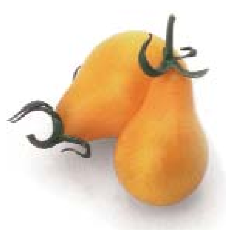
A Handful of Seeds

Seed-Saving and Seed Study for Educators



Lessons linked to California Educational Standards

Practical Information on Seed Saving for School Gardens

History and Lore

A HANDFUL OF SEEDS

Seed Study and Seed Saving for Educators

BY TINA M. POLES

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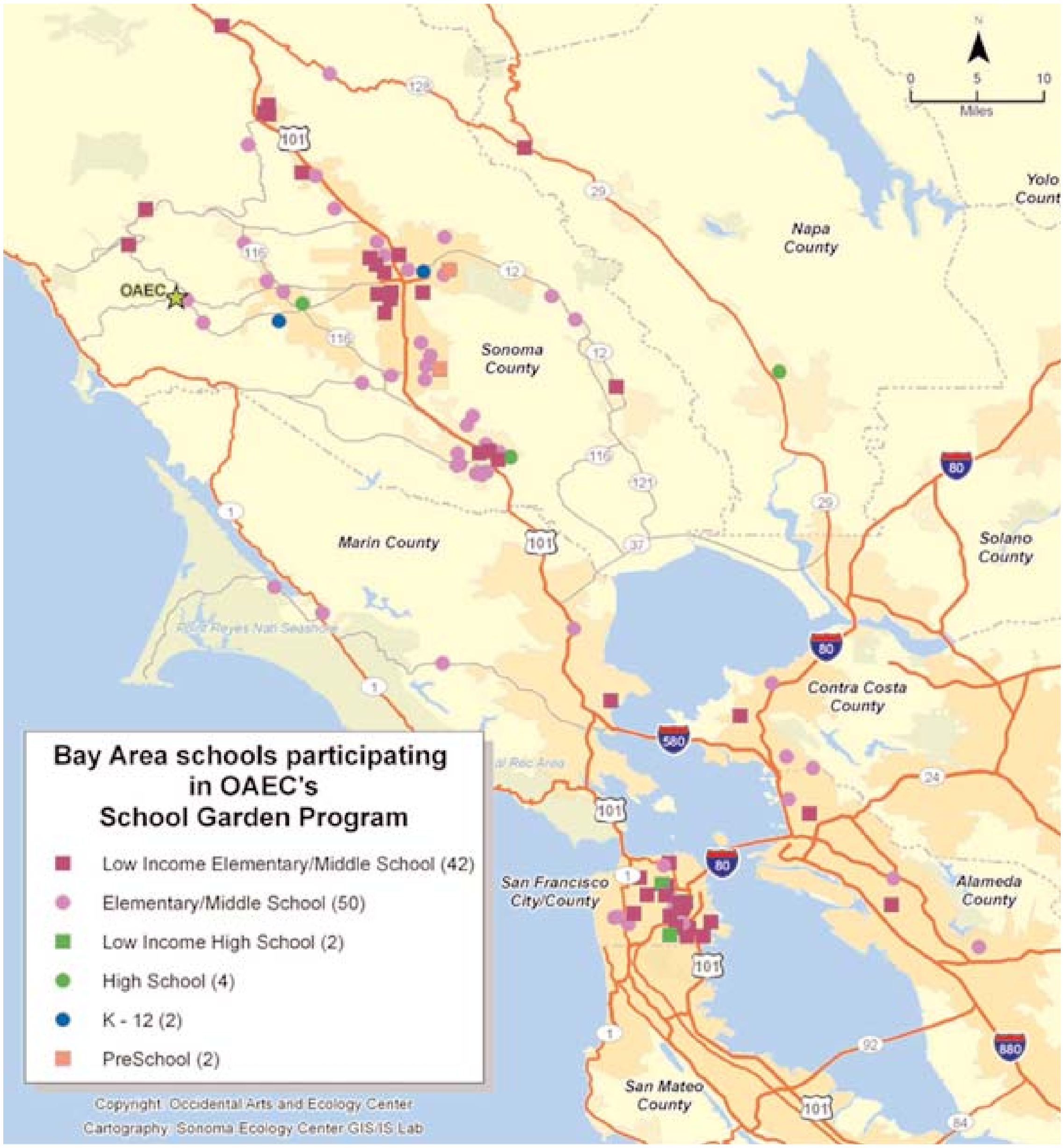
From Tina: I would also like to thank all the educators I had the pleasure to work with, who shared their ideas and enthusiasm for school gardens with me. As always, Richard J. Senghas support of me has been unwavering.

About Occidental Arts & Ecology Center

The Occidental Arts and Ecology Center (OAEC) is a nonprofit educational center, biodiverse organic farm, and native ecological preserve located in Northern California's Sonoma County. Founded in 1994, OAEC offers innovative practical solutions to the pressing environmental, economic and social challenges of our day. These responses and solutions are communicated through research and demonstration, participatory education, and organizing for social change.

Since 1997 OAEC's School Garden Teacher Training and Support Program has been cultivating ecological literacy in school communities. The material in this publication was developed over the seven years that Tina Poles worked as the director of the OAEC School Garden Program. Many of the ideas and curriculum were refined during the School Garden Summer Institutes from 1999 to 2006. During these five-day residential summer trainings, seed saving became a popular theme. Educators who attended the trainings planted seeds, worked with seed curriculum, built seed-processing screens, made seed jewelry, saved seeds, processed seeds, ate seeds, and learned about the politics of seed saving.

To date, OAEC has trained over 400 teachers, principals and core parent volunteers in 173 school garden programs in Northern California, San Francisco, and the greater San Francisco Bay Area and beyond. With support from OAEC staff and the dedication of tens of thousands of students, teachers, parents, administrators, and facility management staff, Northern California schools are expanding the scope and value of school gardens. Many school projects now include recycling programs, vermiculture (worm composting), habitat ponds, cooking from the garden activities, salad bars, and farm-to-school programs.



145 Schools Participate in the Occidental Arts and Ecology Center's School Garden Program as of September 2008

Not shown: OAEC has worked with 43 additional schools outside the Bay Area in California counties Butte, Humboldt, Los Angeles, Mendocino, Orange, Placer, Sacramento, San Diego, San Luis Obispo, San Mateo, Santa Clara, Shasta, Sierra, Trinity, Ventura, and Yolo and in Hawaii, Delaware and North Carolina.

OAEC works to cultivate ecological literacy in children and communities through school gardens and related curriculum. Since 1998, OAEC has trained and supported 397 teachers, helping establish gardens in 145 schools. In 200k approximately 28,000 students directly benefitted from these school garden programs.

A Note About Garden-Based Learning

Belief in garden-based learning is not new. In fact, the philosopher Jean-Jacques Rousseau in the 1700s and the educator Maria Montessori in the early 20th century recognized the value of the garden as a teaching tool. By 1914 there was even a federal government agency created to advocate and provide support for youth gardens. In recent years, school garden programs have increased dramatically in number and diversity, fueled by rising awareness of the serious consequences of childhood obesity and diet-related disease such as Type 2 diabetes.

The rise in school garden programs also reflects the adoption of federal school wellness policies and public concern about where our food comes from. Research shows that participation in garden programs brings benefits for students by increasing their healthy eating habits, cooperative abilities, social skills, and academic achievement. California continues to be a national leader in the school garden movement, and the training and support provided by OAEC staff has been the wellspring for many of the pioneer programs in Bay Area schools including the Edible Schoolyard. A wealth of information on school gardens and garden-based learning can be found at the California School Garden Network website, www.csgn.org. *(see resources section)*

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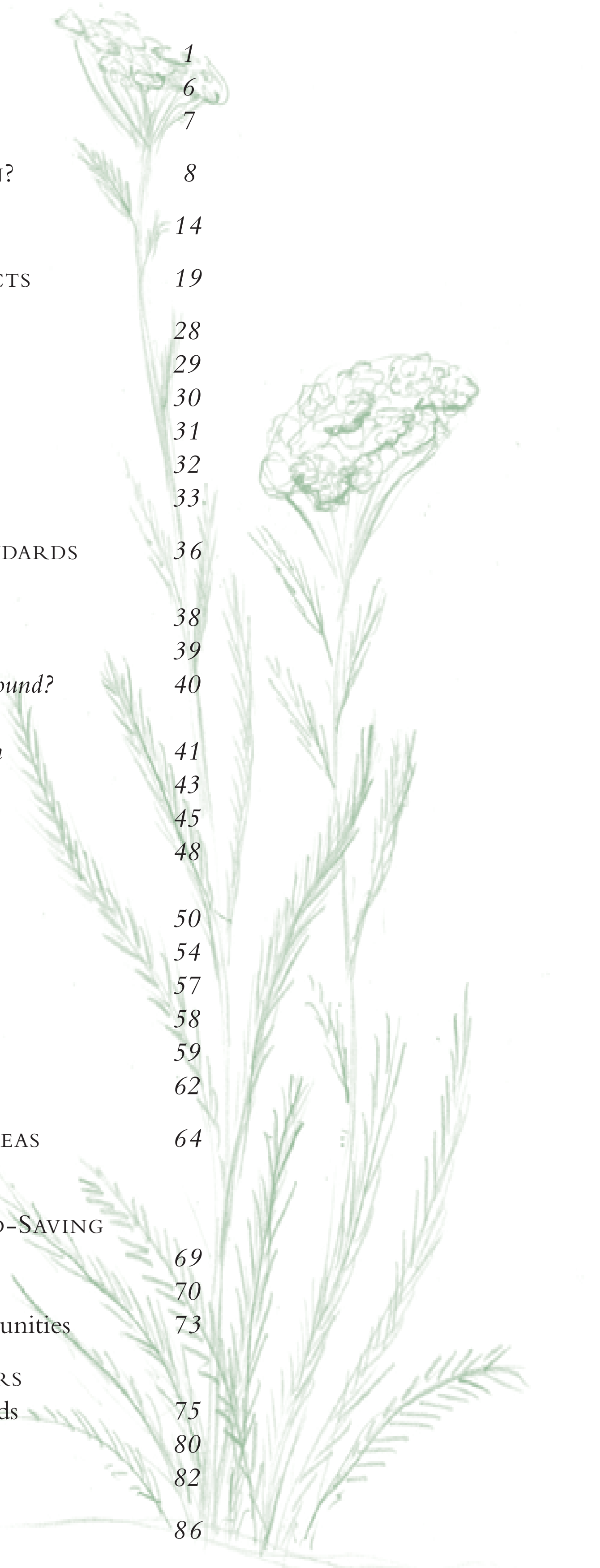


Introduction

The central challenge of our time is to create and maintain sustainable communities—social, cultural and physical environments in which we can satisfy our needs and aspirations without diminishing this potential for future generations. At the core of environmental education or ecoliteracy is the study and understanding of connections and cycles. Children have a natural affinity for the living world. School gardens are a powerful means of instilling life-long environmental and nutritional literacy among children. These gardens can serve as living laboratories for hands-on exploration and learning, and seed saving can be a strong component of teaching ecoliteracy. The outdoor classroom fosters critical thinking skills and increases retention rate in many subject areas, including math, social studies, science, nutrition, and geography. Gardens and seed saving bring nature to children at a scale that can fully engage them.

To fully understand the profound concepts expressed in this simple poem requires a depth of interaction with and knowledge about the natural world that few of us now experience.

We feel by the moon
We move by the stars
We eat from the earth
We drink from the rain
We breathe of the air
We live in all things
All things live in us
—*Author Unknown*

To really understand this poem means that students know that because seeds are 95% water, they are affected by the moon's gravitational pull and experience miniature tides inside them. Seeds drink from the rain and respire. Many cultures plant by moon cycles. Seeds are a source of food for many animals, birds and insects; they provide a concentrated source of protein and carbohydrates.

Seeds have co-evolved with humans, and it can be said that we live in them and they in us. The idea that plants convey meaning and therefore can offer illumination to an attentive person is a commonly held belief in much of the world. In the Western world, we have lost much of this understanding, but as we save seeds with children, we can reclaim this profound illumination.

Purpose and Use of This Guide

This publication presents an introductory seed-saving curriculum for kindergarten through sixth grade, linking to the California state academic Content Standards. It can be used in a school garden project, as a part of an environmental education program, and in outdoor or indoor classrooms. The topic of seed saving is vast, and *A Handful of Seeds* is intended to be a starting point for delving more deeply into this rich and fascinating realm. No teacher could teach the entire contents in any given year, but the ideas and techniques contained in this guide are meant to stimulate educators to include seed-saving and stories about seeds in their indoor and outdoor classrooms.

Seed saving can be used to teach all subjects including science, language arts, mathematics, social science, drama, music, and social skills. Chapter 4, Seed Stories, helps weave seed stories into other subjects you may be teaching, such as history, social studies and art. Curricular links are covered in Chapter 5, Seed Curriculum and Links to Standards, and further lesson ideas can be found in Chapter 6. Chapter 7, Historical Context, presents an introduction to the history and socio-political context of seed saving, including a section on genetic engineering as it relates to our seed and food system. Chapter 8, Background for Teachers, contains a more in-depth description of pollination and the seed-saving process, as well as a look at botanical nomenclature. Chapter 9, Resources, is a compilation of additional reading, resources and Internet links for teachers and students.

Although there are a number of stand-alone lessons included, the primary intention of this publication is to help answer the following questions:

1. How can a school's seed-saving project bring a coherent and increasingly complex understanding of ecoliteracy through the grades?

2. How can the same resource—a handful of seeds—be used to teach and support standards across grades as well as within different subject areas?

3. How can seed saving help apply a standard as well as teach a standard? What are the opportunities to practice fractions or estimation even if not directly teaching those concepts?

4. How can seed saving increase student understandings of natural cycles, stewardship, delayed gratification, responsibility, and connectedness to a place?

These pages are meant to inspire you as teachers and students to be part of a "Delicious Revolution," to use Alice Waters' term, to awaken your students to all their senses, to feed them physically, emotionally and intellectually, and to help them see their connectedness to each other and to the rest of the world.

Chapter 1

WHY SAVE SEEDS IN THE SCHOOL GARDEN?

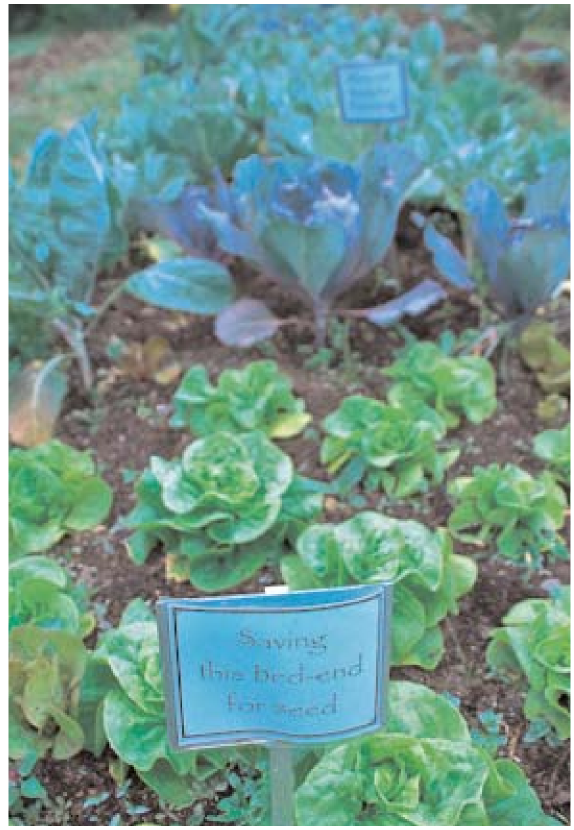
"If facts are the seeds that later produce knowledge and wisdom, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow. Childhood is the time to prepare the soil and once the emotions have been aroused—a sense of the beautiful, the excitement of the new and the unknown, a feeling of sympathy, admiration and love—then we wish for knowledge about the object of our emotional response."

—Rachel Carson, "The Sense of Wonder"

A handful of seeds can be a powerful learning tool across many grades and subject areas. A handful of seeds can be used with kindergarten students to teach math concepts of sorting, using seeds in a variety of shapes and colors. The same handful of seeds in second grade teaches cycles as well as the concept of "then" and "now." In third grade the seeds can be used to apply math standards, such as estimation and classification. Reading books on Native American agriculture and food can link both English and Social Science third grade standards. The seeds, in fourth grade, can be used to help shift the emphasis from "learning to read" to "reading to learn," by reading books on seeds. Reading seed packages and developing their own package designs can help students decide which information to deliver and in what order. Fifth grade history standards focus on the development of the United States through 1850, and seed migration and agriculture are an important part of that history. Seed collections are useful to the fifth grade math concepts of collecting and analyzing data. For example, how many seeds, on average, does a poppy produce? Sixth grade students can use the handful of seeds to analyze samples and generate data sets. The various shapes of seeds generate a hands-on lesson for measurement and geometry standards on calculating areas of objects. Sixth graders can incorporate seeds when studying ancient civilizations and their agricultural systems.

Seed Saving Extends the School Garden Season

Most schools in California follow the traditional September to June calendar. Many of the food crops planted in gardens ripen and become ready to eat during the summer months, when students are not in school. Seeds, however, mature in late August through the fall, allowing for a curriculum to be in place when the school year resumes. With this change in perspective, the garden is not "dead" in the fall, but full of seeds and learning opportunities. By planning your spring garden for seed saving in September, you can begin your school year with seeds ready for harvest and start your seed curriculum on the first days of the new school year.



Another benefit of having a portion of the school garden reserved for seed saving is that the intensity of garden chores is lessened. Garden beds do not have to be cleared as quickly. You no longer have a stand of "dead" plants that needs to be weeded, but a living laboratory of seed-saving lessons.

Harvesting seeds is done in the fall, but processing seeds, making seed packages and packaging seeds can be done in the rainy winter months when access to the garden is often limited. Spreading a tarp out and processing seeds can introduce a joyful yet calm energy to your classroom. Processing seeds is a very meditative activity. Songs can be incorporated into the processing. On a rainy day in January a class may hear the sound of rain falling on the roof, harmonizing with the sound of seeds falling into metal bowls as students process seeds. Students may vividly remember these sensory experiences years later.

Seed Saving is Economical

Saving seeds saves money. Not only are you not buying all your seeds from seed companies, you are also more likely to have successful crops if you grow them from seeds you have saved yourself. Selecting seed from the strongest, most productive plants in your garden each year—taking care to collect seed from a variety of plants to maintain genetic diversity—gradually results in a genetic bank that is highly suited to the unique characteristics of your own specific micro-environment. You increase the likelihood that the offspring of those plants will also do well. You are selecting genetic traits that allow plants to thrive in your particular garden.

Pictured above is a Shekere

Making Gourd Musical Instruments: Over 60 String, Wind & Percussion Instruments and How to Play Them, by Ginger Summit and Jim Widess is a wonderful book on making and using gourd instruments.

Seed Saving Stimulates the Five Senses

Schoolchildren are beginning their journey of understanding the world around them and are developing socially, emotionally, physically, and cognitively. Seed saving provides ample opportunity to enrich development in these four areas. Refining these skills provides a solid foundation for academic learning throughout life. Activities such as cooking in the garden engage the four areas simultaneously. Simply making a snack of sprout wraps with lemon vinaigrette requires children to wash the sprouts, use specific vocabulary, read directions, mix, take turns, taste, and modify the recipe. If they sprout the sprouts themselves, a science lesson on plant parts is generated. Developing a palate for healthy fresh food is an additional bonus. Children will generally eat seeds that they have helped grow, harvest and prepare.

Seeds can be used to bring music to students. Growing different gourds from seeds and then creating drums, lutes and shakers from the gourds will connect your students with countries in Africa and Asia, as well as to indigenous Americans. African slaves made some of the earliest guitars and violins in the United States from gourds. Shaker gourds are probably one of the earliest of all musical instruments. In Africa, hollow gourds are covered with loose netting strung with hundreds of beads. The beads are the seedpods of the grass Job's Tears (*Coix lacryma-jobi*). As the beads slap against the gourd, a loud shaker sound is produced. Using the neck of the gourd as a handle, the sound is amplified by the hollow interior.

Seed Saving Teaches Cycles and Seasonality

By allowing students to experience the full cycle of a plant, from planting the seed to harvesting the seed, the concept of cycles is experienced more deeply than by simply looking at a poster or handout. Seed saving reinforces the natural rhythms of the seasons. When most people see a lettuce plant that has gone to seed, they often do not even recognize it as a lettuce plant. The plant that we think of as lettuce has modified its form as it enters another phase of its life cycle. A tall stalk emerges from the rosette of leaves. The leaves on this stalk are more toothed and spiky, looking more like dandelion leaves, and the flowerets that form are white feathery tufts. With the coming of fall the pumpkins are ready, and in the spring when the earth has warmed, the fruit trees bloom. The garden's rhythms support and reflect the rhythms of the child's year.

Although our modern mega-supermarkets offer every type of food year-round, informed consumers are now yearning to eat in season, even if it has become unclear when foods are in season. Although we are bedazzled by tomatoes in February, remembering the explosion of sweetness last summer, we are almost always disappointed by the taste, a pale shadow of what we experienced six months before. Those anemic-looking winter tomatoes are picked under-ripe in order to survive being shipped thousands of miles around the world. They are grown from a variety that was bred for uniformity of size (to pack in boxes to ship), simultaneous maturing (to harvest on a large scale), thick skin (to survive shipping), and uniform skin color (to reduce blemishes).

When you select seeds from your school garden tomatoes, you can select for traits that you value: taste, ripening in September, not all the fruit maturing at once, nutrition, and color. The natural outcome of children's experiences in the school garden can be to develop a taste for seasonal healthy foods and to become informed food consumers.

The Seed-to-Table concept was developed by some of the early school garden programs as a way to teach deep ecoliteracy. Students who follow a seed from planting through harvesting and cooking, to final composting—all within an overarching agricultural system—will experience an integrative perspective that is more meaningful than if they were to experience each part of the life cycle in a disjointed way. Seed saving takes this concept to the next step of seed-to-table-to-seed. For example, you can plant seeds from one or two crops; tell the seed cultivation story, linking it to curriculum; observe and care for these growing plants; cook using them; save seeds on the plants; compost the inedible parts of the plants to enrich the garden soil; and study how this crop is grown and marketed commercially. Next season, plant the very seeds that your students saved and start the cycle over again in a new class, with the year-to-year continuity becoming another part of the cycle.

Seed Saving Teaches Abundance

Students who have never experienced hunger and who have a large number of material possessions may still feel a profound sense of deprivation. There can be a feeling of limited resources, of alienation and despair which is not limited to students who live in financial poverty. When children save seeds, they experience abundance. When a student tips a poppy pod into his hand and the seeds flow out of the little window opening like a saltshaker, the delight and amazement at the amount of seeds is obvious. One poppy plant produces thousands of seeds, enough to save for next year, enough to cook with, and enough to give away to the whole class. By putting poppy seeds in a large jar, students can observe the possibility that each seed can become a plant and also produce thousands more seeds.

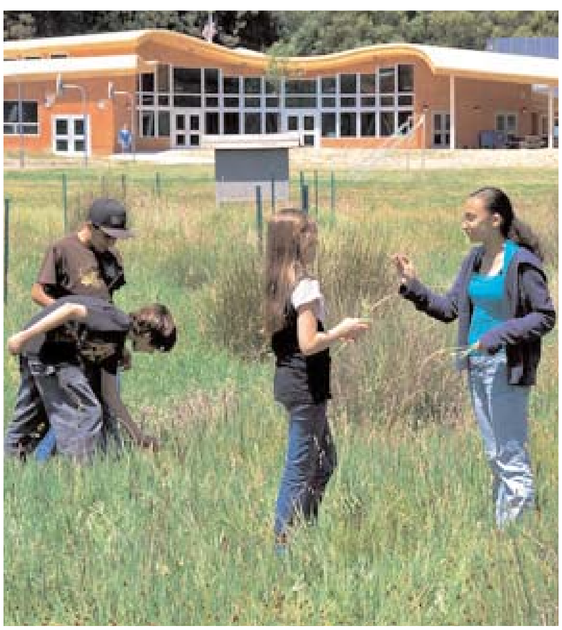
To give you an idea of the dazzling number of tomato varieties, consider a partial list of the 150 varieties sold at the OAEC spring 2009 plant sale, including Andy's Pointed Pink, Black Brandywine, Cherokee Purple, German Red Strawberry, Russia 117, Burbank Red, Black Krim, San Francisco Fog, and Indian

River. These varieties originated all over the world, from counties as different as Scotland and Iraq. The varieties from Russia are almost always black, instead of red. Some tomato varieties produce yellow, green, orange, black, purple, pink-and-red striped, and speckled fruit. The fruit can be pointed, elliptical, fluted, pear- or heart-shaped. Saving seeds of just a few of these varieties opens up a range of curriculum and introduces the idea that all the world does not think of the same red, smooth, round fruit when they say tomato.

Connecting with the seed-saving process is a powerful way for children to gain a deep sense of diversity and abundance. Seed saving can show us that there is enough for us all and that we are a part of the earth's abundance.

Seed Saving Teaches Stewardship

Having a connection with plants throughout their whole life cycle is a powerful experience for many children. The ethics of care and stewardship, beautifying the school grounds, eating together from the harvests, being caregivers and explorers are all allowed to unfold in a garden. Our children are aware of the environmental crisis facing our planet and they often feel a profound sense of helplessness. Being a steward of seeds, both in planting and harvesting, is a tangible act of hope. Seed-saving activities can also move outside the gates of the school garden. Students may become part of a conservation or research project through collecting and saving seeds of threatened or endangered species. (More information and examples of restoration projects can be found in Chapter 6.)



Seed Saving Teaches a Sense of Place

There is a Swedish word, *smultronställe*, which means a favorite spot or a place of personal connection. It translates literally as "a patch of wild strawberries," and it is used as a metaphor for the feeling you have when you find a patch of wild strawberries, little red jewels nestled in a shadowed forest floor, during the endless Swedish summer days. We all need our own *smultronställe* to feel connected to something beyond ourselves, as well as connected to something deep within us. Children might need this even more than adults. By providing opportunities for students to experience the natural world through a school garden or other environmental education program, we increase the chances of their finding their own special local place. Saving seeds, being part of an ancient life-giving and life-affirming act, reaches both into the past and into the future, connecting us to all who went before us and all who will come after us.

Seed Saving is Inclusive

Students who are less successful in a typical academic classroom often shine in environmental education settings. Many teachers have observed that the "behavior problem" students melt away in the outdoor classroom. Seed saving allows strengths to emerge in a hands-on setting that may be rarely seen in the classroom. The garden setting allows teachers to choose multiple styles of teaching such as direct instruction, collaborative learning, inquiry learning, or project-based learning. The garden is well suited to the Constructive Learning Theory, which states that learning is an active process of creating meaning from different experiences, with the teacher acting as the students' guide. Garden-based education allows both teachers and students to participate in the construction of knowledge. Children who are kinetic learners, obtaining their information from doing, find the garden both engaging and calming. Immigrant students, whose connection to growing and cooking food is often culturally stronger than non-immigrant students, can be leaders in the garden. Teachers who grow seeds from their students' homelands will connect them and their families to the school, helping to build a sense of community. Students with limited English skills may be able to express themselves in the informal setting of the garden in a different way than in the classroom.

Although there are hundreds of academic opportunities in gardens, the most valuable concept for children to experience is that of wonder. In the garden children can explore and express their natural affinity with the living world.

Chapter 2

WHAT ARE SEEDS?

"Though I do not believe that a plant will spring up where no seed has been, I have great faith in a seed. Convince me that you have a seed there, and I am prepared to expect wonders." —*Henry David Thoreau*

Seeds are the most sophisticated means of propagation in the plant kingdom, and the most complex structure that a plant produces. It has taken plants 10 million years of evolution to move from primitive fern-like structures to seeds. The evolution of seeds can be compared to the evolution of eggs in reptiles. Just as the egg allowed reptiles to evolve into the first true terrestrial vertebrates, seeds allowed plants to become independent of wet habitats, to travel and adapt to a wide range of conditions, from environments with constant rain to those with almost no rain. Each method of reproduction and dispersal is subdivided into variations of function and form, allowing plants to grow and reproduce almost anywhere on earth.

Seeds range in size from dust-like orchid seeds that can contain up to 1 million seeds in one gram, to the giant Coco de Mer (*Lodoicea maldivica*), whose mature fruit weighs up to 30 kg (60 lbs) and contains the largest seed in the plant kingdom. Until 1768, when the true source of this nut was discovered to be a rare palm tree that grows in the Seychelles, it was believed by many to grow on a mythical tree at the bottom of the sea. European nobles in the sixteenth century collected the shells of these nuts and decorated them with precious jewels for their private galleries.

Although it is not necessary to understand beyond a basic level of plant classification and reproduction in order to teach and enjoy seed saving, a number of students may be intrigued by botany and

Coco-de-mer shell and chain. Kashk l, or Beggar's Bowl, with Portrait of Dervishes and a Mounted Falconer. Iran, A.H. 1280/1880 C.E.

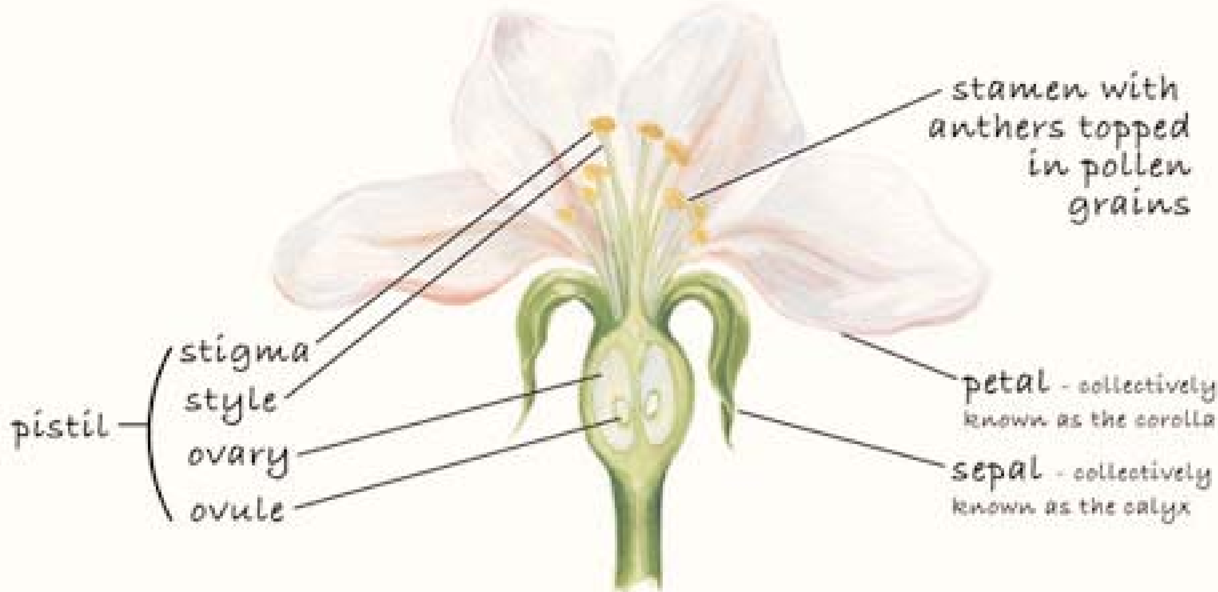
the scientific language. Botanical names can also be used to teach English Language Arts standards on root words. (See Lesson 9 in Chapter 5.) More information on botany, along with a glossary of scientific terms, can be found in Chapter 8, Background for Teachers.

A Primer on Plant Reproduction

A flower exists to produce seeds and a seed is a ripened **ovule**, containing an **embryo**. The male organ of a flower is called the **stamen**, which consists of the long stem-like **filament** with a sac at its tip called an **anther**. Flowers typically have many stamens. As the flower matures, the anther ripens and splits open, exposing the **pollen grains**, the male reproductive material that can be transported to other flowers usually by wind, insects or birds. The pistil, usually in the center of the flower, is the female reproductive organ, comprised of a **style, stigma** and **ovary**. The style connects the pollen-receiving portion of the pistil, the stigma, to the ovary, which contains immature egg(s) cells or ovules. The slender style is above the ovary. The tip of the style, the stigma, is where pollen is deposited.

When pollen contacts the receptive stigma, the pollen forms a **pollen tube** that reaches down through the style to fertilize the ovules (egg cells) in the ovary. Two male **nuclei** or **sperm** move down each pollen tube to the ovule. One unites with the egg in the ovule while the other unites with the two **polar nuclei**. This is called **double fertilization**. The fertilized egg develops in the embryo, which is the next generation of the plant. The fertilized polar nuclei develop into tissue called the **endosperm**, the food for the growing embryo. Some seeds, such as beans, watermelons and pumpkins, contain no endosperm. The coconut's edible part is all endosperm. In corn and wheat, the endosperm is the nutritional part of the seed. Over time, the entire ovary becomes the plant's fruit or seed, containing the fertile ovules that will become the seeds of the next generation. Thus, an apple is the ovary of an apple blossom, holding fertile seeds within it.

The **stamen** and the **pistil** are essential for the formation of a seed. Two other flower organs—the **sepals** and the **petals**—are not necessary for seed production. If a flower has all four organs it is called a **complete flower**. The sepals are the lowermost of the four organs and often look like green leaves. Their main function is to protect the bud until it develops into a flower. The sepals are collectively known as the **calyx**. The petals are above and inside the calyx and are collectively called the **corolla**. They are often brightly colored and may have glands that secrete nectar.


stamen with anthers topped in pollen grains
stigma
style
pistil
ovary
ovule
petal - collectively known as the corolla
sepal - collectively known as the calyx

Cotton plant.

How do Seeds Disperse?

The aim of seeds is sexual reproduction and dispersal, and plants have created a staggering number of ways to reproduce and travel. Without a method of dispersal, seeds would drop down at their mothers' feet, competing for sunlight and water. Spreading seeds away from the mother plant increases the chance that more seeds can find a favorable growing situation without harming the mother plant.

Each method of reproduction and dispersal has developed myriad variations of function and form, allowing plants to grow and reproduce almost anywhere on earth. Thus seeds vary in size and form, yet every one of these methods is a variation on a theme—to reproduce and disperse.

The four main way seeds are dispersed are by wind, by hooking onto passing animals or hitchhiking, by floating in water, or by being eaten by an animal and then moved through the animal's gut. Within these four main strategies there is an amazing array of adaptations to increase the success of the seed's dispersal. Wind-borne seeds, for example, can have one wing, two wings, multiple wings, disc-shaped ring wings, skirts of helically arranged **lamellae**, hairs (the best known of these is cotton, whose seed hairs can be woven into cloth), feathers, parachutes, or balloon fruit full of air chambers. Many wind-dispersal seeds have honeycomb patterns that ensure maximum stability with the thinnest walls, allowing the maximum load capacity for the least amount of weight. This allows the seed to catch slight wind currents and ride the thermals, traveling great distances from their mother plants. Examples of water-dispersed seeds are earpods (*Enterolobium cyclocarpum*), swamp palms (*Raphia taedigera*), coconuts (*Cocos nucifera*), and monkey ladder pods (*Entada gigas*). Seeds that drift on ocean currents have air chambers inside to help them float, along with thick protective seed coats to keep the seed dry. Some seeds have pods that twist as they dry, which can propel the seeds out of the pod at explosive speeds. Other plants use the moisture in the air to move their tiny hairs or awns along the ground. Wild oat seeds can move within minutes of a change in humidity. Some seeds use raindrops to spread their seeds with structures that act like a diving board. When the water droplet hits the plant, the seeds are launched into the air and propelled up to six feet away.

For activities on this theme, see the Adapt a Seed lesson on pg 44, Chapter 5.

{ *In the right place at the right time,*
every seed can give rise to a plant. }

The Language of Botany

We often use the words fruit, nuts, and seeds in non-botanical ways. All **angiosperms** produce fruit, and the variations are endless. There are so many different ways that fruits can be classified that botanists have come up with over 150 technical names for the many types of fruit! The way fruits are classified is complicated, but falls into three main differentiations: Is the fruit wall soft or hard? What is the underlying ovary type? Does the fruit open up at maturity to release its seeds? **Simple fruits** like cherries or tomatoes (yes, tomatoes are fruits) develop from one flower with only one pistil. The botanical term for a simple fruit is a **berry**. The watermelon is a berry with a hard rind. The avocado is a single-seeded berry.

Multiple fruits like blackberries and raspberries developed from a flower with many pistils, which is why these fruits appear the way they do. So a blackberry is not technically a berry, but is an aggregate or multiple fruit. The mature bean pod is the fruit of the bean plant, and bean seeds are ripened ovules. Then there are **compound fruits**, which develop not from one flower but from a group of flowers (which we tend to mistake as one flower, because each flower is so small). Pineapples and figs are an example of compound fruits.

Fruits that have hard cell walls are called **nuts**. Their walls remain closed and the seed is not dispersed from the nut. So botanically speaking, sunflowers, and all our cereals are nuts. Rice is a fruit. Almonds and pistachios are in fact stone fruits, not nuts.

Some students may enjoy knowing and using specialized vocabulary, learning the scientific name and origin of words like *stamen* which comes from the Greek meaning "thread," and *style* from the Greek word for "pillar." As they learn plant classification, they may discover that a watermelon is really a berry and a tomato is a fruit. While not insisting that younger students learn scientific nomenclature, teachers can accommodate students who gravitate to the formal language of botany. Botanical names are useful to teach English Language Arts standards on root words. For activities on this theme, see Seed Sayings on pg 59, Chapter 5.

Chapter 3

SEED-SAVING BASICS AND STARTER PROJECTS

Whoever acquires knowledge and does not practice it
Resembles he who ploughs his land and leaves it unsown.
Sa'di, Persian poet (1184-1283/1291)

Thomas Jefferson once said that he was "an old man, but still a young gardener." Understanding and experiencing the natural world is a lifelong pursuit. You do not need to be formally trained as a botanist to teach seed saving. Much of what you will teach your students is a deep appreciation of the natural world and a passion to be a lifelong learner.

If you are just developing your school garden's seed-saving program, this chapter will get you started with an outline of the basic process and materials needed for collecting, saving and storing seeds. At the end of this chapter you will find instructions for saving the seed of lettuce, an easy plant to introduce the world of seed saving.

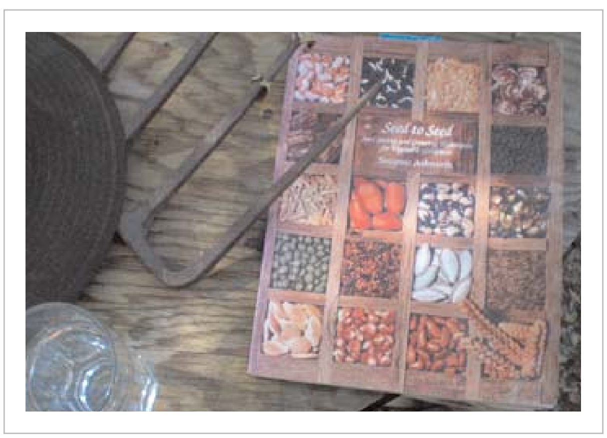
The Seed Garden

You may want to plant a "seed garden" so you will have plenty of seeds to use with your students. Seed saving does not require a big garden space, and can be done in smaller gardens or even using containers. It is best if you do not harvest leaves from the plants whose seeds you will save, but rather allow those plants to go to seed. Be sure to communicate your intentions to save seeds to the rest of your school community with signage reading "Saving for Seeds: Please Do Not Harvest or Weed." It will take time for your school community to develop eyes to see maturing seeds rather than plants that need to be removed. At OAEC we often use "bed ends"—short sections at the ends of the beds—so everyone who comes to the garden knows this section is reserved for seed-saving projects.

Good candidates for your seed garden are fennel, dill, angelica, poppies, Nigella or Love-in-the-Mist, sunflowers, amaranth, lettuce, and cilantro (coriander). They are all easy to grow, self-pollinating, and produce hundreds of seeds. These plants can grow close to one another without fear of crossing. The botanical expression for these types of plants is that they "come true." This means that each flower of the plant will accept its own pollen, so the flower can pollinate itself without the aid of wind or insects. This is important because it means that the seeds always resemble their parents and there is no genetic mixing going on between different plants.

Seed Collecting

Seeds that grow in pods or husks are usually left on the plant until they are completely dry, and are then harvested individually or by removing the entire plant. Harvesting of dry seeds must be done before winter rains set in, to prevent the seeds from molding in storage. At OAEC, we harvest dry seeds into paper shopping bags for processing and cleaning during the winter months.



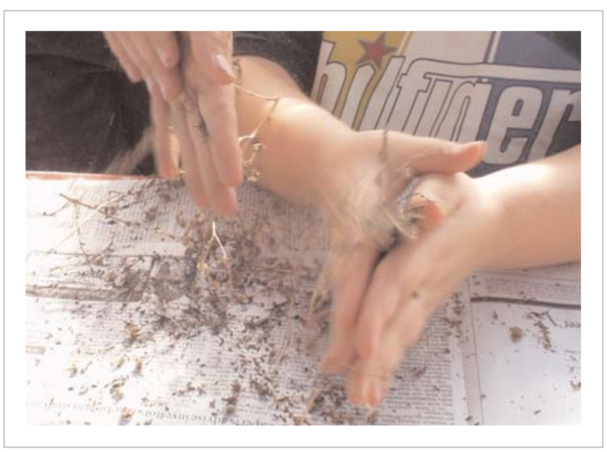
A Wonderful Seed-Saving Book:
Seed to Seed *by Suzanne Ashworth.*
In addition to helpful theoretical information,
Seed to Seed *provides species-by-species details on pollination, isolation, seed production, harvest, processing, storage, and viability.*

Collect seed from the greatest possible number of desirable plants in order to maintain genetic diversity in your collection. This diversity is vital for hardiness and vigor, which influence the ability of plants to adapt to varying environmental conditions. The fact that industrial agriculture is relying on only a small number of genetic lines is one of its fundamental problems, for this results in weakened species that require ever-increasing assistance from pesticides, herbicides and fertilizers.

In the event of an early hard frost warning, pull the plants out and hang them to continue drying for about a week, which allows the seeds to continue maturing fully. Seeds embedded in the flesh of fruits (e.g., tomatoes, squash, berries) are harvested when they are ripe and processed right away before the fruit rots. Environmental factors (weather, disease, pests, drought, seasonal variations) and genetic factors (mutations, variability) can affect plants and their seeds. In selecting the plants from which to save seed, assess the condition of the whole plant, looking for disease and insect resistance, drought tolerance, vigor, color, earliness of fruiting, lateness of bolting, hardiness, uniformity, and trueness. You can influence your future crop characteristics by selecting seeds on the basis of size, shape, color, productivity, flavor, shelf life, and more. Although it is not guaranteed that the same characteristics will be expressed in the next generation, over time you will be able to influence the traits of your seed stock.

It can be a good idea to remove plants that possess undesirable characteristics prior to flowering, thus ensuring that their genes will not influence your seed stock. This is called ***roguing***, and it can be a challenge to small-scale gardeners who often combine food production with seed saving. It may mean pulling out plants that would otherwise produce edible fruits (e.g., tomatoes, squash, beans, peas). With some plants such as lettuce, kale, and carrots, you can rogue before the plants bolt and still eat the food. Make large enough plantings to allow for roguing and to also ensure diversity of your stock.

Seed Processing Methods



Dry Processing: Dry processing is used for seeds that mature and harden on the plant in husks or pods, including legumes, corn, lettuce, and radish. A variety of processing techniques are used, depending on the seeds' size, volume, and weight relative to the chaff. You can be creative and experiment with different techniques and equipment to suit your own circumstances.

The first method is called ***threshing***, a process of beating or rubbing to separate the seeds from their containers. Brassicas such as kale and cabbage seeds that are held in dry pods may be processed this way. Threshing can be done by rolling the seed heads between your hands. You can also place the seeds in a large cloth bag such as a pillow case or a feed sack, and beat it on the floor. Or use your feet, a broom handle or a board. If the seed head is not too tough, you can sometimes press the seeds through a screen, as described below.

Winnowing is the step of separating the seed from the rest of the seed head material and chaff. On moderately windy days, this can be done by gently tossing seeds into the air for the wind to catch the chaff, although this requires practice and a reliably consistent wind speed. The chaff can also be separated by swirling the seed material in smooth metal bowl, collecting the chaff on top, then tipping the bowl and blowing the chaff away, being careful to not send seed off with it.

In some cases, it helps to first separate most of the chaff out of the seeds by using screens of various dimensions. These screens can be purchased from Abundant Life Seed Foundation (see Resources section) or you can make your own using a wooden frame and wire mesh of various sizes. Some chaff will remain after screening, and winnowing can be done as a last step to remove the smallest, lightest material.

Processing tomato seeds.

Wet Processing: For fruits and vegetables with seeds contained in wet fleshy material, like tomatoes, first remove the seeds from the fruit by scraping them out or crushing or mashing the fruit. Notice that tomato seeds have a gelatinous sac around the seeds. This sac contains compounds that are germination inhibitors, preventing the seeds from germinating inside the mother fruit. After all, a tomato is full of moisture and is often warm—the perfect germinating conditions. For these fruits, let the seeds sit in the pulp and juice for several days before washing. The pulp and seeds ferment, and mold eats the sac off the seeds in a few days.

Plastic containers such as Tupperware, yogurt containers, plastic bowls, milk or juice gallon jugs that are cut open, and five-gallon plastic buckets are all good containers for wet processing. Fruits can be pulped, fermented and cleaned in the same container.

To wash the seeds free of pulp and juice, add at least twice as much water to the mixture in a bowl or bucket and stir. Non-viable seeds will float, and can be poured off with the water and fruit debris. Repeat this process until only clean viable seeds remain at the bottom of the container. For the final rinse, put the seeds in a strainer and rinse under running water.

To dry the seeds prior to storage, spread them thinly onto a cookie sheet, screen, glass or ceramic dish, or piece of plywood. Do not use paper or cloth since the seeds will stick to it. Seeds should be dried quickly, out of the direct sun and below 96ºF. In humid areas, a fan may be used. Stirring the seeds frequently hastens drying.

Storing Seeds

When properly stored, seeds can retain their viability for several years. Viability is compromised if seeds are harvested prematurely and if storage conditions fluctuate. When storing seeds, it is essential to keep them in a cool, dry, consistent environment that protects them from high temperatures, moisture, and direct sunlight. Do not store them in a greenhouse, or leave jars of seeds in the sun while gardening, as you will cook your seeds very quickly. Assign a student to be the "seed mother or father," making sure that the jar is kept in the shade and paper seed packages are not placed on the soil where they will absorb moisture and rot. Children can get very excited when planting seeds, so a seed mother or father makes sure that the unused seeds are returned to the classroom, safe and dry.

Store seeds in airtight containers, preferably glass or metal. Glass jars with rubber gaskets, such as baby food jars and canning jars, are perfect. Gallon jars can be used, ideally with homemade gaskets cut out of bicycle or car tire inner tubes.

Envelopes of various sizes are good for storing relatively small amounts of seed. You can record the species, variety names and harvest dates on the envelopes. Coin envelopes work well for seeds as they can be sealed or closed with a paper clip. Students can also make their own seed packets. A template is available at www.tipnut.com/seed-packets or see Resources section.

Common plastic bags such as bread bags are not moisture-proof and should be avoided. If you want to use plastic bags, use a heavy plastic such as Zip Lock™ or Seal-A-Meal™, and store the smaller seed bags together in a glass jar. Paper envelopes and small muslin bags, labeled with the species and variety, can also be used in this way. This enables the storage of several varieties of a species together in one container.

Silica gel can be added to jars to desiccate moisture if you are concerned about variations in humidity. Color-indicating silica gel is available—the small plastic-like beads turn from deep blue to light pink as they absorb moisture. They can be dried out and reused by microwaving them or setting them in a 200°F oven for about eight hours.

Record Keeping

It is important to keep good records when saving seed. Most important is the labeling of your seed material with the species name, variety, and date of harvest. If you have the resources and inclination, several other pieces of information can be very useful, especially if you plan to share your seed or if it will be used within a community or organization. Additional helpful information to record: common names; historical or cultural information; location grown; germination rate; days to maturity; plant descriptors such as height, fruit size, color and shape; productivity; ideal growing conditions; theoretical seed viability. If you and your students create a seed label template, it will help ensure that the same information gets recorded on every envelope of seeds. Some schools have used these homemade seed packets for fundraising, or have created their own school seed catalogue.

Seed Viability and Growing Out Seeds

Although seeds stored under proper conditions can remain viable for several years, viability naturally declines over time and it is important to grow them out regularly and save new seed. Expected seed viability varies depending on the species, ranging from only one year (e.g., parsnip, garlic, Jerusalem artichoke) to ten years (e.g., cucumber). Seed viability data is provided for many vegetables in S*eed to Seed*.

Keeping record of the harvest date of your seeds enables you to make decisions about growing out your stock to retain its viability. You may want to record the theoretical seed viability in the same place as the harvest date for easy reference in future planting decisions.

Collecting and Processing Equipment

Seed saving and processing on a small scale requires very little equipment and expense. Many of the supplies are either adaptable from common household items, or can be made or purchased relatively cheaply.

In fact, a child's hand is one of the most useful tools you already have in your classroom. At the beginning of each school year, students can learn measurements by using their own hands. They can measure one, two and six inches, without having to get out rulers every time. Each child can find these standard measurements on their own hands—one inch from the tip of their pointer to the first knuckle or six inches across the palm and so carry around their own rulers within their hands. This is also a great opportunity to teach that the names and standards of many measurements came from the human body. For example, an inch was the width of a man's thumb and in the 14th century, King Edward II of England standardized an inch to equal three grains of barley placed end-to-end lengthwise.

The following equipment is useful for seed collection and processing:

Metal Bowls—Commonly available, inexpensive aluminum bowls, with gently sloping sides, are perfect for dry processing because seeds can be shelled or shaken right into the bowl and the chaff and debris can be easily blown off the slippery surface. Bowls of varying sizes provide versatility.

Pollinating Bags—To control flower pollination, paper bags can be tied over the flowers in regions where rain is not a threat. Reemay can also be used (see below).

Reemay—This porous, lightweight fabric can be used for bagging flowers and for covering hoops over rows of plants to prevent cross-pollination. Seeds, pods and whole plants can be bundled in Reemay and hung to dry. It is also generally used to protect plants from insect and bird damage. Reemay is available by the foot and by the roll from all gardening stores and most hardware stores.

Row-Marking Stakes—Durable and reusable stakes for recording variety names and other information can be made by cutting wooden lath into 12" stakes and painting the top for easy visibility. Permanent marker is used to write on these, and they can then be painted over and reused. Some seed companies, such as Southern Exposure Seed Exchange, also sell stakes.

Screens—Three or four screens of varying mesh sizes are useful in separating seed from debris. They can be handmade by stapling wire mesh to one side of 12-inch square wooden frames. We suggest constructing four frames with 1/2", 3/8", 1/4", and 1/8" mesh. Educators during OAEC's School Garden Residential Training were able to make one screen in 30 minutes, assuming the wood and screen was pre-cut. Many of participants have gone on to make them with their students, usually in the fourth grade or above.

Seed Collection Bags—At OAEC we use paper shopping bags with clothespins attaching the bags to our shirts or belts, which frees up both hands. These bags can be reused once they have been completely emptied of seeds. To prevent mixing of seeds, be especially careful of the seams of the bag where seeds can get caught. Cutting brown paper bags in half for smaller children helps them not spill the seeds out of the bag.

Begin With Lovely Lettuce

Of all the self-pollinating plants, lettuce is best suited to school gardens for the following reasons:

— It is easy to grow.

— It is a familiar crop for students, but most have not seen lettuce plants go to seed.

— It can be grown in some regions through out the school year.

— Each plant can produce up to 30,000 seeds.

— Seeds do not mature all at once, allowing seed saving to occur over a few weeks.

— Many different and interesting lettuce varieties are available, with a wide range of leaf shapes and colors as well as taste. Lettuce leaves range in color from magenta to bronze, pink and red as well as many hues of green.

— Names such as Deer's Tongue, Besson Rouge, Tom Thumb, and Red Sails stir the imagination of students.

— Not much space is needed to plant a number of varieties of lettuce. Different lettuce varieties can be planted close together without fear of cross-pollination, although if possible, it is best to plant another crop between each row of lettuce.

— In mild climates, succession plantings can occur every two weeks during the fall, allowing you to have ongoing seed savings throughout the spring.

— Lettuce has a long and ancient history, so it can tie in with historical and cultural content areas. Its origin appears to be in Asia Minor and there is evidence that the plant was eaten in Egypt about 4500 BCE. The Romans grew types of lettuce resembling the present Romaine cultivars, and the crop was known in China by about the 5th century.

Where Can We Find Lettuce Seed?

The International Lactuca Database is an international database that lists lettuce varieties and which worldwide seed banks have seeds. Seed varieties can be sorted by country of origin, allowing teachers to weave history and geography lessons into the seed-saving lessons. Countries of origin range from Vietnam, Iraq and Japan. The database website is http://documents.plant.wur.nl/cgn/pgr/ildb}

Lettuce Seed Facts

Soil temperature for germination: 40 to 70°F
Germination time: 3 to 10 days
Seed Viability: 5 years

For excellent information on the best lettuce varieties by state, go to the vegetable variety data collection project at Cornell University, www.vegvariety.cce.cornell.edu

Steps for Saving Lettuce Seed

In the fall, plant out at least five varieties of lettuce. Seeds can be sown directly outdoors in mild climates. Plant some seeds to harvest for eating and more to save for seed. It is best not to harvest leaves from the plants whose seeds you are saving because the plants need to develop fully before going to seed. Be sure to mark your seed-saving project with a durable sign.

Have students taste a lettuce leaf from a plant that has gone to seed. It should be very bitter. This is because most varieties of lettuce exude small amounts of a white, milky liquid when the leaves are broken. This "milk" gives lettuce its slightly bitter flavor, and its scientific name, Lactuca sativa, as "Lactuca" is derived from the Latin word for milk. The milk is called Bitter Sesquiterpene Lactone or BSL, and its levels increase as the plant matures. Since ancient times, BSL has been known to induce sleep.

Since lettuce will bolt to seed when it is hot and the days are long, you will be able to save seeds of the lettuce plants in the spring before the school is out for the summer. As the plant bolts, a stalk grows and small yellow flowers develop. The flowers are actually 10 to 25 individual florets, creating thumb-sized flowers that look like dandelions. Each floret produces one small black or white seed. Note that some lettuce varieties, often those with white seeds, need to be exposed to light to germinate. Plant the seeds of these varieties on the surface of the soil and cover with only a minimum of soil.

Once the seeds have dried on the plant, shake the plants into a brown paper bag to catch the seeds. Seeds are usually clean and should not require much winnowing (see page 22). Store seeds in an envelope or jar and keep in a cool, dry location.

Chapter 4

SEED STORIES

It is hard to imagine, while spinning the seed rack at your local garden center, that each seed is a time capsule reaching back through almost 600 million years of plant evolutionary history, as well as traveling into the future carrying the next generation's genetic code. Our human relationship and co-evolution with seeds is what allowed humans to become farmers, to build towns, cities and nations. Our story as evolving human beings is interwoven with the stories of the seeds of various crops that infuse our mythology, our economy, our social structures, our food systems, our nutrition, and our laws. Seed saving connects us to our agricultural heritage, and can provide us with linkages to different people, places and cultures. The seeds begin to carry with them the stories of the humans to whom they were important. In some cases, varieties are named after the person who bred the variety (Alan Chadwick sweet peas, Jimmy Nardello's sweet pepper), the place of origin (San Francisco Fog tomato), or even an event (Radiator Charlie's Mortgage Lifter, Australian Gold Rush lettuce).

Here are some seed stories, living histories across space and time that you may want to share with students. Once you begin saving seeds, you will undoubtedly begin to accumulate histories associated with your own seeds, to pass along and exchange with others.

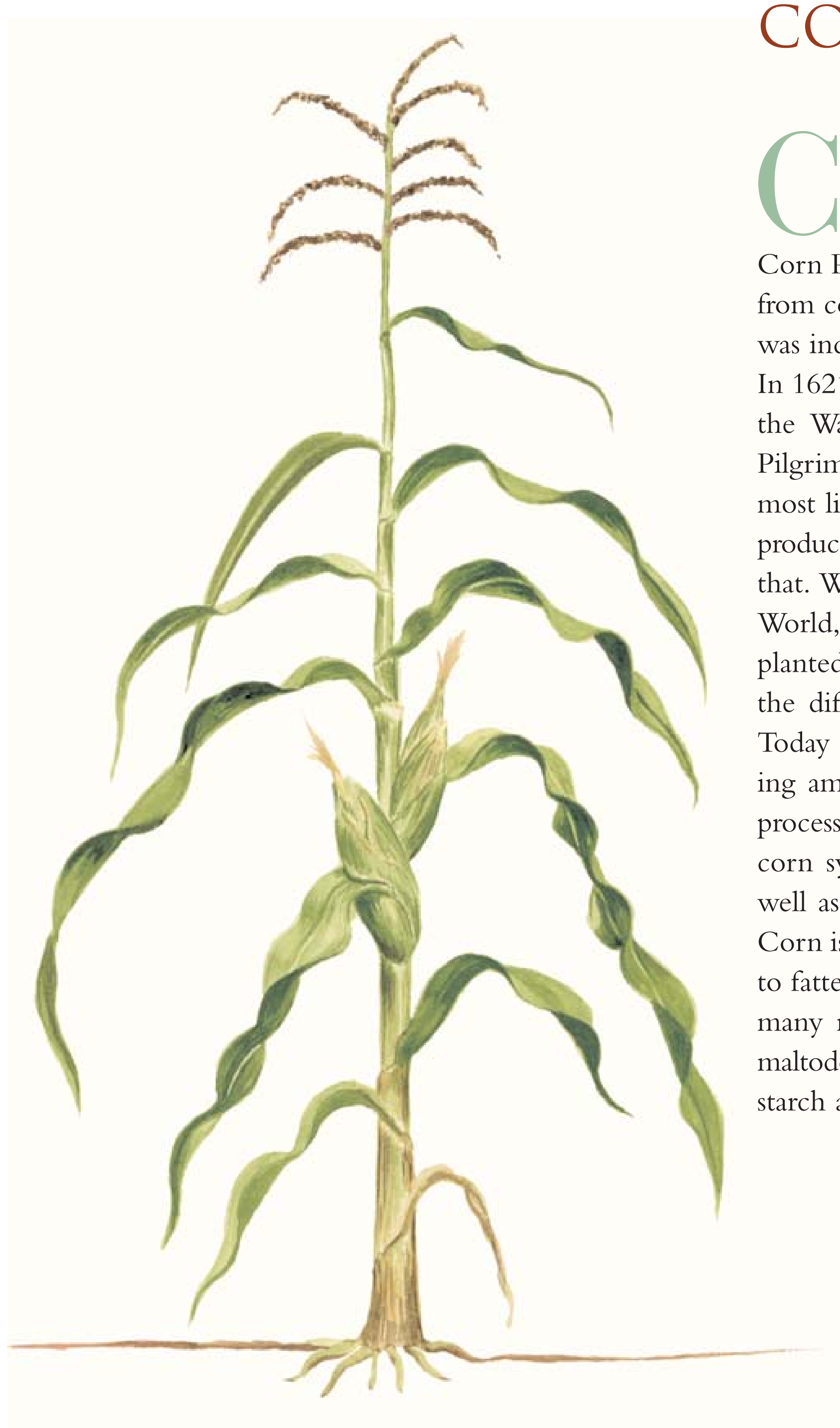
Our story as evolving human beings is interwoven with the stories of the seeds of various crops that infuse our mythology, our economy, our social structures, our food systems, our nutrition, and our laws.

AMARANTH

Various seeds have been central to a number of civilizations. Amaranth was a staple food of great importance to the Aztecs, Incas and Mayas. Every year 20,000 tons of amaranth grain was brought to Tenochtitlan, the former Aztec capital and current site of Mexico City. It was said that a man could march for a day by eating only a handful of these small, shiny seeds. As amaranth is one of only two grains known to be a complete protein containing the eight essential amino acids, this story may have some truth in it.

The Aztecs used amaranth seeds to make flour, first popping the seeds like popcorn. They used the leaves to make sauces and mixed the seeds with the sap of a cactus to make into a drink. Amaranth seeds were also used to pay tribute or taxes to the Aztec Empire. Throughout the year, amaranth seed was ground into a paste with honey and the sap of the maguey plant. The paste would be formed into various shapes and carried through the streets to the great temples and then fed to the people. This amaranth paste was consumed in much the same symbolic way as the Catholic Church rite of the Eucharist, as a ritual communion with God(s). The Spanish found the Aztec "pagan" ritual offensive. Recognizing the sacred value of the amaranth to the Aztecs' heretical religion, the Spaniards banned the cultivation and use of amaranth in the Americas.

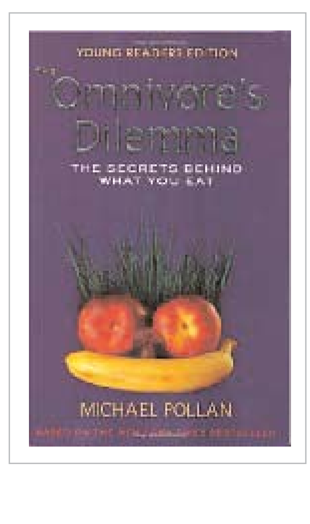
Amaranth grain is one of the two known grains that is a complete protein containing the eight essential amino acids.



CORN

Corn, native to Central America, was so vital to the Maya people living in Mexico that they referred to themselves as "the Corn People." Almost 40% of the Maya diet came from corn, mostly consumed as tortillas, and corn was incorporated into many of their celebrations. In 1621 in what is now Massachusetts, Squanto of the Wampanoag tribe introduced corn to the Pilgrims. Without this grain the early settlers would most likely have perished. A single corn seed can produce 150 kernels of corn and sometimes double that. Wheat, which is not adapted to the New World, produces at best 50 seeds for each seed planted. The difference between those yields was the difference between starving and prospering. Today we in North America consume a staggering amount of corn, not as ears of corn, but in processed food. Corn in the form of high-fructose corn syrup is in every can of soda we drink, as well as in ketchup, mustard, hams, and hot dogs. Corn is fed to hogs, beef cattle and farmed salmon to fatten them quickly and cheaply. Corn goes by many names now such as dextrose, polysorbate, maltodextrin, caramel color, xanthan gum, modified starch and is ubiquitous in most processed foods.

{ *Michael Pollan's book* Omnivore's Dilemma *is an engaging narrative about the food we eat and how it comes to our plate, including an in-depth exploration of the role of corn in our modern food system. In 2009 he released a new edition especially for young readers.* }



POTATOES

The potato, often relegated to dark bins in grocery stores, has an amazing story to tell. The staple food of the people of the Andes Mountains, the potato fueled the Industrial Revolution, caused massive population shifts, and is now the one of the world's four most important food crops. In Peru alone, there are thousands of varieties of potatoes, in a rainbow of colors, growing in different soils and altitudes. In the native Quechua and Aymara languages, thousands of words refer to the potato's shape, usage, origin, characteristics, and the ritual and culture surrounding it. Before the Spanish conquest, the potato was used as a measurement system. Time was measured by how long it took to cook a pot of potatoes. A *papacancha* or *topo* was the plot of land a family needed to grow its potatoes. Because plots at higher altitudes had to lie fallow for seven to ten years, a *topo* in a highland area could be larger than one in the lowlands.

It is believed that the potato was introduced to the Old World by Sir Francis Drake. It soon became an important source of nutrition, finding its way into various culinary traditions. In Offenburg, Germany there is a statue of Sir Francis Drake with the following inscription in praise of the potato: "As the help of the poor against need, this precious gift of God allays bitter want."

The Irish potato famine is a lesson from history warning of the dangers of crop vulnerability arising from genetic uniformity. The potatoes grown in Ireland in the mid-1800s were descended from only two introductions of Andean potatoes, one through Spain in 1570 and the other directly into England and Ireland about 20 years later. Although over 75% of Ireland's farmland was devoted to growing grain crops, it was all exported to England or given to landlords in rent, and potatoes became the staple diet of poor Irish peasants who could not afford grain. When the potato blight (*Phytophtora infestans)* struck, the genetic pool contained no resistance to the disease. For five years potato crops failed. One to two million Irish died and millions more emigrated, mostly to the United States. If not for the blight resistance in other Andean strains, potatoes would not have survived. The Irish potato famine was only the first in a long series of crop epidemics around the world, which have been on the rise as plant diversity has decreased and industrial agricultural practices have become more dominant worldwide. A good reference about the rise of monoculture in modern farming practices and some of its effects is *Fatal Harvest*, edited by Andrew Kimbrell.

{ The Potato: Treasure of the Andes *presents stunning photographs of the people of the Andes. Published by the Centro Internacional de la Papa or the International Potato Center.* }

YARROW

Rhymes about plants often refer to stories about their medicinal uses. Many plants have long medicinal relationships with humans, not only to heal sickness but also to help people prevent disease and remain healthy. Yarrow (*Achillea millefolium)* is a common garden plant with many medicinal and cultural stories. Considered an herb of protection in both Asia and Europe, it was used in battlefields to staunch internal and external bleeding. In Asia, yarrow sticks were the original tool for casting the I Ching, a sacred game of prophecy. Yarrow was one of the seven sacred herbs used by the Druids to divine weather. Yarrow is used in current cancer treatment in Europe, often in packs placed over the liver of cancer patients

A traditional song about yarrow is:

Yarrow, Yarrow, tremble and sway
Tiny Flowers bright and gay
Protect my garden night and day.

Other common plants such as rosemary and thyme have their own stories that could be woven into many Social Studies lessons. When students learn the stories of plants, they may use these stories to help them in their daily lives. For example, if a student is having a hard day, encouraging him or her to sit next to the yarrow patch for protection or the thyme patch to gain strength can help them rejoin the class.

Some modern seed stories reveal the complex trade-offs people have faced as they have lost control of their seed collections to corporations. By the mid-1970s, three-quarters of Europe's traditional vegetable seed stocks stood on the verge of extinction. By that time scientists were beginning to scrape the bottom of the barrel, in this case the gene pool, in search of genetic resistance to an ever-growing list of virulent diseases and pests attacking the world's most important crops. Although modern plant breeding led to a green revolution in the North and massive increase in yields, it also eroded the genetic base for future breeding and increased the risk of large-scale crop failures. Today much of the world depends on single varieties of crops grown in a monoculture, which is a very unstable system. For more about biodiversity, genetic engineering, and the effect of industrial agriculture on seeds, please see Chapter 7, Historical Context.

SEED PIONEERS

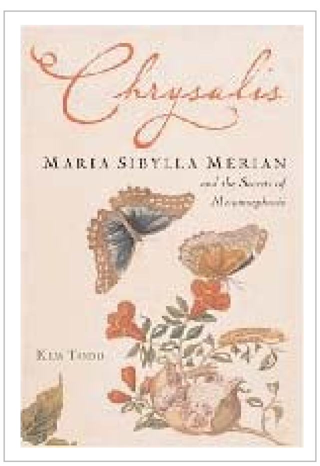
Some seed stories illustrate the eras of exploration and enlightenment.

Carl Linnaeus—(1707-1778), the father of taxonomy, sent his students, known as Apostles, to the far reaches of the known world to collect seeds. Many of them died in the field while attempting to bring seeds back to Sweden. Linnaeus' pupils Anders Sparrman and Daniel Solander circumnavigated the globe on James Cook's second voyage in 1775. Through his extensive study of plants, Linnaeus invented a new system of classification of living things, which he introduced in the Systema Naturae, first published as a pamphlet but later as a multivolume work. His method for naming, ranking and classifying organisms has been modified but is still in wide use today. The 300th anniversary of Linnaeus' birth was celebrated in Uppsala, Sweden, in May 2007. Music was written especially for the occasion and a new tulip variety named in his honor was unveiled.

The first European people to wander deep into the Appalachians Mountains were not looking for land, but for plants. Plants from the New World created a furor of excitement in Europe in the eighteenth century. Seeds of rhododendron, azalea and camellia were all collected from the American woods and shipped to England, France and Russia, and sold for small fortunes.

More information on Linnaeus, his collection and writings can be found at the Swedish Museum of Natural History and the Linnaean Society of London.

Maria Sibylla Merian—(1647-1717) Some stories reflect changes in attitudes towards women. Botany was one of the few sciences where women were able to participate in the Eighteenth century. Although women were not deemed intelligent enough to engage in the formal discourses of classification, they were permitted to identify plants and flowers and draw them at home. Drawing was also an important skill that some women cultivated becoming the illustrators of new plant species that arrived with explorers returning from voyages. Before Darwin or Audubon, Maria Sibylla Merian traveled from Europe to the new world, mainly Surinam (Dutch Guiana) in South America, drawing and cataloguing new flowers and insects. Her observations, writings and drawings which included natural habitat, full life cycles and the relationship between plants and insects, contributed much to the understanding of science and was the foundation of the discipline of Ecology. Six plants, nine butterflies, and two beetles were named for her. However, Linnaeus' system of plant classification based on sexual characteristics drew attention to botanical licentiousness, and by the end of the eighteenth century women were discouraged from learning about plant reproduction for fear that their morals might be compromised.



{ Chrysalis *by Kim Todd is an informative biography of Maria Sibylla Merian's contributions to science* }

Lewis and Clark—When Thomas Jefferson sent Lewis and Clark to explore the West in 1804, one of the key goals of the expedition was botanical discovery and seed collection. Jefferson, a devoted gardener, once pronounced, "The greatest service which can be rendered any country is to add a useful plant to its culture." Although Lewis and Clark are credited with discovering over 100 species of plants during their travels, they learned of many of the plants and their uses from Native Americans, who had had an intimate relationship with these plants for thousands of years. Packed amidst the many boxes of journals, field notes, maps, astronomical observations, and newly "discovered" wild animals such as the prairie dog were the seeds and roots of the Echinacea plant. These boxes were shipped down the Missouri River from the expedition's winter encampment at Fort Mandan, North Dakota to President Jefferson. Lewis and Clark had learned from the Native Americans that Echinacea was a cure for snakebite, "the cure of mad dogs" (Clark) and "an excellent poultice for swellings or soar throat" (Lewis). Today Echinacea still grows wild around Fort Mandan and elsewhere on the Great Plains. It is also one of the top-selling herbal products in the United States and Europe, taken to fortify the immune system and lessen the effect of colds, flu and sore throat.

Luther Burbank—(1849-1926) In Northern California, Sonoma County's most famous son is Luther Burbank, a plant breeder, botanist and pioneer in agricultural science. Burbank was born in Lancaster, Massachusetts, the 13th of 15 children. In his childhood he would often gather wildflower seeds to plant in his mother's large garden. Luther Burbank developed a new variety of potato between 1872 and 1874 in Massachusetts, sold the rights for $150 and used the money to move to Santa Rosa, California. Burbank earned the nickname "the Wizard of Horticulture." He developed over 800 strains and varieties of plants including the Shasta daisy, Santa Rosa plum, Freestone peach, and plumcots, a hybrid between an apricot and a plum. The Burbank potato went on to become the world's predominant processing potato, and McDonald's french fries are made exclusively from this cultivar.

"Every child," Burbank wrote, "should have mud pies, grasshoppers, water-bugs, tadpoles, frogs, mud-turtles, elderberries, wild strawberries, acorns, chestnuts, trees to climb, brooks to wade in, water-lilies, woodchucks, bats, bees, butterflies, various animals to pet, hayfields, pine-cones, rocks to roll, sand, snakes, huckleberries and hornets; and any child who is deprived of these has been deprived of the very best part of his education." —From *Training of the Human Plant,* 1907

Barbara McClintock—The Nobel Museum in Stockholm, Sweden, displays the ears of corn that Barbara McClintock used to study how plants could change their genetic structure under stress by the use of transposing or jumping genes. She won the 1983 Nobel Prize in medicine for this work. Dr. McClintock's life work began when she noticed that some kernels of wild corn had dots of blue, red or brown. The problem of color variegation in maize was of slight importance from a practical point of view, but it fascinated Barbara McClintock because it evidently could not be explained on the basis of Mendelian genetics. With perseverance and skill, McClintock carried out experiments that demonstrated that hereditary information is not as stable as had previously been thought. This discovery has led to new insights into how genes change during evolution and how mobile genetic structures on chromosomes can change the properties of cells. Her work has helped explain the formation of antibodies and furthered cancer research.

Vavilov Institute of Plant Industry

Nikolai Vavilov and the Siege of St. Petersburg—Some seed stories demonstrate courage and sacrifice. During the Nazis' World War II siege of St. Petersburg-Leningrad, Russian botanist Nikolai Vavilov and fellow scientists guarded seeds from famished townspeople, knowing that they could not replace the more than 200,000 varieties of seeds that had been collected over decades. The siege lasted for 900 days and over half a million people starved to death, including at least nine botanists at the Vavilov Institute of Plant Industry, who died of starvation while surrounded by stores of rice, wheat, corn, and peas at the world's largest seed bank.

This story also highlights scientific principles. While collecting seeds throughout the world, Vavilov began to notice a pattern. Genetic variation, the diversity created by thousands of years of agriculture, was not equally distributed around the globe. In a small, isolated area of Ethiopia, he found hundreds of endemic varieties of ancient wheat. Studying other crops, he found some regions were blessed with astonishing diversity, while other areas were relatively impoverished. Vavilov mapped out the distribution of diversity and reasoned that the longer the crop had grown in a region, the more diversity he would find. So by pinpointing the center of diversity, he believed he would find the origin of a plant. Vavilov's research demonstrated that the center of the earliest agriculture was not along the Tigris and Euphrates Rivers as previously thought, but in strips of land 20 degrees and 45 degrees north latitude, bordering on high mountain ranges in the Himalayas and the Hindu Kush. He also found that in the Old World, centers of origin followed latitudes while in the New World, the centers align longitudinally. In both cases, plant origin centers follow the general directions of the highest mountain ranges. Because of the variations in climate and soil that occur in mountainous regions, as well as their isolation, these areas provide ideal conditions for promoting plant diversity. Vavilov theorized that there were seven major agricultural centers in the world. The seven centers are in China, India, Indo-Malaysia, Abyssinia (Ethiopia), the Mediterranean, southern Mexico and Central America, and South America (Peru, Ecuador and Bolivia).

Nikolai Vavilov was arrested by the KGB and died in a concentration camp in 1943.

Chapter 5

SEED SAVING LESSONS & LINKS TO STANDARDS

"Education is not the piling on of learning, information, data, facts, skills, or abilities—that's training or instruction— but it is rather making visible what is hidden in a seed."
Thomas Moore (1779-1852) Irish poet, singer, songwriter

A Word on Standards

The California State Board of Education Content Standards define what every child in the state should learn at each grade level. Standards determine *what* concepts should be taught and *when*, but not *how* they are to be taught. The how is left up to the school districts, schools and teachers. Although there is not a seed-saving standard per se, there are many ways to use seeds and gardens to bring everyday meaning to various standards. Seed development mirrors students' development and maturation, providing them a powerful metaphor. Although there are many stand-alone lessons that can teach specific state standards, having a systematic approach to learning about seed saving, rather than individual pull-out lessons, enriches the experience for your students. Standards are an important lens through which to view what you teach, but they are not the only factor to consider when developing curriculum. Checking off a list of standards, rather than having an integrated seed-saving program, means that much of the value of ecoliteracy is lost to your students. Let the standards be a tool to ensure your students have the knowledge they need, but do not let "teaching to the standards" be the final goal of your school's environmental program. Seed saving is a hands-on way for students to connect life cycles, to practice and apply classroom lessons, and to learn and apply standards.

A valuable tool in linking specific garden-based curriculum to state standards can be found in *A Child's Garden of Standards*, written in 2002 by a team of educators including Tina Poles, previous OAEC School Garden Program Director, and Delaine Eastin, former California State Superintendent of Public Instruction. *A Child's Garden of Standards* is available as a free download on the California Department of Education website under the heading "Publications."

One of the challenges of assigning grade levels for specific concepts and lesson plans is that environmental awareness or "ecoliteracy" among California students ranges from non-existent to a sophisticated understanding of current environmental issues. For example, one group of sixth graders may express amazement that wheat turns yellow and produces seeds, while other six-graders may be able to carry on a conversation about seeds and genetically modified organisms.

Lesson Format

All the lessons in this handbook attempt to lead students through the Steps of Inquiry: Engage, Explore, Explain, Elaborate, and Evaluate. For each lesson, the standards that are noted either teach or apply the standard for the relevant grade levels. Extending the lesson to include other standards, such as writing, reading, listening, speaking, and research components, would expand the standards to additional content areas. The complete California Content Standards can be viewed or downloaded by accessing a link on the California Department of Education website, www.cde.ca.gov/be/st

Lessons 1, 2, and 3 are easy starter lessons that investigate some basic properties of seeds and can be taught in a variety of settings. Lessons 4 through 7—A Seed Is A Plant in a Box with Its Lunch, Adapt a Seed, Botany on Your Plate, and Tropism in Seeds—focus on Math, Science and Social Science while teaching a number of important seed and seedling functions. Lessons 8 through 13—Seed Sayings, What Did You Say?, Seeds' Alluring Analogies, A Rose Is a Rose By Any Other Name, Seedy Information, and Seedfolks have direct Language Arts connections, while helping to weave seed saving throughout the standards.

STANDARD KEY

ELA – English-Language-Arts

HSS – History-Social Science

MATH – Mathematics

M&G – Measurement and Geometry

R – Reading

SCI – Science

lesson one: do seeds need soil to germinate?

objective:

Students answer questions by using direct observation.

grade level: 2 through 5

standards:

Grade 2: SCI 2e,3c,3e,4a,4d,4e,4g
Grade 3: SCI 3a,3d, 5a–e
Grade 4: SCI 6a,6,c,6d,6e6f
Grade 5: SCI 2a,6b–e, 6h, 6i

materials:

2 pots
potting soil
paper towels
marking pens
spray bottle with water
other potting material such as coffee grounds, mulch, or sand
3 seeds of the same plant (lima beans work well)
lab journal for observations

discussion questions:

How did your original predication or hypothesis compare with the results?

What energy was the seed using to grow if it was not using the soil?

How well do you think the seeds will grow on the paper towel vs. the potting soil?

Follow up lesson: A Seed is a Plant in a Box with its Lunch (page 42).

activity:

Pose the question: Do seeds need soil to sprout or germinate? Record predictions and the reasons why they predicted what they did. Most students will think that soil is needed to grow because they need nutrition from the soil. Ask students to think how they could test their predictions.

Measure the dry seeds.

Pose the question: Is it important to plant the same type of seed and at the same depth? Introduce the idea of testing for one variable.

Fill one pot with potting soil, one pot with material of the students' choice. Plant a seed in each pot. The third seed should be placed on a stack of wet paper towels and then fold over the stack.

Water each pot and soak each stack of paper towels. Place seeds in a window. From this point on, seeds should be kept moist but not soaked.

Observe each seed daily and record observations.

All three seeds should germinate, as seeds do not require soil to germinate. If your seeds do not germinate, you now (unintentionally) have a different experiment concerning seed viability or the amount of water seeds need.

lesson two: do seeds need light to grow?

objective:

Students will set up an experiment to see if seeds need light to grow.

grade level: 4 through 6

standards:

Grade 4: SCI 6a,6c,6d,6e,6f
Grade 5: SCI 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i
Grade 6: SCI 5a,5b 7a,7c,7d,7e

materials:

a square of aluminum foil
2 plastic bags per student
paper towels
spray bottle with water
2 seeds (lima beans work well)

discussion questions:

Discuss the outcome and the reasons why seeds do or do not need light. The foil wrapped bags usually grow better than the seeds in just the plastic bag.

extensions:

Does the foil make the plastic bag warmer, and therefore the seeds germinate better? How could we test that hypothesis? Could we make the seeds too hot and cook them so that they will not germinate?

activity:

Ask students to form a hypothesis concerning whether or not they think seeds need light to grow. Have them give their reasons why they formed their hypothesis

Ask the students to set up an experiment using the material provided to answer the question. Depending on the students' abilities, either have each student do the experiment alone, in pairs, or with the whole class

Most students will place one seed and a damp paper towel in each bag. Some students might wrap one seed in foil; some others might wrap the plastic bag in the foil. Yet some others might just wrap the seed in the paper towel. Allow for this experimentation. Before wetting the paper towel, ask the students whether or not they think it is important that the same amount of water is on each paper towel. (This encourages them to be mindful about limiting the number of variables in a scientific experiment.)

Zip the bag shut when you feel you have blocked the light from one seed.

Students should write and draw how they prepared their bags, explaining why they prepared the bags that way, and record their predictions based on their own hypotheses

Bags are left untouched for six days. Before opening the bags, have students review their hypotheses.

lesson three: global travels—how do plants move around?

objective:

Students will understand the variety of seed dispersal mechanisms that exist in the plant kingdom, and how factors in the natural environment can affect how far a seed is dispersed.

grade level: 4 through 6

standards:

Grade 4: SCI 6a, 6c, 6d, 6e, 6f
Grade 5: SCI 6b, 6c, 6d, 6e, 6f, 6g, 6h, 6i
Grade 6: SCI 5a, 5b, 7a, 7c, 7d, 7e
Note: This lesson is best done in early fall.

materials:

A variety of seeds
Meter stick
Fan
Small dry seed, one for each student (bean or watermelon)
Magnifying glass or microscope
Paper (to be cut for wind-dispersed seed demonstration)

discussion question:

Why it is important for plants to have their seeds dispersed away from the parent plant?

Extension: Adapt A Seed from Life Lab (page 44).

activity:

Take the students outside to a place with weeds and ask: Who planted them? Most students will say "no one." Ask the follow-up question: "Then how did the plants get to this location?"

Explain that most seeds have some type of dispersal mechanism or characteristic that enables the seed to scatter or travel a distance from its parent plant. Seeds may disperse by wind, water, animals, burrs, or other mechanical means, depending on the habitat. A seed's dispersal mechanism often reflects the conditions within the habitat.

Have students collect a variety of different seeds from the school grounds.

Set up a number of stations in the lab for each type of seed collected. Each station should include a magnifying glass or a microscope so students can observe small seeds.

At each station, students will:

—Describe the seed's characteristics

—Sketch a diagram of the seed

—Hypothesize how the seed is dispersed

—List conditions in the habitat that affected seed dispersal

lesson four:
a seed is a plant in a box with its lunch

objective:

Students learn about the parts of seeds and their functions.

grade level: K through 6

standards:

Kindergarten: SCI, 2a, 2c, 4b, 4d
Grade 1: SCI 2b, 2e, 4a, 4b
Grade 2: SCI 1c, 2a, 2c, 2b, 4c, 4f.
ELA W 1.9, 2.1
Grade 3: SCI 1b, 5e
Grade 4: SCI 2a, 3b, 6c, 6d

materials:

Lima or pinto beans, soaked in water overnight, two per student
Backpack, filled with crumpled paper to look full, but light enough for a student to wear
Rain jacket or poncho
Snack placed inside backpack (best if it is seeds like sunflower or pumpkin seeds)
Water bottle with straw (to be placed inside backpack)
Hat—best if green
Hand lens, one per student
Tape and labels for seed parts (Seed Coat, Cotyledon, Embryo, New Leaves, and Roots)
Advance Prepartion: Soak lima beans in water overnight.

discussion question:

Are seeds alive or dead? Does the size of the seed determine the size of the plant. Are tree seeds huge?

activity:

1. Dress up one student as a hiker, with a coat and backpack. Ask the student how you protect yourself from the wind, rain and cold. (Answer: a coat.) Explain that a seed also has a coat and when conditions are right for growth, the seed will absorb water and split the seed coat. This is called germination. Put the label "Seed Coat" on the coat and have the student remove the coat and hang it up with the label showing.

2. Ask the student what a hiker would need on a long hike. (Answer: Lunch.) Have the student open the backpack and find the snack. Explain that seeds also store food and they store it in a cotyledon, which provides the initial energy for the plant to germinate and grow. The word cotyledon is from the Greek *kotyle*, meaning "hollow object," alluding to the spoon or bowl shape of the leaves. Attach the "Cotyledon" label to the backpack.

3. What else does a hiker need? (Answer: Water.) Have the student remove the water bottle from the backpack. How do plants get water? (Answer: Roots.) Attach "Roots" to the straw of the water bottle.

4. What else might the hiker need on a hot day? (Answer: A hat.) Attach the "New Leaves" label to the hat. Have the student remove the hat from the backpack and compare the hat to the first green leaves a seedling puts out to absorb sunlight. Plants can make food from sunlight, which humans cannot do. This process is called photosynthesis. When the true leaves emerge, the cotyledons fall off. Have the student remove the backpack.

continued

lesson four—continued: a seed is a plant in a box with its lunch

activity—continued:

5. Explain that the leaves and roots grew from the embryo inside the seed. Put the sign "Embryo" on the student.

Review the various parts of the seeds using the props.

6. Have the students break into pairs. Explain that they will dissect a seed. Hand out four seeds and two hand lenses to each pair. Have them rub the seed between their fingers to see if they can remove the outer covering. What is this and what is it function? (Answer: seed coat and it protects the seed within it.) Inside the seed coat are large fleshy structures. What are these and their function? (Answer: Cotyledons used for stored food to help the plant grow until it produces true leaves. Cotyledon is Greek for "cup-like hollow.) Cotyledons die back as the true leaves emerge to carry out photosynthesis. Question: What happens if you plant a seed too deep? Have the students break open the seed, carefully splitting it lengthwise. What do they see in the inner curve of the cotyledons? (Answer: A tiny plant or embryo, made up of the first true leaves and the root.) Have them use the hand lens and draw the seed and label the parts.

Note: Many teachers use lima beans for this lesson because all the structures are large. However, if this is the only seed you explore with your students, it can lead students to the false belief that only lima beans have these structures and can become a plant. Be sure to allow students to explore other seeds that have less obvious structures, such as peas and sunflowers. It will take more time to find the structures in smaller seeds, but it is worth the effort for students to understand that all seeds have these parts and therefore all seeds have the possibility to become a plant.

extensions:

Monocots have one cotyledon, e.g., corn.

Dicots have two cotyledons, e.g., beans.

Exploring a wide range of seeds that we eat, e.g., popcorn, sunflower and pumpkin seeds, & cereal

Read: *Seed Riddle* by Laurel Anderson

I appear dead before I am alive
Although often quite small, inside my skin a tree can live
I can survive hundreds of years without food or water
I can be as small as dust or as large as a football
Humans and animals eat me
I can fly, swim and hitch a ride
I can survive freezing, fires and intense droughts
What am I?

lesson five: adapt a seed

[Developed from Life Lab—The Growing Classroom]

objective:

To have students understand how seeds are dispersed and create their own seeds that can travel.

grade level: 3 through 4

standards:

Grade 3: SCI 3a, 5e. MATH M&G 1.1
Grade 4: SCI 3c, 6c, 6d. ELA 1.1
Grade 5: SCI 6d, 6h
Grade 6: See extensions M&G 1.1, 1.2, 1.3, 2.0

materials:

Various seeds that show the different dispersal methods such as coconut, dandelion, foxtail, and a ripe fruit. Masking tape, aluminum foil, coffee filters, rubber bands, balloons, cotton, corks, toothpicks, scissors, springs, paper clips, string, yarn, play dough, hand lens, general office supplies and junk draw supplies, electric fan.

discussion questions:

Why have seeds created different ways to move away from the mother plant? What would happen if all seeds just fell to the ground?

Seeds have adapted amazing strategies to be able to move away from their mother plant. The strategies are broken into four main techniques: flying, floating, hitchhiking, and pooping. They fly by using the wind, float by being hollow, hitchhike by having hooks to attach to something, and poop by being so tasty that animals or birds eat them and then poop out the seed.

activity:

Take the students outside to a part of the school campus where weeds are growing. Ask them who planted the seeds for these plants. No one? How did the seeds get there?

Show your students various seeds and examine their structures. A hand lens is useful.

Open up a pepper plant. Count the seeds. If every seed can grow into a pepper plant and each plant produced 10 peppers, how many pepper plants would you have? Why is the world not covered with peppers?

Divide the class into three groups. You can either give each group a "seed"—a small ball of aluminum foil—or let them create their own "seed." Each group has to create a "seed" that can either fly, float or hitchhike. The "seed" must be able to pass a test, such as to be able to fly for 2 feet before it hits the ground, using only a fan and not being thrown, or be able to float in water overnight, or be able to hitchhike on someone's pant leg for 20 feet.

Allow the students to create a design, test it out and modify the design to make it work. This allows students to set up experiments, reflect on what does and does not work, introduce basic physics concepts of lift and surface area. This lesson is much more powerful if students are not rushed in their creation, are provided with many different items to use in their design, and are allowed to modify their designs. It is not easy to create a "seed" and first-time failure allows the students to admire real seed-dispersal methods more than they did before the lesson.

lesson five: extension for grade 6

[Adapted from the Ecology Center at Berkeley]

objective:

After students have finished the "Adapt a Seed" activity, they will calculate the surface-area-to-weight ratio of a few different seed shapes to determine which shape is best for wind dispersal.

grade level: 6

standards:

M&G: 1.1, 1.2, 1.3, and 2.0

discussion questions:

How long and under what conditions can seeds remain dormant? Should scientists pursue animating ancient seeds in an effort to bring back extinct species? Why or why not?

How do seeds get to new island habitats and establish life there?

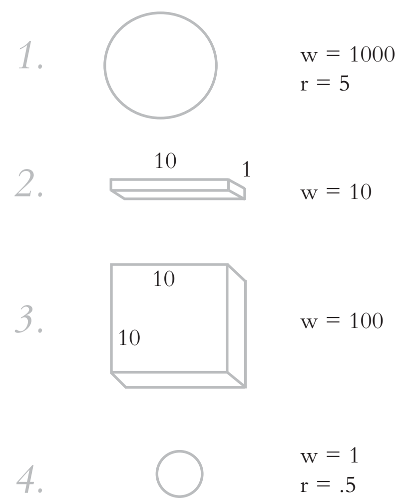
Which methods of seed dispersal are most beneficial to plants in your community? How do the dispersal mechanisms vary with seasons?

How have alien plant species traveled to this country? Is this a benefit or hindrance to this country? Provide examples to support each view.

How do students feel about the idea of genetically altering crops to support human consumption? Should seeds be stored or protected? Why or why not?

activity:

Wind-dispersed seeds have one thing in common: they have a high surface-area-to-weight ratio. This means the seeds are light in comparison to their surface area, just like kites. Figure out the surface-area-to-weight ratios of these four shapes.



1. This represents a heavy seed, such as a coconut. (w=1000, r=5)

2. This column is similar to the hairs on some seeds such as dandelion seeds. (w=10)

3. This thin aerodynamic sheet is like the wing of a maple seed. (w=100)

4. This represents a tiny seed such as the seed of an orchid. (r=.5 w=1)

Useful formulas:

Surface area to weight ratio = surface area ÷ weight

Surface area of a sphere = 4 x pi x square of the radius

Area of rectangle = length x width

lesson six: botany on your plate

note:

The activities in this lesson are taught in a 3-week block, incorporating planting, cooking, nutrition and literature. At the lower grades there is more exploring of seeds in the garden and seeds we eat. Students will read or be read a number of books on seeds. At the upper grades, more science, cooking and mathematics are incorporated into the lessons. Each lesson can have extensions into additional subject areas and standards, such as writing, predicting, researching, interviewing, organizing, and recording.

objective:

Students will explore and celebrate the many seeds they eat, learn how they sustain us and why they are healthy for us.

grade level: K through 6

standards:

Kindergarten: SCI 2a, 2c, 3c, 4a, 4b, 4d
Grade 1: SCI 2a, 2b, 2e, 4e
Grade 2: SCI 2a, 2c, 2d, 2f, 4a, 4c, 4d
Grade 3: SCI 3a, 3c, 3d, 5a, 5d, 5e
Grade 4: SCI 2a, 3b, 6c
Grade 5: SCI 2a, 6a, 6b, 6c, 6d, 6e, 6g, 6h
Grade 6: SCI 5a, 7a, 7d, 7e
Nutrition Grades 4, 5 and 6
Know the six nutritional groups and their functions
Understand the influence of nutrition on health

materials:

Various cereal boxes
Seeds that we eat: popcorn, sunflower, pumpkin, and wheat
Fruits to cut up: apples, kiwi, strawberries
Soaked corn and other larger seeds like beans to make seed jewelry

warm-up activity:

Pass around a seedpod (a poppy seedpod is perfect) and ask the students to use one word to describe the seedpod, only speaking when they are passed the item and no one can repeat the word. Encourage words beyond nouns.

GRADES K AND 1

Read: *Frog and Toad—How Seeds Travel*

activities:

Go on a seed walk in the garden or school. How will they know when they see a seed?

Plant wheat. If possible, visit a local bakery that grinds their grain.

Make popcorn with your students and have it as a snack while reading to your students from one of the following books.

Additional Reading:
Frog and Toad In the Garden by Arnold Lobel; *The Little Red Hen* by various authors; *The Dandelion Seed* by Joseph P. Anthony

GRADES 2 AND 3

activities:

Dissect fruit. What is the function of fruit? (Answer: It protects seeds and aids in seed dispersal.) Cut up and explore fruit such as cucumbers, apples, and tomatoes. Look at the seed patterns. Does all fruit contain seeds? Do they have a different pattern depending on how they are cut?

Cut up a strawberry. Where are the seeds? (Answer: They are on the outside.)

continued

lesson six: botany on your plate—cont.

How many servings of fruit and vegetables should you eat a day? Why? How much is a serving?

Craft a seed necklace: Provide soaked corn and beans and pre-threaded needles. Have students make seed necklaces or bracelets while you read the one of the following books.

Additional Reading: *The Reason for a Flower* by Ruth Heller; *Tops and Bottoms* by Janet Stevens: *A Seed Is Sleepy* by Dianna Hutts Aston: *Fast Food* by Saxton Freymann

Make sprout wraps, using a lettuce leaf to roll up seed spouts. A long chive leaf ties the wrap up nicely.

discussion questions:

What seeds do we eat? (Answer: Wheat, corn, oats, pumpkin, sunflower, barley, rice.)

What seeds have oil in them? (Answer: Hemp, peanut, sunflower, walnut, almond.) What seed has the most oil?

GRADES 3 THROUGH 6

Exploring the Chemical Components of Seeds

activities:

Crush Test for Oil

Fold paper in half, put one peanut seed inside fold, and crush seed. Place a bean seed in another piece of paper and crush the bean seed. Label each seed. Brush away seed parts, leaving a smear on the paper. As water and oil do not mix, we can see how much oil has come out of each seed. Place one drop of water on bean and peanut smear. On which smear does the water bead up? Which one is soaked up more by the paper?

Iodine Test for Starch

Roots and stems store food but not all the same type of food. Some parts of plants store sugars, while other parts store starches. Make iodine tincture by diluting it in a 5:1 ratio with water. Put the solution in a dropper bottle. Look at bread, apple, and the roots of carrots and radishes. In the presence of starch, iodine turns black. If there is no starch, it will remain orange. Ask students to predict which food will have the most starch.

Exploring the Nutrition of Seeds

Background for Teachers:

The main source of nutrition for people around the world comes from seeds and half the world depends on one grass seed alone: rice.

Most oils are pressed from seed. When we eat the seeds instead of planting them, we get the energy or food that the plant stored for its growth.

Chocolate is made from cacao beans, the seed of a New World tropical tree. The Maya people raised these trees and used the beans for a ceremonial drink that they believed had divine origins. Columbus brought the beans back to Europe, where it became a wildly popular drink, although three times as expensive as coffee. The popularity of chocolate led to a heavy reliance on the forced labor of Native Americans and imported African slaves in its production. Carl Linnaeus named the genus that includes cacao beans Theobroma*, which means "Food of the Gods."*

activities:

Have the students smell vanilla extract. Do they think it comes from a plant? (Answer: Vanilla extract comes from the seeds of a type of orchid.)

continued

lesson six: botany on your plate—cont.

Have a seed snack day. Each student brings their own seed snack to school.

discussion questions:

Half of the world's people depend on what seed?

What part of the grass plant do we eat?

What is the difference between whole and processed seeds? (Answer: Removal of the seed coat.)

Identify the bran, germ, and endosperm of a grain and discuss the nutrient value of each. Draw a diagram of a cereal grain or seed.

Discuss the role of fiber and complex carbohydrates in the diet.

Is coffee made from seeds?

What spices are seeds? (Answer: Fennel, mustard, corianders, pepper.)

What seed does chocolate come from? (Answer: Cacao beans.)

Additional Reading—While your students eat seeds, read them one of the following books:
Forgotten Pollinators by S. Buchmann and G. Nabhan; *One Grain of Rice: A Mathematical Folk Tale* by Demi

Exploring Cereal

Cereal grains or grasses are a major source of food. They can be processed into many food products that play a major role in our diets. Explain that most of the things we eat as cereal are really grasses or monocots.

activities:

Ask your students, "Did anyone eat grass for breakfast?"

Look at ingredient lists on the back of cereal boxes. Why is the order important?

Examine how nearly all cultures use cereals as a major part of their diet. List examples.

Have students interview a person from another culture about the grain products they eat and how they are prepared.

Have students research one staple food—its origin, history, how it grows, how it is processed, how it is eaten.

Explain why the germ is removed and sold separately (except for whole grain).

extensions:

Discuss the Spice Trade Routes as part of history and geography lessons that support grade level state standards.

In the book *Spice: The History of a Temptation*, author Tom Standage explores the centuries-old desire for spice in food, medicine, magic, and religion. The author follows spices back through time, through history, myth, archaeology, and literature.

The book *Cooking Up World History* by P. Margen and S. Barchers examines cultures from around the world, providing introductions to the food of each of the countries, with recipes and an extensive annotated bibliography.

lesson seven: tropism with seeds

objective:

Complete a scientific experiment, testing a single variable to understand how plants respond to different environmental conditions.

grade level: 5 and 6

standards:

Grade 5: SCI 2a, 6d, 6h
Grade 6: SCI 5c, 7a, 7e

materials:

For each group of three students:
One Petri dish
Four soaked corn seeds
One piece of filter paper
One graduated cylinder
Water—if there is no sink in the classroom, water should be brought to class in a bucket
Cotton
Cellophane tape
Grease pencil
Scissors

discussion:

Discuss with the class an interesting characteristic of plants: they can change their growth in response to their environment. These changes are called ***tropisms***. Plants can exhibit the following kinds of tropisms:

Phototropism—the way a plant grows or bends in response to light

Geotropism—the way a plant grows or bends in response to gravity

Hydrotropism—the way a plant grows or bends in response to water

Thigmotropism—the way a plant grows or bends in response to touch

Explain that tropic responses can be positive or negative. A positive response is when the plant moves toward or in the direction of the stimulus. A negative response is when a plant moves away from the stimulus. For example, roots respond *positively* to gravity by growing down into the soil. The trunk and branches respond *negatively* to gravity by growing up toward the sky while at the same time responding *positively* to light.

activity:

Divide students into groups of three. Tell them that they are going to perform an experiment to test geotropism, a root's response to gravity. Have students follow the steps below:

Take four corn seeds that have been soaked in water overnight. Place them flat in the bottom of a Petri dish with the seeds' pointed ends facing inward. Think of them as "hands on a clock" at 12, 3, 6, and 9.

Cut a piece of filter paper so that it just fits in the Petri dish. Place the filter paper into the Petri dish, covering the seeds. Be careful not to disturb the positioning of the seeds.

Without moving the Petri dish, pour 15 milliliters of tap water on the filter paper. You might have students practice this slowly before they pour onto the paper. Then place enough cotton over the filter paper so that when the cover of the Petri dish is put on, the paper and the seeds will not be able to move. The cotton should absorb any excess water.

Once you've placed the cover on the Petri dish, tape it shut. Turn the Petri dish over. You should be able to see the seeds in the bottom of the dish, in the same position they were originally placed.

continued

lesson seven: tropism with seeds—cont.

With a grease pencil, write the name of your group on the Petri dish.

Tape the Petri dish containing seeds to the wall of a cupboard, with the bottom of the dish (showing the seeds) facing out. Close the cupboard door so that no light is exposed to the seeds for the next few days.

Note: The dishes are kept in a dark cupboard so that the only variable being tested is the seeds' response to gravity. Their response to light is not being tested. Students should find that the roots grow downward, illustrating the effects of geotropism.

After students have finished setting up and storing their Petri dishes, have each student predict the results of the experiment by drawing how they think the roots will grow from each of the four seeds. Have students write their predictions.

Each day, students should make an observation and record the data on their sheets. Have them record the date and draw how the roots from each seed are growing. Have students record their observations for three days. As students are collecting data, have them look in reference books and on the Web to learn more about tropisms.

Have students write a short paragraph summarizing the results of the experiment on their data sheets. Did the root growth match the predicted sketch?

extensions:

Tropisms in your neighborhood. Suggest that students collect information over a set period of time. How many tropisms did they observe? Was one kind of tropism more prominent than others?

discussion questions:

Which tropisms affect both plant root and plant stem? Consider both positive and negative tropic responses.

Observe flowers growing in your school. Do they change the way they grow, depending on where the light is? If so, how does this help the plant survive?

What do you think would happen if you placed a light source below the plant? How would the stem grow?

Which do you think has a stronger influence on a plant—geotropism or phototropism? How could you design an experiment to test this?

vocabulary:

Tropism: The movement of an organism in response to an external stimulus. Tropisms are a unique characteristic of plants that enable them to adapt to different features of their environment.

Geotropism: Growing or bending in response to gravity. The effect of geotropism on plants is tremendous, causing the roots, stems and leaves to grow in different ways.

Gravity: The force that draws objects to the center of Earth. Gravity causes the roots of plants to grow down so that the plant is anchored in the ground and can absorb minerals and water through its roots.

Hydrotropism: Growing or bending in response to water.

Photoperiodism: Growing or bending in response to light. The response of an organism to naturally occurring changes in light during a 24-hour period

The Language of Seeds

There are a number of ways that seeds can be used to teach Language Art standards through the grades. The following lessons—What Did You Say?, A Rose is a Rose, Seeds' Alluring Analogies, Seed Sayings, Seedy Information, and SeedFolks—bring seeds into your students' language arts program, as well as other noted standards. Another way to bring the language of seeds to your students is to read some of the books listed in the resource section.

lesson eight: what did you say?

objective:

Using scientific plant names to teach root and suffix endings.

grade level: 4 through 6

standards:

Grade 4: ELA 1.3, 1.5
Grade 5: ELA 1.2, 1.4
Grade 6: ELA 1.3

materials:

List of word roots: the best website for looking up botanical names is http://uio.mbl.edu/NZ/advancedsearch.htm

Lists of the meanings of botanical root words can be found at http://davesgarden.com/guides/botanary/

Worksheets: It's All Greek to Me! and Greek Create a Plant (pages 53 and 54)

The Dictionary of Root Words and Combining Forms by Donald J. Borror is a small but wonderful source of word roots.

background for teachers:

When your students learn some root words they not only understand the language of the sciences, but also the English language. This is because many English words come from Latin roots. Sometimes the common names of plants are actually the scientific names, such as rhododendron, citrus and magnolia

Students know more Greek and Latin than they realize. Most fourth graders and older students will know the meaning of many words on this Worksheet, and it is a good way to open up the discussion of Greek and Latin prefixes.

discussion:

The more root names your students know, the easier it is for them to know something about the plant. A plant whose name includes rubri (red) and flora (flower) would tell you the color of the flower before it even blooms. Root words can also tell you where a plant is from, such as *arabica* (Arabia) and *japonica* (Japan).

continued

lesson eight: what did you say?—cont.

Some plants are named after the first person who first described the plant in writing, or after someone the discoverer admires, such as *lewisis, clarkia, Montypythonoides*, or *Darthvaderum*. Sometimes scientists are being rather silly giving funny names to plants. Dracula is an orchid that has flowers that look like a bat.

activity:

Using the worksheet, have your students use the root word lists to create their own organisms and give them a new scientific name. Can your students select a name that would help someone know something about the plant by its name alone? Have students add their own name to the end of the binomial, as the describer of the new organism.

Some general rules about scientific names: To give a species a place name, add "*ensis*". So a plant named after the city of Oakland would be written *oaklandensis*. If the place name ends in a vowel, such as Santa Rosa, drop the vowel and add the *ensis*, so you have *Santa Rosensis*.

If you want to name your organism after a friend, you add an "*i*" if it is a boy's name, so Richard becomes *Richardi*. If it is a girl's name, you add an "*ae*," so Ursula becomes *Ursulae*.

To reinforce this standard throughout the year, classes can practice using the information contained in scientific plant parts and plant names.

continued

lesson eight: worksheet one

It's All Greek to Me!—Exploring the Binomial System

Name______________________________ Grade/Section______________________________

What do you think these words mean?

Gigantean ______________________________ Gollum ______________________________

Mississipiensis______________________________ Pedi ______________________________

Flora ______________________________ Cranio ______________________________

Intermedia ______________________________ Ptero ______________________________

Officinale______________________________ Digitii______________________________

Atlanticus ______________________________ Dorsi ______________________________

Horribilis ______________________________ Eco ______________________________

Draculoides ______________________________ Agua ______________________________

Crypto ______________________________

Look at these scientific names. What do you think is the common name for the following animals?

Naja naja naja ______________________________ Canis familiaris ______________________________

continued

lesson eight: worksheet two

"Greek Create a Plant"

Name______________________________ Grade/Section____________________________

Create your own plant.

Give the plant a binomial name that would help someone understand something about the plant by its name alone.

Describe your plant physically—its habitat, flower structure (number, color, arrangement of flower), what it would be used for by humans.

Draw a picture of your plant. Imagine you are sending this plant back to a scientific department.

lesson nine, part one: a rose is a rose by any other name

objective: Students will be introduced to plant nomenclature. Students will learn that asking the correct questions helps to key out plants using a dichotomous key.

grade level: 4 through 6

standards: R 1.7, 1.8; ELA 1.9

background for teachers:

A common but erroneous approach to biological classification is teaching that the classification of human artifacts—such as hardware, buttons or shoes—accurately mirrors biological classification. These approaches make it seem that all classifications devised by humans are just a matter of arbitrarily choosing one of several superficial features to construct the classification, such as button shape or color. However, biological classification differs fundamentally from the classification of other objects. The difference is that organisms cluster into discrete, non-arbitrary, ordered groupings only because of their mutually shared evolutionary ancestry.

That this is no arbitrary grouping of organisms is evident from—*and only from*—matching similarities across different sets of biological data. When you use objects such as buttons to try to teach classification, students come to the conclusion that any coherent classification of a group is as meaningful and valid as any other classification because there is no non-arbitrary, intrinsically superior scheme. The point of asking the correct questions in a key is to see the congruence between plants. Questions such as whether a plant has needles or leaves are important in botanical classification. No tree with needles will be closely related to a tree with leaves because those morphological differences represent two distinct evolutionary paths.

activity:

Have the class stand in a circle. Select one student to stand with you and tell the student to select one of his/her classmates, but not tell anyone (including teacher) who they have selected.

Tell the class that you will know who the person has selected by asking four yes or no questions. One student will be left standing after four questions.

First question is always "Is it a boy?" or "Is it a girl?" 50% of the class should sit down depending on the answer.

Second question is often eye color, but it depends on the class.

Each question should get 50% of the remaining students to sit down. Usually four questions are enough in a class of 25 students.

Now talk about why your questions were useful. Why did you ask the questions that you did? Is it important to ask questions that have clear yes or no answers? What happens if you ask a question that is open to interpretation, such as, "Do they have wavy hair?" Demonstrate less-then-helpful questions, such as, "Is this person in fourth grade?" or, "Is this person in school?"

Allow the students to take turns being the questioner and see if anyone can find the person in three questions.

After your students have played this game for a few rounds, move to Part 2.

lesson nine, part two: constructing a dichotomous key

objective:

Students will learn that organisms are classified according to morphological and ecological characteristics.

grade level: 4 through 6

standards:

R 1.7, 1.8; ELA 1.9

materials:

The following materials are to be placed in a box, one box for each group:

20 plant specimens. These should vary with regards to leaf shape, flowers, and plant type, i.e., grass, evergreen, shrub, herb, etc. Photographs can be used in place of actual specimens.

Large sheets of white butcher paper.

Markers, preferably three different colors.

discussion questions:

Ask the class general questions about their classification experience.

a. As scientists, how did you classify your specimens? In other words, what characteristics did you use to determine which specimens went in which group?

b. As scientists, why do we classify living things?

c. Is classification helpful when trying to learn about a lot of living things?

d. Do specimens seem different when they are organized into groups rather than in one big pile?

advance preparation:

The boxes will be prepared in advance of the class. Specimens must be obtained and any photos should be done in color and laminated for durability. When creating the boxes it is important to select organisms in each group that can be further divided, based on visible **morphological** characteristics.

At each workspace, tape a large piece of butcher paper to worktable.

Make three columns on the paper. At the top of each section, write *Group 1, Group 2, Group 3*. Make a line next to each heading for writing down the characteristic of that group.

background for teachers:

This lesson introduces the students to the main divisions in plants. The lesson emphasizes the differences and similarities between these groups. The skills reinforced in the lesson are the abilities to closely observe morphological differences between organisms and to group specimens accordingly. Students should understand that all organisms have both similarities and differences.

key points to make to students:

Your key must cover plants that grow in the area where you are. A field guide from the East Coast is not helpful if you are in California.

Questions in a dichotomous key are branches in the road. A yes answer will send you one way and a no answer with send you down another road.

continued

lesson nine, part two—cont.: constructing a dichotomous key

If there is a question where the whole class does not agree on the answer, note that spot in the guide. If you end up not being able to key it out, that will most likely be the place where you went on the wrong path.

The deeper you go into the key, the harder it can be to answer the questions in the key, which was also true when you were trying to figure out the selected student.

activity:

Introduction: Hold up the box of items you will be using. Then demonstrate what will be in the box. At the same time you can also show proper handling of specimens. Sometimes you will just have the photo (pull out a photo) or sometimes you will have the entire organism (pull out samples and talk about handling).

1. Divide class into groups of five, with each group having their own butcher paper and box. Tell students that they are going to divide the specimens in their box into three groups. It is not necessary to tell the students the characteristics to observe; this will give them the opportunity to be creative.

2. Ask each group of students how they divided their groups. What characteristic was used?

3. After students have classified their specimens, they must come up with one characteristic in each column that all the specimens share. Have them write the characteristic on the line next to the "Group" heading.

4. Next, students divide each group into three subgroups. If time is short, you can have the students do subgroupings for one of the main groups only. After all the specimens have been classified, students should come up with one characteristic for each subgroup.

extensions:

Keying out in the field: Key out one tree or plant on the school grounds. Set up mystery trees to key out. Each tree should have a number and students should be able to key out each of them.

Pacific Coast Tree Finder by Tom Watt, published by Nature Study Guide Publishers, is a useful pocket guide for keying out trees of the West Coast.

lesson ten: seeds' alluring analogies

objective:

Students use analogies, seeing the connection between form and function, the similarities and differences, while practicing their observation and writing skills.

grade level: 4 through 6

standards:

Grade 4: ELA 1.2
Grade 5: ELA 1.2, 1.3, 1.4. 1.5
Grade 6: ELA 1.2, 1.5

materials:

Various seeds.
Magnification lenses, 5x and 10x.

discussion questions:

Why does the seed remind you of what you wrote down?

Can we create theories about the function of what we observe, based on what it reminds us of?

For example, if a seed coat reminds you of a shield, does it act as a shield?

Do the similar structures of many living organisms reflect their similar function? How could you be led to a false conclusion when you compare something to something else? Do the lines on the seed coat act in the same way as a river? Does the root system act like a river? In what ways are they similar and in what ways are they different?

activity:

Have students look at various seeds through their hand lens. Ask students what the seeds remind them of when they are magnified. Allow the students to observe the seeds for a few minutes and at different levels of magnification. Have them write down their observations. You can ask the students to use the word "reminds me of" in their sentence.

Some examples of student writing: "The milkweed seed reminds me of a tangle of hair in a brush," "The sunflower seed reminds me of the skin on a zebra," "The roots remind me of rivers on a map," "The seed coat reminds me of the scales on my goldfish."

extensions:

Make books illustrating the seeds' sprouting stages along with the art and analogies writing. If it is assembled as an accordion book, it can be displayed in the classroom.

lesson eleven: seed sayings

objective:

Students will review how seeds and plant parts are used in metaphors.

grade level: 4 through 6

standards:

Grade 3: HSS 3.2.2, 3.2, 3.5.1, 3.3, 3.5.3
Grade 4: R 1.1, 1.2, 1.3, 1.4, 1.6
Grade 5: R 1.1, 1.2, 1.5
Grade 6: R 1.2, 1.4, 1.5

materials:

a square of aluminum foil
2 plastic bags per student
paper towels
spray bottle with water
2 seeds (lima beans work well)

discussion questions:

Discuss the outcome and the reasons why seeds do or do not need light. The foil wrapped bags usually grow better than the seeds in just the plastic bag.

extensions:

Does the foil make the plastic bag warmer, and therefore the seeds germinate better? How could we test that hypothesis? Could we make the seeds too hot and cook them so that they will not germinate?

activity:

Have students brainstorm the names of plant parts and their meanings—roots, branches, seeds, blooms, flowers, roots. Once you have checked that all the students understand the literal meaning of all the words you have generated, ask them to guess meanings for the following metaphors: the bloom of youth, to get to the root of a problem, to plant an idea in someone's head, you reap what you sow, to grow like a weed, to raise seed money, to go out on a limb, sowings one's seeds.

Have the students write a story using as many metaphors as they can. It is sometimes easier for students to understand metaphors when they are exposed to them on a related topic, rather than as individual unrelated metaphors. The goal is to use language creatively without losing the meaning of the story.

lesson twelve: seedy information

objective:

Students will understand what information a seed package has on it and in what order. Students will design a school seed package.

grade level: 4 through 6

standards:

Grade 4: ELA 2.1, 2.2, 2.3, 2.7
Grade 5: ELA 2.1, 2.2, 2.5
Grade 6: ELA 2.3, 2.4, 2.5

materials:

A wide variety of seed packages.
Worksheet: Seed Package Anatomy
Overhead projector (optional)

discussion questions:

Ask the students why seed packages have information and pictures on them. What information would they need on a seed package?

What question is the seed package trying to answer? (How do you know how and where to plant the seeds and care for the plant as it grows?)

Are charts or words better? Do you need both?

Is it helpful to have a picture of the seedling as it is coming up or just of the mature plant? Are art or photographs more helpful?

Is it important to present the information in a particular order?

activity:

Gather as many different types of seed packages as you can. It is sometimes easier to project the seed packages on an overhead screen so you can read the information and compare different styles. Have students carefully examine the packets and read the information on them.

Hand out an assortment of seed packages from various seed companies and have students fill out the Anatomy of a Seed Package worksheet.

extension activity:

After studying seed packages, students can design their own for seed saving, either on a computer as a technology link or by hand. Have students look at various seed packages and think about what information is on the package and why. What information needs to be on every seed package? What happens if you put down too much information? What size envelope will you use and will your information fit on the envelope?

The Seed Package Anatomy Worksheet allows students to observe and record how information is presented by words and images on commercial seed packages. They can use the information they gather when designing their own seed packages.

The Edible Schoolyard in Berkeley makes great seed packages. All the information on the package is uniform and typed, but students individually draw the picture on the front.

continued

lesson twelve: seedy information—cont.

some information that is on most seed packages:

Viability. Most seed packages contain a "sow-by date," usually on the bottom on the package. Often 2009 is written as "09". This does not mean the seeds will not grow after that date. You can check viability by placing 10 seeds in a damp paper towel, rolled up. In a few days, count the seeds that have sprouted. If only 5 have sprouted you have 50% viability. You can use the seeds, but will need to sow them at twice the normal density.

Date. This is the date that the seeds were collected. Sometimes it says "packed for 2010" which means it was harvested the season before, which would be 2009 in this example.

Purity. Amount of dirt or chaff must be listed. Also if the package contains a mix of seeds, the seeds are listed in order of the highest percentage first. Do most school gardens need to have purity listed on their seed packages?

Weight. This is useful for calculating yields. Will you need to buy one or ten packages to plant enough seeds for your school? Some packages list seeds by weight in milligrams or ounces or by the number of seeds. There are 1,000 milligrams in a gram and 28 grams in an ounce.

Origin. Where the seeds were collected. This can be useful to know, as it might give you a clue about how well the seeds will do in your garden.

Variety. Scientific and common name. The package will tell you if the seed is an annual, perennial or biennial (Why is this important?) and if the plant is a hybrid or open-pollinated. If you are planning on saving seeds from these plants, you need open-pollinated varieties.

Culture. Information about how and where to plant, how far apart to plant seeds, number of days to germination, number of days to maturity, spacing, care, sunlight, height of plants, and any special care.

continued

lesson twelve: worksheet

Seed Package Anatomy

Name________________________________ Grade/Section________________________

From what company is your seed package?____________________

Is there a picture on the front of the package?________
If yes, describe it. A photograph or a drawing? Color or black-and-white?

Does the picture help you know what the seeds will grow into?________

Is there an address on the package?________ Is there a website or phone number on the package?________

Is there a date on the package?________ If yes, what does the date refer to?________
Why do you think this is important?

Is there a weight on the package?________ If yes, what is the weight?________

Does the seed package have the scientific name of the seeds?____ If yes, What is the name? ________________

Does the package tell you how many days it will take after planting for the seeds to mature?________
If yes, how many days?________

Does the package tell you how deep to plant the seeds?________ If yes, how deep?________

Does the package tell you how long it should take for the seeds to germinate or sprout?________
If yes, how many days?________

Does the package tell you what conditions the plant wants to grow in?
How is it worded, i.e., sun, shade or ?____________________

Does your package tell you how to harvest and use the plants?________ Was it useful?________
Why or why not?

How many colors are on your package and what are they?

What design features does your package have, such as borders, art?

How many different sizes of fonts are on your package?________

Is all the information organized in the same orientation?—i.e., left to right? Or is some up and down along the package?

Does the package tell you how many plants the seeds will grow? ________
How is that information presented to you—numbers or chart or ? ________

Trade seed packages with a classmate. Compare their package to yours. Do you think that you would buy your package or your classmate's?________ Why?

lesson thirteen: "Seedfolks"

grade level:

6 and above (book includes references to teenage pregnancy)

Seedfolks by Paul Fleishman is a wonderful book for understanding seeds, urban community gardens and different cultures. Some issues raised in *Seedfolks*, such as teen pregnancy and drugs, might not be suitable for your students or at your school, so teachers should pre-read this book to make sure it is appropriate. For some sixth graders those issues are part of their daily lives, but each teacher should evaluate the content of some of the chapters. One option is to select only certain chapters to read aloud or to have students read. The book is still powerful, even without all the voices.

Seedfolks explores immigrant communities in the United States, using the garden as a metaphor for their experiences. The book is structured as a series of first-person vignettes told by 13 different characters. As each narrative unfolds, the reader begins to understand why each of the characters come to a vacant lot in a bleak Cleveland neighborhood to plant seeds and create a garden. The neighbors do not know each other, and have language barriers as well as prejudices. Each voice shows the readers the similarities and differences that can simultaneously exist between people, and the barriers they must overcome to find common ground. On page five, make sure your students understand that the world "Negro" was the name used for African Americans during the time period of the Great Depression.

language arts activities:

The language arts skills and strategies of recognizing point of view, compare and contrast, and identifying problems and solutions can all be explored with this book.

Compare and Contrast

Select four characters in the book and consider what culture each character represents, what seeds they plant and why. Why does each character come to the garden and what do they gain from their participation?

Is your neighborhood like the one in *Seedfolks*? Do you know your neighbors? What makes someone a good neighbor?

Identify problems and solutions

In *Seedfolks*, there is a problem getting water to the garden. How does the group work together to solve this problem? What other problems does the garden have and how are they solved? Do you think that there might be other problems in the future?

Identify steps in a process

During the planting of the garden, the neighborhood turns from strangers to a community. As you read the book, have students notice what steps lead to this change. A large diagram of this process can help students see the connections between the characters and can be updated after each chapter.

Recognize point of view

How does the author give each character a distinct voice and distinguish them from each other as they tell their stories? Can you tell a character's personality by how his/her story is told? What is an example of the same event as described by different characters? How do they differ? Why would they see the same event differently?

continued

lesson thirteen: Seedfolks—cont.

cross-curriculum links:

Language Arts

Have students write their own vignette to add to the collection. What are the background, age, voice, and set of problems? How will they interact with the other characters in the book? Edit and collect each student's work and make a booklet. Have students compare two characters. Using a Venn diagram or other mapping tools, have them map out the differences and where they overlap.

Social Studies

Each character in the book comes from a different country. Find each of the countries on a map. Have students pick one character and research seeds and plants from that country. What factors lead people to immigrate to the United States? Are there any neighborhoods near you like the one in Seedfolks? Are there local community gardens?

Nutrition

What are the main foods grown from each country represented? Can you cook one dish from one of the character's country of origin?

Art — Design a new cover for the book. What makes a good book cover? What information do you need? What event in the book do you think should be on the cover? Who is the audience for the book?

Drama

Have students come to the front of the class, in character, and answer questions about their garden. What about characters who are in the book but do not have a first-person account, such as Royce and Virgil's father? How can you represent them?

additional questions for discussion:

Kim starts a garden without realizing it. How does she do that and what are her reasons for planting lima bean seeds?

What does Ana assume about Kim when she watches her burying her seeds?

On page 13 Gonzalo says, "The older you are, the younger you get when we move to the United States." What does he mean by this?

What does Sam think and feel about how the garden is organized?

Sam likes to spend his time "sewing up the rips in the neighborhood." How does he do this in the garden? Do you think other characters like his approach to them?

What does Florence mean by the word Seedfolks? Why do you think the author chose the title he did?

How do some of the stereotypes that characters have about other people change over time? How is this demonstrated without passing judgment on each other?

How do the characters overcome their language barriers to communicate? Give examples.

Chapter 6

MORE SEED-SAVING CURRICULUM IDEAS

Here are some additional ideas of how various teachers have incorporated seeds into activities for grades K through 6. Although there are no specific lesson plans, their ideas may inspire you to develop your own lessons while addressing appropriate content standards. *A Child's Garden of Standards: Linking School Gardens to California State Standards* is an excellent resource for making these links.

The theme of seeds and seed saving can be used to teach multiple grade levels to meet California State Standards, such as third grade History-Social Science Standards or the sixth grade History Standards.

Kindergarten

Place seeds such as sunflowers, beans or carrots on a table. Place the empty seed package on the table and ask the students to guess which seed belongs in each package.

Have students arrange seeds in order from smallest to largest.

Read *Jack and the Beanstalk* by various authors, and *Seed to Sunflower* and *Acorn to Oak Tree*, both by Barbara Reid.

Sing songs with your students about seeds and plants. A good source of kindergarten songs can be found at wwww.dcs.edu/hasp/Plants/Song.html

Grade One

Read a book on the topic of seeds. A great book to read in first grade is *The Dandelion Seed* by Joseph P. Anthony and Chris Arbo. Other good books for this grade level are *A Seed Grows* by

Pamela Hickman and Heather Collins; *The Tiniest Acorn: A Story to Grow By* written by Marsha T. Danzig; *A Seed is Sleepy* by Dianna Hutts Aston; and *The Carrot Seed* by Ruth Kraus.

Grade Two

Write about seeds in your language arts curriculum.

Read *The First Forest* by John Gile and Tom Heflin. What type of tree would they create if they were the tree makers? After observing trees and acorns, viewing painting and art of trees such as Van Gogh's *Tree Roots and Trunks*, *Auvers-sur-Oise*, have your students paint and draw trees.

Explore acorns and other nuts or seeds from trees.

Grade Three

Seeds as travelers in the exploration and human migration around the world. This approach could be used at multiple grade levels to meet California State Standards, such as third grade History–Social Science Standards.

Describe ways in which plants are important to other living things, and the effects of human activities on plants.

Read *Just a Dream* by Chris Van Allsburg and *The Lorax* by Dr. Seuss. Ask the students to reflect on ways they can improve their schoolyard, their home or their classroom. In what ways can they take action?

Standards	Activities
Ways in which local Indian nations obtained food and clothing and used tools long ago and in the recent past	Research seeds grown by local indigenous peoples. See if it is possible to obtain some of these seeds and plant them.
Study people who came to the region long ago.	Study migrant workers. What seeds did they bring with them from China and Mexico? What food did they grow?
Use of natural, human and capital resources by local producers.	Visit a local organic farm that saves seeds. Compare resources they need to save seeds vs. what resources your school uses to save seeds.
Customs and folklore of local American Indian nations long ago and in the recent past.	Read stories about Native Americans and the food they ate. Plant and save seeds from the food in the stories.
Individual economic choices involved trade-offs and the evaluation of benefits and costs.	Discuss the origins of the food in the students' lunches and how it compares to food in your garden. Are there any seeds in their lunch?

Investigate the requirements of plants and the effects of changes in environmental conditions on plants.

Measure the growth of the plants and chart them using a graph. Compare and order objects by their linear dimensions. Construct bar graphs and pictographs using scales with various multiples.

Grade Four

Use your seed-saving program to graph and chart the variables that the class observes.

Design seed packages for seed saving. Graph and chart seed-saving results.

Formulate a survey on what type of seeds your school would like to save.

Make seed-saving screens as part of a mathematics lesson.

Analyze and evaluate the role of media around seed issues, such as how food comes from the farm and gets to the table, or the climbing obesity rates. Look into whether or not your school district has adopted a wellness mandate. See USDA www.fns.usda.gov/tn/Healthy/wellness To view sample policies, visit www.ecoliteracy.org or www.actionforhealthykids.org

Grade Five

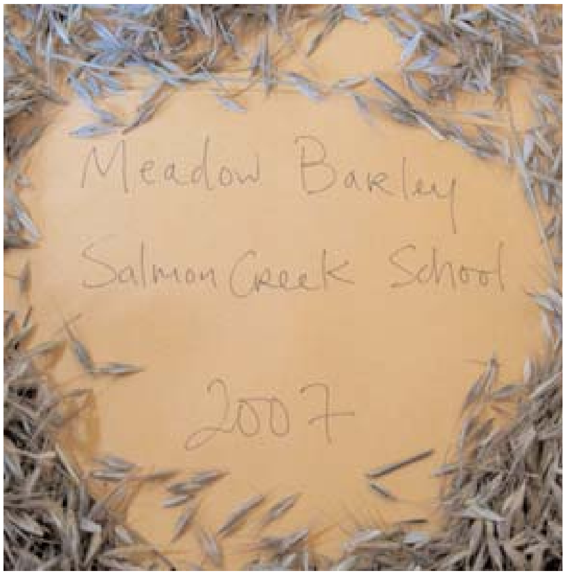
Read the myths of Hades and Persephone. Discuss the importance of seeds in mythology and the symbols they represent such as birth, harvest, food, life, and wealth. Discuss other stories they know which have seeds in them.

Have students to do a search on the Internet for mythology and seeds and find various cultures that include seeds as an important symbol in their mythology.

Have students create their own myth using the seed as the central symbol in their story. Publish the students' stories in a class collection of seed mythology.

Do a research project on an ancient civilization and the types of crops they planted based on their needs and environmental conditions. Investigate flooding of the Nile in ancient civilizations and the impact on their planting practices.

Additional reading: *The Vision Seeker* by James Whetung; *The Lotus Seed* by Sherry Garland.



Grade Six

Plant an ancestor medicinal garden. Research medicinal plants from the countries of origin of your students. Tell the plant stories to the class. Good reference websites are www.herb-net.com and www.swsbm.com.

Introduce your students to poetry with a nature theme written by other children. Some good anthologies are *Salting the Ocean—100 poems by Young Poets* by Naomi Shihab Nye; *I Never Saw Another Butterfly—Children's Drawings and Poems from Terezin Concentration Camp, 1942-1944* by Hana Volavkova; and *The Palm of my Heart: Poetry by African American Children* edited by Davida Adedjouma.

Seeds can be used to study ancient civilizations, world culture and geography. Study early humans—Mesopotamians, Egyptians, Kush, Hebrews, Greeks, Indians, and Romans. Each of these civilizations had seeds in their diet, a religious connection to seeds, and systems to share food. Studying that common thread through each of the ancient civilizations would provide a basis for students to understand the critical role that seeds played in early human civilizations. A good reference is *Food Civilization: How History has been Affected by Human Tastes* by Carson Ritchie.

Some Ideas for Older or Advanced Students

Seeds as Architecture

Equally fascinating links are seeds and architecture. With the development of computer drafting programs, complex biological forms are possible to imagine, draw and construct. The convoluted forms, articulated surfaces and **tensile strength** of seeds can provide inspiration for human dwellings. Round seeds with honeycomb-patterned seed coats are replicated in **geodesic domes**. The papery **lamellae** of larkspur seeds (*Delphinium pereginum*), increase the ability of this seed to catch the wind for dispersal. Under an electron-scanning microscope, these seeds look just like roof tiles, undulating across a horizontal surface. In fact, under enough magnification, many seeds are often revealed as much more intricate and beautiful than the flowers that produced them.

Seeds and Restoration Projects

By saving seeds and propagating plants, your students can be part of an actual research and conservation project beyond the school garden. By expanding seed projects to the edges of the school campus or other locations, the opportunities for students to make discoveries and come into deeper relation with earth stewardship are increased. There are often university studies or governmental organizations such as the Coastal Conservancy or the U.S. Forest Service that may want to partner with a school. Some schools have even started entrepreneurial projects propagating native plants for state parks or for California Department of Transportation restoration programs, which then generate a source of funding for the school garden.

One rich source of seed-saving projects is native plants. The native plants that remain in their ancestral habitat have evolved over a very long expanse of time, uniquely adapting to the local climate, soils and specific ecological conditions of a place. Native grasses, for example, once covered large areas of the California landscape and historically made up an important part of the local native people's diets. The native people actively "gardened" these grasslands by using controlled burns to encourage greater productivity of their favored food crops. Areas of study to explore with students might include uses of these crops by indigenous people, an examination of adaptations to the local microclimates, processes of **succession**, local genetics, or an historical journey into the sense of place from native habitation up to the present and future.

Protecting Endangered Habitat

The California Coastal Prairie now ranks as one of the most endangered habitats in California. In Sonoma County, Occidental Arts and Ecology Center partnered with nearby Salmon Creek School and Partners for Fish and Wildlife on a three-year Coastal Prairie Stewardship Study to increase the viability of native grasses on the school campus. Sixth graders collected data, identified different plant species, collected seed for re-vegetation and helped to establish study plots that field-tested various restoration methods. These results helped determine the most effective ways to restore native grassland for this specific microclimate. For more information, see California Native Grasslands Association, www.cnga.org.

Chapter 7

HISTORICAL CONTEXT OF SEEDS AND SEED-SAVING

Co-Evolution of Plants, Insects and Humans

About 11,000 to 12,000 years ago, humans started shifting away from hunting and gathering and towards agriculture, beginning by preferentially encouraging and selecting favorite wild food plants. This shift created an interdependent relationship between humans and a small number of domesticated crops. Favored plants adapted to human needs, and as they gradually became dependent on humans to survive, we concurrently came to depend on their cultivation for our survival. Once sowing was discovered, seeds came to be valued as the source of future sustenance and people began to selectively save seeds, to covet and protect them.

Food crops co-evolved with humans, shaping and being shaped by the soil, **hydrology**, climate, ecology, culture, and economy of the each local area. Plant diversity is not evenly distributed throughout the world, but instead is concentrated in certain geographic areas depending on how long a crop has been grown there. The longer the plant's history of cultivation, the more time there has been for the crops to evolve and diversify, and the greater the number of varieties represented. These "centers of diversity" and the **landraces** (ancient varieties) found there have provided plant breeders with powerful tools against genetic weakness arising from uniformity. See Chapter 4, Seed Stories, for more information on how centers of diversity relate to centers of origin.

Varieties specifically suited to each region thrived with the assistance of observant farmers who selected for the strongest strains with characteristics best suited to the area, and then saved seeds from the largest, most productive and tastiest plants. Ancient agrarian cultures developed festivals, rituals and traditions based on the cycle of sowing and harvest. In addition to their importance as a food source, plants have played a role in shaping human dwellings, clothing, tools, musical instruments, medicines, and more.

For most of our agrarian history, plants and their pests and diseases have coexisted in a fragile balance developed over a long period of time. Pests and diseases are self-limiting to a great degree. Highly virulent diseases that kill all of their hosts subsequently die off themselves, and insect pest populations decline when their food sources dwindle. Over the long term, the most successful pests and disease are those that limit, but do not eradicate, the target plant species.

The traditional small-scale subsistence farming practice of growing a variety of diverse crops prevented the concentration of disease and provided physical and ecological barriers to insect and fungal pests. Wild relatives of cultivated crops sometimes grew near the fields and frequently crossed, infusing the crops with pest-resistance and hardiness.

Effects of Industrial Agriculture

The ever-increasing uniformity of domesticated food crops has led to decreasing plant hardiness, increasing susceptibility to pests, and more dependence on human intervention. Plant breeders have always depended on a diverse genetic pool to produce improved varieties. In the search for pest and disease resistance today, plant breeders look first to existing modern varieties and then to the landraces. As a last resort breeders turn to wild relatives for resistant genes, since they have survived without the help of pesticides or human intervention. All the major cereal crops and several others such as sunflower, potato and carrots have a wild companion that was either a progenitor or resulted from a cross between wild and domestic plants.

An extensive bank of genetic diversity is essential for surviving the periodic crop devastations that have occurred historically and are still very much with us. In the 1870s, coffee rust hit India and East Asia, and resulted in the British habit of tea drinking that continues to this day. A stem rust decimated wheat in the United States in 1904. In the 1940s American oat varieties decreased by 80%, and increased pest problems were subsequently experienced in the 1950s. Brown spot disease damaged rice crops in India in 1943 and corn blight hit the United States in the 1970s. For each of these epidemics, scientists found genetic resistance in the ancient landraces and wild relatives living in the world's centers of diversity. Protecting the diversity of our modern varieties, landraces and wild relatives is essential for the maintenance of a genetic base for plant breeding. Without this diversity, as Gary Paul Nabhan says, we will "drown in a shallow gene pool" (Gary Paul Nabhan, *Enduring Seeds: Native American Agriculture and Wild Plant Conservation*, North Point Press 1989).

The co-evolution of plants, pests and humans has also been shown to have a direct benefit to human health. Plants produce differing compounds, depending on the environmental conditions where they are grown. The USDA sets nutritional values for each vegetable or fruit we eat, regardless of where or how it was grown. So according to the USDA, a tomato grown on a local organic farm is considered identical to one grown in a greenhouse with chemical inputs and shipped from across the globe. However, it is not surprising that there is actually a difference in the quality of the nutrition of crops grown under different conditions. Plants produce a number of compounds, such as **polyphenols**, to protect themselves against pests. Polyphenols contain **anti-oxidants**, important in cancer prevention. Plants that are treated with pesticides do not need to mount defenses against pests and therefore do not produce nearly the same levels of polyphenols. Also, industrially farmed plants can be grown in much poorer soil, as the plant's nutritional needs are being applied via chemical fertilizer. These plants do not have access to the building blocks in healthy, humus-rich soil to manufacture many of the compounds needed for human nutrition. Humans have evolved to profit from this co-evolution between plants and their pests. The current industrial agricultural system has broken that link to our food.

Corporate Control of Seeds and the Food System

The corporate control of seeds that began during the so-called Green Revolution of the 1960s has been accomplished in part through the dissemination of seed, chemicals and experts and continues to this day. Typically seeds are sold with a combination package of fertilizer, herbicide and pesticide, which are sometimes actually part of the seed coat. Seed companies are often subsidiaries of pharmaceutical corporations (which rely in large part on plant matter for drug production), or of the fiber and textile industry (also often plant-dependent), or of petroleum companies or agricultural chemical companies. Increasingly, private corporations have been underwriting

The following groups have more examples on this topic: International Forum on Globalization, www.ifg.org and ETC Group, www.etcgroup.org.

research at public universities and laying claim to the patent rights for resulting marketable products, effectively privatizing the fruits of our finest public educational and research facilities and influencing research priorities.

By the late 1980s, the struggle for control of breeding material—seeds and the genes inside them—had become intensely economic and political. Nations and companies currently vie for access to and benefits from the world's germplasm. Based on 2006 revenues, the top 10 seed corporations account for 55% of the world's seed sales. The top three companies (Monsanto, Dupont and Syngenta) account for two-thirds of these sales. (www.etcgroup.org/en/materials/publications.html?pub_id=615)

When only a few corporations own the patents on seeds, seed saving becomes illegal, farmers become dependent, and the security of our food and farming systems is fundamentally threatened. The commercialization of agriculture threatens to annihilate the customs of traditional peoples worldwide who hold land in common and consider seed as a common good to be given or traded, not as a commodity that can be sold.

Declining Plant Diversity

The Rural Advancement Foundation International (RAFI) surveyed the diversity in seed stock of 75 types of vegetables available commercially in the U.S., comparing the numbers of varieties available in 1983 to what was available in 1903. They determined that only 3% have survived this 80-year period. So 97% of the 1903 varieties are now extinct. We have lost approximately 93% of our runner bean, lettuce and carrot varieties, 96% of our sweet corn and chard, 81% of our tomatoes and collards, 95% of our onions, cucumbers and cabbage, and 98% of our asparagus and celery. In addition, 86% of the apple varieties and 88% of the pears used between 1804 and 1904 have since been lost. (Cary Fowler and Pat Mooney, Shattering, University of Arizona Press 1996).

The motives that drive the corporate research and development of new plant cultivars rarely coincide with those of consumers. Desirable characteristics from the agribusiness point of view are primarily driven by maximum profit, long shelf life, ease of packaging and transportation, uniform size and color, extended growing seasons, blemish-free appearance, and minimal labor costs in planting, cultivating and harvesting. As a result, the variety of foods commercially available has decreased markedly in recent decades, and the taste, nutrition, quality, diversity, and cultural considerations of consumers are ignored.

Genetic Engineering

The current rush of agribusiness towards genetic engineering further threatens ecological agriculture and genetic diversity. Genetic engineering (GE) in plants is the creation of food crops that could never exist in nature, such as bacterial genes in corn or human genes in rice. Currently the two most commonly engineered traits on the market are (1) the resistance to herbicides that would normally kill the crop, and (2) the ability to produce an insecticide that kills a wide spectrum of insects including the target insect pest. The risks associated with these crops fall into four categories:

1. Health issues such as food allergies, the production of novel toxins in the food supply, and the use of antibiotics in the technological process that may hasten the development of antibiotic resistance.

2. Environmental issues such as increased pesticide use, loss of biodiversity, and inadvertent harm to insects and other wildlife.

3. Threats to farmers resulting from loss of markets, genetic contamination of crops, and liability.

4. Increasing corporate control of the food supply due to patents on GE seeds and crops. According to the U.S. Department of Agriculture, in 2004 about 46% of U.S. corn, 76% of cotton and 85% of soybeans were genetically engineered. Most of these crops are used in small amounts in processed foods containing corn syrup, soy lecithin and cottonseed oil, as well as in animal feed. It has been estimated that approximately 70% of processed foods in U.S. supermarkets contain some GE content.

The specter of ecological genetic pollution ushered in by genetic engineering, and the rampant extinction of food crops lends urgency and necessity to preserving heirloom varieties and regaining regional, democratic control over the sources of our seed. The act of saving seed, even on a small scale in the school or backyard garden, is a part of the life-affirming response to corporate control and elimination of food diversity and genetic stability.

More information about the hazards and issues associated with genetic engineering in agriculture is available at the website of Californians for GE-Free Agriculture, www.calgefree.org, including links to additional resources.

Carrying on the Tradition: Seed-Saving Communitites

The act of saving seed, whether as farmers, horticulturalists, or backyard gardeners, is an ancient and powerful practice. In addition to individual efforts, we can also organize and participate in larger ways. We have much to learn from a grassroots model in India that was founded by activist and scientist Vandana Shiva and her colleagues. They operate an organization called Navdanya (seed in Hindi), which supports indigenous farmers in conserving agricultural diversity, and places the farmer at the center of conservation and in control of the political, ecological and economic aspects of food and seed production.

They believe that:

> "Conservation of agricultural biodiversity is impossible without the participation of the communities who have evolved and protected the plants and animals that form the basis of sustainable agriculture… Seed conservation and sustainable agriculture cannot take place in an economic vacuum, but must fit into and transform the economic context in which agriculture is practiced." (*The Seed Keepers*, Navdanya, 1995)

Another valuable model from the developing world is that of ANDES (Quechua-Aymara Association for Nature Conservation and Sustainable Development). ANDES' work is rooted in the traditional indigenous farming communities of the Peruvian Andes. The organization aims to protect and nurture biological diversity, sustainable agriculture and indigenous culture by providing training and technical assistance to community farmers and organizing around issues of indigenous knowledge, intellectual property and policy development. One of their projects involves protecting and maintaining local food cultivars and organizing "biodiversity fairs" where primarily women from communities within a region gather to share their diverse crop varieties and stories.

North Americans can become involved with Seed Savers Exchange (SSE, www.seedsavers.org). SSE's 8,000 members grow and distribute heirloom varieties of vegetables, fruits and grains. The focus is on heirloom varieties that gardeners and farmers brought to North America when their families immigrated, and traditional varieties grown by Native Americans, Mennonites and Amish. Since SSE was founded in 1975, members have distributed an estimated 750,000 samples of endangered seeds not available through catalogs and often on the verge of extinction. Similar organizations exist in Canada (Seeds of Diversity, www.seeds.ca) and the United Kingdom (Heritage Seed Library, www.hdra.org.uk).

Also in the United States, Native Seed/SEARCH in Arizona (www.nativeseeds.org) works to conserve, distribute and document the adapted and diverse varieties of agricultural seed, their wild relatives, and the role these seeds play in cultures of the American Southwest and northwest Mexico. They promote the use of these plants by distributing seeds to traditional communities and to gardeners worldwide. They also work to preserve knowledge about the traditional uses of the crops that they steward.

On a more local level, community seed banks and seed libraries are possible. They serve the practical purpose of distributing and circulating seed locally. These groups also provide an educational and organizing vehicle to raise community awareness of the threats to agricultural biodiversity and the necessity to conserve it. For example, at the Ecology Center in Berkeley, California, a seed library has been established to store and disseminate vegetable and flower seeds, and to track local histories linked to each variety. A little research may uncover a seed-saving group in your community.

Chapter 8

BACKGROUND INFORMATION FOR TEACHERS

This section on botany is meant to be used as a reference to consult as needed. Scientific terms appear in bold font and can also be found in the Glossary.

Botanical Nomenclature

We are all more comfortable using common names for plants. Why say "*Leucanthemum*" when you can say "daisy"? The problem is that there are hundreds of different plants called "daisy" around the world and the same plant can have many different common or vernacular (local) names. *Lotus corniculatus*, for example, is known as Bird's Foot Trefoil, Hens and Chickens, Tom's Thumb, Granny's Toenails, and Dutchman's Clogs. In seed saving, knowing the names of species is essential. While it is rare for plants from different species to cross and produce offspring, it is common for varieties within a species to cross. Measures must be taken to ensure that this crossing does not happen if you want to maintain the genetic purity of a variety. Also common names can be misleading. What we call Spanish moss, *Tillandsia usneoldes*, is not from Spain nor is it a moss. How would you look that plant up in a book, if you only had the local common name?

Latin (and some Greek) is used for scientific nomenclature because Latin is a dead language and does not change over time. Scientific names are also recognized around the world. When a botanist in Paris, Prague, Pittsburg, or Portland refers to *Punica granatum* (pomegranate) they are all talking about the same plant.

Every plant belongs to a botanical **family** that shares similar genetic traits, typically in their fruit and flower structure. Families are subdivided into **genera**, which are even more closely related in their appearance. Genera are further divided into **species**. Each plant name is comprised of a genus (the singular form of genera) plus a species, and the name is always written in italics with the genus capitalized. The genus name is like a surname or last name, for example, *Burbank*. The species name is similar to a given name, for example *luther*, so you know that he belongs to the family *Burbank* and will share traits with other *Burbanks*, but as he is not the same as his brother or cousin. They have different species or first names. So this name would be written scientifically as *Burbank luther*.

Introduction to the Botany of Flowers and Seeds

When **pollen** contacts the receptive **stigma,** the pollen forms a **pollen tube** that reaches down through the **style** to fertilize the **ovules** (egg cells) in the **ovary**. Two male nuclei or sperm move down each pollen tube to the ovule. One unites with the egg in the ovule while the other unites with the two **polar nuclei**. This is called **double fertilization**. The fertilized egg develops in the **embryo**, the next generation of the plant. The fertilized polar nuclei develop into tissue called the **endosperm**, the food for the growing embryo. Some seeds contain no endosperm, such as beans, watermelons and pumpkins. The coconut's edible part is all endosperm. In corn and wheat the endosperm is the nutritional part of the seed. Whole grain means that the endosperm has been milled into the flour and not removed. Whole wheat flour contains the bran and germ, but those parts are sifted out of white flour. Over time, the entire ovary becomes the plant's fruit or seed, containing the fertile ovules that will become the seeds of the next generation. Thus, an apple is the ovary of an apple blossom, holding within it fertile seeds.

After fertilization, the embryo, which started as a single cell, grows rapidly. There are three main structures. The **epicotyl** or shoot, the **hypocotyl** or root, and the **cotyledons** or leaves. So the whole plant or tree that we see above ground develops from the tiny **epicotyl** and the elaborate root systems of plants and trees starts from the tiny **hypocotyl**.

Pollination

In contrast to animals, plants usually have both male and female reproductive organs located on the same flower. Squash, watermelons and cucumbers are an exception to this rule, producing separate male and female flowers on each plant (**monoecious**). Individual plants of some species have one-sexed flowers. This means that flowers on one plant have either **stamens** or **pistils**, but not both. These plants are called **dioecious**. Spinach and kiwi are examples of dioecious plants. The terms come from the Greek. Monoecious means "one house" and dioecious means "two houses."

Self-pollinating plants have male and female parts on the same flower and therefore do not depend on insects or wind for fertilization, although they can also easily cross-pollinate with other plants. In contrast, monoecious and dioecious plants depend on insects to transfer pollen from the **anthers** of some flowers to the **stigmas** of other flowers on the same or different plants. Honeybees are especially effective pollinators, collecting and distributing pollen grains with the hairs of their bodies as they move from flower to flower in search of nectar and pollen. Bumblebees, sweat bees, solitary bees, moths, butterflies, wasps, and flies are also pollinators.

Some plants are well designed to take advantage of wind pollination. For example, corn pollen is produced in the tassels at the end of each stalk of corn, and the wind shaking the plant causes the pollen to drop onto the silks (the female stigma) on the ears. Each kernel in a corn plant is the result of pollination, so what we see as one corn on the cob is really hundreds of genetically different embryos. The corn tassels are the male parts or anthers of the plant, producing up to 14 million grains of pollen per plant. The ovary or female part of the flower is in the cob, which is made up of hundreds of tiny flowers in a husk. How is the pollen going to travel to the ovary and penetrate the husk? Each flower sends out a silk—a style with a sticky tip—to grab a grain of pollen floating in the wind. When you eat an ear of corn and some of the kernels are not plump, it is because no pollen fell on the silk connected to that kernel and the ovary was not fertilized. To refer to corn as passively wind-pollinated is to diminish this amazing plant's ability to reproduce.

{ *The Story of Corn by Betty Fussell has more details of corn's pollination.* }

Preventing Cross-Pollination and Maintaining Varietal Purity

Fertilization can only take place between plants of the same genus and species. However, cultivars within a species can cross-fertilize. Pollination between plants of the same cultivar yields offspring with genetic traits identical to the parents, ensuring genetic purity. Cross-pollination of different cultivars creates offspring with a new combination of traits from its genetically different parents. In traditional plant breeding science, when attempting to develop new plant varieties, this is advantageous because cross-pollination can produce new and perhaps favorable traits. It is also an advantage in the wild, resulting in the evolution of varieties that are hardier, more pest-resistant or more competitive in some other way. However, when saving seed, the goal is to obtain varietal purity in order to maintain and propagate the characteristics of a given desirable cultivar. This section describes techniques that can be employed to prevent cross-pollination.

***Isolation and Time*—**The most basic method for preventing cross-pollination between varieties of a plant species is to grow it far enough away from other varieties with which it could cross. Recommended **isolation distances** developed by commercial seed producers over years of experience provide a guideline for most vegetable crops, but are usually larger than practical or necessary at a smaller scale. Characteristics of your site, such as plant population size, pollinator population, availability of other nectar sources, and geographical and vegetation barriers (buildings, hills, trees and other tall plants, etc.) all play a part in determining isolation distances.

Using isolation distances to ensure varietal purity can be challenging, especially if you are gardening in a small or dense area, since plants growing in neighboring yards and fields must also be considered. To minimize the isolation distance needed, consider the following techniques:

—Planting tall barrier crops in a perimeter around the variety you wish to protect

—Providing many sources of pollen for visiting insects

—Planting the desired variety in a block and collecting seed from the center where cross-pollination is less likely

—Collecting seed from the first blooms of the earliest-blooming variety

Staggering the planting times of varieties can also protect varietal purity and works best in climates with long growing seasons. Plant the first crop of one variety as early as possible, and when it starts to flower, plant the next variety. The first planting will need to set seed before the second planting flowers in order for this technique to work. It is most effective for varieties that have very different maturity dates. It is also important to leave enough time for the seeds of the second planting to mature and dry before the cold, wet season begins. Time isolation works well for corn, sunflowers, lettuce, and members of the Umbellifereae family—dill, chervil, celery, fennel, carrot, coriander, parsley, etc.

***Mechanical Isolation*—**These techniques involve the use of a physical barrier to prevent cross-pollination. Though there are several options, only the most straightforward are mentioned here. Others are described in most seed-saving reference books.

Bagging is typically used to prevent self-pollinating plants from crossing with other individuals, and involves covering individual flowers or cluster of blossoms. This is most practical if you need only a small number of seeds. Reemay or other light fabrics are used by tying pieces around the flower head with string, twist ties, sewing, or stapling. Paper bags can be used in areas where summer rain is not an issue. Plastic bags should not be used because they can cause the flower to overheat in the sun and are not ventilated. The base of the bag must be tight around the stem to prevent the entrance of small insects. Also note that plants with fine pollen grains pollinated by wind can pass through fabrics such as Reemay.

Another technique for self-pollinators is to cage individual plants or a group of plants in a wooden or PVC frame covered with spun polyester cloth or window screen. Wire hoops covered with Reemay can also be used to isolate a group of plants in a row.

***Hand Pollination*—**This method is used mainly for vegetables that are insect-pollinated, although it can be used for wind-pollinated crops, too. Specific details vary depending on the species, but the general technique is as follows. Prior to the first pollen production, protect both male and female flowers by bagging. Using something like a Q-tip or paintbrush, transfer the uncontaminated pollen by hand from the male flower onto the receptive stigma of the female flower. Continue to protect the female flower to prevent additional pollination until it sets seed.

SEED-SAVING CHART

FAMILY	CROP EXAMPLES	FAMILY CHARACTERISTICS	MODE OF POLLINATION	ISOLATION DISTANCE	SEED VIABILITY
AMARYLLIDACEAE Onion Family	onions, leeks, scallions, chives, garlic, shallots	characteristic onion odor monocots inflorescence umbellate flowers bisexual, 6 parted, actinomorphic fruit a capsule	insect: flies & bees	1 - 3 miles	2 - 3 years
BRASSICACEAE Mustard Family	mustard, kale, broccoli, brussel sprouts, cauliflower, collards, kohlrabi, turnips, cress, cabbage, radish	leaves alternate flowers actinomorphic, racemose flower parts: 4, 4, 6, 2 fruit: nuts, silicles, siliques	insect	1/2 mile	4 - 5 years
CHENOPODIACEAE Goosefoot Family	orach, beet, swiss chard, quinoa, spinach	most members halophytic alternate leaves flowers cymose flowers often bracteate, minute, greenish, actinomorphic fruit a nutlet	wind	2 - 5 miles	5 - 6 years
COMPOSITAE Composite Family	endive, radicchio, artichoke, sunflower, lettuce, jerusalem artichoke, cardoon	largest family of flowering plants sap sometimes milky leaves alternate or opposite inflorescence a collection of disk and ray flowers often have bracts flowers uni or bi-sexual flower parts: 5, 5, 5, 2 fruit an achene	self & insect	1/2 mile	3 - 8 years
CUCURBITACEAE Squash family	gourds, watermelon, cucumber, muskmelon, squash, pumpkins, melons	tendril bearing vines alternate leaves, angled stems tender heat loving annuals have separate male & female flowers flowers 5 parted, actinomorphic fruit a berry or pepo	insect	1/2 mile	5 - 6 years

SEED-SAVING CHART

FAMILY	CROP EXAMPLES	FAMILY CHARACTERISTICS	MODE OF POLLINATION	ISOLATION DISTANCE	SEED VIABILITY
LEGUMINOSAE Bean Family	peanuts, soybeans, lentils, jicima, runner beans, lima beans, common beans, peas, fava beans	one of the three largest flowering plant families leaves alternate, compound flowers zygomorphic, bi-sexual flower parts: 5, 5, 10, 1 fruit a legume	self & insect	1/2 mile	3 - 4 years
SOLANACEAE Nightshade Family	sweet & chili peppers, tomatoes, tomatillos, eggplant, potato	many members contain alkaloids alternate leaves flowers bi-sexual, actinomorphic flower parts: 5, 5, 5 - 10, 2	self & insect	500 feet	3 - 10 years
UMBELLIFERAE Carrot Family	celery, celery root, dill, chervil, cilantro, carrot, fennel, parsnip, parsley	many members aromatic, oily or poisonous flowers umbellate or umbrella-like flowers bi-sexual flowers 5 parted, 2 carpelled fruit a schizocarp	insect: honeybees & hairy insects	1/2 mile	3 - 8 years
AMARANTHACEAE Amaranth Family	amaranth	leaves alternate flowers bracteate, bi-sexual, actinomorphic flowers 5 parted fruit a nutlet	wind & insect	2 miles	5 years
GRAMINEAE Grass Family	corn, sorghum	monocots flowers many and inconspicious flowers uni or bi-sexual	wind	2 miles	4 - 10 years
LABIATAE Mint Family	basil, mint, lavender, rosemary, thyme, shiso, hyssop, sage	many have aromatic oils square stems, opposite leaves flowers bilabiate, zygomorphic flowers 5 parted fruit: 4 nutlets	insect	150 feet	5 years

GLOSSARY

Angiosperms: "contained seeds," the ovules are sealed within the carpel and the seeds sealed within a fruit. Angiosperms are a large group of flowering plants that use the sexual reproduction method called "double fertilization."

Anther: the pollen-bearing part of the flower.

Antioxidants: a substance such as vitamin E, vitamin C, or beta carotene thought to protect body cells from the damaging effects of oxidation.

Awn: a hair- or bristle-like appendage on a larger structure, found on many grasses.

Bolt (bolting): to produce flowers and seeds prematurely.

Calyx: the outer part of the flower, formed of several divisions called sepals, which protect the bud.

Carpel: the structure that encloses the egg in angiosperms, composed of ovary, style, and stigma.

Chaff: the dry coverings of grains and other grass seeds, which are separated from the seeds by the process of threshing.

Complete flower: having both male and female functional parts in the same flower. Also called a perfect flower.

Compound fruit: a fruit derived from more than one flower.

Corolla: all the petals of a flower.

Cotyledon: the first leaf in an embryo.

Dicotyledons, dicots: having two cotyledons. One of the two major groups of angiosperms.

Double fertilization: An exclusive process of angiosperms in which one male nucleus pollinates the egg nucleus to form a zygote, which develops into an embryo, while the other male nucleus joins with two other nuclei in the embryo sac to form endosperm.

Embryo: in plants, part of the seed consisting of precursor tissues for the leaves, stem (hypocotyl), and root, as well as one or more cotyledons. Develops from the egg cell after fertilization.

Endosperm: stored plant nourishment that surrounds the embryo.

Epicotyl: the embryonic shoot above the cotyledons. In most plants the epicotyl will eventually develop into the leaves of the plant.

Family: a large group of related genera. One of the main units of the taxonomic classification of living things. The classification units in descending order are class, order, family, genus, and species.

Filament: the stalk of the stamen.

Genus, genera (plural of genus): a unit in the taxonomic classification of living things. Usually the first part of a plant's scientific name. In descending order the classification units are class, order, family, genus, and species.

Geodesic dome: a dome that has many flat straight-sided faces formed by a framework of bars that intersect to form equilateral triangles or polygons.

Hardiness: the ability of a plant to withstand winter cold and summer heat.

Hydrology: the scientific study of the properties, distribution, use, and circulation of the water of the earth and the atmosphere in all of its forms.

Hypocotyl: the part of the embryo that will develop into the stem.

Lamellas: thin structures resembling plates or gills. These can be part of the petals in certain flowers.

Landraces: domesticated plants adapted to the natural and cultural environment in which they live or originated. They often develop naturally with only minimal assistance or guidance from humans using traditional breeding methods.

Microclimate: climate specific to a small area. This may vary significantly from that of surrounding areas.

Monocotyledons, monocots: plants with one cotyledon or seed leaf. One of the two major groups of angiosperms.

Monoecious: a type of angiosperm that has separate male and female flowers on the same plant, such as corn, palms, and oaks.

Morphology: the form and structure of an organism or one of its parts.

Multiple fruit: a fruit formed from a cluster of flowers. Each flower produces a fruit that matures into a single mass. Examples are pineapple, fig, mulberry, osage orange, and breadfruit.

Nut: a dry, usually single-seeded fruit.

Ovary: the hollow chamber that contains eggs. In plants it is usually in the enlarged lower part of the pistil.

Ovules: the female cells or eggs.

Petals: a part of the corolla of a flower. The corolla is the name for all of the petals of a flower.

Pistil: the seed-bearing organ of the flower, consisting of the ovary, stigma, and style when present.

Polar nuclei: the two nuclei in the center of the embryo sac.

Pollen grain: the male spore of a seed plant.

Pollen tube: the slender tube that is emitted by a pollen grain, which penetrates and fertilizes the ovule.

Polyphenols: a group of chemical substances found in plants, characterized by the presence of more than one phenol unit or building block per molecule. Often used in plant self-defense.

Roguing: the removing of diseased or off-type plants from seed collection.

Sepals: leaf-like appendages just below the flower petals of angiosperms. All of the sepals taken together form the calyx.

Simple fruit: derived from flowers having just one pistil. Examples are legumes (beans and peas), tomatoes, grapes, avocados, and peppers.

Species: one of the main units of the taxonomic classification of living things. In descending order the classification units are class, order, family, genus, and species.

Stamen: the thin stalk that is topped by the pollen-producing anthers.

Stigma: the pollen-receptive tip of the pistil. The stigma receives the pollen from the anthers.

Style: part of the female reproductive structure of a flower connecting the stigma and the ovary; the slender part of the pistil, rising from the ovary and ending at the stigma.

Succession: the development of a plant community over time, from its initial stage to its climax stage; usually from a community consisting of grasses to one of shrubs and, finally, to forest. Also, the changes in the species composition of communities following a natural or human disturbance like the natural filling of a pond or the clearing of a road through a forest.

Tensile strength: the maximum stretching force that a material can withstand before breaking.

Threshing: removing seeds from their pods by beating or striking the pods against a hard surface.

Tropism: the movement of an organism in response to an external stimulus. Tropisms are a unique characteristic of plants that enable them to adapt to different features of their environment.

Phototropism: the way a plant grows or bends in response to light.

Geotropism: the way a plant grows or bends in response to gravity.

Hydrotropism: the way a plant grows or bends in response to water.

Thigmotropism: the way a plant grows or bends in response to touch.

Wet processing: a method of cleaning seeds in preparation for storage. Removes the gel coating from seeds by fermenting for several days and then drying. Tomatoes seeds are cleaned using this process.

Winnowing: a method to separate the light chaff from the heavier seeds by pouring them from one container to another while blowing on them. This is often the final stage before seeds are packaged for storage.

Zygote: a cell that results from fertilization.

Chapter 9

RESOURCES

Connecting With Other Schools

According to the OAEC school garden survey of the seven counties in the Greater San Francisco Bay Area (June 2008), 62% of the schools that responded incorporate seed saving into their garden programs. When schools that received the OAEC School Garden Training were surveyed, 76% reported seed saving as a part of their garden programs. This means that in the Bay Area there is likely to be a nearby school with a seed-saving program. Seed-saving partnerships between schools can provide you with seeds, advice and curriculum ideas as well as opportunities to exchange seeds. A request in your school district newsletter asking about other schools' seed-saving programs might produce a rich exchange for you and your students.

Recommended Reading

Organic Gardening:

Cornucopia: A Source Book of Edible Plants. Stephen Facciola. Kampong Publications, Vista, California 1990.

The Heirloom Gardens. C. Jabs. Sierra Club Book, San Francisco, California 1984.

Heirloom Vegetable Gardening. William Woys Weaver. Henry Holt and Company, New York, New York 1997.

Taylor's Guide to Heirloom Vegetables. Benjamin Watson. Houghton Mifflin Company, Boston/New York 1996.

Uncommon Fruits & Vegetables: A Commonsense Guide. Elizabeth Schneider. Harper & Row, Publishers, Inc., New York, New York 1986.

Uncommon Fruits Worthy of Attention: A Gardener's Guide. Lee Reich. Addison Wesley, 1992.

The Vegetable Garden. Andrieux M.M. Vilmorin. Ten Speed Press, Berkeley, California 1985.

Seed Saving Techniques:

Harvest Editions and Winter Yearbooks of the Seed Savers Exchange. Kent Whealy. Seed Savers Publications, Decorah, Iowa 1981-1998.

Garden Seed Inventory: Second Edition. Kent Whealy. Seed Savers Publications, Decorah, Iowa 1988.

Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada. L.H. Bailey. Macmillan Publishing, New York, New York 1976.

The Seed Starter's Handbook. Nancy Bubel. Rodale Press, Emmaus, Pennsylvania 1978.

Breed Your Own Vegetable Varieties: Popbeans, Purple Peas, and Other Innovations from the Backyard Garden. Carol Deppe. Little, Brown and Co., Boston/Toronto/London 1993.

Collecting, Processing and Generating Seeds of Wildland Plants. James A. Young & Cheryl G. Young. Timber Press, Portland, Oregon 1986.

Seeds: The Ultimate Guide to Growing Vegetables, Herbs & Flowers. Sam Bittman. Bantam Books, Toronto/New York/London/Sydney/Auckland 1989.

Seed to Seed: Seed Saving Techniques for the Vegetable Gardener. Suzanne Ashworth. Seed Saver Publications, Decorah, Iowa 1991.

Park's Success With Seeds. Ann Reilly. Geo. W. Park Seed Co., Inc., Greenwood, North Carolina 1978.

Seed Savers Exchange: The First Ten Years. Kent Whealy. Seed Savers Publications, Decorah, Iowa 1986.

Seed Saving & Human Culture

Food Civilization—How History has been Affected by Human Tastes. Carson Ritchie. Beaufort Books, New York, New York 1981.

Enduring Seeds: Native American Agriculture and Wild Plant Conservation. Gary Paul Nabhan, with a Foreword by Wendell Berry. North Point Press, San Francisco, California 1989.

The Seed Keepers. Vandana Shiva, Vanaja Ramprasad, Pandurang Hegde, Omkar Krishnan, and Radha Holla-Bhar. Navdanya, New Delhi, 1995. This booklet is available by writing to The Research Foundation for Science, Technology and Natural Resource Policy, A 60 Hauz Khas, New Delhi 110 016.

Lost Crops of Africa Vol. 1 Grains. Board on Science and Technology for International Development. National Academy Press, Washington D.C. 1996.

Lost Crops of the Incas: Little Known Plants of the Andes with Promise for Worldwide Cultivation. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation Board on Science and Technology for International Development, National Research Council National Academy Press, Washington, D.C. 1989.

Blue Corn and Square Tomatoes: Unusual Facts About Common Garden Vegetables. Rebecca Rupp. Garden Way Publishing, Pownall, Vermont 1987.

Corporate Agribusiness & the Threat to Biodiversity

Fatal Harvest: The Tragedy of Industrial Agriculture. Andrew Kimbrell (ed.) Island Press, Covelo, California, 2002.

Hope's Edge—A New Diet for a Small Planet. Francis Moore Lappe, Tarcher, 2003. Lappe traveled to nine counties on five continents to ask the question "Why have we, as societies, created that which, as individuals, we abhor?"

Seeds of Change, The Living Treasure: The Passionate Story of the Growing Movement to Restore Biodiversity and Revolutionize the Way We Think About Food. Kenny Ausubel. Harper, San Francisco, California, 1994.

Shattering: Food, Politics, and the Loss of Genetic Diversity. Cary Fowler and Pat Mooney, University of Arizona Press, Tucson, Arizona, 1990. An excellent and comprehensive presentation on subjects of the value of agricultural diversity, the crisis of genetic erosion, the politics and business of plant genetics, and genetic resource conservation.

The Unsettling of America, Wendell Berry. All of Wendell Berry's essays and poems are highly recommended.

Seed Companies

Abundant Life Seed Foundation
www.abundantlifeseeds.com
PO Box 772
Port Townsend, WA 98368
tel: (360) 385-5660

Beckers Seed Potatoes
R.R. #1
Trout Creek, Ontario POH 2LO
tel: (705)-724-2305
Email: beckers@vianet.ca
(catalog requests only)

Cook's Garden Seed and Supplies
CooksGarden.com
PO Box 535
Londonderry, VT 05148
tel: (802) 824-3400

Deep Diversity
www.one-garden.org
P.O. Box 15700
Santa Fe, NM 87506-5700

Ecology Action—Bountiful Gardens
www.bountifulgardens.org
5798 Ridgewood Road
Willits, CA 95490
tel: (707) 459-6410

J.L. Hudson Ethnobotanical Catalog of Seeds
www.JLHudsonSeeds.net
Star Route 2, Box 337
La Honda, CA 94020
(no telephone) Amazing catalog with seed stories

Johnny's Selected Seeds JohnnySeeds.com
Foss Hill Road
Albion, Maine 04910-97310
tel: (207) 437-4305

Lawson Bag Company (pollinating bags)
www.seedburo.com
PO Box 8577
Northfield, IL 60093
tel: (708) 446-8812

Seed Companies

Native Seeds/SEARCH
www.nativeseeds.org
526 N. 4th Ave.
Tucson, AZ 85705
tel: (520) 622-5561

Nichols Garden Nursery
www.nicholsgardennursery.com
1190 North Pacific Highway
Albany, OR 97321-4580
tel: (541) 928-9280

Pinetree Garden Seeds
www.superseeds.com
Box 300
New Gloucester, ME 04260
tel: (207) 926-3400

Ronniger's Seed Potato Co.
www.ronnigers.com
P.O. Box 307 Ellensburg, WA 98926
tel: (800) 846-6178

Vermont Bean Seed Company
www.vermontbean.com/
Garden Lane
Fair Haven, VT 05743
tel: (803) 663-0217

Seeds of Change
www.seedsofchange.com
P.O. Box 15700
Santa Fe, NM 87506-5700
tel: (505) 438-8080

Seed Savers Exchange
www.seedsavers.org
3076 North Winn Road
Decorah, IA 52101
tel/fax: (563) 382-5990

Rene's Garden Seeds
www.reneesgarden.com
6060 Graham Hill Rd. Suite A
Felton, CA 95018
tel: 888-880-7228

Southern Exposure Seed Exchange
www.southernexposure.com
PO Box 170
Earlysville, VA 22936
tel: (804) 973-4703

Swallowtail Garden Seeds
www.swallowtailgardenseeds.com
122 Calistoga Road, #178
Santa Rosa, CA 95409
(800)-723-1771

Territorial Seed Company
www.TerritorialSeed.com
PO Box 157
Cottage Grove, OR
tel: (541) 942-9547

Wild Garden Seed
www.wildgardenseed.com
Shoulder to Shoulder Farm
Box 1509
Philomath, OR 97370
tel: (541) 929-4068

Useful websites

California School Garden Network	www.csgn.org
School Garden Network of Sonoma County	www.schoolgardens.org
San Francisco Green Schoolyard Alliance	www.sfgreenschools.org
The International Potato Center	www.cipotato.org
The Food Museum	www.foodmuseum.com
Edible Schoolyard	www.edibleschoolyard.org
Life Lab	www.lifelab.org
National Gardening Association	www.kidsgardening.com
Center for Agroecology & Sustainable Food Systems, University of Ca Santa Cruz	http://casfs.ucsc.edu/

Other Recommended Organizations and Conferences

Eco-Farm Conference

www.eco-farm.org • 831-763-2111
Organized by the Ecological Farming Association in Watsonville, California, this annual four-day winter forum is the world's foremost sustainable agriculture conference. Eco-Farm features prominent keynote speakers and more than 50 workshops on the latest advances in agricultural production, marketing, research, and important issues. It is held on the last weekend of January in Asilomar, California.

Bioneers

www.bioneers.org • 877-BIONEER
The Bioneers Conference is an annual three-day gathering of social and scientific innovators with practical and visionary solutions for the world's most pressing environmental and social challenges. This inspiring conference is held in San Rafael, California each October and is also transmitted by satellite to more than 18 locations nationwide.

Center for Ecoliteracy

www.ecoliteracy.org • Berkeley, CA (510) 845-4595
Provides some funding for school gardens, and is also a source of publications on the subject of ecoliteracy and school gardens.

Bioversity International

http://www2.bioversityinternational.org
The world's largest international research organization dedicated solely to the conservation and use of agricultural biodiversity.

International Society for Ecology and Culture (ISEC)

www.isec.org.uk • Devon, UK

Dedicated to protecting both biological and cultural diversity. This non-profit organization operates the Lahdak Project in the Indian Himalayas, running a wide range of 'hands on' projects to counter the negative effects of conventional development in that region.

Native Seeds/SEARCH

www.nativeseeds.org • Tucson, AZ • (520) 622-5561

Conserves, distributes and documents the diverse varieties of agricultural seeds and their wild relatives, as well as the role these seeds play in cultures of the American Southwest and northwest Mexico.

Seed Savers Exchange

www.seedsavers.org • Decorah, IA

A non-profit organization of gardeners dedicated to saving and sharing heirloom seeds. SSE provides a seed exchange network, a seed catalogue, and other publications. The Flower and Herb Exchange is a project of Seed Savers Exchange, and is focused on preserving heirloom and unusual flowers and herbs that are not commercially available.

Seeds of Diversity

P.O. Box 36, Station Q, Toronto, Ontario M4T 2L7 Canada • www.seeds.ca

A Canadian volunteer organization that conserves the biodiversity and traditional knowledge of food crops and garden plants.

Navdanya

New Delhi, India • http://www.navdanya.org/

Navdanya "*nine crop*s" started as a program of the Research Foundation for Science, Technology and Ecology founded by world-renowned scientist and environmentalist Dr. Vandana Shiva. Navdanya is a network of seed keepers and organic producers spread across 16 states in India. The main aim of the Navdanya biodiversity conservation program is to support local farmers, rescue and conserve crops and plants that are being pushed to extinction and make them available through direct marketing.