying, its animals fleeing.*
>
> *The elders gathered in worry. "If the mountain falls," they said, "the balance will break."*
>
> *Among the plants that grew near the mountain's base was a humble yucca, slender and quiet, with leaves like spears and flowers like pale moons. The other plants mocked her. "You are too small," they said. "You cannot hold anything."*
>
> *But the yucca whispered to the Earth. "Let me try."*
>
> *That night, as the stars blinked in silence, the yucca sent her roots deep—deeper than any plant had dared. She drank from the last hidden spring and held the soil tight. Her leaves caught the wind and sang to the rain. And when the moth came—white-winged and gentle—it danced through her blossoms, carrying pollen like prayers.*
>
> *The rains returned. The mountain sighed. Life crept back. The elders saw what had happened. "It was not strength," they said, "but devotion."*

> *From that day on, the yucca was honored. Her fibers were used in ceremony, her flowers in healing, her story in teaching. And the moth, her silent partner, was never forgotten.*

So, when you see the yucca bloom beneath the stars, remember: even the smallest can hold the mountain.

Explore Fiber to Function

Students investigate the **structure and strength** of plant fibers:

- Compare **yucca leaves** (or substitute raffia, corn husks, or long grass) to other materials (paper, string, plastic)
- Prior to cutting a yucca leaf, explain the practice of giving a blessing to a yucca plant before you cut off the yucca leaves.
- Show VIDEO: Yucca Cordage Made Easy https://www.youtube.com/watch?v=XdlNpZOx2D8
- Soak, pound, and scrape fibers (if using real yucca) to reveal inner strands
- Try twisting or braiding fibers and test their strength

Explain Why Yucca Works

- Remind students that the yucca plant is a desert survivor and a cultural resource.
- Share that Diné and Pueblo peoples have used yucca for cordage, baskets, brushes, and ceremony for generations. Yucca fiber is used for rope & tools. The strong fibers from yucca leaves were historically used to make ropes, harnesses, and other tools for managing livestock. The strong fibers of yucca were used in basket weaving and clothing, connecting craftsmanship to sustainability.
- **Ask:** What makes yucca fibers strong? How do the plant's structure and chemistry (e.g., saponins, fibers) help it survive? Why might Indigenous peoples choose yucca for tools and ceremony?

Add to the class chart:

Feature	Function	Cultural Use
deep roots	water access	soil protection, resilience
long fibers	strength, flexibility	ropes, sandals, brushes
saponins	cleansing	soap; birth ceremonies

Elaborate Braiding with Purpose

Students create their own **yucca-inspired braid:**

- Practice 2- or 3-strand braiding with natural fibers
- Use braids to create bookmarks, bracelets, or classroom decorations
- Reflect on how braiding connects to community, identity, and survival

Evaluate: Braiding Reflections

Students complete a journal or oral reflection: Compare Indigenous knowledge of yucca to modern ecological sustainability practices and consider cultural uses of yucca.

- *"What did I learn about yucca?"*
- *"How does braiding connect us to the past?"*
- *"What can we learn from plants and people who live in balance with the land?"*

Optional: Create a class "braid wall" where each student adds a strand representing their learning, family, or values.

Phase 3: Analyze **yucca's role in Indigenous traditions**, especially Navajo agricultural and medicinal uses.

Yucca as Nourishment	Lesson #9

Learning Objectives: Students will research traditional uses of yucca for food and learn that *t*he yucca plant supports biodiversity by providing food and fiber for animals and humans.

NGSS (Science) Standard: LS2.A: *Interdependent Relationships in Ecosystems* - Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (Systems and System Models) or Construct an argument that plants have internal and external structures that support survival. **LS1.C (Energy in Animals),** ESS3.A: *Natural Resources* – Yucca plants have been used by Navajo farmers for food, fiber, and medicine, demonstrating sustainable resource use.

Diné Culture Standards: Concept 3, PO 3: I will recognize the edible plants in my environment. ***Nihinaagóó nanise' daadanígíí shił bééhózin dooleeł.***

Diné Bizaad Vocabulary Wall: ***Ts'áászi' at'ééd*** is yucca flower: Edible blossom, used in cooking and ceremonies. Yucca fruit is called ***hashk'aan.***

Need to know: Yucca plants have been used by Navajo farmers for food. Stalks, buds, flowers, and some fruits have served as food. The fruits of banana yucca are fleshy and succulent, roughly like short, fat, green bananas. (Most other yuccas have dry, hard fruits.) Banana yucca fruits are traditional foods. They are prepared by roasting or baking, stripping out the seeds, pounding the remaining flesh into a pulp, forming the pulp into flat cakes, and sun-drying for later use. Eat yucca. 😐

Prep

- Cut specimens of yucca flower to observe

Why is this important? Teaching students that yucca is edible reinforces traditional foodways and survival strategies, respect for land-based knowledge passed down through generations and reinforces the humane idea that plants are relatives, not just resources.

Materials

Yucca identity plate

a photo of a yucca root dish

Resources

VIDEO(s):

https://www.youtube.com/shorts/CA_mWPS2VII yucca flowers & pods being cooked

https://www.youtube.com/shorts/n7Sb492vbRI yucca root being harvested

Introduce project

Show students a photo of a yucca root dish (like baked or mashed yucca).

Ask: Would you eat this? Where do you think this food comes from?

Engage "What's on the Plate?"

Show a short clip of yucca being harvested or cooked.

Remind students that the **yucca plant** is a traditional food source for many Indigenous peoples, including the Diné. At one time, the entire yucca plant was the staple of the Navajo diet (Frisbie & Sandoval, 2018, p. 145). Share that it's not just food—it's part of identity, family, and survival. There are 2 edible components: the fruit and the root

Explore Yucca as Food

- Set up a **yucca tasting station** (if available and safe) or show a cooking demo video.

  Students:

- Observe raw vs. cooked yucca
- Compare to potatoes or other root vegetables
- Discuss preparation methods (peeling, boiling, baking)
- Compare yucca vs. yuca (cassava) using a Venn diagram.
- Watch a demo or video on safe preparation (peeling, boiling, frying).
- Optional: Soak dried yucca root and observe texture changes

Explain Clan, Kinship, and the Plant That Connects Us

Introduce the concept of Diné clan relationships:

- **Clan Symbol:** In some Navajo and Pueblo cultures, the yucca plant has been used as a clan symbol, further indicating its cultural significance.
- Among the Diné (Navajo) clans, there is one called Hashk'ąąn Hadzohí, which translates to "Yucca Fruit Strung Out" or sometimes "Banana Yucca Clan". This clan name reflects the importance of the yucca plant in Diné life—not just as a food source, but as a symbol of resilience, utility, and connection to the land.

- The clan system is deeply rooted in identity, kinship, and storytelling. So when a plant like yucca becomes part of a clan name, it's a sign of how central it is to both survival and cultural meaning.
- Introduce the idea that Diné people identify with four clans: born to, born for, maternal grandfather's clan, and paternal grandfather's clan.
- Explain that Diné people introduce themselves by their four clans
- Discuss how plants like yucca are tied to family roles, ceremony, and identity
- Share that yucca is used in birth ceremonies, cleansing rituals, and daily life
- Discuss how cooking transforms starches and removes saponins.
- Chart nutritional content: carbs, fiber, vitamins.
- Link to energy transfer in food chains and digestion.
- Explore Indigenous uses: food, fiber, soap, ceremony

Create a class chart: (cut out cards and write each term, ask students to place the cards where they think it should go)

Yucca Use	**Science Connection** *(Western)*	**Cultural Connection** *(Indigenous)*
food	nutrition, energy	shared meals, survival
soap	chemistry, saponins,	cleansing, ceremony
fiber	engineering, structure	basketry, weaving, identity

Share that Hashk'ąąn Hadzohí is a clan associated with the yucca fruit, which carries meanings of protection, resilience, and survival.

Elaborate: My Clan, My Plant, My Plate

Students create a **"Yucca Identity Plate":**

- Draw or collage a plate with foods that represent their family or culture
- Include yucca and label its uses
- Write a short reflection: *"How does food connect to who we are?"*
- Invite students to share a family food story or recipe

Evaluate: Roots of Identity

Students complete a journal page or oral reflection: Exit ticket: "Three ways yucca nourishes people and the land."

- *"What did I learn about yucca?"*
- *"Why is it more than just a plant?"*
- *"How do the Diné show respect for food and family?"*

Optional: Create a class "clan web" showing how we're all connected through food, land, and story.

Phase 4: Design a **hands-on experiment or coding simulation** related to yucca plant sustainability.

Healing from the Desert: Yucca as Medicine		Lesson #10

Learning Objectives: Students will learn that the yucca plant has medicinal and healing properties & contains saponins, which create natural soap through chemical reactions. Test & Engineer a natural soap-making experiment using yucca roots, which contain saponins using the soap-making process of dried yucca root and water; understand the cultural significance of yucca in Diné ceremonies; explore the chemical properties & examine saponins, the compounds that make yucca a natural cleanser that make it useful for cleansing; compare traditional and modern applications of yucca through a hands-on soap-making experiment.
NGSS: 5-PS1-3: Identify materials based on their properties; 5-PS1-4: Mixing substances to form new ones; 5-LS1-1: Plants get materials for growth from air and water; 5-LS2-1: Movement of matter in ecosystems
Diné Character Building Standards: Concept 4, PO 3: I will express appreciation for the teachings from my relatives. ***Shik'éí be'iina' dóó bina'nitin náás deeyíléhígíí baa ahéédh nisin dooleeł.***
Diné Bizaad Vocabulary Wall: *Azee'* is **medicine:** traditional healing practices
Need to know: Roots can be used as a laxative; Saponins contain bioactive compounds that make them valuable for medicinal applications. Their structure includes a hydrophobic aglycone (sapogenin) and a hydrophilic sugar moiety, allowing them to interact with biological membranes and influence various physiological processes. Here are some key medicinal properties: *Anti-inflammatory* effects – Saponins help reduce inflammation, making them useful in treating conditions like arthritis and digestive disorders. *Antimicrobial* properties – They exhibit antibacterial and antifungal activity, which can support wound healing and natural cleansing. *Immune system modulation* – Some saponins, like those found in ginseng, enhance immune responses and may help fight infections. *Cholesterol-lowering* effects – Saponins bind to cholesterol in the digestive tract, reducing absorption and supporting heart health. *Antioxidant* benefits – Their ability to neutralize free radicals contributes to cell protection and longevity
Why is it important? Understanding how plants like yucca produce healing compounds helps students grasp key life science concepts: structure and function, energy transfer, and adaptation. It also introduces them to chemistry through natural substances (i.e. saponins, antioxidants, and anti-inflammatory agents) without needing a lab full of synthetic chemicals.

Materials

pH test strips

Navajo Medicine: https://www.usahistorytimeline.com/pages/navajo-herbal-remedies-nature-s-pharmacy-9744b2ba.php

dried yucca root

water

jars

strainers

observation sheets

Introduce project

- Show students a photo of a yucca plant and a bottle of herbal salve or tea. **Ask:** What do you think this plant can do? Have you ever used a plant to feel better?
- Introduce the idea that yucca has been used for centuries by Indigenous peoples to treat inflammation, arthritis, skin conditions, and more
- Explain that many people use plants for medicinal purposes.
- Ask students to discuss any examples of this that they use at home.

Engage: "Can a Plant Be Medicine?"

- Show a short video clip of yucca's traditional medicinal uses
- **Ask:** *"Can plants heal people? How do we know?"*

Explore Plant Power Investigations

#1 Saponin Soap Test

Students test different plant materials (yucca root, soapwort, or safe substitutes) for saponin content:

- Soak and shake chopped yucca samples in water
- Observe which ones foam
- Observe how saponins in the plant create natural suds.
- Discuss the chemical function & structure of saponins, what allows them to clean and soothe and why they were valuable long before
- Record results and discuss: *"What does the foam tell us?"*

#2 Testing the pH of Yucca Water

- Let students grate dried yucca root and mix it with warm water.
- Test pH of yucca water vs. tap water
- Yucca contains natural compounds called **saponins,** which act like soap and can change the pH of water. When students mix yucca with water and test its pH, they're observing a real chemical interaction
- Testing pH teaches students how to:
    - Use tools like pH strips or meters
    - Record and interpret data
    - Compare results across samples (e.g., tap water vs. yucca water)
- Students learn where it falls on the pH scale—acidic, neutral, or basic—and what that means for its uses. For example:
    - A slightly acidic pH might explain its cleansing power
    - A neutral pH might make it gentle on the skin

Explain

- Plants with medicinal properties used in traditional medicine for their healing qualities, used to treat ailments and restore balance and harmony. This includes the yucca plant.
- Discuss the concept of Hózhó (balance, harmony, and wellness) and show how yucca supports that balance in both physical and spiritual ways & that it has long been used by Diné medicine people for cleansing, wound care, and digestive support.
- Explain that its saponins give it natural antimicrobial and anti-inflammatory properties, which make it useful for:
    - Treating minor wounds, rashes, or joint pain
    - Supporting digestion in people and livestock
    - Yucca poultices were applied to wounds, burns, and skin irritations, using its antimicrobial and anti-inflammatory properties to promote healing.
    - Yucca tea was sometimes used to ease joint pain and digestive issues, reflecting its role in internal cleansing and wellness.
    - Yucca was often included in ceremonial preparations, particularly in rites of passage and healing rituals.

Elaborate

Create a class chart:

Yucca part	Compound	Use
root	*saponin*	*soap, joint pain relief*
leaf	*antioxidants*	*skin protection*
flower	*nutrients*	*traditional tea*

Saponins Help Livestock	Lesson #11

Learning Objectives: Students will learn that the yucca plants store energy efficiently, and their roots contain saponins, which aid digestion in livestock. Saponins contain bioactive compounds that make them valuable for medicinal applications [in humans and animals];
NGSS (Science) Standard: LS1.C: *Organization for Matter and Energy Flow in Organisms* – ESS3.A: *Natural Resources* – Yucca plants have been used by Navajo farmers for food, fiber, and medicine, demonstrating sustainable resource use.ESS3.C: *Human Impacts on Earth Systems* – Indigenous agricultural practices with yucca highlight land stewardship and sustainable farming.
Diné Culture Standards: Concept 3, PO 4: I will identify the usage of herbs. ***Azee' chodao'ínígíí shił bééhózin doleeł.***
Diné Bizaad Vocabulary Wall: *Azee'* is medicine**:** traditional healing practices; ***Ch'il łikan bigaaní*** is rumen
Need to know: Yucca contains saponins, natural compounds that can aid digestion and reduce intestinal inflammation. Historically, farmers noticed that animals consuming yucca-rich forage had fewer digestive issues and improved nutrient absorption. Scientific studies have since confirmed that yucca extract can help reduce ammonia emissions in livestock and support gut health. Traditional knowledge, passed down through generations, played a key role in recognizing yucca's medicinal properties before modern research validated its effects.
Why is it important? Saponins contribute to ruminant health. Saponins can enhance **ruminal fermentation,** helping livestock break down food more efficiently. They reduce populations of rumen protozoa, which compete with beneficial microbes for nutrients. This leads to: better nitrogen retention, increased protein availability and enhanced overall digestion **Related STEM career fields:** Ethnobotany, Chemistry, Sustainable livestock care

Materials

Antimicrobial and Digestive Effects of Yucca schidigera Extracts Related to Production and Environment Implications of Ruminant and Non-Ruminant Animals: A Review:https://www.mdpi.com/2077-0472/12/8/1198

blank, 4 panel comic strip

colored pencils

Resources

VIDEOS:

For students:Stop Motion Animation Basics for Kids! Photography Lessons with Heidi HopeStop Motion with Drawings: https://youtu.be/SFXZdpIc0Kw https://youtu.be/J3pzivXGMfI Stop Motion Animation | Kid's Activitieshttps://youtu.be/70iNa0JR47k

For teacher: Stop Motion: A How to Guide

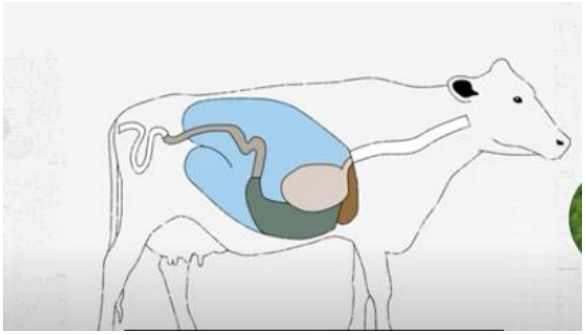
Introduce project "Can Soap Help Livestock?"

- Show students a photo of a Diné sheep herder or a traditional livestock corral.

- **Ask:** How do you think people kept their animals healthy before modern medicine? Do you think plants could help?

Engage

- Yucca plants contain a natural chemical called **saponin.** When livestock eat food mixed with yucca extract, the saponin helps their stomachs (specifically, the **rumen,** one of the stomach chambers in a cow) break down food more easily. This makes digestion smoother and as a result, cows produce less **methane gas**, which is a major contributor to climate change.



- Think of it like this: saponins are tiny helpers that calm the bubbles in a cow's stomach, making it easier to absorb nutrients and waste less energy. Saponins extracted from yucca plants have been shown to improve digestion in cattle while reducing methane emissions, offering both environmental and nutritional benefits. These naturally occurring compounds act as defaunating agents in the rumen, selectively reducing populations of protozoa that contribute to methane production. By disrupting the microbial ecosystem responsible for methanogenesis, saponins help shift fermentation pathways toward more efficient nutrient utilization. In addition to lowering methane output (a major greenhouse gas) saponins enhance nitrogen use efficiency and support better feed conversion, which can lead to improved weight gain and overall animal performance. Research has demonstrated that dietary inclusion of yucca-derived saponins at appropriate levels (typically 0.5–1% of dry matter) can significantly reduce enteric methane emissions without compromising animal health. **Scientists and farmers now use yucca as a natural way to support healthier animals and a healthier planet.**

- Create a class chart:

Yucca Use	Science Connection	Livestock Benefit
root suds	saponins=foam	cleans fur, repels parasites
wash water	antimicrobial	soothes skin, reduce infection
feed additive	anti-parasitic	supports digestion, removes worms

Explore Comic Strip

Storyboard the Message

- Problem: Cow with an upset stomach (groaning, bloated, maybe dramatic mooing)
- Solution: Yucca root with magical saponins enters the scene
- Result: Happy cow, reduced gas, improved digestion, maybe a dance party
    - **Panel 1:** A cow looks worried, saying, "I'm making too much methane!"
    - **Panel 2:** A wise desert plant (yucca) says, "Let me help you with some saponins."
    - **Panel 3:** Inside the cow's belly, digestion becomes smooth—fewer bubbles!
    - **Panel 4:** The cow smiles: "Now I feel great and I'm helping the Earth!"

Scratch Rumen Reaction Simulator

Use Scratch to code a Rumen Reaction Simulator

- Concept: Students simulate a cow's digestive system with and without yucca-based saponins
- Student codes: A stomach graphic that produces methane bubbles after digestion. A toggle for "yucca treatment" that reduces methane output (fewer animated bubbles). A data dashboard showing methane emissions, feed efficiency, and carbon impact over time.

Explain

- We will use Cloud Stop Motion to animate how yucca's saponins help cattle feel better. This is a blend of chemistry, storytelling, and animal science. It's also a perfect way to show others how plant-based compounds can reduce inflammation and support digestive health in livestock.

- The dual impact of using saponins to support digestive health and mitigate environmental impact—makes yucca saponins a promising tool in sustainable livestock management, especially in arid regions where the plant is native and culturally significant.

Elaborate

- Show the video to explain Stop Motion Animation https://www.youtube.com/watch?v=wVjMFU11hVA&t=10s
- Show the video How I Animated This Freezing Rain Cloud https://www.youtube.com/watch?v=6ej4MsVm4OE

- Place a toy cow and a yucca root (or paper cutouts) on a table. **Ask:** "What if this cow could move? What if this plant could heal it—on camera? You're going to make that happen. With stop motion."

🎥 *Video Script*

Title: "Can Yucca Help Save the Planet… One Cow at a Time?" or "Design a Yucca Livestock Remedy"

Challenge: Design a natural treatment for livestock using yucca.

Students:

- Choose a health issue (e.g., itchy skin, parasites, dirty hooves)
- Design a product (e.g., yucca wash, hoof soak, herbal salve)
- Label ingredients and explain how it works

Students create a short video explaining how yucca's natural saponins help reduce methane emissions, relieve itchy skin, or can be used to make a shampoo for livestock. They can include:

- A skit or animation (i.e. a "burpy" cow before and after yucca or a sheep with dirty hooves, etc.)
- Fun graphics showing how saponins break down food and lower gas.

🎬 ***Commercial Creation Plan using Stop Motion.*** https://www.stopmotionstudio.com/ or https://cloudstopmotion.com/

Characters & Props

- Clay or LEGO cows
- Yucca root character (cape, lab coat, or superhero mask?)
- Gut model (paper intestines, maybe a "rumen rollercoaster")
- Speech bubbles or signs for key facts
- LEGO figures, clay models, paper cutouts, or classroom objects.
- Backgrounds made from construction paper or printed scenes.
- Tripods or DIY stabilizers (like stacked books) to keep cameras steady.

Script Ideas

- **"Feeling bloated, Bessie? Try Yucca Root Rescue!"**
- **"Saponins: The gut's best friend!"**
- **"From desert plant to dairy delight—Yucca saves the day!"**
- **"The Mystery of the Moving Plant"** Show a short, silent stop motion clip of a yucca root bubbling in water (real or animated). **Ask:** "What's happening here? Is this magic or science?" Reveal: It's saponins in action—and students will animate their own healing story using stop motion.
- **"Foam and Film Challenge"** Set up a mini demo: shake yucca root in water and watch it foam. Say: "This foam has been used to heal skin, soothe cattle, and clean ceremonial tools. But today, it's going to star in your movie."
- **"Cow in Crisis!"** Present a cartoon cow with a sad face and a thought bubble: "My tummy

hurts!" **Ask:** "What plant could help this cow feel better?" Reveal: Yucca! Students will animate the cow's healing journey using stop motion and science.

Stop Motion Tips

- Use Cloud Stop Motion on Chromebooks
- Keep camera steady with DIY tripods
- Encourage 10 frames per second for smoother motion
- Move objects slightly between each photo.
- Use onion skinning (if available) to align movements.

Once frames are captured:

- Add music, voiceovers, or sound effects.
- Insert titles and credits.
- Export as MP4 or GIF.

Performance	Lesson # 12

Learning Objectives: Students reflect on what they've learned about yucca's cultural, ecological, and scientific significance, then apply that knowledge by designing a modern-day solution inspired by traditional yucca uses.
NGSS: 5-LS1-1: *Support an argument that plants get the materials they need for growth chiefly from air and water.* Students explore how yucca grows and thrives in arid environments, connecting traditional ecological knowledge with plant biology.; 5-LS2-1: *Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.*Students investigate yucca's role in ecosystems and its use by humans and livestock, including saponins aiding digestion.; 5-PS1-3: *Make observations and measurements to identify materials based on their properties.* Students test yucca fibers, observe saponin reactions, and compare plant-based materials in engineering tasks.; 5-PS1-4: *Conduct an investigation to determine whether the mixing of two or more substances results in new substances.* Students explore how yucca saponins interact with water to create foam—linking chemistry to traditional soap-making.; 3-5-ETS1-1: *Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.* Students design yucca-inspired inventions or tools, connecting ancestral innovation to modern design thinking.; 3-5-ETS1-2: *Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.* Students prototype and evaluate solutions—like biodegradable cleaners or fiber-based crafts—using yucca as inspiration.
Diné Language Standards: Concept 3, PO 3: I will demonstrate my cultural knowledge in oral presentations. ***Shee'é'ool'įį́ł baa ákonisinígíí baa náháshne' dooleł.***
Diné Bizaad Vocabulary Wall: Yá'át'ééh *(yah-ah-teh)* – Excellent, beautiful, harmonious

Materials

Indigenous Stewardship Methods: [Indigenous Stewardship Methods and NRCS Conservation Practices]

Integrating Indigenous Farming Practices: [https://ecolonomics.org/integrating-indigenous-farming-practices-into-modern-sustainable-agriculture-systems/]

Introduce project

Show what you've learned about the yucca plant: its cultural, ecological, and scientific importance, by choosing one of the following final projects. Your work should reflect both traditional knowledge and STEM practices. Choose 1 of the following activities…

Choice Board

Symbolism in Storytelling: Threads of Mutualism

- Similar to Shannon Conley's art quilt, students design quilt squares or paper panels that represent:
    - The yucca plant

    - The moth
    - The desert ecosystem
- The idea of balance and interdependence
- Begin with a Diné story or teaching (with permission or from a trusted source) that highlights yucca's role in cleansing, protection, or survival
- Then ask: Why do you think this plant was chosen for such important moments?
- Create a class "yucca plant" quilt on the wall, with each student's contribution forming the leaves or blossoms. Assemble them into a class "quilt" that tells the whole ecological story.

Science Investigation Poster: Yucca's Secret Weapon-Saponin

Design a poster that explains a hands-on investigation you conducted (e.g., testing saponins, modeling fiber strength). Include your question, procedure, results, and what you learned. Use yucca's biology to explain its symbolism:

- Protection: Its sharp leaves deter predators.
- Purification: Its saponins create natural soap.
- Resilience: It survives in harsh desert climates.
- Adaptability: It grows in rocky, dry soils with minimal water.

Watercolor & Braiding Exhibit

Curate a mini exhibit that includes your braided yucca fiber and a watercolor painting inspired by traditional uses. Write a short artist's statement explaining the science and cultural meaning behind your work.

Yucca-Inspired Agricultural Engineering

Design a modern-day invention inspired by yucca's properties. Create a prototype or sketch and explain how it blends traditional knowledge with engineering design. Share how Diné farmers traditionally used dryland farming, crop rotation, and plant knowledge (like yucca) to sustain families and ecosystems. Use yucca to explore:

- Low water needs → drought resilience
- Deep roots → erosion control and soil stability
- Multi-use plant → food, fiber, soap, medicine = zero waste
- Pollinator relationships → biodiversity and ecosystem health

Illustrated Storybook or Zine

Write and illustrate a short story or zine that teaches others about yucca's importance. You can include diagrams or character-driven narratives that blend science and story. Let students observe, draw, or model these traits and connect them to human qualities. "Yucca survives where others can't. It protects, cleanses, and grows again after hardship. What does that remind you of in your own life or community?"

A **student zine** template is a simple, foldable booklet layout that helps learners organize their ideas into a mini-magazine. It's usually made from a single sheet of paper folded into 8 pages, no staples

needed! Zine Planning Template students plan and create their own zines. It's great for visual thinkers and project-based learning. You could use these templates for a yucca-themed zine that combine:

a. Traditional uses of yucca (medicine, ceremony, fiber)
b. Scientific properties (saponins, drought resistance)
c. Personal reflections or clan connections Illustrations, bilingual vocabulary

Evaluate Rubric

Criteria	**4** Exceeds Expectations	**3** Meets Expectations	**2** Approaching	**1** Needs support
Engineering Design Process **Naaltsoos bá hooghanígíí nihá níł hóló**	Follows all steps with creativity & iteration. Thoughtfully improves design based on testing and feedback	Follows the design process and makes revisions based on test results.	Follows some steps. Limited testing or revision.	Needs help to follow the design process. Little or no testing or revision.
Content Knowledge/ **Nitsáhákees** *(nih-tsa-ha-kiss)*	Demonstrates deep understanding of yucca's cultural, ecological & scientific roles; integrates multiple concepts	Demonstrates clear understanding of yucca's significance with accurate science & cultural connections	Shows partial understanding; some ideas may be unclear or incomplete	Limited understanding; major misconceptions or missing key ideas
STEM Practices **Nahat'á** *(na-ha-t'ah)*	Skillfully applies science & engineering practices (e.g., modeling, investigating, designing) with evidence & reasoning	Applies relevant STEM practices with some evidence & explanation	Applies STEM practices but lacks clarity or depth	Minimal use of STEM practices; unclear or unsupported
Creativity & Design **liná** *(ee-nah)*	Project is original, engaging & thoughtfully designed; shows innovation & care	Project is well-organized & creative; shows effort & thought	Project shows some creativity but may lack cohesion or polish	Project is incomplete or lacks creative effort
Communication & Presentation **Yódíílzin** *(yo-deel-zin)*	Communicates ideas clearly & effectively through visuals, writing, or oral presentation; audience engagement is strong	Communicates ideas clearly; presentation is organized & understandable	Communication is uneven; some parts unclear or underdeveloped	Communication is unclear or missing key components

Cultural Relevance & Reflection **K'é** *(keh)*	Thoughtfully connects project to Indigenous knowledge, personal identity, or community values; includes meaningful reflection	Includes cultural connections & some reflection on learning	Limited cultural relevance or reflection; may feel surface-level	No clear cultural connection or reflection included

Reflective Journal

Cultural & Ecological Inquiry

- How has the yucca plant helped Diné communities survive and thrive in the desert for generations?
- What can we learn from traditional uses of yucca to solve today's environmental challenges?
- How can we use what we know about yucca's structure and chemistry to design sustainable products?
- In what ways can yucca inspire engineers and coders to create eco-friendly innovations?
- How can studying yucca help us become better caretakers of our land, animals, and communities?

CODING SIMULATIONS

1. Yucca & Carbon Tracker (Scratch or TinkerCAD)

Concept: Students create an interactive simulation where a yucca plant absorbs carbon from the atmosphere through photosynthesis. **What students code:**

- A yucca plant sprite that "breathes in" CO_2 molecules.
- Variables that track carbon stored in roots, leaves, and soil.
- A time-lapse element showing carbon accumulation across seasons or droughts.
- Optional: Include livestock that emit methane and explore offsets from plant carbon uptake.

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