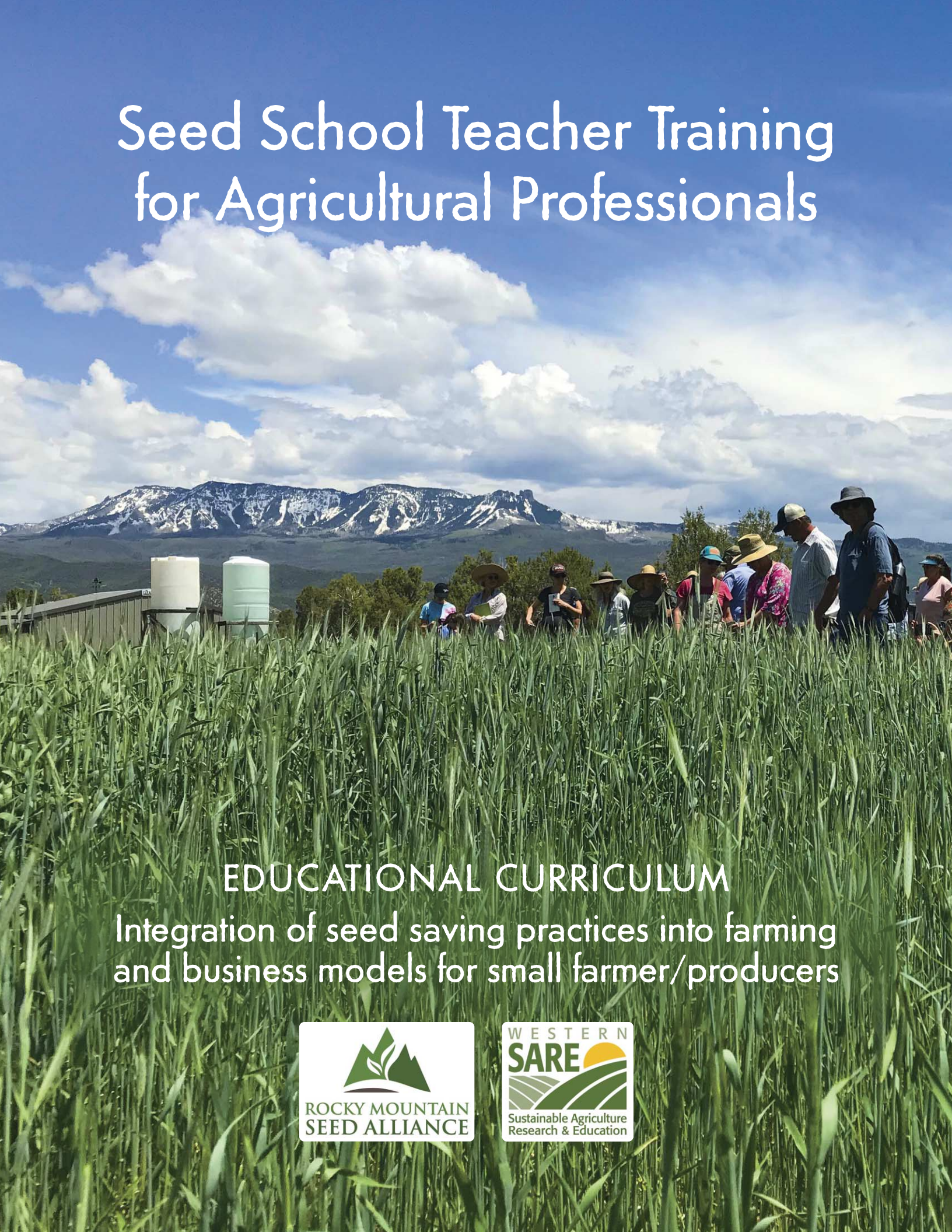
Seed School Teacher Training for Agricultural Professionals



EDUCATIONAL CURRICULUM

Integration of seed saving practices into farming and business models for small farmer/producers

ROCKY MOUNTAIN SEED ALLIANCE

WESTERN SARE Sustainable Agriculture Research & Education

Seed School Teacher Training for Agricultural Professionals

EDUCATIONAL CURRICULUM

Table of Contents

Welcome to the Seed Teacher Handbook

We are thrilled to share information and resources that will deepen your journey as a seed saver and a seed teacher. Seeds are truly the gifts that keep on giving. If you have made your way to this handbook, then you already understand the power of seeds. We hope this handbook will be a useful tool in your seed education work, whether you are teaching high school students, Master Gardeners, local community members, apprentices, beginning farmers, or farm owners and operators. Special thanks to Sustainable Agriculture Research and Education (SARE) and the great people managing the Western SARE grant program for their support in this effort, and for understanding the importance of seeds in sustainable agricultural practices.

Background for Seed Teachers

Seed saving is an ancient tradition going back nearly 12,000 years. This back-and-forth dance with the plants has transformed the human race and is a fundamental part of our story as a species. Through the careful techniques of growing, selecting, and replanting seeds from the best plants each season, ancient farmers and gardeners created an incredible diversity of crop varieties that helped them adapt to changing geographic and climatic conditions. But in our modern lives, this timeless tradition has fallen out of common practice, and much of the

A Note on Diversity and Inclusion: Seeds are a powerful and age-old way to connect with one another across cultures and identities. As a seed teacher, we encourage you to be curious about your own personal perspectives and biases, noting how these might inform or obscure your awareness of the issues at hand. Be especially mindful when working with audiences from diverse racial, ethnic, and cultural backgrounds to ensure all voices and views are heard and respected. If you are unfamiliar with how to approach these differences, consider attending a training in diversity and inclusion. Draw on speakers and co-presenters from different cultural and racial identities to offer broader perspectives. The seed saving movement offers us a profound way to bridge our differences, heal old wounds, and recognize our common humanity. Remember to stay humble and learn from each other—just as you learn from the seeds!

abundant seed diversity we once stewarded has all but disappeared. Your work as a seed teacher and a seed steward can ensure the timeless practice of seed saving lives on, so future generations may benefit from the bounty and resilience that those before us provided.

Cultural Considerations

What roles have seeds played in shaping our cultures and communities? How do indigenous connections to seeds differ from our modern use of these vital resources? How does the relationship to seeds differ across the various identities of our community members? In your own work and classes, we encourage you to explore these questions and examine the practice of seed saving through a variety of perspectives, from its indigenous roots to today's revival of traditions. We also encourage you to weave in stories and ecologies from your own region to make your courses relevant to your audiences. Most importantly, *empower your students to save seeds* and to become part of the ongoing story.

A Note on Scale

As a seed teacher, it is important to know your audience and address the scale of seed saving that is most relevant to that group. **That said, basic seed saving should be a pre-requisite for any scale of saving seed.** The modules, discussions, and activities in this workbook are a guide for everyone, at any point along their seed journey. As scale increases, so does the need for more advanced harvesting and cleaning equipment, processing and storage facilities. Often, the goals of seed selection and breeding will be different among larger scale operations. While this manual focuses on smaller scale seed saving practices, a reference sheet on larger scale equipment and resources for seed cleaning is included as an appendix.

IMPORTANT RESOURCES

In each module you will find learning objectives, discussion points, activities, and a list of resources for each topic. Relevant handouts are also listed and these are included in the Appendices and online in the Curriculum File. Enjoy!

Seed School Online

Each of the following modules can be found in Seed School Online. If you attended Seed School Teacher Training, you received Seed School Online. Please review Seed School Online for each of these modules if you'd like further information on the topics. If you need assistance accessing your Seed School Online account, or if you haven't taken it and would like to explore it for additional information supporting this curriculum please contact **Belle@RockyMountainSeeds.org**.

PowerPoint

You are welcome to reference and use the PowerPoint files in your seed education efforts. Bill McDorman's PowerPoint presentations are available in the Curriculum File in Google Drive that you received in your Seed School Teacher Training Course — **https://drive.google.com/drive/u/1/folders/1eaiYDURZeNGyTALzr_At-hQ5T5SYRyM_** — please offer credit to Rocky Mountain Seed Alliance.

Module 1: Selection and Genetics

When you buy vegetables, do you select specimens that are beautiful, flavorful, or fragrant? Perhaps you are selecting for a size that will be easier to cut and prepare, or a variety that tastes best in your special recipe? Or maybe you are looking for one that will store longer? While consumer selection happens at the product level, genetic selection starts with the seed. Most common vegetable *cultivars* have been selected for generations, and sometimes over thousands of years, to become the familiar varieties we know and enjoy today.

This module will introduce students to seed selection and basic genetics to help them understand *genotypes* and *phenotypes* in plants, as well as the relationship that genetics has with seed saving. Remember to keep any discussions of genetics simple so your participants do not feel overwhelmed or discouraged from seed saving. Keep it fun! Hands-on activities and group discussion will help inspire and instruct.

Learning Objectives

To provide a basic understanding of genetics and crop and seed selection. Consider your audience and custom design your lesson accordingly. For instance, Mendel's Laws may not be necessary in a basic seed saving course.

The power of selection as a breeding technique

Breeding by selection has been happening since humans began cultivating plants. You can use selection in your home gardens and farms to preserve and refine traits that are of interest to you, such as color, flavor, or hardiness.

> Selecting an early maturing tomato in your garden for seed

The importance of natural selection in the creation of locally adapted crops

As the impacts of climate change mount, it is increasingly important to create climate-resilient crops that can be preserved for future generations. *In-situ seed conservation* (preserving seed diversity by growing them out in a particular place) taps into the inherent ability of the plants to adapt to these changes and thrive in a dynamic growing environment. Along with maintaining

biodiversity in the field, this technique will also help with disease and pest pressures.

Selection techniques

The following techniques are selection practices that students can try in their own farms and gardens

Mass selection: Mix many varieties together to cross pollinate, and after a generation or two, begin selecting from the best plants.

Dave Christensen's Painted Mountain Corn is a selection from approximately 70 strains of native corns that he selected for Northern growing conditions including fast-maturity, hardiness, and adaptations to high winds and cold temperatures as well as heat and drought.

> "Natural selection may be more discerning than farmers (or plant breeders) in identifying and preserving adaptively superior types."
>
> — Robert Allard, *Principles of Plant Breeding*, 2nd Edition

Grex: Mix two or three varieties together (including hybrids), and after a generation or two begin selecting for a small number of traits like flavor and color with the aim of leaving as much other diversity in the population as possible.

Carol Deppe's Beefy Resilient Grex Bean is a cross of Gaucho common bean and Mitla tepary bred for maximum resilience and flavor.

Disease/insect pressure: Select seed from plants that survived disease and insect pressures.

Kale or other plants that survive a freeze are good candidates for seed saving. If just one plant survives, then the seed from that plant will be worth saving!

Tomato blight: Any survivors? Save seed from these plants!

Grains of less interest to grasshoppers and birds are also good candidates and species to save.

Dehybridize: Gardeners are often told they cannot and should not save seeds from F1 Hybrids. This is not true. The "F" in F1 hybrid stands for filial or offspring. F1 means the first generation offspring after controlled pollination between distinct (inbred) parents. Seeds saved from F1s, called F2s, lack the consistency of F1s. This is because recessive traits hidden in the F1 parents are expressed in the F2 children. Larger farmers needing consistency and uniformity in their crops cannot afford the surprises often found by planting F2 seeds. Seed saving gardeners with more flexibility can and should welcome this opportunity to discover new combinations of the most desirable traits. By saving the seeds year after year from plants that look like the original F1 parents, a gardener can actually "dehybridize" a variety in as little as 7 or 8 generations.

Tips for success:

❊ Grow out the largest number of F2s possible. This will reveal more plants like the F1 parents from which you can save seeds and shorten the overall time needed to stabilize the line.

❊ If seeds are saved from desirable offspring each year and then planted, the number of desirable offspring will increase greatly each year until most all look like the original F1.

❊ Gardeners can still eat "off-types", so nothing is wasted.

Unexpected cross: Save and grow out seed from an unintended cross that offered valued results.

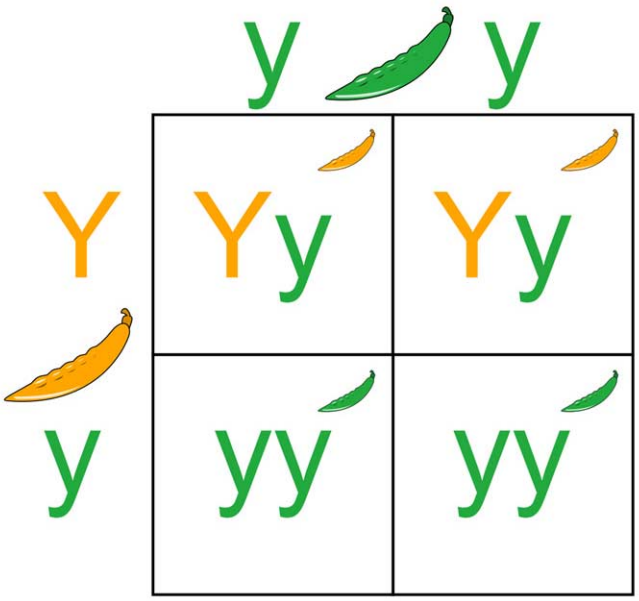
Waltham Butternut Squash was an unintended cross ("an accident") that has become a bestselling squash.

Intro to Mendel's laws

Gregor Mendel recognized genotypes, phenotypes, alleles and the dominant roles and inheritance of certain genes in subsequent generations. By studying the genetics of pea plants, Mendel observed and tracked flower color, flower position, seed shape, and seed color. In crossing for flower color, he learned that the dominant flower color trait in the first (F1) generation was violet, and that the trait that was hidden or lost was white. This trait is considered the "recessive" trait. The Khan Academy website has an effective and simple description of Mendel's laws. In *Basic Seed Saving* by Bill McDorman, dominant and recessive traits are identified in many of the 48 plants discussed. This book is offered in our teacher trainings and is a great resource.

Punnet Squares

The Punnet Square (right) is a method for assessing future generations of recessive and dominant traits. Descriptions and demos are available online at Khan Academy. Handout for students are attached in the Appendices and in the Curriculum File.



Discussion Points

Leigh Kuwanwisiwma, Hopi Elder and former Director of the Hopi Tribe's Cultural Preservation Office, saves seeds from all of his Hopi blue corn—even the damaged ears. As such, we might say he practices "non-selection." However, geneticists would offer that Hopi corn is the result of hundreds, if not thousands, of years of careful selection starting from the crop wild relative of corn, *teosinte*. Over millennia, Hopi farmers transformed this wild grass into the corn varieties they plant and save seed from today. There may be multiple layers of practice here. From a scientific perspective, you need upwards of 400 corn plants to maintain a healthy, genetically diverse population. In Leigh's words, each kernel of corn represents "all my children, and we bring them all in." This technique is key to developing resilience in a variety because it maintains a high level of genetic diversity and viability, which in turn allows the crop to adapt to unique geographic and climatic conditions. In a changing climate or growing environment, such adaptability is crucial. Past seed stewards may have originally selected for certain culturally desirable traits and in the process created a stable and adaptive crop population.

What traits might farmers and growers seek in a certain crop? What traits would you like to select for?

Activities

1. Selection activity with corn

Set up or pass around cobs of corn and ask students what traits they would like to select. Have students look closely at the cobs and share the phenotypes and visible traits they see. How do these phenotypes relate to the seed's function and purpose? Complement this activity with a slide show presentation on the different types of corn (example included in the appendix and the student file). Discuss how they are used and how to tell what type it is. Encourage other discussions, such as inviting students to share a corn tradition or variety that is special to them.

2. Germination testing

Give each student a paper towel, a gallon-size Ziploc bag, and seeds for germination testing. Wheat seeds work well for this activity. Also provide spray bottles of water to share and permanent markers for writing the date the germination test was started and the seed variety on the bag and on the paper towel. Ask participants to spray the paper towel first. Then explain the 10x10 grid for doing a germination test of 100 seeds. (This format offers easy percentages, though other grid sizes can also work if less seeds are available.) Lay out the seeds on the 10x10 grid and spray again to keep seeds in place while horizontally rolling the paper towels. Place towel in the Ziploc bag. Alternatively, another paper towel can be sprayed with water and laid on top of the grid towel and the "sandwiched" towels can be gently slipped into the bag.

Lots of floury endosperm.

Good for tortillas, breads, pancakes.

Floury and flinty endosperm.

Common for industrial agriculture.

Flinty endosperm.

Good for polenta, grits.

Hard seed coat and round seeds make it explode as it heats.

Eaten at "milk" (green) stage.

Terms

Cultivar: An assemblage of plants selected for desirable characters that are maintained by human interaction.

Genotypes and phenotypes: A *genotype* is the genetic makeup of the organism. The *phenotype* is the physical trait those genes express.

Teosinte: Wild plant relative of corn.

In-situ conservation: Conserving seed diversity "in place" by growing it out, which enables seeds and species to adapt to changing climates and circumstances over subsequent generations. Compare this to *ex-situ conservation*, which is the approach used by seed banks to preserve seed diversity by storing it.

Grex: A seed grex is a diverse genetic pool from many different varieties that have been allowed to interbreed. Grexes have much more diversity than a "true" open-pollinated or hybrid variety.

RESOURCES

PowerPoint

Bill McDorman — **Selection/Genetics**

Further reading

Allard, Robert (1999). *Principles of Plant Breeding*, 2nd Edition. New York, NY. John Wiley & Sons, Inc.

McDorman, Bill (2016). *Basic Seed Saving*, 3rd Edition. Cornville, AZ: Higher Ground, LLC. *Basic Seed Saving* is available for Kindle on Amazon, or to order a hard copy contact **Belle@RockyMountainSeeds.org**

The Khan Academy website:

Mendels' laws: **www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-introduction-to-heredity/a/the-law-of-segregation**.

Punnet Square: **www.khanacademy.org/science/high-school-biology/hs-classical-genetics/hs-introduction-to-heredity/v/punnett-square-fun**

Handout

Punnet Square *(available in Appendices and Google Drive)*

Module 2: Biology and Structure

Have you ever looked closely at a flower? Have you looked *really close*—so close it seems like you are looking through the lens of a kaleidoscope? Have you peered through a magnifying glass (or loupe) at the particles of pollen that can be found on a lily? Or zoomed in to admire the geometric patterns at the tip of a stamen? These are all activities you can share with your students to encourage a childlike wonder for the biology and structure of plants and how that relates to seed saving. Use basic terminology and hands-on activities to encourage playful interaction.

Learning Objectives

To provide students with a basic understanding of the biology of plants and seeds that enable the seed cycle to continue. This is a foundation for pollination and germination, which is a separate module.

Beauty/complexity

First and foremost, help students fall in love with seeds (if they haven't already!). This is a key component in seed saving and in truly caring for anything. Have seeds of all shapes, sizes, and varieties available for students to touch and experience.

Basic seed structure

Help students understand basic seed terminology, seed structure, and how the structure relates to growth of seeds.

Seed Coat: Protects seed, retains moisture, regulates oxygen, sensitive to temperature and light; Disruption of seed coat triggers hormone action and germination

Endosperm: Supply of nutrients for the embryo (i.e., the "lunchbox" of the seed); Non-living proteins and starches that are dissolved by enzymes

Embryo: Fertilized ovule from which the radicle and cotyledons grow.

Cotyledons: First leaves

Radical: First root

Pericarp: Outer seed coat on corn seed/kernel

Aleurone: Additional layer inside the pericarp on corn seeds that can add colors to the kernel

Consider drawing on TEK in your presentation of seed/plant biology with students. Indigenous cultures have important perspectives and stories for understanding plants, experienced through thousands of years of interacting with the natural world. Traditional ecological knowledge (TEK) offers valuable information not bound by the concepts and terms of western botanical science. Resources for this include *Native Science* by Gregory Cajete, *Original Instructions*, by Melissa K. Nelson, and *Braiding Sweetgrass* by Robin Wall Kimmerer (see resources below). Invite students to share terms, concepts, and customs around seeds and plant biology from their native languages and cultures.

How water triggers germination

Softens seed coat allowing more oxygen into the seed and hydrates stored enzymes and food thereby prompting growth.

Activities

1. Seed identification bowls

To help students observe seeds more closely, offer a seed bowl activity. Choose up to 10 seed varieties and place in numbered bowls. Ask students to identify the seeds. Also ask students what they notice about the seeds. What traits does each seed have that might help it germinate easily? Share responses and stories from the seeds that you know, and encourage students to be creative with their answers. Use seeds specific to the region to highlight cultural and community relationships with seeds.

2. Journaling

Invite students to choose a seed to journal about for 15 minutes. Offer prompts for students, such as: *What features do you notice on the seed? What type of seed is this? What will it become? Where would you plant this, and in what type of conditions?* Be creative, encourage students to use their imagination, and have fun!

3. Bean dissection

Start soaking large beans like fava or scarlet runner two to three days prior to the class so the cotyledons and radicle begin forming inside the embryo.

Distribute beans to students along with small knives (steak knives work well) to cut open the bean lengthwise to examine the cotyledon and radicle. What else is visible? You can also use loupes or hand lenses for a closer view.

Share a time-lapse video of seed germination, such one listed below, that shows not only the beauty and power of this process, but also offers close-up views of seed biology.

Bean time lapse: **www.youtube.com/ watch?v=w77zPAtVTuI**

Germination of a seed: **www.youtube.com/watch?v=E__rbDzNOZI**

RESOURCES

PowerPoint

Bill McDorman — **Selection/Genetics**

Further reading

Cajete, Gregory (2000). *Native Science: Natural Laws of Interdependence.* Santa Fe, NM: Clear Light Publishing.

Elpel, Thomas J. (2004). *Botany in a Day: The Patterns Method of Plant Identification.* Pony, MT: Hops Press, LLC.

Kessler, Robert, Wolfgang Stuppy, Alexandra Papadakis, and Sir Peter Crane (2006). *Seeds: Time Capsules of Life.* Firefly Books.

Kimmerer, Robin Wall (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants.* Minneapolis, MN: Milkweed Editions.

Nelson, Melissa K. (2008). *Original Instructions: Indigenous Teachings for a Sustainable Future.* Rochester, VT: Bear & Company.

Handouts

Various handouts are available online that show the different parts of the seed, from simple to complex. Find one that is appropriate for your audience, or use the basic seed structure diagrams from Bill's PowerPoint.

Module 3: Harvesting, Processing, and Storage

For many, the most exciting and gratifying aspect of seed saving is the harvesting and processing of seeds. Processing the fruits of our labor, or the bounty of our forage, affirms our role as stewards and connects us to ancestors who also stewarded and carried forth generations of seeds. The cycle continues and our role in the dance is as important as ever. We acknowledge those that have come before us to protect and sustain the seeds, and we honor the roles of today's stewards by carrying on this tradition.

For student engagement in this ancient and ongoing tradition, have seeds on hand for processing (i.e., cleaning) and if possible visit a farm, garden, field, or even walk along a road for hands-on harvesting experiences. With a fan, tarp, bin, bucket, or basket you can make any location work for cleaning seeds, though larger scale operations will obviously require larger scale equipment. Cleaning seeds is generally the most popular activity, so try to offer as much time as possible for students to have direct experience with cleaning different seeds. Stomp beans together on a tarp to thresh, and use the wind or fans to winnow. You don't need to buy professional seed cleaning screens. Many household items such as kitchen sieves and hardware cloth (or burlap) can be used effectively. Get creative!

Learning Objectives

To offer students background, techniques, and hands-on experience in harvesting and processing, as well as to inform students about best storage practices. Address scale as it relates to your audience. This is often a favorite part of seed saving courses, so plan accordingly so that you have ample time and materials for students to enjoy these activities.

Harvest / process

The "craft" of seed saving: Seed saving is a craft that often reflects the cultural and ecological setting where the seeds are grown. For instance, in windy areas the wind may still be used as a preferred method of winnowing (using air to blow and separate the chaff, or vegetative debris, from the seed), though

fans may be used when needed. The scale of seed production also needs to be considered. For larger scale seed processing, winnowing equipment may be necessary, which may involve a combine or a gravity table and separator. The "Clipper" by A.T. Ferrell Company, is a classic seed cleaner that is still being produced. The Eliminator 224 Seed Cleaner is based on the same design. Many growers move into combines and clippers for seed cleaning as they scale up their operations.

Some seeds, such as einkorn and spelt, require specific cleaning equipment. Factoring in the cleaning requirements for crops at the farm scale, especially for plots larger than one acre, is critical when embarking on seed saving. At the garden and smaller plot scale, harvesting and cleaning by hand (and foot) is effective and enjoyable for most growers. Finding an existing seed cleaning operation or purchasing equipment cooperatively with other seed growers is also a great option.

Cure: Curing is the process of ripening your seeds for germination, usually post-harvest. This can take place in the field or in an indoor space, depending on various factors including frost, heat, precipitation and other weather considerations, as well as pests and diseases. Some seeds require fermentation to "cure" (e.g., tomatoes and some growers prefer to ferment squash and cucumbers). This process enhances disease prevention. Dry seeded crops like beans turn brown and dry on the plant when ready for harvest.

Thresh: The process of separating seeds from chaff—the small remaining pieces of pods or vegetative coverings on seeds.

Scalp: To separate the larger chaff from the seed.

Sift: To separate the smaller chaff from the seed.

Winnow: An ancient technique of using wind and moving air to blow chaff away from seeds during cleaning.

Storage

Cool, dark, dry: This is the "mantra" for successful seed storage. Generally, seeds last longer as storage conditions get colder. Root cellar temperatures, around 50–55° Fahrenheit, is a good target. Keep seed storage below 80° Fahrenheit. to avoid faster die-off. Absolute darkness is best. Make sure seeds are dry before storing, preferably at or below 25% moisture—especially with corn, grains, and dry beans. A Dickey-John grain moisture meter is a useful tool. A portable one can be purchased for around $200 (see resources). Hanging seed plants upside down, using drying racks, and drying seed crops indoors on tarps are all effective methods of drying seeds at any scale. For additional methods, including the oven-drying method, see: **www.echocommunity.org/en/resources/0d004660-25c1-451b-808e-e738d1703eff**.

Some seeds, like grains, are dried in the field in bundles, though weather conditions must be assessed to avoid mold and

mildew damage, and pest damage in any drying situation is an important consideration. Most vegetable and flower seeds can be stored in drier climates without special protection, especially if packaged on dry days and put in glass or moisture-proof plastic containers. Silica can also be used for prolonged storage in humid conditions. Do not vacuum pack your seeds. Seeds are living, breathing embryos and require oxygen to remain viable.

Seeds protect seeds: The seeds in the middle of stored seeds are generally protected because of the steady climate and insulation that the outer seeds provide, and thus may be the most viable of the lot. If you are feeling unsure about the viability of your seeds, select from the middle for germination tests or planting.

Keep it simple: There is no need for elaborate seed storage facilities, even at the commercial level. Follow the "cool, dark, and dry" concepts and use available resources.

Discussion Points

What is your scale? What do you want to grow? What will you need? Do you need specialized equipment for your scale? *(Partner discussions are a great method for deeper exploration.)*

Activities

1. Wet processing

Tomatoes are a great option for this activity. Use ripe, organic, open-pollinated (non-hybrid) tomatoes. Each student can have a tomato and container (small wide-mouthed mason jars work well) to start this activity in class and take home to ferment and finish processing. Prepare a fermented sample in advance to demonstrate the final cleaning process.

Slice tomato at the equator to open the seed cavities, and squeeze the seeds into a container.

Add a small amount of water and let ferment for 2-5 days. The white mold that forms is an indication of proper fermentation and helps remove the gelatinous covering, which accelerates

germination. Fermentation also works as an antibiotic to help prevent diseases in the seed.

Stir occasionally. The viable seeds will fall to the bottom.

Water winnow (rinse off the fermentation with water) and strain through a sieve.

Dry on a paper towel or plate. Be sure to label them.

2. Dry processing:

Use whatever seeds are available for cleaning and at the scale that the teaching facility supports. In classrooms with tables, set up trays with dried beans, grains, or other seeds to thresh by hand. Corn can be used with corn shellers. If outdoor spaces are available, set up a tarp and fan for foot threshing and winnowing. Use seed screens, colanders, hardware cloth, or whatever you have available to demonstrate the different options and creative ways to process seed.

RESOURCES

PowerPoint

Bill McDorman — **Harvest/Cleaning/Storage**

Further reading

Ashworth, Suzanne (2002). *Seed to Seed: Seed Saving and Growing Techniques for Vegetable Gardeners*, 2nd Edition. Decorah, Iowa: Seed Savers Exchange.

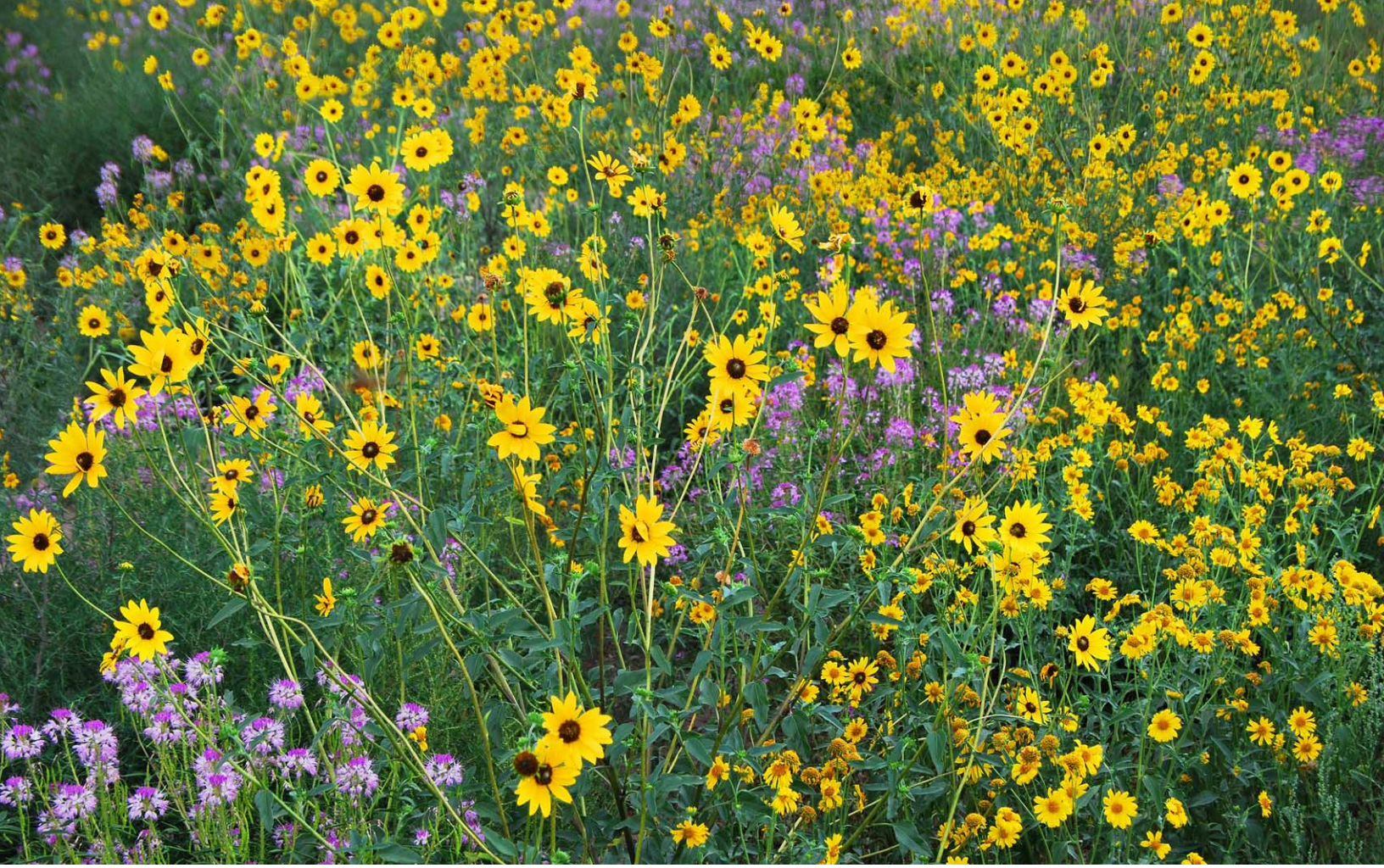
Buttala, Siegel, Zystro, et al. (2015). *The Seed Garden: The Art and Practice of Seed Saving*. Decorah, Iowa: Seed Savers Exchange.

McDorman, Bill (2016). *Basic Seed Saving*, 3rd Edition. Cornville, AZ: Higher Ground.

Navazio, John (2012). *The Organic Seed Grower: A Farmer's Guide to Vegetable Seed Production*. White River Junction, VT: Chelsea Green Publishing.

Handouts

Harvesting and Handling Seed Record, RMSA Seed Accession Form



Module 4: Wild Seeds

Wild seeds are an important component of a regenerative landscape. They offer the advantage of being adapted to the particular climate and ecology of the area being planted. Many wild species require less water and maintenance once established. They can be integrated at the farm scale to assist in pollination, create beneficial insect habitat, and contribute to the biodiversity of your farm and landscape. Growing wild crops for seed can also be a niche for farmers looking to diversify their income.

Learning Objectives

Manage for a "reasonable landscape"

1) Landscape systems like Xeriscape and Native are gaining in popularity. These can also offer ideas and tools that may be important to reach your goals in your particular landscape, such as grouping and zoning for compatible water levels.

2) Use the "reasonable landscape" model as your guide. Manage your landscape first so it requires:

- Little or no water — turn down your water and turn down your maintenance
- Little or no maintenance
- No biocides

Wild seed myths

- You need new topsoil before you can get started
- Biocides are necessary
- Wild seeds are organic
- Wild seeds need little or no care
- Wildflower mixes are perennial

Understand plant succession

A basic understanding of the natural plant succession in your area will help you tremendously in trying to manage a wild landscape.

- Skip the pioneer species, especially the weedy ones
- Only spend time, energy, and money on seeds and plants appropriate to the natural successional stage. (In other words, don't try to recreate a native landscape until conditions are right to support it.)
- Mowing may be the best non-biocidal tool for controlling unwanted plants in early stages of succession. Mow before seed heads emerge.

The best wild landscape knowledge is local

The most specific, useful, tried, and tested information about what works and what doesn't can usually be found closest to where you are planting or seeding. Ask to see where any recommended seed mixes have been planted in a similar area (at least five years before) so you can see how natural succession will affect them.

Taxonomical keys

Along with the following examples, find a taxonomical key specific for your state and region.

- *Flora of the Pacific Northwest* — the original standard for the West
- *Intermountain Flora* — update for the Mountain West with better drawings
- *Flora of North America* — massive project yet to be completed. Volumes 24 and 25 covering Poaceae (the grasses) have been completed and completely update the genera classification of western grasses

Noxious weed lists

Find the noxious weed list for your state or region.

Tetrazolium (TZ) testing

Tetrazolium salt stains the living tissue in seed embryos by measuring seed respiration, thus highlighting seeds that are viable and giving a quick estimate on germination potential. TZ tests substitute for germ tests for hard-to-germinate wild seeds that may require lengthy germination times, scarification (cutting the seed coat), or dormancy prior to germination.

Learn to identify plants by their flowers and later when they are going to seed

View the PowerPoint examples to see popular flowers and what they look like when ready for seed collection.

Discussion Points

What wild plants are common in your region and in your farms, gardens, and yards? What greater purpose do they serve? Which ones are "keepers" and which ones would you actively manage to eradicate? How would you eradicate them?

Activity

Nature walk — Take a walk outside the classroom, even if it is confined to city streets, alleys, or parking lots. Wild edible and medicinal plants and flowers can be found almost anywhere, at most any time. If it is not the season for flowers, look for leftover seed pods, seed heads, and even seeds. Employ local expertise when possible.

RESOURCES

PowerPoint

Bill McDorman — **Wild Seed**

Resources

Find seed growers in your region and locality, or use climate and longitude matching to find compatible seeds for your farm and landscape. There are also online resources for how to propagate native plants including any treatments required by native seeds to increase germination.

1. Regional seed wildcrafters

Sierra Seed Supply: **sierraseedsupply.com**

Sun Mountain Natives: **sunmountainnatives.com**

Inside Passage: **insidepassageseeds.com**

2. Contract seed wildcrafters and growers

Wind River Seed: **windriverseed.com**

Granite Seed: **graniteseed.com**

S & S Seeds: **ssseeds.com**

Applewood Seeds: **applewoodseed.com**

3. Commercial wildflower seed growers (Larger growers with wholesale purchase requirements.)

Wild West Seeds: **wildwestseed.com**

Wild Seed Farms: **wildseedfarms.com**

4. Small seed companies that sell wild seed

Snake River Seed Co-op: **www.snakeriverseeds.com**

Grand Prismatic Seed: **www.grandprismaticseed.com**

Seeds Trust: **www.seedstrust.com**

See more sources via the RMSA seed directories at: **rockymountainseeds.org/resources/search-our-directories**.

5. Online resources

Nativeseednetwork.org: Free resource to find and link with others to buy and sell native seeds.

Plants.usda.gov: The foremost government resource for all things plants. Go here first.

6. State Native Plant Societies

Search online to find a local chapter of your state Native Plant Society. This is your best shortcut to learning local plant life. Find the masters. Spend time with them.

7. Taxonomy keys (essential for making definitive plant IDs)

Cronquist, Arthur H. and Noel H.Holmgren (2012). *Intermountain Flora — Vascular Plants of the Intermountain West, U.S.A*; The New York Botanical Garden.

Hitchcock, C. Leo (2018). *Flora of the Pacific Northwest.* 2nd Edition*;* University of Washington Press.

8. Learn taxonomy

Elpel, Thomas J. (2004). *Botany in a Day: The Patterns Method of Plant Identification;* Pony, MT: Hops Press, LLC.

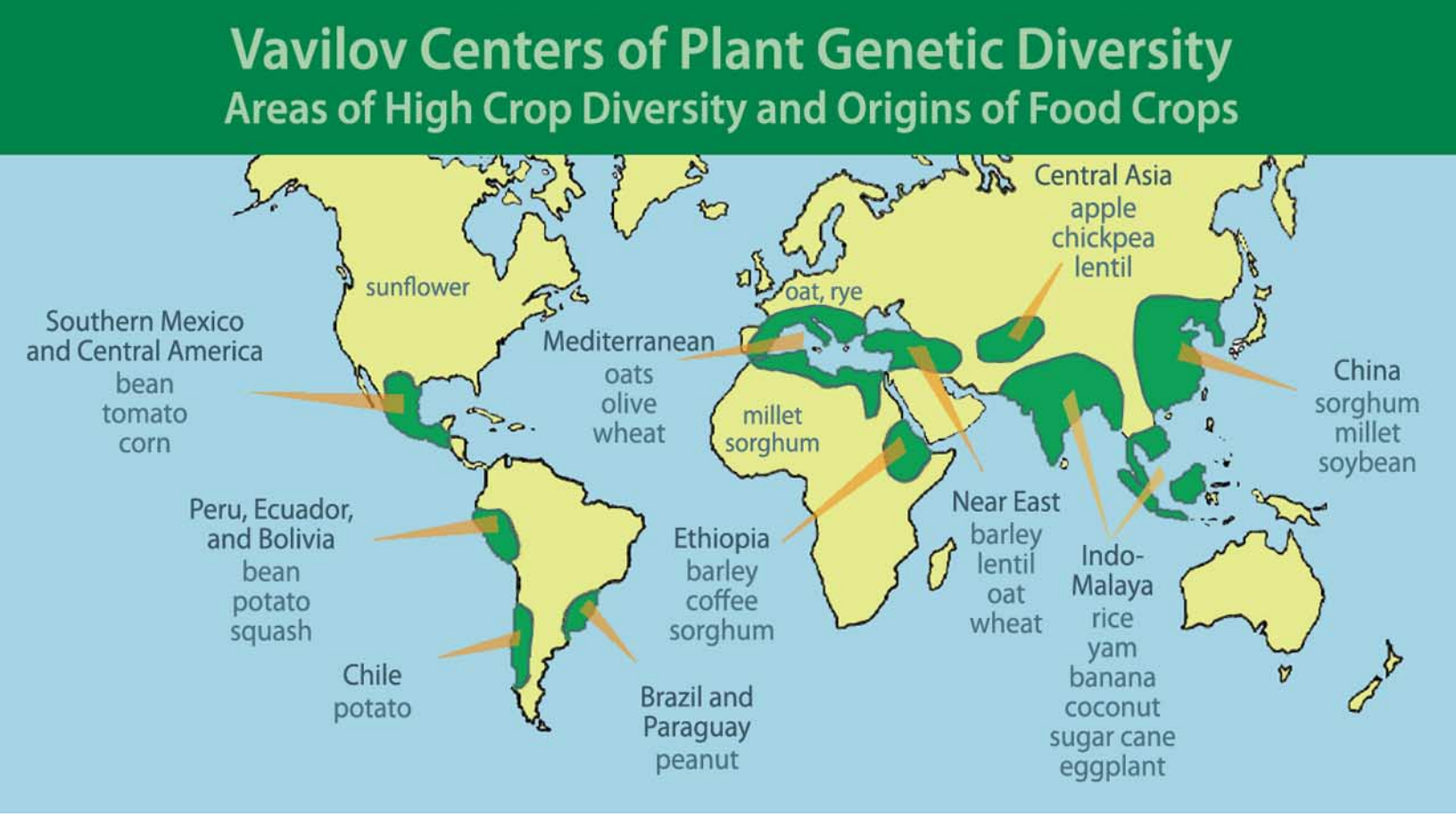
Harrington, H.D. (1977). *How to Identify Grasses and Grasslike Plants: Sedges and Rushes;* Swallow Press.

9. Garden press

Flora of North America Editorial Committee (2006–2019) *Flora of North America;* Oxford University Press.

Handouts

Dried wildflowers with seeds still attached



Module 5: History, Industry, and Patents

Honoring the stories, traditions, and ancestral heritage of the seed diversity we steward is a vital part of the seed justice movement and should be featured in your educational efforts. Seed saving has been practiced for millennia by indigenous peoples around the world. A thorough telling of the history of human interaction with seeds must account for the far-reaching impacts of colonialism, which has for centuries been a process of cultural appropriation and oppression. The history outlined in this module is focused on the complexities in the modern era, and should not be taken as the only or "official" narrative in the complex, multicultural saga of plants, seeds, and people.

Learning Objectives

History

The history of seed protection is as varied as seeds themselves and encompasses a vast spectrum of intentions and interests—from indigenous seedkeepers and grassroots seed stewarding, to farmers breeding seed for their own operations, to more restrictive elements of government and industry control.

1) Where our food comes from

Food originated from wild plants, which is well-illustrated through Vavilov's Centers of Diversity (or Centers of Origin) that show the wild ancestry of many of our cultivars

Barley: 10,500 years ago from the Sea of Galilee

Wheat: 9,000 years ago from eastern Iraq

Corn: Approximately 8,700 years ago from southern Mexico, though origin stories from various traditions are present throughout Central and South America

Carrots: 5,000 years ago from wild carrots in Europe. First cultivated as a storage root 1,100 years ago in what is now Afghanistan

2) The first 9,850 years of plant breeding was effective

Plant and seed breeding was necessary for survival. Plant breeding was happening in every environment for local adaptation of food crops and what we would now call food security.

Patenting

Like patenting overall, the history of seed patenting is fraught with political, ethical, and cultural concerns. While for thousands of years seeds had been traditionally saved and shared among communities, the patenting of seeds, as reflected in the timeline below, was an effort that quickly led to centralized seed ownership and control. The impacts of this dramatic transformation in humanity's age-old relationship to seeds cuts across social, cultural, economic, environmental, and spiritual lines. It is hard to overstate the importance of this shift and its role in the many challenges that we face today, as local communities and collectively as a species.

1850: Patent and Trade Office is established and begins offering free seeds.

1861: By this date, 2.4 million seed packets had been distributed through the Patent and Trade Office's free seed program.

1862: President Lincoln signs the Morrill Act, which set up the land grant college system through proceeds from federal land sales. These institutions were established for the study of agriculture, science, engineering, and other fields in response to the Industrial Revolution. By 1887, land grant colleges expanded to include agricultural experimentation stations to help communities develop crops for local climate, soil, and disease issues.

1883: The American Seed Trade Association (ASTA) is formed around the idea that seeds should not be given away freely but are commodities to be sold.

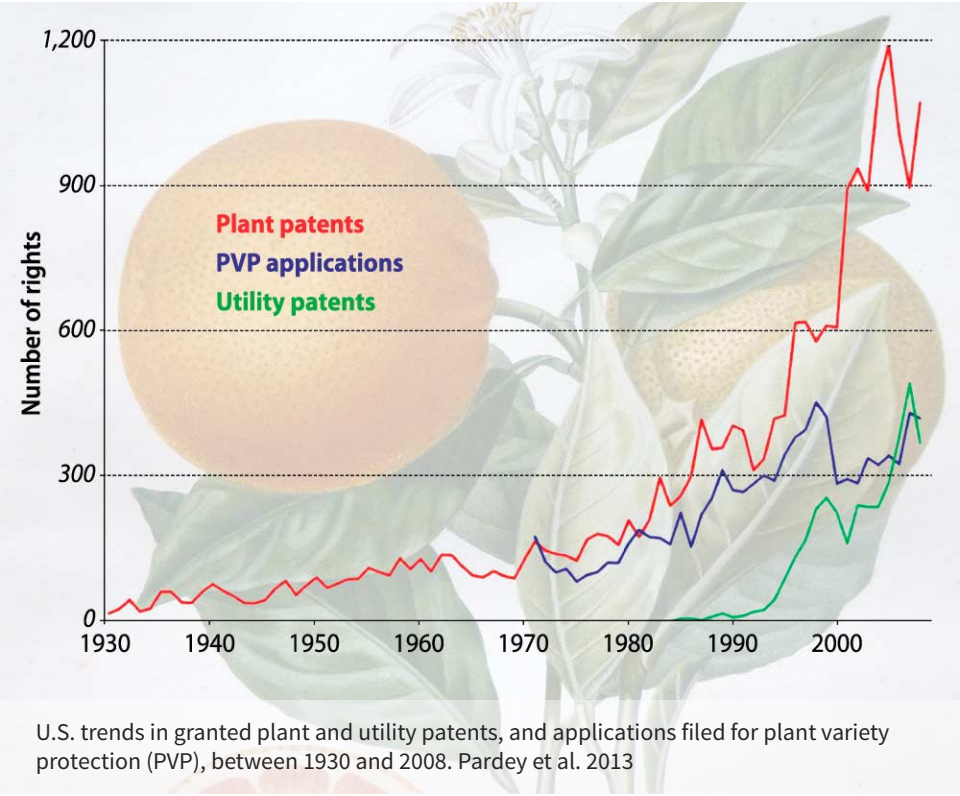
1897: By this date, 1.1 billion packets of free seeds had been distributed by the U.S. government.

1898: USDA's Office of Foreign Seed and Plant Introduction is created with help from Dr. David Fairchild and Frank Meyer. Fairchild served as its Chairman from 1904-1928. Frank Meyer was a "food explorer" sponsored by the office.

1924: Congress ends the USDA Seed Distribution Program in response to lobbying pressure from the ASTA.

1930: The Plant Patent Act (PPA) is passed

- First patenting protection for plants
- Relaxed enablement requirement for new matter — allowed for the marketing of plants without improving the genetics
- Applies to asexually reproduced plants (not including edible tuber propagated plants)
- 20-year term from date of filing
- Right to exclude others from making, using, selling, offering for sale and importing the plant, or any of its parts
- Protects a single plant and asexual progeny



U.S. trends in granted plant and utility patents, and applications filed for plant variety protection (PVP), between 1930 and 2008. Pardey et al. 2013

1970: The Plant Variety Protection Act (PVPA) is passed for seed propagated crops. Companies could now "own" seed-producing plant varieties and could claim *new and distinct* plant varieties as their intellectual property. The actual genetics of the plant could not be owned.

1980: Utility Patents for plants become legal as a result of the U.S. Supreme Court case of Diamond v. Chakrabarty (447 U.S. 303)

- Upheld that "anything under the sun made by man", including living things, could be patented
- Case concerned the patenting of oil-eating bacteria
- "The fact that micro-organisms are alive is without legal significance."

1985: The legal case of Ex Parte Hibberd (227 USPQ 443) expands on the legal precedent set by *Diamond v. Chakrabarty*

- Ruled that seeds, plant tissue cultures, and the plant itself are patentable subject matter under the utility patent statute
- The Hibberd utility patent application concerned "genetically engineered" maize which had high levels of tryptophan

1986: Coordinated Framework for the Regulation of Biotechnology: regulatory policy on genetic engineering developed by President Reagan's administration

- No new laws would be passed to regulate biotechnology; existing statutes are sufficient to review the products
- Updated in 2017

2001: J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred Int., Inc. (543 U.S. 124); J.E.M. resold Pioneer's patented corn seeds without permission

- J.E.M. claimed the original PVPA allowed farmers to save their own seed
- The court ruling held that newly developed plant breeds fall within the scope of §101 (passed in 1952 and concerning the patenting of machine, manufacture, or composition of matter), and that neither the PPA nor PVPA limits this coverage

Utility patents and Plant Variety Protection (PVP) patents are applicable and applied to seeds, and have become pertinent in the global seed arena. Following are the specifics and the differences in these patents.

1) Utility patents are granted by the United States Patent and Trademark Office

They are based on a specific trait or attribute of an individual variety. Others may use utility patented varieties under the following circumstances:

- Varieties can *only* be used for crop production
- Varieties *cannot* be used for seed saving to resell, give away or plant
- Under *no* circumstances can the variety be used in a breeding program except that of the patent holder
- Patented material may not be used commercially by others for 20 years

2) Plant Variety Protection patents are granted by the United States Department of Agriculture and prohibit unauthorized commercialization of a unique seed or tuber-produced variety. The following stipulations apply:

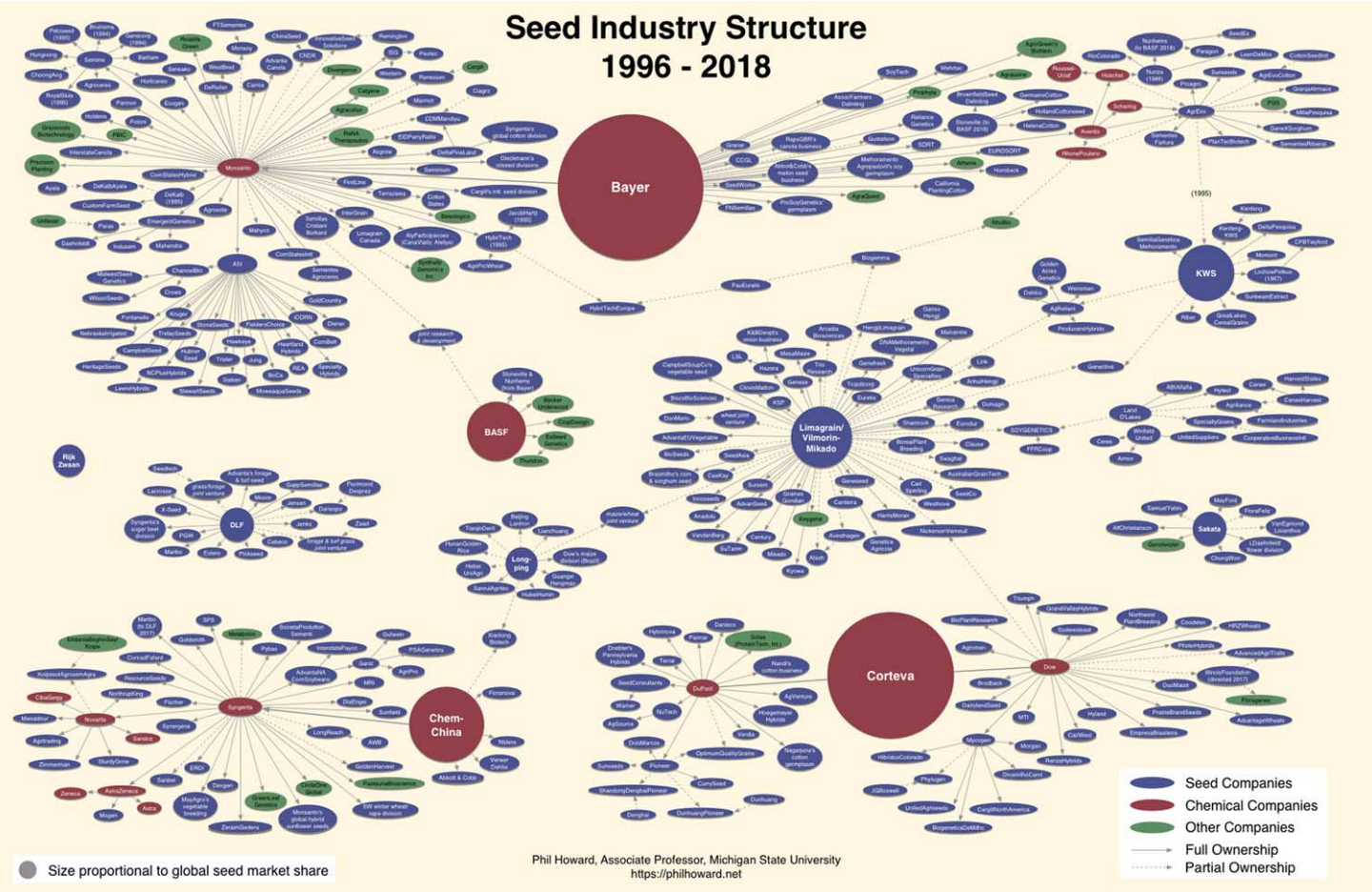
- A grower may save the seeds of a PVP variety for planting for their own use, but cannot legally distribute the seeds without permission
- Once the PVP has expired (20 years for most plants and 25 years for perennial trees or vine species) seed production for distribution is allowed
- PVP varieties may be used in breeding programs

3) Rise of Certified Organic Utility Patents

More and more organic seeds are being utility patented and offered in our favorite seed catalogs, however these varieties are not always being disclosed so the grower must research before selling or using the seed for seed breeding, per the above requirements.

4) International context to plant patenting

Plant patenting has become an issue around the globe and has been addressed in the Convention on Biological Diversity (Nagoya Protocol) and the International Treaty on Plant Genetic Resources for Food and Agriculture. See these sources for more info.



Industry

With the rise of industrial agriculture during the post-war Green Revolution, farms became large-scale operations requiring genetically uniform hybrids for mechanized cultivation and harvesting. Commercially sold seeds were a core component of this new, highly centralized model of food production. Seeds had once been viewed as part of the "commons"; no one could own them, and they contributed to the strength and resilience of our communities. But as the industrial agriculture model took hold, seeds became increasingly privatized and consolidated under corporate ownership. Beginning with the first industrial hybrids, bred to perform under high-input conditions, industrial agriculture has continued to develop proprietary seeds (through genetic engineering and other techniques) that are grown using patented pesticides, fertilizers, and other products. This ecologically destructive model has led to a decline in soil health, polluted ecosystems, and contributed to an alarming reduction in crop diversity that threatens the resilience of our food system.

1) Extreme centralization

In the past several years, we have seen a dramatic increase in corporate consolidation of seed ownership. The "Big 6" agrichemical/seed companies, who once comprised nearly a quarter of the seed industry, have merged into four companies that now control over 60% of global proprietary seed sales (for more information, visit **www.cornucopia.org/seed-industry-structure-dr-phil-howard/**).

2) Loss of diversity

From these mergers and the further centralization of the seed industry, the biodiversity of our seed supply is all the more threatened and impacted. Seed diversity is winnowed down as more capital gets invested into developing a small number of patented crops—nearly all of which require chemical inputs sold by the seed corporations. A report published in 1999 by the United Nations Food and Agriculture Organization (FAO) put this diversity loss in stark terms, claiming "more than 90% of crop varieties have disappeared from farmers' fields" (for more information, visit **www.fao.org/docrep/007/y5609e/y5609e02.htm**).

Discussion Points

1. Why is the loss of diversity a problem for our seed and food systems?

2. What impacts has the industrialization of agriculture had on our seeds and food security?

3. How can regionally adapted seed systems address these impacts?

4. How does plant and seed patenting affect our right to save seeds?

Activities

1. Small group exercise

Have participants break into small groups. Ask participants to discuss the following questions for 10 minutes. Announce the half-time mark at 5 minutes. After 10 minutes, bring everyone back together and ask for volunteers to raise their hand to share what their group discussed.

1) How do you feel about seed patenting?

2) How do you feel about seed companies that promote mostly organic and open-pollinated seeds patenting their varieties to protect them as intellectual property?

3) How should traditional seeds be considered regarding patents and intellectual property rights? How should the rights of traditional seedkeepers be considered when talking about intellectual property rights?

4) Don't contemporary seeds come from a lineage of stewardship, selection, and breeding?

2. Spectrogram

Create an imaginary line on the ground that signifies an axis. Choose one end of the line to represent "10" or "the highest" on the scale and the other end to be "0" or "the lowest." Announce a topic and have participants arrange themselves along the line wherever they feel they fit according to the scale. This can be used with any topic or issue, such as where an individual feels they are on the scale with their "seed saving knowledge," or if participants feel that patents of seeds are appropriate. Discuss why participants chose their positions on the spectrogram.

1) Use the spectrogram to pair people together to discuss their positions

2) Pair people representing opposite sides of the issue together for discussion

RESOURCES

PowerPoint

Bill McDorman — **History, Industry, Patents**

Further reading

Cummings, Claire Hope (2008). *Uncertain Peril: Genetic Engineering and the Future of Seeds*. Boston, MA: Beacon Press.

FAO (1999b). Women: Users, preservers and managers of agrobiodiversity. Rome: FAO.

FAO (2004). What is happening to biodiversity? Rome: FAO.

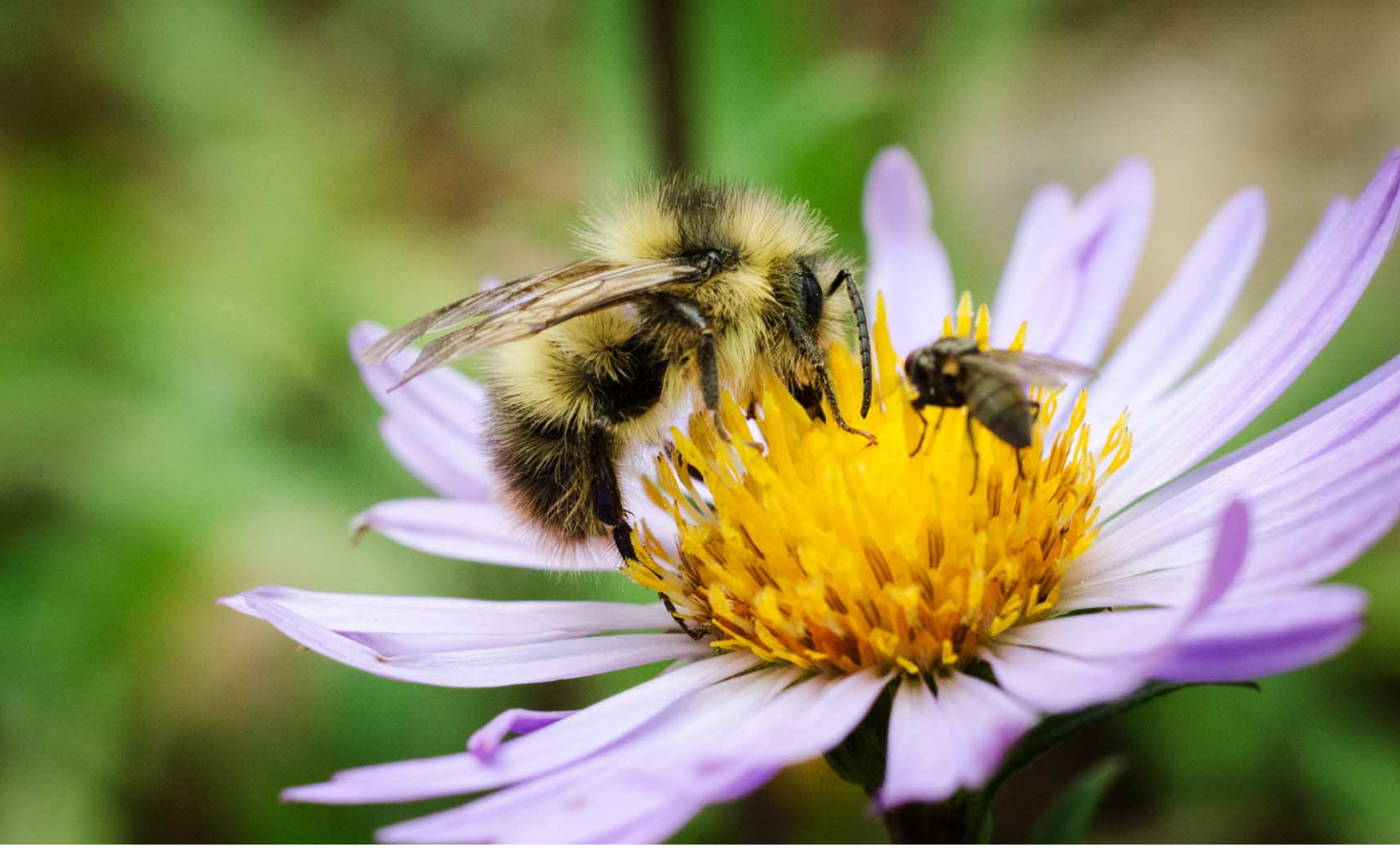
Fowler, Cary & Pat Moony (1990). *Shattering: Food, Politics and the Loss of Genetic Diversity*. Tucson, AZ: University of Arizona Press.

Khoury, Colin. How Diverse is the Global Diet? *CIAT.* May 15, 2017. **http://blog.ciat.cgiar.org/how-diverse-is-the-global-diet**

Khoury, C., A.D. Bjorkman, H. Dempewolf, J. Ramirez-Villegas, L. Guarino, A. Jarvis, L.H. Rieseberg, and P.C. Struik. Increasing Homogeneity in Global Food Supplies and the Implications for Food Security. *PNAS 111* (11):4001– 6. March 18, 2014. **doi:10.1073/pnas.1313490111**

Kloppenburg, Jack (200). *First the Seed: The Political Economy of Plant Biotechnology*, 2nd Edition. Madison, WI: University of Wisconsin Press.

Nabhan, Gary (2011). *Where Our Food Comes From: Retracing Nikolay Vavilov's Quest to End Famine*. Washington, DC: Island Press.



Module 6: Pollination and Breeding

A Note on Terminology: There is an evolving conversation taking place surrounding gendered language and biases in botanical terminology. Some people are opting to use gender neutral terms such as "pollen-giving" and "pollen-receiving" rather than male or female to identify flower parts. Additional terminology shifts include "bisexual" and "unisexual" in place of "perfect" and "imperfect" flowers. In this module, we have employed the newer language with the older terms in parentheses. Note that many resources and handouts may use these older terms. When presenting this material, use your discretion and gauge your audience in deciding which language to employ. You may choose to point out these variations in terminology to avoid confusion and open up an engaging discussion into your audience's preferences, feelings, and opinions on this topic.

Pollination and breeding are the foundation of seed saving, and breeding can be one of the most exciting and rewarding endeavors for seed savers. Learning about breeding systems (i.e., how specific plants reproduce) is fundamental for seed breeding and requires a basic understanding of botanical science. However, teaching these concepts doesn't have to be tedious, overwhelming, or overly serious. Find ways to make it fun and encourage students with examples of amateur breeding experiments that have changed agricultural history (like Waltham Butternut squash). Remind students that they can create varieties that may be better adapted to their farms, gardens, and customers' and communities' tastes.

Learning Objectives

Pollination: The process of fertilizing seeds

1) Flower parts

Pistil: Pollen-receiving (female) part of the flower that also houses the ovary

Stigma: Pollen-collecting part of the pistil

Style: Pollen tube that transports pollen from the stigma to the ovary

Ovary: Enlarged portion of the pistil where the ovules, or unfertilized seeds, are produced

Ovule: Develops into a seed after fertilization

Stamen: Pollen-producing (male) part of the flower

Anther: Part of the stamen where pollen is produced

Filament: Stalk of the stamen

Pollen: Produced and distributed on the tip of the anther

Petals: Modified leaves that surround the reproductive parts of flowers; often brightly colored and/or unusually shaped to attract pollinators

Sepal: Leaf-shaped structure that holds the petals together

Peduncle: Stem of the flower

2) Bisexual/unisexual flowers (perfect/imperfect)

Bisexual (perfect) flowers have both pollen-giving and pollen-receiving parts

Unisexual (imperfect) flowers have only pollen-giving or pollen-receiving parts. They are present on plant species that have other pollen-giving and pollen-receiving flowers appearing either separately on the same plant (monoecious) or on separate plants (dioecious).

Hand pollination: Manually engaging in the process of pollination

This technique is often used with cross-pollinating species, such as squash. For self-pollinating species, manually opening the flower when pollen is "prime" for giving and receiving is required. For a visual demo, offer a hands-on squash pollination activity or use the squash pollination slides in Bill's PowerPoint. Remind students that for best results in cross-pollination projects, they should identify and mark the pollen-giving and pollen-receiving flowers the evening before hand pollinating so the pollinators do not disturb the process by bringing in pollen from other species or varieties. It is important to also "tag" the plants that have been pollinated, as the method used to keep pollen contained (tape, "twisty tie," clothespin, etc.) may become compromised later on by plant growth, weather, insects or other variables.

Breeding: Actively selecting and/or hand-pollinating plant varieties to achieve desired seed trait results

In general, breeding is performed for plant "improvement," such as for boosting resistance to disease or pests, increasing hardiness, or choosing more desirable plant qualities for the conditions. Seed selection is a form of plant breeding.

Plant improvement projects are essentially a function of controlling pollen

By learning the plant's breeding system, pollen can be efficiently controlled and used for breeding and plant improvement.

Family, Genus and Species: Breeding generally happens within plant species. (Normally species don't cross outside of their own species.) The following attributes are important to know in regards to a plant's breeding system:

Bisexual or Unisexual Flowers (Perfect or Imperfect)

"Selfers" (self-pollinating plants with bisexual flowers)

- Outcrossing unlikely
- Fertilization takes place before flower opens
- Involves genes from single parent
- Adapted to specific niche
- Examples: Tomatoes, peppers, lettuce

"Crossers" (cross-pollinating plants with bisexual or unisexual flowers)

- Prevents self-pollination
- Fertilization occurs after flower opens
- Involves genes from two or more parents
- Adapts to changing environments
- Examples: corn, cabbage, carrots

Isolation: Preventing unwanted crossing from occurring

1) Techniques: Distance, buildings, wind, timing, cages, species

2) Distances: The more outcrossing the variety, the greater distance needed

Selfers: Isolation requirements are minimal, depending on the species

Crossers: Isolation can require distances of up to 2 miles or more, depending on species and circumstances (wind, timing, etc.)

Breeding roadmap: The following concepts can help you develop and define the process for your breeding project

1) Choose goal

2) Find "parents" to assist with that goal through trials

3) Cross: Using the breeding system considerations, cross your variety accordingly

4) Grow out multiple generations: "Stabilizing" a population depends on the breeding system. Usable populations can be established in as little as 3 or 4 generations.

5) Navazio Half Sib Family Selection

Saving seed from one parent that has been openly pollinated by other plants of a selected population will offer increased genetic diversity. This seed will share the same "mother" (pollen receiver) yet will have pollen from a selection of pollen givers, which can help support desired traits while also avoiding inbreeding depression. (See Navazio, John and Jared Zystro (2014). *Introduction To On-farm Organic Plant Breeding.*)

- Save seeds from the best 50 plants. Keep separate.
- Plant 50 family plots, each with the seeds from a single plant.
- Select only from family plots with all or nearly all plants that meet your selection criteria.

6) Landrace

A landrace is a traditional variety of a crop grown and adapted to the natural and cultural environment of a particular place. It usually contains more genetic variation. This can give it an advantage over improved uniform varieties in its ability to adapt to changing and challenging growing conditions, especially diseases and pests. Continue to select from a large population of the best plants for your particular needs.

Discussion Points

1. What type of pollination or breeding project would you like to try? What are the considerations for this breeding project?

2. What if plants (such as squash) cross in your garden? This may not result in the "true-to-type" variety that farmers are accustomed to selling, but your unique creation may become a community favorite. Examples of this abound in local farmers markets and CSAs. Also offer examples like Waltham Butternut squash. You may accidentally create a delicious new variety that becomes your region's (and farm's) claim to fame. And best of all, you can always eat them!

3. Share other examples of well-known or otherwise successful breeding projects. Examples: White Eagle's (Carl Barnes') Glass Gem Corn, Dave Christensen's Painted Mountain Corn

Activities

1. Flower dissection

Lilies work well for this activity. Provide small knives (such as steak knives) and let students dissect the flower. Project an image (or provide a handout) of flower parts and terms and ask students to look for each of the flower parts.

2. Squash flower hand pollinating

Bring in pollen-giving and pollen-receiving squash blossoms for each student if possible, otherwise bring one set for demonstration in front of the class. Supply other necessary materials like a clothespin and "flagging" items and instruct students visually how to hand-pollinate the flowers, and to properly seal and tag flowers after pollinating.

RESOURCES

PowerPoint

Bill McDorman — **Pollination and Breeding**

Further reading

Deppe, Carol (2000). *Breed Your Own Vegetable Varieties: The Gardener's & Farmer's Guide to Plant Breeding & Seed Saving.* White River Junction, VT: Chelsea Green Publishing Co.

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Navazio, John (2012). *The Organic Seed Grower: A Farmer's Guide to Vegetable Seed Production.* White River Junction, VT: Chelsea Green Publishing.

Navazio, John (2014). *How to Breed Carrots for Organic Agriculture.* Port Townsend, WA: Organic Seed Alliance.

Navazio, John and Jared Zystro (2014). *Introduction to On-farm Organic Plant Breeding.* Port Townsend, WA: Organic Seed Alliance.

White, Rowen and Bryan Connolly (2011). *Breeding Organic Vegetables A Step-by-step Guide for Growers.* New York, NY: Northeast Organic Farming Associations.

Handouts

A handout showing flower terms is particularly useful for visual learners. You can copy the diagram from Bill's PowerPoint, find or draw your own, or use this online resource: **www.amnh.org/learn/biodiversity_counts/ident_help/Parts_Plants/parts_of_flower.htm**

Front inside cover of *Botany in a Day* by Thomas J. Elpel

Organic Seed Alliance Variety Trial Evaluation

Module 7: Big Picture and the Spirit of Seeds

As seed stewards and seed teachers, our role is twofold: to maintain and propagate seeds for future generations, and to guide and inspire others on the path of seed saving. This timeless tradition is a deep part of who we are, binding us on an ancestral level. Since the dawn of humanity, seeds have been our sustenance, providing us with food, clothing, medicine, and meaning. Our reverence and gratitude for them is warranted. Through teaching others about the practice of seed saving, we are honoring and giving back to the seeds that have given so much to us, for so long. Make this module your own, in a way that resonates with you at a deep level of meaning, purpose, and emotion. What is the *spirit of seeds?* How do they move you? Share this with your students, and invite them to share their experiences and connections as well.

> "If your life's work can be accomplished in your lifetime, you are not thinking big enough." — Wes Jackson

Learning Objectives

Big picture: Seeds are the Big Picture! Following are some of the ways that seeds transform the world in which we live, both locally and globally.

1) Self-replicating technology

Seeds are more resilient than modern technology!

Resilience: A 2,000 year old date palm seed found at an archaeological site in Israel was sprouted in a lab in 2005; named "Methuselah", the tree is still growing strong today and even producing fruit!

Adaptation: Teosinte, the ancient relative of corn, has been replicated over more than 8,000 years, transforming from a wild tropical grass in Mexico to a staple crop grown worldwide, even in the far northern latitudes!

2) Exponential potential

A handful of seeds can become a farm that feeds a community

Red Fife wheat: Canada's oldest wheat that set Canadian wheat standards for more than 40 years. Its offspring is Marquis, which replaced it as the number-one wheat in the early 1900s. Reportedly originally from the Ukraine and came to David Fife in Peterborough, Ontario from a friend in Scotland. (Amazing how seeds travel!)

3) Regional identity: Seeds create culture and define communities

Siberian tomatoes: Due to the sociopolitical circumstances during the Soviet era, households in Siberia relied on their gardens for food and survival. Tomatoes became a particularly valued family crop, with each family having a prized heirloom. These seeds have been passed down through generations and each have a story to tell.

Anasazi beans: Reportedly found at an archaeological site, these beans have become a dryland heritage crop in southwest Colorado.

White Sonora wheat: A Slow Food Ark of Taste crop, White Sonora is one of the oldest wheat varieties that arrived in North America. Jesuit missionary Father Kino reportedly carried it to the borderlands of Mexico and the United States in the late 1600s where it quickly became part of the regional cuisine, especially for use in flour tortillas.

4) Biodiversity

Seeds offer diversity to a living system and diversity creates resilience in living systems; the strength of any ecosystem is its biodiversity.

5) Climatic changes

When a broad range of genetic diversity is present in a population of living beings, such as plants or animals, these populations are better able to withstand the pressures of environmental change, pests, diseases, and other challenges.

Spirit: The spirit of seeds is transformational and inspires stewards in personal ways. Share ways that the spirit of seeds inspires you. The following may be relevant and helpful, though offer your own connections and invite others to share.

1) Beauty

The beauty of seeds inspires seed saving and offers a creative component to the art and craft of seed saving. Glass Gem corn has attracted over 18,000 Facebook followers.

2) Inspiration

Who are your seed heroes and heroines? Who and what inspires you regarding seeds?

3) Cultural Transformation

Rainbow Jewel (Glass Gem) Corn was a seed project initiated by Cherokee seed steward Carl Barnes (White Eagle) who collected corn from many tribes in an effort to seek out his indigenous roots and explore the wisdom of his ancestors.

4) Deep identity

Hopi corn is so deeply intertwined with the cultural identity of the Hopi people that there is no differentiation between the two. According to Hopi elder Leigh Kuwanwisiwma, "All of the corn are my children." Find and connect with your ancestry through seeds.

Discussion Points

1. Gather responses from the group about why seed saving is important to them. What scale are your students working at and why is seed saving important at that particular scale?

2. What does the "big seed picture" look like? Where are we currently headed, and where do we want to go?

3. How do climate change and other ecological, political, and social factors play into the big picture for seeds?

4. What has been lost with the declining biodiversity of our food and seeds? What might happen (in our food system, communities, cultures) if we continue to lose this diversity?

5. What seeds make your food system unique? Are there any distinctive dishes, crops, or recipes that define where you live and make it special? Can you think of some popular foods that are intimately linked to a certain region or country of origin?

6. What are the impacts that industrialization has had on our seeds, food systems, and food security?

7. How can we help rebuild seed diversity through our choices as eaters and food buyers?

RESOURCES

PowerPoint

Bill McDorman — **The Big Picture**

Resources

Chace, Teri Dunn (2015). *Seeing Seed: A Journey into the World of Seedheads, Pods, and Fruit.* Portland, OR: Timber Press.

Chaskey, Scott (2014). *Seedtime: On the History, Husbandry, Politics and Promise of Seeds.* Emmaus, PA: Rodale Press.

Holmgren, David (2009). *Future Scenarios: How Communities Can Adapt to Peak Oil and Climate Change.* White River Junction, VT: Chelsea Green Publishing.

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Mirabal, Robert and Nelson Zink (2011). *Believe in the Corn: Manual for Puebloan Corn Growing.*

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Roach, John. "'Methuselah' Palm Grown From 2,000-Year-Old Seed Is a Father." *National Geographic.* March 2015.

Siebert, Charles. "Food Ark." *National Geographic.* July 2011.

Smith, Paul (2018). *The Book of Seeds: A Lifesize Guide to Six Hundred Species from Around the World.* Chicago, IL: University of Chicago Press.

Teitel, Martin and Jeremy Rifkin (1992). *Rain Forest in Your Kitchen: The Hidden Connection Between Extinction and Your Supermarket.* Washington, DC: Island Press.

Module 8: Adding Seed Production to Your Farm

Adding seed production to your farm has many values and virtues. Producing seeds on-farm provides additional income, increases pollinator populations, creates a more holistic farm ecology, and can help you save money in your seed costs. Integrating seed production into your current markets (and with the crops you are already growing) can enhance your farm production plan, making it more robust and diverse. With careful consideration of what you already have in place, along with a needs assessment for getting started, seed production can be an exciting, lucrative complement to your current farm operations.

Considerations of Seed Production

Benefits: Why add seed production to the farm?

Adds diversity to the farm ecology.

See all stages of plant life which offers a deeper understanding of the crops already growing at the farm.

Attract and support pollinators and other beneficial insects through the flowering stages, before plants set seeds.

Have farm-adapted seed which will increase plant growth, yield, and adaptation to your unique growing conditions.

Save money by not buying off-farm seeds.

Added income from seed sales and events such as seed workshops that can be held on-farm.

Forty lettuce heads in 40 sq. ft. sell for $3 each ($120) or produce 1 lb. of seed ($260)

Challenges: What are the challenges of adding seed production to farm operations?

Time: Extra time is necessary for harvesting, cleaning, and processing seeds.

Storage: Special precautions and considerations are needed for storing seed at a viable temperature, free from pests like mice and birds, etc.

Insect/disease: Seed production comes with its own set of insect and disease challenges. Insects like Lygus aren't usually a problem for market vegetables or flowers, but they can severely damage a seed crop.

Crop rotations/timing: A full life cycle for the crop is required so crop rotations and timing need to be considered accordingly. Space needs to be provided for full-season seed crops.

Isolation: Isolation distances for pollination need to be considered with other crops and species growing nearby.

Options for selling seed

Many revenue streams are possible for selling seed. The key is to determine which is best for your operations and interests, and ideally already in-line with your farm.

Direct market: Direct marketing your seeds on your website and social media, at your markets, and through custom accounts is a viable option that offers the greatest revenue and can also enhance your branding. Additionally, direct marketing of your seeds can offer supplemental income during farm "off-season," however it requires more work; similar to another full-time job, and you will still need to coordinate sales during farm season.

Sell seed to a seed company: Selling seed to a company can alleviate a lot of time and work, but the drawbacks are that you will make considerably less compared to direct sales and you will need to procure buyers, usually in advance.

Grow seed on contract for a company: Pros: the company provides the seed. Cons: you will likely be required to grow crops determined by the company rather than your own interests, and you need to connect with a seed company to commence the relationship. There's also pressure to successfully deliver the seed, despite challenges that may arise during the season that affect the overall health and success of the crop.

Create or participate in a seed cooperative: Seed cooperatives are a productive way to share resources and time requirements among many seed growers through a cooperative model. See examples of seed cooperatives for models and inspiration.

Snake River Seed Cooperative, Triple Divide Seeds, Common Wealth Seed Growers

Strategies for successful seed growing

With advance prep and planning, seed growing can be a compatible and complementary addition to your farm operations.

Consider your current crops/markets and determine where seeds could offer added value, such as in your CSA or at farmers markets. CSA producers might consider a seed CSA as seeds become available.

Consider the scale that you will be growing seed, including timing and space considerations that could complement your crop plan. The quantity of seed can vary widely from crop to crop, which may impact the scale you seek, and sales outlets will vary according to scale.

- **Large-scale:** The larger the scale, the more equipment is generally needed to produce higher volumes. Specialized equipment can be expensive, and selling higher volumes of seed may require buyers outside your community. Storing, packing and shipping larger volumes is also a consideration.
- **Mid-scale:** Mid-scale seed production is more flexible and offers opportunities for breeding projects and more attention to detail. Harvesting and cleaning equipment can be simple with tarps, buckets, box fans, etc. Storage can be a challenge, though it is easier than at larger scales.
- **Small-scale and personal use:** The smaller the scale, the less infrastructure is needed. Seeds don't necessarily need to be cleaned free of chaff, which saves time and fuss, particularly if you are using it for your own farm needs. When growing at smaller scales, population sizes are a consideration for crops that require greater genetic variation.

Demand and competition: Research what crops would be valuable to your market(s) and assess the competition. Perhaps you can grow and sell your seed cooperatively, or grow unique seeds not available elsewhere?

Grow what you love! What do you love to grow and to eat? Growing seeds of your favorite varieties takes your passion to the next level—an excitement which you can share with your customers, friends, and family.

Discussion Points

What seed crops would you like to add to your farm production plan and what would it take as far as equipment, space, timing, and other considerations to achieve this? What markets do you already have established that would support your seed production efforts?

RESOURCES

PowerPoint

Casey O'Leary — **Adding Seed Production to Your Farm**

Resources

Navazio, John (2012). *The Organic Seed Grower: A Farmer's Guide to Vegetable Seed Production*. White River Junction, VT: Chelsea Green Publishing.

Module 9: The Myths of Seed Saving

Many myths prevent farmers and gardeners alike from saving seeds. This module focuses on myth busting and inspiring your audience to save seeds. Offer analogies that are relevant to your audience. For students who feel uncertain or nervous about seed saving, alongside the myth-busting encourage them to start with the basic principles, self-pollinating species, and favorite varieties.

Only "experts" can save seeds

Seeds have been saved for thousands of years. Traditional Ecological Knowledge (TEK), observation, trial and error, general interest, accidents, and amateur experimenting have led to countless varieties that are popular today. Part of the fun of saving seeds is that you don't have to "be an expert" or have a degree in seed saving. You can learn as you go, and you can even break the rules. Seed saving is an art and a craft, so be creative and playful. You may even outsmart the experts! Many self-taught seed savers have learned so much through their observation and experience that they have become the true "experts" in the field.

Saving seeds is too difficult

Seed saving should not be overwhelming. There's no need to learn Latin, or even biology, to begin. Starting simply with a self-pollinating variety, like beans, and particularly one that is of special interest, is the best approach. Seeds are very forgiving in many cases.

My seeds will not be as good

Actually, your seeds may very well be better. They will be adapted to your environment and your practices. You will build a personal relationship with your seeds that will help them grow. They will be "fresh" for the next season, and you will likely find increased performance and yields as you continue to grow them out.

You can't save seeds from hybrids

Quite the contrary. If you find a hybrid you really like, you can grow it out and select for the trait(s) that you like and continue growing those. It will take several generations, curiosity, and patience, but it's a fun practice. Experiment and you will learn a lot along the way.

Seed saving is not worth my time

Seed saving may well be the most important thing we do with our time as farmers and gardeners. Our seeds need to be adapted to our farms, regions, and communities. Working together on harvesting and cleaning can be very rewarding and time-saving. Seed saving also helps build community, connecting neighbors and creating local heirlooms that may be the sustenance for future generations. It's also a great way to save money on seeds, so the (financial) value of seed saving is exponential.

I might make a mistake

Many seed "mistakes" have become some of our most beloved varieties like Waltham Butternut squash. And don't forget—you can eat your mistakes! You might find a mistake that you grow that becomes your personal favorite, like a special "pumpzini," or a beautiful new variety of corn. Regardless, you will learn a lot in the process. Mistakes in seed saving often come with rewards for the brain and the belly!

The Principles of Seed Diversity

1) No one should suffer from hunger, food insecurity or malnutrition.

2) The survival of a food system depends upon its seed diversity.

3) Every seed crop is a gift resulting from thousands of years of human care and should not be privatized.

4) With seeds, we inherit a responsibility to care for and pass on seed diversity to future generations.

5) More seed diversity is created when more gardeners and farmers save seeds.

6) Seed education is fundamental to the creation of more seed savers, and thus, more seed diversity.

7) Complicated rules to assure uniformity need not be applied to small-scale seed saving for diversity.

8) Each region has a responsibility to provide safety back-up for its seed diversity.

9) Seed stories teach us how to care for our seeds and ourselves. They must also be preserved.

10) Saving your own seeds is important. Joining forces with other seed savers is transformative.

Module 10: Cultural Considerations of Seed Saving

Seed saving is an ancient practice stretching back over 12,000 years. By learning these traditional methods and saving your own seeds—even from one plant—you are taking part in one of humanity's oldest experiences. You are rejoining a ritual that makes us who we are. In doing so, you are helping to create a more sustainable, beautiful, and diverse world for present and future generations. And by teaching others to save seeds at any scale from container gardeners to farmers' fields, you are making this abundant world all the more possible. Thank you!

Learning Objective

To encourage a deeper understanding and contemplation of seed heritage and lineage by honoring traditional seed keepers and acknowledging the indigenous origins, cultures, and traditions of the seeds we steward today.

Discussion Points

1. Where does the lineage of seed begin and end?

❊ How do cultural migrations play into seed stories and legacies? Consider how seed is transported and acquired (shared or stolen) along migration routes, and how this informs our understanding of a seed's story.

- ❊ Many cultures have origin stories that involve corn. What issues arise when attempting to identify the original culture or geographical location of a seed or food crop? What benefits or impacts are there in determining this origin, and who are the beneficiaries?
- ❊ Beans found at an ancestral Puebloan site have been grown out and trademarked "Anasazi Beans" by farmers in Dove Creek, Colorado. The Anasazi Bean™ has become a claim to fame and key crop for many farmers there. What are the cultural, economic, legal, and ethical considerations of this situation?
- ❊ New Mexico chiles are landrace crops with varieties that are often specific to local communities that have grown and developed them over centuries. For example, Chimayó chiles reflect the *terroir* (i.e., the place-based, characteristic taste and flavor) of the New Mexican town of Chimayó's rich soil and Hispanic culture. Hatch chiles, considered one of the most famous New Mexico varieties, were originally a project of the New Mexico State University breeding program. What different cultural considerations arise when thinking about saving seed from these varieties?

2. From whose perspective are the stories (histories, "herstories", uses, recipes, origins) of certain seeds told? What other perspectives might be considered, and how can we honor and acknowledge them in our seed work?

3. How does cultural ecology (the study of human adaptations to social and physical environments) relate to seed saving?

4. How do we create seeds for current and future generations, while still honoring the traditional origins and keepers of the seed?

Activities

1. Invite presenters of various cultural traditions to participate.

2. Discuss traditional seeds that have become available through seed catalogues.

Is it appropriate to sell traditional seed that is connected to a specific tribe or community? Create a spectrogram (see "Activities" in Module 5) to see if people feel it is appropriate to sell traditional seeds, and then pair people together from opposite sides of the spectrogram to discuss their position. Be mindful when engaging in these activities with attention paid to various identities and positions of social/cultural privilege within your audience. Be sure that all participants consent to this activity and ground rules are set for giving space to strong emotions that may arise in a compassionate and equitable manner.

3. Discuss and/or spectrogram the following examples

Hopi corn: Traditional corn of the Hopi people that can be frequently found in seed company offerings.

Zuni Gold beans: Traditional beans of the Zuni Pueblo. Zuni elders have stated that once the beans leave the Zuni Pueblo, they are no longer Zuni, although the name prevails in seed catalogues.

Anasazi beans: Reportedly found at an ancestral Puebloan site in the Four Corners region. The name was trademarked by Adobe Milling Company, and has become a top seller in pinto beans.

Chimayó chiles: *Terroir* (environmental/land characteristics) offers unique flavor to certain cultivars, such as chiles. Are they still Chimayó chiles when they are grown elsewhere than Chimayó, New Mexico?

4. Include cultural ecology

How have the seeds adapted to various cultures and environments? How have seed migrations affected seeds and cultures?

Additional Teaching Considerations

1. What is your own core value regarding this topic? What are your biases? Be aware (and forthcoming?) of core values and biases. Be open to change.

2. What is your personal teaching approach and how can you integrate that into this module?

3. How do you respect different backgrounds, cultures, and perspectives and create a safe space for discussion? Consider attending a cultural diversity and inclusion training if this is unfamiliar to you.

4. What is the "relationship to land" of the people you are working with? How does this relate to seed saving, farming, and other agricultural practices?

Terms

Cultural ecology: The study of human adaptations to social and physical environments.

Human adaptation: Biological and cultural processes that enable a population to survive and reproduce within a given or changing environment.

RESOURCES

Cultural Resources

Emigdio Ballón, Agricultural Director at Tesuque Pueblo Farm and Seed Bank —

https://tribalcollegejournal.org/emigdio-ballon-sowing-seeds-independence/

https://greenfiretimes.com/2016/05/preserving-indigenous-seeds-and-food-crops/

Clayton Brascoupe, Traditional Native American Farmers Association —

https://www.abqjournal.com/990408/sprouting-hope.html

Rowen White, Indigenous Seedkeepers Network, Sierra Seeds, Seed Savers Exchange —

http://sierraseeds.org/a-note-from-rowen/

https://civileats.com/2017/04/19/returning-native-seeds-to-their-roots/

http://blog.seedsavers.org/blog/planting-sacred-seeds-in-a-modern-world

Lynda Garvin's PowerPoint — **Teaching as an Outsider**

Seed Saving Courses

Look into these seed saving courses if you haven't already:

Seed School (Rocky Mountain Seed Alliance)

Seed School Online (Rocky Mountain Seed Alliance)

Seed Academy (Seven Seeds Farm)

Seed Seva (Sierra Seeds)

Even More Inspiration

There are several pioneering seed grower cooperatives, extension offices, and seed libraries that are inspiring seed saving and sharing models. Following are a few samples:

Kitchen Cultivars — **https://www.glynwood.org/what-we-do/regional-foodprograms/kitchen-cultivars.html**

RMSA network — **RockyMountainSeeds.org**

San Miguel Basin Colorado State University Extension — **https://sanmiguel.extension.colostate.edu**

Sandoval County Master Gardeners — **http://sandovalmastergardeners.org**

SeedLibraries.net

Sierra Seed Cooperative — **sierraseeds.org**

Snake River Seed Cooperative — **snakeriverseeds.com**

Triple Divide Organic Seed Co-op — **tripledivideseeds.com**

Appendices

Punnet Square Worksheet

Organic Seed Alliance Variety Trial Evaluation

Seed School In a Day Sample Syllabus

Scaling Up: Larger Scale Equipment Resource List

Bibliography

Internet Resources

Punnet Square Worksheet

Example: A green pea plant (GG) is being crossed with a green pea plant (Gg) — yellow is the recessive color.

	G	G
G	GG	GG
g	Gg	Gg

GenoType = 2 GG: 2 Gg ; 0 gg

Phenotype = 4 Green pea plants: 0 yellow pea plants

Part 1. Complete the following monohybrid crosses: Draw a Punnett square, list the ratio, and describe the offspring. Be sure to remember that the **capital letter is dominant.**

1. A green pea plant (Gg) is crossed with a yellow pea plant (gg).

2. A tall plant (TT) is crossed with a tall plant (Tt).

3. A tall plant (Tt) is crossed with a short plant (tt).

4. A red flower (Rr) is crossed with a white flower (rr).

5. A white flower (rr) is crossed with a white flower (rr).

6. A black chicken (BB) is crossed with a black chicken (BB).

Part 2. Complete the following problems. List the parent genotypes, draw and fill in a Punnett square, and then list the offspring genotypes and phenotypes.

1. A homozygous dominant brown mouse is crossed with a heterozygous brown mouse (tan is the recessive color).

2. Two heterozygous white (brown fur is recessive) rabbits are crossed.

3. Two heterozygous red flowers (white flowers are recessive) are crossed.

4. A homozygous tall plant is crossed with a heterozygous tall plant (short is the recessive size).

5. A heterozygous white rabbit is crossed with a homozygous black rabbit.

Organic Seed Alliance Variety Trial Evaluation Form

Organic Seed Alliance
Variety Trial Evaluation

Evaluation: ___________________________

Crop type: _____________________________

Date: __________________________________

Location: ______________________________

Farm: _________________________________

Evaluator: _____________________________

Traits (fill in traits to be evaluated)

Var #	Rep #	Variety* *for blind test, fill in variety name after evaluation								

Comments:

Comments:

Comments:

Comments:

Comments:

Comments:

Comments:

Comments:

Comments:

Comments:

Seed School In a Day: Sample Syllabus

Schedule		*Notes*
9:00 – 9:30	**Opening Ice breaker: Name, affiliation, favorite plant from which to save seed**	*Maybe write affiliation on flip chart and mark off how many of each "affiliation" — i.e. educator, grower/ farmer, activist, backyard gardener, MG, other?*
9:30 – 9:50	**Activity: Seed Bowl Identification**	*Set up 10 bowls in order in advance*
9:50 – 10:20	**Module 1: Selection** (PPT)	
10:20 – 10:30	**Activity: Corn selection** — What are you looking for? Inspect the kernel; what do you see? If it was on the plant what would you select for?	*Distribute 3 cobs to each person. Facilitator will "t" up.* ***Make this empowering.***
10:30 – 11:00	**Module 2: Basic Terms** (PPT)	
11:00 – 11:15	BREAK	
11:15 – 11:35	**Activity: Dissect seeds and flowers**	*Students with aid of facilitator*
11:35 – 11:55	**Module 3: Breeding** (PPT)	
11:55 – 12:00	**Activity: Pick your plant**	*Students with aid of facilitator*
12:00 – 12:20	**Module 4: Myths** (PPT)	
12:20 – 12:30	**Activity: Catalogs, Lunch Discussion**	*Students with aid of facilitator*
12:30 – 1:20	LUNCH & GROUP PHOTO	
12:00 – 12:20	**Module 5: Harvest/Cleaning** (PPT)	
12:20 – 12:30	**Activity: Tomato**	*Students with aid of facilitator*
12:00 – 12:20	**Module 6: Grains** (PPT)	
12:20 – 12:30	**Activity: Seed Cleaning with box fans** (arugula, lettuce, beans, wheat, cilantro, etc.)	*Students with aid of teacher and facilitator*
3:30 – 3:40	BREAK	
3:40 – 4:00	**Module 7: Germination/Seed Storage** (PPT)	
4:00 – 4:15	**Activity: Germ Test**	*Students with aid of facilitator*
4:15 – 4:30	**Module 8: Seed Patenting** (PPT)	
4:30 – 4:45	**Activity: Discussion**	*Students pair off to discuss pros and cons with aid of facilitator*
4:45 – 5:00	**Module 9: The Big Seed Picture** (PPT)	
5:00 – 5:15	**Survey**	*Facilitator*
5:15 – 5:30	**Closing circle/activity:** Beliefs and Actions — What are you going to do? Where are you going from here?	*Students with teacher and facilitator*

Seed School In a Day: Sample introduction and supply list

Introduction

Remind participants to join RMSA, facebook pages (Seed School and RMSA), Seed Stewards, and Grain Trials. T-up that this is a crash course of a 6-day course — moving through quickly, hoping that they will explore more seed trainings, e.g. Seed School Online, Seed School TeacherTraining, Seed Academy, Seed Seva, and monthly Q&A Tuesdays every month.

Supplies

- Trays
- Corn cobs (enough for everyone to have three if possible)
- Fermented tomato already processed, also enough tomatoes for every student (RIPE)
- Germination test in advance
- Paper towels, paper plates, plastic bags, seed envelopes
- Lilies or other flower with exposed flower parts
- Soaked bean seeds in advance (fava?) enough for class
- Misc. seeds to clean and process
- Screens if you have them
- Spray bottles, knives, loupes, shellers
- Easel, Avery nametags (3" x 4" – 6 up) #74536
- Powerpoint Projector, clicker
- An array of seed catalogs or ask students to bring their own
- Packets — Seed Book, Brochure, Grow Your Own Seeds

Scaling Up: Larger scale equipment resource list

Seed Cleaning

Southern Exposure seed cleaning screens. Set of 5, current price $30 (without frames): **http://www.southernexposure.com/seed-cleaning-screens-set-of-5-p-1968.html**

Southern Exposure frames for seed cleaning screens. **http://www.southernexposure.com/2piece-set-of-seedcleaning-frames-p-2065.html**

Strictly Medicinal Seeds hand cleaning screens. Set of 8, current price $199.50: **https://strictlymedicinalseeds.com/product/stainless-steel-and-cedar-seed-cleaning-screens-set-of-8/**

Southern Exposure corn shellers. Available in both smaller size for popcorn and larger size: **http://www.southernexposure.com/sheller-for-corn-p-198.html**

Clipper M2B Seed Cleaner. A contemporary version of the classic Clipper Seed Cleaner that is used for many vegetable seeds and grains, and according to their website is well-suited for cleaning hemp, wildflower and native grass seeds as well. Over 175 different sizes of screens are available. Learn more and see a video on how it works on this website: **https://www.commoditytraders.biz/used-equipment/clipper-m2b-seed-cleaner/**

Eliminator 224 Seed Cleaner. An even newer version of the Clipper M2B, suited to clean vegetable seeds and grains and hemp, wilflower, and native grass seeds. Clipper 2b and M2B screens will fit the Eliminator 224. More info and a video are available on the website: **https://www.commoditytraders.biz/new-equipment/eliminator-224-seed-cleaner/**

Moisture Testing

Dickey-John Portable Grain Moisture Meter. **https://www.spraysmarter.com/dickey-john-grain-moisture-tester-m3g.html?gclid=CjwKEAjwlujnBRDl2teOp_veulQSJAC5bHgt7c6_SCORrTdyrk1sItwFXfolTQL-7apt9FPQhABWMBoClQ3w_wcB**

Additional testing options include oven drying, bite and bend tests, and the salt jar test. To learn more about additional methods of testing moisture, without moisture meters, see: **https://www.echocommunity.org/en/resources/0d004660-25c1-451b-808e-e738d1703eff**

Seed Packets

Cambridge Pacific. Printed seed packets: **https://www.cpacific.com/**

Southern Exposure. Blank seed packets at bulk quantities: **http://www.southernexposure.com/more-seedsaving-supplies-c-236_238.html**

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Internet Resources

http://www.aosaseed.com/ Website of the Association of Official Seed Analysts, Inc. which establishes rules for seed testing & influences seed legislation at the state and federal levels in the USA.

http://www.biodiversityinternational.org/ Biodiversity International "undertakes, encourages and supports research aimed at enhancing the sustainable use and conservation of agricultural biodiversity to the world's most vulnerable communities…"

CommunitySeedNetwork.org Community Seed Network.

http://www.crcworks.org/crcdocs/azsouthsum11.pdf Southern Arizona Local Farm & Food Economy, Highlights of a data compilation by Ken Meter, Crossroads Resource Center (Minneapolis) for Community Food Bank of Southern Arizona, December 30, 2011. Covers Cochise, Graham, Greenlee, Pima, & Santa Cruz Counties of Arizona.

http://www.crcworks.org/crcppts/azsouth12.pdf Ken Meter's powerpoint presentation about the state of agriculture in Southern Arizona.

https://www.culinarybreedingnetwork.com/ Culinary Breeding Network.

http://www.etcgroup.org ETC Group monitors the impact of emerging technologies and corporate strategies on biodiversity, agriculture and human rights. Source of seed ownership graphs.

http://www.fourseasonfarm.com/ "Four Season Farm is an experimental market garden in Harborside, Maine, owned and operated by writers Barbara Damrosch and Eliot Coleman. The farm produces vegetables year-round and has become a nationally recognized model of small-scale sustainable agriculture." Find links to books by these authors at their website.

http://www.kew.org/index.htm Founded in the 16th & 17th centuries along the Thames in England, Kew Gardens has been a leader in plant & seed science and in conserving the Earth's biodiversity. Their mission statement is simple: To inspire and deliver science-based plant conservation worldwide, enhancing the quality of life.

https://www.khanacademy.org/ Khan Academy.

http://www.thelearninggarden.org/index.html The website for one of the first school-based gardens in the US.

http://www.library.pima.gov/seed-library/ Pima County Seed Library web page.

http://www.mediafire.com/view/?zw6n2g4f2ou6rqz Hungry for Change, Borderlands Food and Water in the Balance, The Southwest Center's Kellogg Program in Sustainable Food Systems by Gary Nabhan, Maribel Alvarez, Jeffrey Banister and Regina Fitzsimmons.

https://www.msu.edu/~howardp/ Philip H. Howard, Associate Professor, Michigan State University, teachs undergraduate and graduate courses in Community, Food and Agriculture, as well as a graduate course in Research Methods. He is the source of the corporate ownership graphs.

http://www.nativetech.org/ "An internet resource for indigenous ethno-technology focusing on the arts of Eastern Woodland Indian Peoples, providing historical & contemporary background with instructional how-to's & references."

http://www.pesticide.org/ The Northwest Coalition for the Alternatives to Pesticides has scores of material safety data sheets on hundreds of pesticides with fact filled information researched by the non-profit organization not the companies who make the chemicals.

http://plants.usda.gov/java/ The USDA plants database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories.

http://www.regenerativedesign.org/ Regenerative Design Institute at Commonwealth Garden; Penny Livingston Stark.

http://www.responsibletechnology.org/ A website that "has become one of the most respected resources for online videos, podcasts, blogs, and reports for accurate and up to date information on GMOs."

https://www.researchgate.net/figure/8-The-location-of-Vavilov-Centers-of-Diversity-Origin-identifying-areas-of-highest_fig5_279384228 Vavilov Centers of Diversity

http://www.richmondgrowsseeds.org/ Richmond Grows, from Richmond, CA; helps educate folks on starting a seed lending library and also provides seeds, education and information about saving seeds.

http://www.seedalliance.org/Home/ Website of the Organic Seed Alliance in Port Townsend, Washington. Find info about organic farming and gardening as well as seed-saving. Webinars and online research docs.

www.seedsavers.org Seed Saver's Exchange.

http://www.soilsecrets.com/ssindex.swf The website of Michael Martin & Kari Melendrez, leaders in growing regionally-adapted trees of the Chihuahuan Desert in the Southwest USA. While a student in 1974, Michael began developing a protocol for healthy soil that is now called Soil Secrets.

http://www.topleaffarms.com/index.html Benjamin Fahrer, Top Leaf Farms (Rooftop Ag).

https://wildboarfarms.com/ Wild Boar Farms; Brad Gates, exotic tomato breeding.

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