

Supplemental Section 3. Resources to Support Content Teaching: Plant terminology guide, Literature, and Videos

Nonfiction Literature:

- Gail Gibbons “From Seed to Plant”
- Gail Gibbons “The Vegetables We Eat”
- Grace Lin “The Ugly Vegetables” (theme of diversity in plants and people)
- Growing Minds Farm to School Bookshelf: <https://growing-minds.org/childrens-literature/>.

Videos

- Boxlapse Youtube channel has many timelapse videos of different types of plants
<https://www.youtube.com/channel/UCiL9l2J57t5OG2aZ0huswZw>
- *Basic video about plant structure*
- <https://florida.pbslearningmedia.org/resource/5dea21b4-6c92-46ff-982c-8650f9429c01/think-garden-plant-structure/>

Plant terminology:

There is an enormous and overwhelming number of very specific terms for describing what plants look like. Several extensive glossaries are available online that provide terminology for plant parts and variation that goes well beyond what an elementary teacher would introduce to their students, including the following:

- <http://www.calflora.net/botanicalnames/botanicalterms.html>
- <https://florabase.dpaw.wa.gov.au/help/glossary#P>.

Nevertheless, it can be valuable to introduce some vocabulary to students to describe what they are seeing in order to help students be precise in their descriptions. Here are three online resources that can provide background information to teachers as well as an abbreviated list of terms, beyond the basic "roots, stem, leaf, flower, fruit", that might be useful for lower elementary students.

1. *Illustrated Glossary of Botanical Terms*: This is an excellent resource for teaching terminology and showing examples and teaching examples of leaf shape, leaf arrangement leaf venation, and leaf surface.

<http://conservationresearchinstitute.org/forms/CRI-FLORA-Glossary.pdf>
2. *Seedling identification Guide*: Although this guide does not include vegetables it has clear images and descriptions of cotyledon and true leaf characteristics for a diverse range of plants.

https://faculty.washington.edu/jhrl/Kaiser_PNW_SeedlingGuide_2019.pdf
3. Vegetable Seedling Identification Guide: This guide has photos of some common vegetables in early stages of development.

<https://www.almanac.com/content/vegetable-seedling-pictures-and-identification>

Below is a tractable list of terms we found to be most useful in helping young students think about and describe variation

- *alternate* versus *opposite* leaf arrangement

- *cotyledon* or seed leaf
- internodes
- *leaf margin*
- *technical or non-technical terms for leaf shape*—(e.g., cordate or heart shaped);visual guides (<https://kids.britannica.com/kids/assembly/view/89144>) can help with distinguishing them.
- *plant embryo*
- *petiole*
- *seed coat*
- *trichomes*
- *true leaf*

References:

Wilhelm, G. and L. Rericha. 2017 Illustrated Glossary of Botanical Terms. *Flora of the Chicago Region: A Floristic and Ecological Synthesis*, Indiana Academy of Science Conservation Research Institute, conservationresearchinstitute.org/forms/CRI-FLORA-Glossary.pdf. Accessed 10 Dec. 2021.

Supplementary Section 2: Lesson Scheduling Suggestions and Materials

Part 1		
Lessons	Time Required for Lesson	Interval Between Lessons
Lesson 1: Recognizing Variation at Different Scales	40 minutes	1 week
Lesson 2: Observing and Characterizing Variation among Plant Types	40 minutes	1 week
Lesson 3: Characterizing Quantitative Differences Among Groups of Plants Using Graphs	40 minutes	1 week
Lesson 4: Using Quantitative and Qualitative Measurements to Distinguish Groups	40 minutes	1 week

Lesson Scheduling

Part 2		
Lesson	Time Required for Lesson	Interval Between Lessons
Lesson 1: Connecting Shared Traits to Inheritance	40 minutes	1 week
Lesson 2: Variation and Similarity in Seed Traits	40 minutes	1 week
Lesson 3: Connecting Life cycle of Plants to Plant Traits	2-3 30-minute sessions	2-3 weeks (while mini-gardens are growing)
Lesson 4: Communicating About Science	60 minutes	1 week
Lesson 5: Open ended exploration-recognizing and applying patterns	3-5 40-minute sessions over period of 3-4 weeks	

Materials:

Material	Cost for 30 students	Source
Plants for in-ground Garden	\$8 if started from seed in a garden bed	Local nursery
	\$19 (sold as 4-packs of starts)	Local nursery
Leaves for quantitative analysis (2 bunches of Leafy greens with minimum of 30-35 leaves in each bunch)	\$5	Grocery store or farmers market
Clamshell mini-gardens	\$75 If purchased fully equipped with seed/soil and containers and shared by a pair of students	https://www.legacygreens3.com/grow-kits
Clamshell containers 6*6*4	\$0 if donated \$17.99/50 containers	Deli https://www.amazon.com/Smygoods-Containers-Disposable-Clamshell-Container/dp/B08TLQXPHJ/ref=sr_1_1_0?crid=3OU6UOBUSSA9P&keywords=clamshell+containers+4x4&qid=1639855490&srefix=clamshell+containers+4%2C162&sr=8-10
Seed starting pellets	\$12.99	https://www.amazon.com/Expanding-Potting-Compressed-Microgreens-Succulent/dp/B08L6FBGYN/ref=pd_lpo_2?pd_rd_i=B08L6FBGYN&th=1
Seeds (ca. 6 ounces of seeds)	Highly variable depending on choice of seeds or seed mixes (\$6-\$20)	https://www.amazon.com/Variety-Sprouting-Microgreens-Non-GMO-premeasured/dp/B08JHFRTXY/ref=pd_lpo_1?pd_rd_i=B08JHFRTXY&psc=1

Supplementary Section 1: Adaptations and Extensions

Adaptations

Our experience adapting to COVID restrictions

While we have in-ground gardens at our school, we faced a number of common challenges during the course of our studies. Because this set of lessons was tested during COVID-19, we also had additional challenges, such as the need to consider proper distancing measures between students. As a result of preparing to meet these challenges we found the lessons to be quite adaptable and believe that this experience might help other teachers plan for successful garden-based lessons.

First, we supplemented in-ground garden plants with materials that could be used in the classroom. We purchased a set of individual microgreens gardens for each student. These were clear plastic clamshell containers with coir fiber pellets and seed packs. While we purchased these as kits (<https://www.legacygreens3.com/>, \$7/kit, 1 kit per child) and was lucky to receive more than half as donations, they could be even more affordably sourced if a deli or restaurant was willing to donate them or if children could bring used (clean) containers from home. We also used potted plants in the garden setting for the initial lessons because they made it easy to space and group students according to my needs, and made it possible to move inside during inclement weather. At least four types of plants should be used to demonstrate some of the variety among plants, and at least 4 individuals per plant type. We lost a bunch of in-ground plants to the depredations of a nocturnal animal visitor. Having access to protected material in the mini-gardens was helpful.

We also relied on non-fiction literature and digital resources where time did not permit visits to the garden, or where our plant material was not abundant enough or at the right stage for our observations. These various flexible resources for plant-based learning supplemented (and augmented) our use of in-ground garden beds into which we planted a selection of vegetables both from seed and purchased plants: spinach, fennel, bok choy, cilantro, watermelon, okra, carrot, loofah gourds, arugula, stir fry greens and radishes.

Concerns teachers may have with garden-based teaching and possible solutions:

I don't have access to an in-ground garden.

- Use whatever wild or landscaped areas on campus as you can to connect students to in-ground plant characteristics.
- If possible, use potted plants to set up above-ground gardens-- movable pots allow for ease of sorting plants, spacing or grouping students intentionally, and replacing damaged or lost plants.
- Use mini-gardens that can be stored in the classroom for activities that involve following plants through their life cycles and for growing edible plants. A light source and heating pad might also be necessary to stimulate germination in regions with long winters.
- Use purchased edible plant parts in order to look at a broader array of plant types, specific plant parts, or when a larger quantity is needed for graphing or other activities.

It seems too risky to build lesson plans around plants that might not survive, or might not be ready when I need them. I need to be able to complete these lessons on schedule.

- Use mini-gardens for their ease of care and rapid growth. Mustards, beans, okra, and watermelon are among a large variety of seeds that will germinate quickly and can be used to make observations when plants are small.
- If you have the budget, use purchased edible plant parts. The grocery store is likely to have mature plant parts you can use in place of your own if you need to keep the lessons moving faster than your garden is growing.
- Make use of digital resources. Photographs can be valuable tools for focusing attention on particular plant parts, showing diversity among plants, and showing plant development. Time-lapse videos are particularly helpful for learning about how plants grow and change and for comparing different types of plants.

I don't have time for this! Adding in time to wash hands, put on gloves, teaching how to use tools safely, and then it rains!

- Visit the garden for only those lessons where observing in-ground plants is most impactful
- Use a mix of live plants, seeds, and photographs showing different stages, time-lapse videos showing germination and development, and purchase produce if time or supply does not permit for harvesting
- Use mini-gardens or pots to bring learning inside if weather conditions don't cooperate.

Behavior Management in the garden is challenging. Materials management can seem more difficult when dealing with tools, and students who have not spent much time outdoors can struggle with worries about dirt, wet, or insects.

- Use small groups when possible. If the whole class must be outside at once, divide the class into a group that can be seated and work on an independent task while you work with a smaller group in the garden.
- Use potted plants if it is possible to set up above-ground gardens; movable pots allow for greater ease in spacing or grouping students intentionally. Some students might find it difficult to remain outside for any length of time, and potted plants allow them to continue to work if there is a decision to move indoors.
- Use mini-gardens. Giving students individual ownership over a garden space is easier with these self-contained gardens. Having control over a discrete space like this can help motivate students to take responsibility for the care of plants and make it easier for kids who need more personal space in order to focus.
- Garden time can be soothing to children who struggle in a classroom setting. Lessons based in the garden can more easily incorporate movement. The potted plant sort was organized and structured, but purposefully engaged students in moving physically through the space and handling the plants. Student needs for personal space, breaks from sitting, and the chance to regain equanimity can often be met more easily and with less disruption in the less-confined space of the garden.

Gardens cost money to build and maintain. What resources are available to help get started with school gardens.

- There are numerous organizations out there to help you get started with school gardening. Here are several recommendations of places to look for information on grants, curriculum linked to the garden, suggested methods for starting and sustaining gardening programs as well as links to interactive communities with garden educators.
 - https://kidsgardening.org/?mc_cid=fe84c1bc35&mc_eid=429a99a43a
 - https://www.seedyourfuture.org/educator_grants
 - <https://lifelab.org/>
 - <https://wischoolgardens.org/>
 - <https://edibleschoolyard.org/>
 - <http://sfyl.ifas.ufl.edu/sarasota-docs/hortres/GrowtoLearnSchoolGardeningGuide.pdf>

Extensions

During our studies students became very interested in finding and planting seeds from their lunches, found on the playground, or brought from home gardens. While the class started some of these germinating, it was clear they would not get to see most of them sprout before the end of the school year, and that seeds from their lunches might not be fertile or mature. In order to seize this opportunity for students to build on their enthusiasm and facilitate learning from this real-world connection, you can plant some seeds from lunches while also explaining

the idea that seeds, like other plant parts, need to mature and sometimes need special conditions to sprout. If time allows, students can research which seeds are most easily saved, such as peas, beans, tomatoes and focus on those. In our class students brought in avocado and mango, both of which have very large seeds that are wonderful for sprouting in a classroom. Although the plants grew slowly—it took 2-3 weeks for the roots and shoots to begin to emerge— they were wonderful for observing the parts of the seed and seedling. To follow their development further there are some excellent time lapse videos (Boxlapse Youtube Channel, <https://www.youtube.com/c/Boxlapse/videos>) of avocado, mango and many different plant seeds germinating and progressing through their development. The videos give students the chance to observe both the similarities in form and pattern of development of diverse types of plants, and to observe the variety of seed shape, leaf shape and rate of growth in different types of plants.

Another extension opportunity would be to explore chemical traits as well as physical ones. In comparing seedling traits, students can be encouraged to notice any differences in taste by eating them, prompting students to expand their idea of variable traits to include chemical traits. This would be most successful if seedlings from different plant families are used. For instance, plants in the mustard family all have a spicy mustard flavor, whereas plants in the bean family have a milder bean flavor and wheat sprouts are sweet.

Assessment of the investigative question “How can we tell if plants are in the same family group:
Expectation: Students recognize that plants have differences in their traits, but that young plants are very like their parents. They use the model of the plant seed to recognize that the seed and seedling look very different than the adult, but that a seed from a parent will develop adult traits that are very like their parents’.

Minya was excited to plant her garden. The garden teacher gave her seeds they had collected from plants they grew at the farm. There were broccoli seeds, arugula seeds, and lettuce seeds. But when Minya got home, she saw the seed bags had opened and the seeds had become mixed.

Here’s what Minya saw when she put her seeds on the table:



1. Do you think Minya could sort the seeds back into the three groups?

YES NO MAYBE

- a. What are some differences she could use to separate the seeds into groups?

- b. Is there any other information she could use to help her with this task?

- a. c. How many groups can you sort the seeds into?

2. Minya decides to grow the mix of seeds in her garden.

Do you think she could figure out what type of plant each seed produces once they grow into seedlings?

YES NO MAYBE

What reason best explains your answer?

a. Yes, each type of plant has cotyledons that look different from all other plants, and the seedlings can be sorted as soon as they sprout.

b. No, every plant looks totally different when it grows. She should just throw out the seeds and buy new ones.

c. Maybe. Sometimes cotyledons from different types of plants look very similar, but each seed will grow into an adult plant that looks a lot like its parent plant.

3. If Minya checks on her plants every day, what should she look for to help her decide what type of plant each seed is growing into?

Rubric

Understanding	Beginning	Developing	Accomplished
Related individuals resemble each other	Does not recognize that the seeds can be sorted into groups based on qualitative attributes or claims they can tell which seed comes from which plant without supporting evidence.	Sorts plants into groups and names either one or more qualitative attributes that can be used to recognize groups. Does not have any suggestions on how to get more information to help with sorting.	Sorts plants into groups and names either one or more qualitative attributes that can be used to recognize groups, and recognizes that it is challenging to into three different types using seed characteristics (broccoli and arugula look very similar). Suggests checking seed traits against the original seed collection from the teacher or checking seeds still on adult plants.
Uses model of seed to understand emergence of seedling and adult traits that can be used to classify groups	Does not recognize that seedlings have seedling traits and adults will have adult traits that can be used to classify and recognize plant types. Does not indicate that observations made at seedling and adult stages might provide different information.	Recognizes that as seeds grow into seedlings and adults, seeds of each type will produce traits that are very similar to the traits of other plants of their type. Recognize that Minya will see patterns of traits that allow her to classify and recognize plant groups. Understands that seedling and adult stages might provide different information.	Recognizes that as seeds grow into seedlings and adults, seeds of each type will produce traits that are very similar to the traits of other plants of their type. Recognizes that Minya will see patterns of traits that allow her to classify and recognize plant groups, and that she could determine which plant is which by comparing her plant traits with known adult or seedling traits of arugula, broccoli, and lettuce. May even reference flower and fruit traits.