Seeds and The Next Generation

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…the next generation mean[s] everything, an evolutionary imperative worth any investment of energy and adaptive creativity.[1]

Introduction

In a quest for some sense of normalcy, I cut across the school yard grass to the side door nearer my classroom and knocked for my friend to let me in. A shortcut reserved for mornings running late, the squish of wet shoes always seemed a small price to pay for a saved five minutes. But my sneakers squeaked loudly on the impossibly glossy linoleum of the hallway, impossibly perfect for mid-October in an elementary school. I hurried to my classroom to start my morning Zoom with students amidst unpacked boxes and stacked desks. Our empty pod and quiet rooms felt like an alien landscape, unfamiliar and barren. It was our first day back and we were gearing up for returning to school in a hybrid model, while still in the midst of a global pandemic.

My students' exuberant morning greetings and flurry of questions and stories helped distract me from the discord of my surroundings. I was drawn into the now familiar negotiation of tech issues, slow bandwidth and student engagement. Our class had already become familiar and comfortable with one another. I surfaced an hour later to notice that my sneakers were almost dry, but the floor was littered with tons of plant detritus. My immediate annoyance (and guilt) about the mess I had made suddenly faded when I studied the floor. The oblong flakes scattered at my feet were seeds…glorious seeds, signs of renewal and nature's determination to march on despite setbacks. Seeds herald in the next generation. I had carried these into the classroom that morning and realized that I would also carry my students upon their return, whatever form it should take. They are the next generation, worthy of our best efforts.

Background

I teach at Keene Elementary school in the Christina School District. Christina has historically been the largest district in Delaware and is spread out between the City of Wilmington, Suburban Newark, and the nearby region of Bear.

Our school is considered a Title 1 school and has over 70% of our students receiving free or reduced lunch. The majority of our students come from non-traditional households. Many of our families are single parent or even another relative (grandparents, aunt or uncle, older sibling). It is not unusual for a family to have

transportation and technology issues. We also have a large population of English Language Learners from a variety of cultures: Asian, Hispanic, Middle Eastern and the Caribbean. Despite this wide range of differences, Keene is a close-knit family.

I am dual certified, so I have Special Education students assigned to my room. These students' IEPs range from Speech Therapy only, to Occupational Therapy, Learning Disabilities, Autism, and Severe Oppositional Disorders. There are also children with 504 Plans for Attention Deficit Disorder. I do have a full time Special Education teacher that pushes in every other day and a paraprofessional who comes in on the interim days. We find ways to motivate and engage these students by providing as many hands-on opportunities as possible. Using a Project-based approach to content helps keep the students vested in their own learning

Location

William B. Keene Elementary School is located in a region known as "Bear" in New Castle County, Delaware. The school address is technically "Newark, Delaware" but our location is far from the bustling college town of that name. Despite the school's proximity to some of its feeder neighborhoods, its location between a major highway and a strip of woods, means that all students are either bus riders or car riders, not walkers. This corridor of the highway has a very transient population and many of our students come and go throughout the K-5 grade span of the school.

Neighbors

Our location is next to the Troop Two State Police Barracks, which is a mixed blessing. We have the benefit of quick security response but proximity to the transportation and exchange of suspected criminals. These issues clearly impact the school, and local community in outdoor activities.

We are very fortunate in our other two neighboring resources. One of which is the Glasgow YMCA, and the other is Glasgow Regional Park. The YMCA has multiple programs and runs the Before and Aftercare program at our school. They have both indoor and outdoor swimming pools and a large amount of outdoor green space for various activities. There are pavilions with tables for gathering, as well, one of which is directly adjacent to our school parking lot.

With more than 250 dedicated acres, Glasgow Park has plenty of green space, an almost 3-mile paved trail, gravel trails, a catch and release pond, a skate park, large and small bark parks, tennis courts, basketball courts, playgrounds, pavilions, activity and information stations, and even a sledding hill. They host a variety of community events throughout the year and even have a farmers' market in the summer and fall. There are important buildings located there: a historic farmhouse, barn, and outbuildings that are currently being restored for additional event usage.

Rationale

We are transitioning from a Science curriculum based on prepared kits to new curriculum based on the Next Generation Science Standards (NGSS.) The NGSS promotes an inquiry-based learning approach that is hinged on relevant, real world observations of occurrences or problems they term "phenomena." NGSS gives students insight to the power of phenomena to drive inquiry. One of the ways we can become more in synch with our surrounding environment, and our place within it, is to consider Indigenous wisdom. Indigenous philosophies and practices, particularly those of the local Lenape, are not just focused on the "next" generation, but on the next seven generations! Native Americans were preserving and protecting the environment long before modern technology. We can incorporate these two guiding processes to establish more meaningful interactions between students and their local environment.

At my school we established an outdoor classroom a few years ago. Each year we have sought to improve upon the classroom's setup and usage. We have found that one of the factors frequently cited by teachers is that they aren't sure how to use the space beyond one or two lessons. Learning firsthand from the Lenape about the local environment, then utilizing today's technology to study their surrounding environment would give students greater purpose when utilizing our outdoor learning spaces and would expand application opportunities. My elementary students are already questioning their role in our rapidly changing environment. This unit will help students become actively engaged in understanding scientific processes and problem-solving.

Learning Objectives

The NGSS framework has three main components: Cross Cutting Concepts (CCCs), Disciplinary Core Ideas (DCIs) and Science and Engineering Practices (SEPs.) Life Sciences are one domain of the Disciplinary Core Ideas of k-12 science education. I am interested in developing a unit that identifies anchor phenomena and applies the NGSS standards to interdisciplinary lessons for our outdoor classroom. Students will address CCCs (patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change) and utilize SEPs (scientific inquiry - the formulation of a question that can be answered through investigation, and engineering design - the formulation of a problem that can be solved through design.)

Background Content

Don't judge each day by the harvest you reap but by the seeds that you plant[2].

The Importance of Seeds

"The sowing of seeds" is such a powerful act that it has been adapted to represent a myriad of human behaviors and thoughts, and why shouldn't it? Neatly packaged by nature, a seed holds all the promise and beginnings for the next wave of life. It is easy to believe that seeds have always been the primary form of plant propagation but for the first hundred million years, plants that reproduced by spores were the dominant plant form. Once seed producing plants gained a foothold however, they progressed rapidly and with great variety, pushing other forms of propagation to the sidelines.[3] In his book, *The Triumph of Seeds*, Thor Hanson shares the theory that the evolution of man was dependent on the success of seeds. He goes on to contend that without seeds to sow, our ancestors would have been destined to continue a nomadic lifestyle.[4]

Hanson further explains the success of seeds based on the following factors: nourishment, unity, endurance, defense and travel (mobility).[5] These factors are woven into the fabric of our everyday usage of seeds. People eat, drink, sleep, wear, and yes, even "breathe" (smoke) seed products daily.

The Secrets of Seeds

Many characteristics of seeds appear in the book, "*A Seed is Sleepy*" by Dianna Hutts Aston and beautifully illustrated by Sylvia Long, but the one line that always gets a big reaction is "A seed is naked." which references gymnosperms.[6] The term gymnosperm literally means naked seed, so named because the seeds develop without any flowering or fruit. There are four divisions of this plant group but the one most familiar to people is probably Conifers, the cone bearers. This plant group typically has larger female cones that are fertilized from pollen blown from the much smaller male cone. After a process that may take up to two years to complete, the new plant embryo will also be blown to a new location to become a new plant.[7] Some of the largest and oldest trees produce their seeds this way. While these seeds are not necessarily a food source for people (except maybe pine nuts), from prehistory to modern day, humans have been utilizing many parts of these trees.[8] Gymnosperms would be around for almost 160 million years before plants would develop a new method of seed production.[9]

When I read Thor Hansen's explanation regarding the intimate reproductive lives of plants,[10] I couldn't help but visualize a demure plant choosing to cover herself, some version of Eve suddenly donning a fig leaf. His personification helps us to understand that the transition from plants producing naked seeds, to producing enclosed seeds, had a two-pronged approach. The first was to protect the pollen while attracting new forms of pollination, the second was to protect and nurture the developing embryo while attracting new forms of seed dispersal. This new group would be termed angiosperms, or "seeds in a vessel," but more commonly known as "the flowering plants."[11] While angiosperms seem to have burst onto the scene, newer research is showing that they were probably already here or developing, but not initially showing up clearly in the fossil record. While

there are vast collections of early seed fossils, they go largely unidentified because they typically aren't preserved with the parent plant.[12]

Advanced seed production would lead these plants to eventual world domination. I envision the process taking place over time like the little cartoons drawn in the corner of the book with each page representing a tiny little change, almost unnoticed, until you speed flip through it with your thumb. The resulting animation springs to life in full detail and color. So, we went from a prehistoric world of shaded greens to a vast rainbow of plant life.

I couldn't help but wonder how exactly a form of seed production which demanded more from the parent plant, and a new dependence on other living species, translated to such rapid success and diversity. Honestly, neither could Darwin as he termed this ten-million-year evolution (an overnight miracle, historically speaking) an "abominable mystery." It is a mystery that has challenged botanists ever since, but continued efforts of Paleobotanists and new DNA analysis is helping to shed new light on the evolution.[13]

Seed Superpowers

A Seed is Patient

The speedy evolution of seeds belies one of their greatest strengths, their ability to wait. They wait for the opportune time and conditions. Beyond waiting for the right growing season, temperatures, or rainfall, seeds may wait for an acceptable growing surface or medium, the correct chemical conditions, certain light refraction or angles. Their ability to wait is enhanced by low temperatures, light exposure, and humidity. They will wait months, years, decades, centuries: nestled in the soil in naturally occurring seedbanks; carefully categorized and tended in climate controlled national seedbank fortresses; hidden in ancient ruins; steadfast for thousands of years in the permafrost.

A backyard gardener unintentionally starts new weed growth as lurking seeds are moved up to the surface when other weed roots are pulled out. Countries work independently and collectively to save seeds to preserve diversity and availability, especially in the event of catastrophic events but must regularly test their stock for successful growth. A 2,000-year-old date palm seed recovered from an archeology site becomes a healthy, reproducing tree. A 32,000-year-old squirrel stash retrieved from deep in the Siberian permafrost contributed seed tissue that was grown into a new flowering generation. Except for the last example, all these seeds were able to germinate naturally when given the right conditions. A seed waiting for optimal conditions is considered dormant.

A Seed is Prepared

One of the key factors to this endurance trait of seeds is the level of nourishment provided within the seed enclosure. Enclosed seeds have 3 main components: the outer seed coat, the nourishing layer or endosperm, and the embryo itself. The endosperm provides food for the seed embryo with starches, proteins or oils.[14] There are two types of seeds for the angiosperms, monocot and dicot, where the "cot" is short for cotyledon. The cotyledon is the embryonic leaf (mono) or leaves (di) of the developing seed plant. While the endosperm layer is clearly observable in the monocot seeds, it is absorbed by the cotyledon in the dicot seeds. Either way the endosperm does its job of feeding the seed while it waits for germination. Most human diets have high levels of monocot consumption in the form of grasses and grains. While we typically use dicots such as bean seeds to show students parts of a seed, we should include monocots, as well. This can be accomplished by cracking dried corn, or even coconuts which have both liquid (coconut water) and solid (coconut meat) forms of endosperm.[15] The ability of ancient plants to start increasing levels of seed nourishment contributed to the growing angiosperm population.

If you've ever helped a student peel the remains of a packed lunch from the bottom of an overloaded backpack, you know the importance of properly protecting goods. In the same vein, it is common knowledge in elementary circles that condiment packages were not intended for young kids to open and may even stump many adults. We prefer to get our restaurant leftovers in sturdy containers because we know we can rely on them to preserve. We know that it is more ecologically sound when those containers are biodegradable or compostable, but we also know they will have a much shorter shelf life. We store our foods in ways that will best suit the kind of food, how long it needs to be stored, whether it will be transported, and so on. In a practice known as biomimicry, it is likely we copied most of these practices from our seed producing plant neighbors.[16]

Container storage is designed to keep some things in, and other things out. For seeds it is about keeping water out, that is until it is time for water to come in. Water is essential to germination, the growth of the seed. When the time and conditions are right, water enters the seed coat, is absorbed by the seed embryo which then swells, eventually bursting the seed coat. If you are a plant looking for quick germination, your seed has a thin coat, like a fold-the-flap sandwich baggie meant for easy access. These seeds typically are found in warmer, moist climates. There is a dizzying range of seed coat thicknesses. Specialization is not just in coat thickness but also in layers that may serve as insulation or even flotation. Many plants growing near, or in, water produce seeds with air trapping properties that allow the seed to float until an appropriate resting place is achieved rather than simply sinking beneath the surface of the water.

A Seed is Protected

Of course, I've barely scratched the surface about seed coats, and for some seed coats, all they need is a good scratching. The appropriate term for this is scarification. Some seed coats are so tough that they require an external element to create an opening for

water to seep in. Birds and small animals can create cracks or chips, or large animals with sharp teeth or grinding molars that pierce or crush can achieve this effect. Other times a seed coat may require the chemicals of an animal's digestive track, or the heated decomposition in a manure pile, even fire can be the needed element. In the wake of some environmentally devastating incidents, it is not unusual to see new life spring forth because some seed coats were finally breached.

While all the material and genetic code contained within the seed is the true miracle of life, it really is the outer packaging that developed such diversity. In *Enduring Seeds* by Gary Paul Nabhan, the chapter *"The Flowering of Diversity"* gives an amazing account of the simultaneous evolution of angiosperms, pollinators, and the birds and animals that depended on them as a food source. In this case, there is a fossil record right here in North America in Colorado's Florissant Valley. The wide diversity and near perfect preservation conditions have provided much information. Detailed fossils show flowers and insects in minute detail that provide evidence of co-dependence. There the bird and animal population are also well represented.[17]

A Seed is Packaged

Paleo packaging had two distinct jobs. The first was to attract the pollinators through scent, sight, and safety. Scent had the benefit of traveling a greater distance, while colors attracted a variety of insects and birds. The number, shape, and formation of petals often created a safe space for pollinators to collect their food, rest, and sometimes even mate. The flowering plants were in competition in multiple categories like a beauty pageant but with much higher stakes than a crowned title. Once the flower's job was successfully completed, seed packaging stepped in. Ancient angiosperms began varying their seed by size, shape, color, number, and texture. Tiny sticky seeds could travel long distances on oblivious hosts. Seeds with air pockets or winged appendages could float on air or water, alike. Fibrous mats held many seeds together until dispersed to float and stick wherever they may. Some seeds were packaged in large clumps knowing that many would be eaten but some would drop in the process and be left to sprout. Bright red seeds attracted birds but may have gone unnoticed by color-blind mammals who may have consumed or damaged too many. In other cases, seeds were packaged in strongly scented fruits to attract consumption by larger animals, counting on the aid of animal digestion for scarification. If the plan wasn't to be eaten, it was to be transported. All manners of hooks, barbs, and arrows allowed seeds to cling to their animal or avian host in hopes of furthering the success of the next plant generation.[18]

Seeds and Human Survival

It is believed that early humans were primarily predators, hunters before gatherers. We can surmise that they learned about plants as food sources by observing their prey. Then perhaps at times when their hunt was unsuccessful or prey was scarce, they turned to

these plant resources. They began to learn that they could collect these food sources and carry some with them or look for similar types when they migrated to follow their animal quarry, the megafauna. These people became another pack animal for seeds, offering either scarification or transport services. Humans reproduced and migrated across entire continents in search of climate refuge and prey. They were still big game hunters when they migrated into the Americas, because there was still big game. This did not last forever, as the megafauna became extinct and humans were left to scramble for new food sources. The early humans collected plants and seeds on their own, but also profited by taking over seed stores of other animals. The loss of megafauna was potentially catastrophic for humans and some plant species, but they instead seemed to turn to one another. Giant fruits and seeds previously dependent on the crushing jaws of megafauna became a food source for humans and may have in fact been some of the earliest cultivated crops.[19]

Plant and seed collection, along with eventual cultivation became integral to human survival. Much of what we know about their earliest relationships comes to us through Indigenous cultures with oral histories and practices rich in understanding of the environment, and respect for the earth.

Indigenous Cultures

Some seed and plant usage by indigenous cultures is regionally specific, while other usage exists in some variation across cultures and continents. Indigenous people relied primarily on native plant sources, passing down related wisdom from one generation to the next.

My local region is the original homeland of the Lenni Lenape. The name for this region in the Lenape language is Lenapehoking.[20] The Lenape are part of a larger group often referred to as the Delaware Indians, with “Delaware” as more of a reference to the Delaware Valley region. Original Lenape territories ranged from Southeast New York down through New Jersey and Eastern Delaware, and westward through Pennsylvania out to Ohio. The nearby Nanticoke territory was along the Eastern shore of the Chesapeake Bay. The Nanticoke was considered a separate tribe but is believed to have originated from the Lenape. There have been many names attributed to the indigenous people in this area, but colonialism caused many of the Lenape to intermarry with the Nanticoke people, eventually forming the Nanticoke and Lenape Confederation. The individual tribes and the confederation have tirelessly sought to maintain traditions, beliefs and practices despite primarily existing within colonial and modern-day communities.[21] This is also significantly true for Indigenous people across the Americas. It is important to learn about Native American history in general, but then delve more deeply into the history specific to your region. Having local knowledge allows you to guide student connection to their local environments.

Much the way we studied the pre-history of plants, we will start with the early people that traveled to this part of the world.

Early Prehistoric Indigenous Cultures of the Americas – The Paleoindian Period

The Clovis People

In order to understand a bit more about the Lenape and America's indigenous people we need to back up and talk about the Clovis People. I assure you any such research you choose to conduct on your own related to these topics will lead you down endless intertwined historical avenues. I will try to weave the various threads I encountered into a meaningful framework for the Indigenous people of North America.

Multiple resources I read while researching both ancient people and plant species often included ancient animal, bird, and water species. This really is not surprising given the nature of biodiversity and the connected web of all living things. What we know of ancient civilizations, cultures, and species come from our discovery of archeological and geological evidence. For cultures without written records we rely on any pictorial evidence (such as cave paintings,[22]) fossils, and artifacts, to increase our understanding of long-lost lives.

Many of my resources referenced the Clovis people as the first people to populate the Americas. The general theory is that these individuals crossed into North America by means of the land bridge that once existed between Siberia and Alaska. Even today, the two lands are not that distant, hence the often-spoofed comment from former vice-presidential candidate Sarah Palin, that you can see Russia from Alaska.[23] The land bridge existed while sea levels were lower and other water sources were frozen solid. The theory goes on to explain that these individuals first spread out across North America, then southward into Central and South America some 13,000 years ago. Having that general background knowledge was sufficient to understanding its use as a reference point in the historical record. I did not give it any greater consideration beyond a reference. Typically, we tend to not question widely referenced information…until lately. It seems that more and more lately, we are learning to question those things that we have previously believed to be accurate based on widely circulated theories. Often a shift in thinking requires a catalyst, however.

I was struck when listening to a recent virtual talk given by Chief Dennis Coker, of the Lenape Nation, and the Clovis reference came up again. When asked about the "age" of the Lenape people, Chief Coker mentions the Clovis point as the accepted dating point of the peopling of the Americas. I realized that for me to have better understanding of the Lenape, I needed to have a better understanding of the Clovis theory.

A 2013 article in Smithsonian Magazine recounts the 1932 discovery of unique spear points within a large mass of mammoth bones, by Edgar B. Howard. The location of his find: Clovis, New Mexico would be the origin of the name given to these spear points, "Clovis Points." What made the discovery so unique was the consistency of the craftmanship and quality of these points. Furthermore, these Clovis points would end up being discovered across the continent, over 10,000 of them by the time of the article. This significance was increased when it was determined that the widespread dissemination of either the so-called Clovis people or the skill of making Clovis points, took place within a few hundred years. To cement their place in archeological history, it was determined that Clovis points are unique to the Americas as there is no evidence of their existence in Siberian artifacts despite the belief that the first peoples had migrated from there.[24]

That last detail begs the question, "If not from Siberia, then from where?" While the lack of Clovis related artifacts in Siberia makes the case for the Clovis people being the first known culture of the Americas, it also throws into question the long-held belief that their ancestors migrated across the Bering Land Bridge from Siberia. Turns out there are other theories. While we have continued to find archeological evidence that predates the Clovis finds, it is really scientific technology that is putting theories to the test in more recent times.

Beringia

One such advancement has been genetic studies of archeologic finds in comparison to modern day individuals. In his article titled, "First Americans lived on land bridge for thousands of years, genetic study suggests," Scott Elias states that genetic evidence indicates that the DNA split between modern day Native Americans and the Siberian people happened around 25,000 years ago but there is no evidence of a migration at that time. During the peak of the last ice age there is not evidence of human habitation in that area of Siberia or on the Americas' side of the land bridge. Between archeological evidence of habitation in northeast Siberia 30,000 years ago, to post ice age evidence of people in the Americas dating back some 15,000 years, there was nothing, "the record goes silent."[25] Based on a 1930's studies of tundra plant survival by Eric Hulten, sediment core samples from the region, and other plant and insect species studies, the author and his colleagues, John Hoffecker and Dennis O'Rourke proposed that the conditions that would have existed on the Bering Land Bridge would be comparable to modern day Alaska and would have supported a human population. What's more, they indicate that 15,000 years in that location allowed the population to develop those genetic differences from the mainland Siberian peoples. Their detailed paper was published as "Out of Beringia" in Science magazine in 2014.[26] It makes me wonder if 15,000 years of the archeological record is buried in the Bering Strait.

So, when the first people came to the Americas by way of the Bering Land Bridge it was less of a "bridge" and more of a 15,000-year waystation of Darwinian evolution.

That's why there is no similarity between Siberian artifacts and the Clovis points. Perhaps the early versions of the Clovis points are also deep in the Bering Strait. Perhaps.

Back to The Clovis Culture

Despite their widespread distribution across the Americas, Clovis points did not stay in use for an extensive period. What archeologists and anthropologists have determined was that the Clovis people were not necessarily just big game hunters as the original mammoth find implied. Based on studies of other sites it is agreed upon that Clovis people were primarily nomadic and made use of the resources at hand. As the people traveled, their stone tools eventually changed and were adapted to new environments. Climate changes and species extinction would further shift the practices and tools of these people, but their subsistence as nomadic hunters would persist. [27]

Pre-Clovis Model

More recent archeological discoveries point to an even earlier migration of people into the North American continent, supporting the theory that people may have arrived in intermittent waves, rather than a single wave. The Pre-Clovis population were most likely made up of smaller, nomadic family groups.[28]

Yes, the origins and timing of the earliest peoples of the Americas are still up for debate and research, as they should be. Without a definitive written record, we have been dependent on earlier archeological and anthropological analysis. We are finally learning to question the historical record, reexamine the impacts of viewpoint, and utilize science and technology in new ways to support our understandings within the broader world context.

Middle and Late Prehistoric Indigenous Cultures of the Americas

This time period is defined by climate changes, advances in tools and increased populations rather than specifically identified groups. There is much evidence that advancements in technologies and food acquisition spread from the southwest into the North and East, following the environmental shifts in the wake of the receding ice. As the climate warmed from the Archaic to the Woodland time periods, the plant and forest species began shifting. Hardwood tree species infiltrated the coniferous forests that previously dominated the MidAtlantic and Northeast regions providing increased food sources in the form of nuts and seeds plus the birds and woodland animals that fed on them. The initial increased availability of food reduced the traveling needs of the people, allowing for extended stays in a region and the population grew…and grew.

The archeological record shows the effect of these changes as almost a chain reaction. Improved access to food sources led to reduced traveling for hunting, and extended stays

in areas, which allowed for population growth and tool development. Greater demands on resources in smaller areas resulted in increased competition between groups of people, and tool specialization for geographic regions and resources.[29]

Evidence of social groups forming exist in larger settlement sites, advanced meal preparations and tools. The less nomadic lifestyle developing would lead to the use of bowls and other household items out of materials not made for traveling such as heavy soapstone and eventually breakable pottery. Trade networks are revealed in the artifacts as tools and such are discovered far from where they naturally occur.

At this point we begin to see direct results of seed plant usage within the population and the resulting shift in practices. The use of plants and seeds increased through new uses such as grinding for flour and the beginning of purposeful planting. Settlements continued to expand and, in some areas, included boundaries defined by crop growth.[30] The Paleoindians began to put down roots.

By the late woodland period, well established settlements of varying sizes are clearly represented in the archeologic record. In Western Pennsylvania, Ohio, West Virginia and Indiana the people established farming villages, but some surrounded themselves with barricades which leads researchers to believe they either feared other groups or actively participated in some level of warfare with them.[31]Large settlements towards the east did not really develop until later. There are sufficient indicators that most groups were independent of one another but still connected through trade and related languages.[32]

The Algonkian/Algonquian Family

Defining Prehistoric civilizations is a tricky thing. It turns out that the naming of early peoples can be problematic, too. Confusion mostly arises when names are assigned to groups of people by other people, rather than using a name by which the people identify themselves. Case in point: Columbus' assumptions and inappropriate labeling of the indigenous population as "Indians."

Along the East coast of North America from Canada, down through Virginia the various groups of people, or tribes, were separate but related through language. They each had their own dialects but were part of the same language family that was named Algonquian or Algonkian. This name applies to the language rather than the people but is used to refer to a collection of tribes, much the way speakers of the English language are not necessarily all English. (There is a tribe known as the Algonquin in Canada, however they refer to themselves as the Anishnabe.[33]) Moving out of prehistory into early modern times, the Algonquian Family of tribes were in residence during the early European contact period of the North Eastern portion of the Americas.

Like their ancestors, the Algonquian tribes lived in their respective regions for hundreds of years prior to European contact. They continued to hunt, gather, trade, and farm, maintaining settlements with some seasonal migration. Also like their ancestors, these tribes kept no written records but relied on oral history passed down from generation to generation to continue their practices and beliefs. Some indigenous populations were decimated by disease, warfare, and displacement and some tribes were completely lost. Without a written record we must rely on archeology and the oral histories that remain to gain understanding of their culture and wisdom.

The Lenni Lenape

As mentioned earlier, I live in an area that is part of the Lenapahoking, original territory of the Lenni Lenape (often just called "Lenape".) The tribe's name is believed to mean "The Original People" and collective indigenous histories seem to recognize the Lenape "as the 'trunk' of the Algonkian family tree."[34] Most historical records indicate that the Lenape were given a certain level of respect within the larger network of Algonquian tribes, even referenced as "The Grandfathers." They were primarily peaceful, and often functioned as mediators in conflicts between the other tribes. Their society is matrilineal which means that lineage is passed through the mother's side for clanship and kinship. While there were gender split duties regarding daily responsibilities it was based on shared work rather than a male dominated culture. Males were expected to marry outside of their mother's clan. The Lenape eventually grouped into the three major clans: Wolf, Turtle, and Turkey, although there were originally many more.[35]

The Lenape belief is that they are of the earth and that all living things have spirits that should be honored. This belief system was reflected in their careful use of resources, lack of waste, and practice of giving respectful thanks for each resource before using it. While regions or areas might be designated for use by certain groups or families, there was not a practice of land ownership, or any resources for that matter (cue later conflicts with Europeans.) They primarily hunted deer and smaller woodland animals, making use of all parts of the animals in clothing and tools. While there is not much written about their bear hunting practices, it is known that bear grease was regularly used in their hair, and to protect their bodies from insects. Natural materials were used to create dyes for decorating clothing and body paint, as well as tattooing for both men and women. They also fished and shelled extensively, becoming one of the major producers of wampum, a bead currency made of shell.

In addition to collecting and using native plants, the Lenape grew corn, beans, squash, sunflowers and tobacco. The first three of those were grown as the "Three Sisters." Much like the widespread use of Clovis points, growing the three sisters has been a practice found across most of the Indigenous groups of the Americas. The importance of these plants is reflected in the oral history of each tribe, all of them share some version of the "Three Sisters" story[36]. Usually the three sisters are personified, appearing in times of

hardship but once received and cared for by a family or tribe, they reveal their true plant selves and share their bounty and remain with the people. That last detail is revealing in the way that it highlights the continued practice of honoring and growing the Three Sisters. The first seeds planted were the corn so that the stalk had the opportunity to begin gaining height and strength, after that, some variety of runner beans would be planted that would use the cornstalk as a trellis of sorts. The beans would provide a source of nitrogen to the soil, and then some type of fall or winter squash seeds (like pumpkins) would be planted. The squash plants contributed shade to the base level of the other two plants which helped inhibit other competing plant growth and improved water retention in the soil. These mutually benefitting companion plants received a final boost in the form of small fish buried in with the seeds to add more nutrients to the soil. These crops were harvested and used fresh, roasted, dried and ground. They provided both an immediate and long-term food source for the Lenape. Sunflowers were also grown as a food source with the seeds being an excellent source of oil, also. Tobacco was grown for ceremonial use, was considered sacred, and either sprinkled into fire, buried in the earth as forms of offerings, or smoked during special gatherings to communicate with the spirits and Creator.[37]

The Lenape sowed and reaped following specific procedures of gratitude and recognition for the benefits their crops would bring. They even recognized the value of not depleting the soil and rather than practicing what we now call crop rotation, they rotated their settlements to new locations as needed. To continue their farming in the new location they would have saved the best of seeds during harvesting to be planted the following season. Like their animal food sources, remaining plant material from their crops would also be utilized to its fullest in the form of mats, baskets, even toys.

Herbs and plants that were either grown or gathered from the wild for medicinal purposes required very specific methods of gathering that often were directly related to their intended use or recipient, Many medicinal plants could only be collected by the tribes medicine man who in turn passed that knowledge to a younger member of the clan.[38] The Lenape relied extensively on gathered seeds, nuts, and fruits for food, ceremonial practices and medicinal uses. Recognizing and utilizing all this information is dependent on a continued sharing of tribe history.

Conclusion

The histories of seed plants and people are both ones of adaptations, evolution and dispersal. Despite their presence many millennia prior to people, the seed plants and people have become almost inextricably intertwined, many times to the detriment of the plants. We must choose to be aware, choose to care, if we are to prevent or reverse the loss of biodiversity in more recent history. It is the intentional conservation of resources, and deep appreciation for other living things that I would like to see students embrace from Indigenous cultures such as the Lenni Lenape. Our overall objective in adopting

Lenape practices is preserve the environment for many generations to come, rather than just the current generation.

Teaching Strategies

Ancient people had to rely on observation and shared knowledge to develop their understanding of the world around them and their place within it. This is the same approach encouraged by the Next Generation Science Standards (NGSS). While not the source of the name "Next Generation" for these standards, they align beautifully with indigenous wisdom's focus on future generations. Spend time learning about the NGSS on their extensive website. It will truly give you in-depth understanding of the necessary teaching strategies. I will, however, provide an overview in the Standards Appendix.

In her book, *Braiding Sweetgrass*, author Robin Wall Kimmerer blends plant study with ancient indigenous practices and modern-day interactions. She highlights the beautiful and fulfilling experiences that take place when humans interact respectfully and responsibly with nature. The author, who is also a professor, often cites the importance of physically connecting her students with their real-life subjects. One of her observations struck me as particularly true for my student population, and many other urban and suburban student populations. She relates the experience of teaching to a class of front row eager learners, and a remainder of glazed eyed, disconnected or uninspired students. She mistakenly felt that her impassioned lessons and sharing of her life experiences would engender engagement with the bulk of her class. Instead she found that the engagement of those "up front" learners was often based upon shared experiences and exposures, rather than just interest. Students who had interacted with growing plants had different access to the class information than the ones that had no hands-on experiences. To remedy this issue, she began starting all her courses in the garden or field locations to build that schema.[39] This is exactly the objective of outdoor classroom spaces. We need to *directly* connect students with natural experiences for them to deepen their understanding.

While the unit easily lends itself to Language Arts, Social Studies, and Science applications, be sure to consider all the S.T.E.A.M. (Science, Technology, Engineering, Art, and Math) connections as well. Indigenous wisdom tells us that the plants sing their stories, that we can honor earth and share stories with our movements. Let this unit be a springboard to many forms of learning. May you find much to harvest, and many seeds of inspiration.

Learning Activities/Lessons

Developing this unit during the COVID-19 pandemic presented a unique set of challenges. No-one is sure what classroom instruction will be like until a large portion of the population is able to receive the vaccine. Already this school year we have

experienced education in both a remote and hybrid approach, while other schools have returned to full in-person with many COVID restrictions in place. I have included activities for virtual adaptations, as well as in-person instruction, accordingly.

Activity 1 – Plant/Seed Walk

Lead students on a walk of the school grounds looking for evidence of grasses and flowering plants. This is possible in person or virtually either during a virtual class meeting like Zoom, or a prerecorded video if necessary. If you are unable to access your school grounds, then utilize the area around your home, or video in areas near your students' homes. Even the most urban settings will have plant growth in sidewalk and parking lot cracks. Share the video during a virtual class so that students can make observations and share them with one another. Take these walks throughout the school year to allow students to make observations about seasonal effects on seed/plant growth. Have them reflect on what stages of the plant life cycle they can expect to see and what evidence they observe to support their expectations. This can be supported by graphic organizers like anticipation grids and KWL charts. Students with the available technology can take photos of their discoveries or if the school has a camera for student use. Keeping journals with notes and drawings allows students to go back and re-examine earlier evidence and thinking to guide their new inquiry.

Activity 2 – Seed Collection / Classification.

As the season allows, take your Seed Walk activity a step further by collecting seed specimens. This involves teaching students how to gently tap seeds from plants rather than wholesale plucking of plants or entire seed heads. Teach them the importance of leaving seeds for new growth and food for other creatures. Provide them with magnifying glasses if in person to do up close observations of the parent plants and the seeds. Another option is to use foldscopes which are relatively inexpensive paper microscopes, about $1.75 each/Class set of 20 for $35.00[40] (maybe ask PTA/PTO or write grant for larger set.) Have them work in a small (but spread out) group to discuss ways to sort their seeds. Teach about "Seed Superpowers" as explained above and have them consider those traits for sorting. What experiments could they conduct to discover specific traits? If in-person is not an option, encourage families to assist students in seed collecting in their immediate vicinity (even if it is just supervising a quick trip outdoors.) Acknowledging that this may still not be a possibility for some students, have students work in breakout rooms during virtual class, grouping similarly located students with seed samples, together with those who are unable to collect (normalize this.) Another option is to work whole group to observe seeds that the teacher has collected from a location specific to the students such as school grounds or park area frequented by students. Remember the objective is to build connections for students, so keep it local as much as possible rather than utilizing store bought seeds or science kit seeds.

Activity 3 – Reference Charts

More follow-on work to the previous activities. Have students create individual or group reference charts based on their classifications. Challenge them to find ways to verify the accuracy of their charts and ways that they could be utilized by others. In the absence of individual seed samples to use, students could also use their own (or provided if needed) close up photos of local seed samples to create their chart. This can be done using google slides or other applications such as Peardeck to provide them with drag and drop capabilities with the photos. If using Schoology or a similar learning platform, the assignment could also be created using Kami. Schoology, Kami and Google classrooms all allow you to push individual copies of the assignment for students to manipulate. This approach to the assignment can even be extremely valuable for in-person instruction as it can provide students a chance to document their seed collections with their own photographs, and to create a locally accessible database for seeds in their area. Reference charts could also be generated for plants and seeds used by the local indigenous tribe complete with seed samples collected by students or teacher, if needed. So many possibilities and applications here!

Activity 4 – Seed Saving and Germination Research Project

Students select a seed of local importance whether it is from a pollinator garden or food garden. They will then research appropriate manners for seed collection/retrieval from selected plant(s), storage methods, and germination requirements. What can they conclude about the seed's traits based on its requirements? Research may utilize in-person resources from libraries or virtual, on-line resources. Teacher may choose to create a research resource collection in class with pulled book and magazine/journal resources, or a virtual collection through a Google Slides "library" collection of books and videos. Bitmoji classrooms are an excellent presentation format for easily accessible virtual resources. I highly recommend checking out Bitmoji Craze for Educators Facebook group for tons of free, searchable resources like this. There are also many of these type resources available for purchase on teacher sites.

Activity 5 – From Pollination to Germination, One Seed's story.

Another research project utilizing same type strategies as Activity 4 only with a focus on the topic above.

Activity 6 – Biomimicry Experiment

The focus of NGSS is a blend of scientific inquiry and analysis, engineering in a problem-solving format. Biomimicry is the most beautiful union of these with Mother Nature. Indigenous cultures have long understood this and utilized it. Modern man has only recently returned to honor this way of thinking. Have your students select a seed

superpower and test different ways to recreate it with everyday materials. They can incorporate varying levels of the trait to indicate levels of success (or document "fails.") Possible ideas: "Dressing" something to attract attention; packaging for different items and needs; packaging for endurance; creating shapes or appendages to assist transport (In Activity 7 you can tell them that this is how Velcro was invented.) Be sure they can identify what seed trait they are seeking to mimic, maybe even have a seed example to include in their documentation. They need to write about, photograph, or draw the different stages of their experiment as they go including materials used, conditions, etc. Explain to them that many "failed" stages of experiments have become amazing inventions like nylon, Gore-Tex, silly putty, and more. This is such a great experiment for them to conduct virtually or in person. They must get creative with whatever supplies they have around. This can be a short- or long-term project. The documentation can be incorporated into google slides or another app for older students. This is also an excellent subject for Activity 9 below.

Activity 7 – Biomimicry Research

After conducting their own experiments, students can research an existing product that was developed based on nature. This needn't be limited to plant inspired inventions.

Activity 8 – Alternative Expressions

Have students use art or storytelling to express their questions or understanding of the importance of seeds. Possible projects: create an outline or shape of a person, animal, or bird using types of seeds they either consume, transport, or both; write a story like a native tale that reflects the origins or use of a seed or seeds; diagram the role of a seed within the local ecology; write a free verse poem in the style of Doug Florian,[41] for the spirit of a chosen plant, pollinator, consumer, or disperser; illustrate seed traits by comparing them to other things living or non-living (like phone or something.) write a "Diary of a Seed" based on "Diary of a worm/fly/spider" series. All of these are possible with the use of in-person or virtual resources. It is important for the teacher to take the extra step to have student work shared if virtual. You can even create a virtual gallery of the works.

Activity 9 – Flip books

Utilize a video tutorial to show students how to create a flip book using a paper rough draft, index cards and a rubber band or binder clip for the final version. I liked *How to Create a Flip Book*[42] and *How to Create a Flip Book*[43] but I recommend doing a search and watching several to see what would be best for your students' age group and abilities. Possible subjects for flip book: an indigenous activity or story; seed life cycle; germination; pollination; seed dispersal; seed food chain; human migration. Try doing one or more yourself to see how you can model for students. There is even an app called

Stop Motion for a digital version. This is a great opportunity for collaboration with your art teacher, as well.

Activity 10 – Three Sisters Garden

The Three Sisters Garden has been grown throughout the Americas by multiple indigenous groups. Read some version of the Three Sisters tale such as that shared in *Braiding Sweetgrass*.[44] In some directions for planting a Three Sisters garden, it is recommended to stagger the planting times of the three seeds to allow each an establishment window. In Kimmerer's chapter on the Three Sister's she shares that it is the genetic programing of the seeds themselves that result in the staggered germination and growth that makes the difference.[45] Students will likely catch this procedural difference on their own, otherwise point it out. Ask them how to explore the accuracy of the two approaches. Obtain your sample seeds from a local seed store so that they are appropriate for your region. Have them test out their ideas either in small cups or sprouting containers to observe and record the germination of each seed type. They should then move on to conducting the experiment using local soil rather than potting mediums (Be sure to have them make note of the differences between the two.) If conducting this activity virtually, create the tests under student direction in a virtual class meeting. Provide them with close up photos or videos for their regular observations. Be sure to obtain your local soil sample from the school grounds where you intend to eventually plant your garden. There are many possible variations based on the different strains for each of the seeds that could also be explored. Have students study local seed directories for which varieties are best for your area. Explore ways to replicate the fertilization provided by the fish that was often included in the indigenous plantings. If you really want to recreate that step, your local pet store that sells feeder goldfish will always have a supply of those that do not make it, another option is any place that sells fresh or frozen fish bait. Most home centers sell a liquid fish-based fertilizer otherwise. The ultimate goal is to grow your Three Sisters gardens right on the school property. Because the growing season spans two school years it is important to really involve multiple grade levels in this whole learning process. Another benefit of this type of gardening is that it is set up to require little maintenance so students who are "off" for the summer will be replicating some of the Lenape practice of seasonal focusing. Returning the following school year, students can work on harvesting and composting. Have a schoolwide harvest celebration that acknowledges indigenous cultures rather than the commercialized/fictionalized Thanksgiving. If there is a surplus of produce it can be donated to local families in need, shelters, or even sold at a local farmer's market as a fundraiser. Be sure to save seeds for the following year's planting. If we are still in an altered state of education, then video, photograph, virtually garden.

Guest Speakers/Field Trips

Research your local Indigenous group and find out if there are any speakers that would be willing to talk with your class, ask them for recommendations for any sites that have accurate model representations of indigenous life. Contact your local university to see if there are any professors of indigenous studies or plant studies that would meet with your class. Check local science and natural history museums for in-person or outreach programs. Many nature centers, park services and garden centers are also happy to talk or work with students, some will even partner with the school for the actual garden. Surf the web for indigenous videos and resources. I have included a few for the Lenape in my reference section. Tik Tok actually has a whole category devoted to indigenous videos that are short and informational, often debunking common myths about their particular group's culture. This is also a way to show students a sampling of a wide range of indigenous cultures, promoting understanding that the local culture is not the only representation. Obviously, prescreening is a must and may also allow you to pinpoint segments of longer presentations that you may wish to use. This is actually an area where we have seen the pandemic benefit academic communities because speakers who might not otherwise have the time to travel to a school to speak are often willing to join a virtual class meeting for a brief talk or Q&A session. Even virtual fieldtrips may be available that are free or more affordable because there are no transportation fees.

Appendix on Implementing Next Generation Science Standards (NGSS)

Delaware has been transitioning our science program to the NGSS. In 2014, Delaware and Rhode Island even collaborated in analyzing the alignment of science curriculum kits with the NGSS to determine how existing curriculum materials could be adapted, and what new resources were needed.[46] The important thing to note is that it is much the philosophies involved in the NGSS as the standards themselves that are important.

Specific Standards Addressed

While the standards shown here are specific to the activities described above, there are many additional standards that could be addressed based on grade level and subject focus. Be sure to go to the NGSS website for greater understanding of their overall objectives.[47]

Life Science

2-LS4-1 Biological Evolution: Unity and Diversity – *Unit overall where human activity, pollinator and seed transporter diversity are critical,*
Make observations of plants and animals to compare the diversity of life in different habitats.
3-LS4-3 Biological Evolution: Unity and Diversity – *Unit overall*
Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

3-LS4-4 Biological Evolution: Unity and Diversity – *Why did ancient populations migrate to begin with?*
Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. [Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.]
5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics – *Unit overall*
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Earth and Space Science

K-ESS2-2 Earth's Systems – *Unit overall*
Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
5-ESS2-1 Earth's Systems – *Unit overall*
Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
K-ESS3-1 Earth and Human Activity – *Unit overall*
Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.

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Read for pleasure and contemplation.

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