STEMMING UP Gardening®℠

Florida Agriculture in the Classroom, Inc.

A comprehensive guide for Florida educators designed to integrate science, technology, engineering and math into a school garden.

FLORIDA Agriculture IN THE CLASSROOM

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Table of Contents

Chapter 1

Grow to Learn

Introduction to Florida School Gardening • Getting Started
Boots on the Ground • Expanding Your Garden

Grow to Learn: A UF/IFAS Publication

Chapter One is an excerpt from school garden guide *Grow to Learn*, a publication created by the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) and the Florida Department of Agriculture and Consumer Services (FDACS). Florida Agriculture in the Classroom received permission from UF/IFAS to publish parts of *Grow to Learn*. References to page numbers in *Grow to Learn* are mentioned throughout the chapter. To access the full *Grow to Learn* publication, please visit: http://uffnp.org/wordpress1/wp-content/uploads/2015/09/FDACSFNW_Grow-to-Learn_Book-LOW-RES.pdf.

Introduction to Florida School Gardening

Every year, a growing number of teachers are incorporating gardening into the academic experience for their K-12 students. School gardens provide countless ways to engage students with hands-on learning opportunities. They also offer the opportunity for school staff, parents, and community volunteers to share skills, offer wisdom and experience, and enjoy the bounty and beauty of a growing garden.

What Does a School Garden Look Like?

School gardens can take many forms. They can be established directly in the schoolyard, in raised beds, in containers, or even in water. They can produce fresh and nutritious food to use in the cafeteria, to eat as snacks, to take home to families, or to share with those in need. They can beautify the school grounds, attract butterflies and other pollinators, and create native plant habitats.

Why Garden with Students?

In whatever form a school garden takes, it can support and enhance the learning environment of the school. They help by engaging curiosity, nurturing environmental awareness, improving self-esteem and interpersonal skills, promoting healthy eating and physical activity, and fostering academic achievement. Students love being in a garden and taking care of plants, watching them grow from tiny seedlings to food-bearing plants over the course of the growing season. School gardening contributes to a nurturing learning environment for the entire school, community and beyond.

How Do I Create a Sucessful School Garden in Florida?

A Florida school garden will have some distinct differences from one grown in other regions of the country. Our particular climate and soils can be both a challenge and a boon to school gardening. This manual addresses the challenges and offers ideas for taking advantage of the positive aspects of Florida gardening. County Extension Agents with the UF Institute of Food and Agricultural Sciences (IFAS) have a wealth of experience and access to the latest research on optimizing gardens of all types. We are here to support your educational objectives and help make your Florida school garden a beautiful and bountiful place for students to learn.

Getting Started

Before the first seed is even sown, a garden of any type requires careful planning. If this is your first school garden, you will be putting in some time initially gathering a garden team, assessing your educational goals for the garden, making decisions about what type of garden will fit those goals, finding a site where your garden will thrive, and putting together a plan for obtaining funds and supplies. It may sound overwhelming, but this is one of the most exciting parts of the gardening adventure. Taken a step at a time, this preparation is not only achievable, it can be creative and fun. Begin to build teamwork and enthusiasm before the shovel hits the soil.

Planting the Seed | Your Gardening Vision

Even though you are just starting out, and most of the specifics will be fully developed later, it is important to begin to identify a vision for your garden. It's crucial to plan and think creatively ahead of time in order to have some solid ideas to present to the school community.

Basic Questions to be Considered

- How many students will participate?
- How will it contribute to the learning environment of the school?
- How will it contribute to specific goals for students?
- What type of garden? In-ground? Raised bed? Container? Hydroponic?
- Who will be responsible for maintenance?
- Where will it be located? A convenient water source and full sun are key issues.
- How will you fund the start-up as well as long-term sustainability?
- How will the produce be used?

Growing Your Team

It takes a village to grow a garden and your first task is to begin growing that village of supportive and interested people–your garden team. For most school gardens, the first stop is the principal's office. The principal's support is not only necessary to move forward, but he or she may also suggest other important members for your team within the school community, and possibly in the community at large.

Be sure to cast a wide net for members of your garden team. You will be surprised at the number of gardeners in your school and community. Enthusiastic non-gardeners can also be instrumental when it comes to helping facilitate something that will be positive for students.

Growing Your Team | At School

- Fellow teachers bring ideas, enthusiasm, and expertise to the table as well as more students and potential volunteers.
- Custodians, responsible for the care and maintenance of the school grounds, are vital allies in a successful school garden. They should not be responsible for care of the garden, but will want to work closely with those who are in charge in order to keep the schoolyard safe and beautiful.

- Food Service Staff are great people to have on board, with their interest in nutrition and skills regarding food preparation and safety. They may also have funding and/or be able to lend space, tools, and supplies for food preparation.
- After-school program and club staff may be interested in using the garden in their programs and helping with garden chores.
- Parent-Teacher Associations may be able to provide volunteers and funding.

Growing Your Team | In the Community

Neighbors living near the school might be available to volunteer expertise and advice to the new addition to the neighborhood. This can be a wonderful way to help bridge the generational gap between youth and elders.

- Parents are not only potential volunteers, but will likely have community connections that will benefit the garden.
- Local business representatives, from your local garden supply store to national retail outlets, can be a huge help in making your garden sustainable. Some may even have community service programs and want to get their hands dirty.
- Local Service Organizations and Clubs, such as Garden Clubs, the Kiwanis, and Boy and Girl Scouts may want to help with the garden project and even help fund it.

- Farmers, busy as they are, have been known to offer field trip destinations, compost materials, extra seeds, and transplants to school gardens. They can also be guest speakers, sharing gardening knowledge on a farm-scale.
- UF/IFAS County Extension Agents and the FDACS Farm to School Program have up-to-date resources on how to plan, budget, and grow your school garden. They also have information on local Junior Master Gardener programs, 4-H endeavors, and other youth agriculture activities suited to a school garden.

Planning & Designing the Garden

While you're gathering and meeting with the garden team, take the next step toward bringing the vision to life: design. This section presents some of the early decisions that will need to be made and an estimated budget based on those choices. More detailed information about constructing, planting, and maintaining your garden can be found in Section II: Boots on the Ground on page 10.

Planning your garden is an exciting exercise in creativity. Enjoy leafing through gardening books and magazines and browsing online. Visit school and community gardens, botanical gardens, or your local UF/IFAS demonstration garden (see County Contacts beginning on page 176 for information on your local UF/IFAS Extension Office). You will be inspired! Be sure to include your garden team and students in the process. They can offer valuable insights, and the more they are involved at the beginning, the more enthusiasm they will have for seeing the project through.

Throughout this creative process, garden plans will begin to develop. One way to move the process from brainstorming to actual planning is by asking participants to put their ideas on paper and draw what they would like the garden to look like. Discuss the particular features of the garden that are most important to them. Which of these are feasible for your first garden effort? Which can be developed over time? Ask yourself how these elements connect with and support your teaching goals and standards. As your school garden begins to take shape in your mind, you can decide what type of garden will best suit your vision.

Choosing a Garden Site

Where you locate your garden will be one of the most important decisions you make. The space will not only need to provide the right elements for a garden to thrive, such as lots of sun, healthy soil, and available water, but will also serve as an outdoor classroom. Therefore, you will need to consider both people and plants as you look for a site. That said, empty fields and spaces between walkways are possible spaces for a garden. Even spaces with asphalt and concrete can be used for container gardens.

Here are some things to consider as you look for the best possible space in your schoolyard:

SOIL | If the garden will be in-ground, is the area free from standing water which can harm plants and attract mosquitoes? Is the soil free of construction debris (gravel, building material, etc.)? Does the site support plant life (sod, weeds)?

IRRIGATION | Is it close to a water supply? Is it municipal water or does it come from a well? If from a well, has it been tested for potability and to determine pH and salinity? In addition, wells should not be located near livestock or a septic drain-field. Surface water (pond, lake, river, etc.) should not be used. Catchment systems, like rain barrels, should only be used for ornamentals. They should be properly located and exclude possible contamination from animals or other sources by using screening and/or lids on openings.

SIZE | Does it fit your garden plan? Is there room for students to work? Are there pathways between plantings and places to sit?

SUN | Does it get at least six hours of sunlight during the day, even in the winter months?

TOOL STORAGE | Is there a nearby place to store tools or to locate a storage shed?

SECURITY | Will the location discourage vandalism? Is it safe from foot traffic, playgrounds, and sports activities?

UTILITY LINE | Have you checked about underground lines that might be damaged by digging? Call 811 or visit www.sunshine811.com.

ACCESSIBILITY & CONVENIENCE | Is the site easy for both students and teachers to access safely and conveniently? Have ADA standards been considered?

Best Practices: Soil | Safety

- Locate gardens away from potential contamination sources (garbage, utilities, animals, water runoff, flooding, septic systems, etc.). Contact the utility companies or call 811, the national "Call Before You Dig" number, a few days before digging to ensure that you avoid gas or electric lines.
- Identify soil history from all sources. Have soil tested to determine levels of contaminants such as chemicals, lead, etc., if there is a history or evidence of possible contamination.
- Create reasonable barriers to keep wild animals away from the garden. Examples include fencing or cages over produce items such as strawberries, leafy greens or other foods that are eaten raw.
- Consider purchasing soil that has been commercially packaged and labeled for growing food crops. Soil purchased from a commercial source ensures traceability.

- Use non-toxic, non-leaching materials for raised-bed gardens, containers, stakes, or trellises. Do not use wood treated with copper arsenate, used tires, single use plastics, or old railroad ties.

From "Food Safety Tips for School Gardens," USDA–See "Digging Deeper" on page 11 for information on soil testing services. Contact your UF/IFAS County Extension agent for directions on how to collect and submit a soil sample. The sample analysis report will give you a fertilizer recommendation for your garden.

Garden Types

While it's possible to grow a garden indoors, a big advantage of Florida gardening is that we can grow outdoors almost year-round! There are a number of different ways to grow plants in your school garden: in containers, in raised beds, directly in the ground, in water, or you can use a combination of these methods. Regardless of the type(s), it's best to start small and leave room to grow as you become more experienced and confident. What type of garden fits your site, budget, and volunteer support?

IN GROUND | This is likely the least expensive system initially, but it's important to know the history of the soil and that it is contaminant-free. Drainage characteristics, soil pH, and soil texture also need to be considered carefully.

RAISED BEDS OR CONTAINERS | Both raised beds and containers are filled with a purchased growing medium instead of garden soil. Raised beds are large frames that are usually installed directly over the soil. Containers, on the other hand, can be used anywhere there is enough sun. They require minimal labor to prepare or construct and have the added benefit of being mobile.

HYDROPONIC | Hydroponic gardens are soil-less systems that use media or water and nutrients to help plants grow.

Getting What You Need | Making a Budget & Fundraising

Once you have your garden team and plan, you are ready for the next big step: obtaining supplies and funds. It is challenging and exciting to present your vision to people and organizations that can move it into reality. Be prepared to present the goals for your garden, including plans for possible future development, and a complete list of supplies you need to make it happen. Some organizations and individuals may be able to contribute the supplies directly, while others may donate money for the cause.

Supplies for Your First Garden

The first step is to make a list of the supplies you will need for your first garden.

SUPPLIES FOR IRRIGATION | PVC pipe, faucets, hoses, nozzles, watering cans, drip irrigation supplies, etc.

SOIL AMENDMENTS | compost, potting soil, fertilizer

GROWING MEDIA | potting soil, compost, vermiculite, peat moss, etc.

PLANTS | transplants and/or seeds

FROST PROTECTION | cloth or plastic, stakes and pins

TOOLS | shovels, rakes, trowels, buckets, gloves, etc.

EDUCATIONAL SUPPLIES | books, signs, labels, etc.

PLANT SUPPORT | trellises, etc.

*Pages 15-20 of *Grow to Learn* has great information for estimating costs for your school garden.

Boots on the Ground

Once you have your plan, your people, and your supplies, you're ready to pull on your gardening gloves and get to work. In this section we will start by discussing garden construction. Whether your garden is going to grow in-ground, in raised beds, in containers, or in the water, you will need to prepare a place for your plants to thrive. Next, we will focus on choosing the right plant at the right time of the year and how to get them off to a good start. You will learn about nurturing and nourishing your growing plants in the next section, which is all about soil nutrients, irrigation, and compost. As the season goes on, your garden chores will switch to maintaining a healthy place for plants, people, and pollinators. We will take a look at pests (insects, diseases, nematodes, etc.) which are the facts of life in any garden. Finally, we'll look at some ways to expand your garden as you grow in experience by saving seeds, attracting pollinators, growing perennials like fruit trees and mushrooms and/or expanding your hydroponics system. Like a newly planted seed, a garden is full of potential and possibilities. It's time to grow!

Garden Construction | Laying the Foundation

CONTRIBUTORS from UF/IFAS John McLaughlin | Eva Worden | Sean McCoy | Terry Brite DelValle | Stacy Spriggs | James M. Stevens | Tom Wichman

This section examines the different types of gardens, the materials, and the skills needed to be successful. Follow the links for detailed information on materials and construction compiled by experienced County Extension agents.

Once you've decided on the type of garden that best suits your needs, it's time to schedule a work day and begin construction! This is a great opportunity to invite the people who have supported the garden quest and are willing to take it to the next level by getting their hands dirty. The garden team can make the work easier and more fun by planning ahead. Be sure to have the necessary supplies and clear directions on hand. Be prepared to coordinate volunteers so that everyone has a role in getting the garden off to a good start. Make sure to schedule the event well in advance so volunteers can save the date.

In Ground

The simplest type of planting bed is an area of cleared land at ground level that is improved through the use of soil amendments. An advantage of the in-ground garden is the relatively low cost. The biggest disadvantage is the additional labor required to prepare the site, amend the soil, and maintain it weed-free throughout the growing season. It is important to have in-ground garden soil tested for nutrients by your UF/IFAS Soil Testing Lab at least three months in advance of planting so that it can be amended and prepared for your plants. This time period is important if lime is recommended as it releases slowly and requires several months before its benefits are fully realized. UF/IFAS soil labs can also check for lead contamination for a nominal fee ($15). Testing for further contamination is very expensive. If there is any doubt about possible contamination, it is best to try for one of the container systems below. The easiest way to begin a new garden is using the "no dig" method. With this method, you break your garden preparation into two parts, at least three months apart. During the first workday, you can create a no-dig garden bed by spreading a deep layer of mulch and compost over the area you plan to use for planting. On the second workday, three months later, you can unveil your (relatively) grass and weed-free garden bed, which will be well-nourished and ready for planting. While this method requires some forethought, the actual labor will be much less than it would be to dig through healthy turf or weeds and then apply fertilizer and compost. Ideally, you can plant directly into the mulch with little effort and place the seedlings into healthy soil. Another option is to rent or borrow a tiller to break ground. After clearing the grass with rakes, you can add composted organic matter to the beds, as well as any other amendments recommended after your soil sample is tested.

Contained

While planting directly into the ground is the least expensive option, it is worth considering other options for several reasons. First, most Florida soil is composed of deep sand, which has little natural fertility and needs to be watered often. While this is not as prevalent as in other parts of the country, there is a concern about soil contamination, particularly if the school is built on the site of an older building. For these reasons, many schools have decided to use other options such as raised beds, containers, and hydroponics.

RAISED BEDS | Raised beds are a great option for getting your garden off the ground! They can produce a lot of veggies in a small space while contributing to the beauty of the school landscape. Raised beds offer a number of advantages. For instance, they are filled with a disease-free growing medium (potting soil), easy to cultivate, less likely to be damaged by foot traffic, and are a good option if there is a concern about soil contamination. The downside is that they are more costly than planting directly in the ground and they can require more irrigation due to the increased loss of moisture through the sides of the bed.

Traditionally, bed walls are constructed from wood, masonry, and synthetic lumber and can be built with a minimum of skill and expertise. There are also several possibilities for filling the beds, including purchased potting soil mixes.

With enough volunteers, you may be able to construct raised beds, fill them with soil, and plant all in one work day. It is fun, hands-on work and students can assist with the construction and filling with a minimal level of skill. These can be planted immediately.

CONTAINER GARDENING | If you have a small area or don't have the capacity to grow a large garden, container gardening might work for you. Many plants grow in pots just as well as they do in the ground. In many ways, the requirements of a small container garden are very much like those of any garden: sun, water, healthy soil, and nutrients. But you may also consider how plants are grouped together and if there is room to grow. If there will be more than one plant in the same pot, be sure that all your plants meet the same requirements for water, sun, and nutrients. Also be sure that the size of the container matches the size of your plant.

When we think of container gardens, we usually think of clay or plastic pots. However, a wide assortment of containers may be used, ranging from hanging baskets and flower pots to tubs and refuse cans. Almost any container is suitable as long as it is sufficiently durable, has good drainage, and is large enough to hold the fully-grown plant or plants. In this respect, gardeners are limited only by their imagination. An old bathtub might yield prize tomatoes, while an old plastic beach ball cut in half could become an excellent herb container.

Containers dry out more quickly than most in-ground gardens and require more frequent watering. Self-watering containers solve the problem with a reservoir for holding water that uses capillary action to deliver water into the growing medium, keeping the soil consistently moist. You can also make your own.

Hydroponics

GROW A GARDEN WITHOUT SOIL | Hydroponics is the growing of plants in any medium other than soil. There are a number of hydroponics systems on the market. The most basic are fun and simple to put together and are also quite inexpensive. One key advantage to hydroponics gardening is that many diseases, insects, and nematodes can be avoided by using the liquid media. A very simple system can be created using a plastic container. This can be anything from a bucket to a storage container to a child's swimming pool. The container should be filled with perlite and kept damp with a mix of water and soluble fertilizer. Short-term crops that like water such as lettuce, basil, mint, watercress, chives, scallions, beans, and peas are examples of crops that grow well with this approach.

Plants for Your Garden | What to Grow, How to Grow It & When to Harvest

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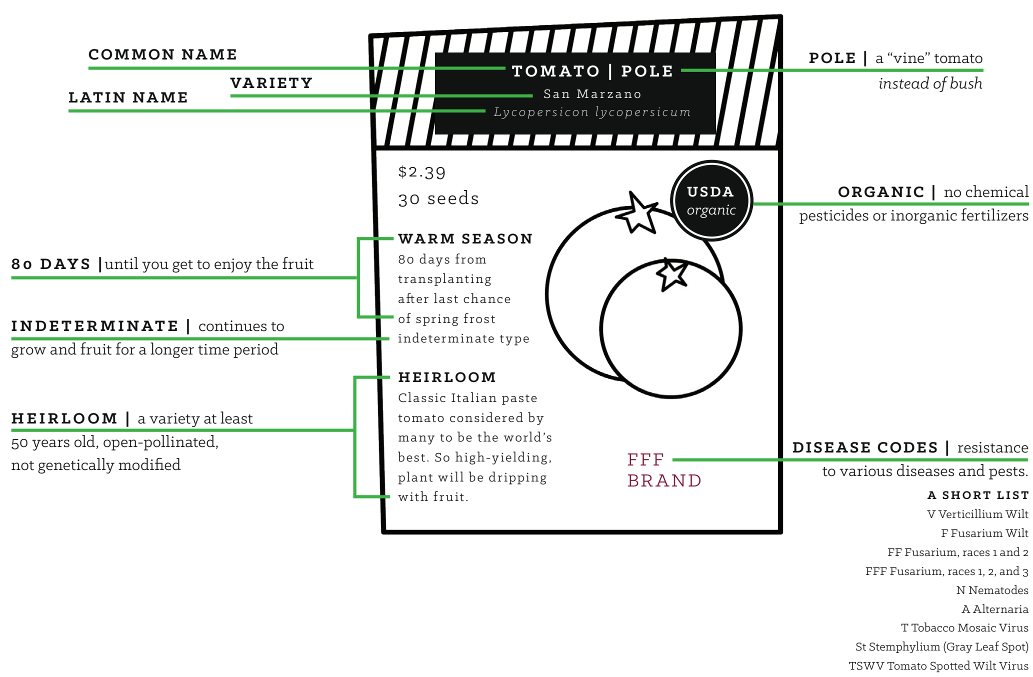
A wonderful selection of vegetables and herbs can be grown in your school garden during most of the school year. Choosing vegetables for your particular region and getting them off to a good start are simple tasks that have a huge impact on your success. This section will look at plant selection, placement in the garden, and how to actually get them into the ground and growing.

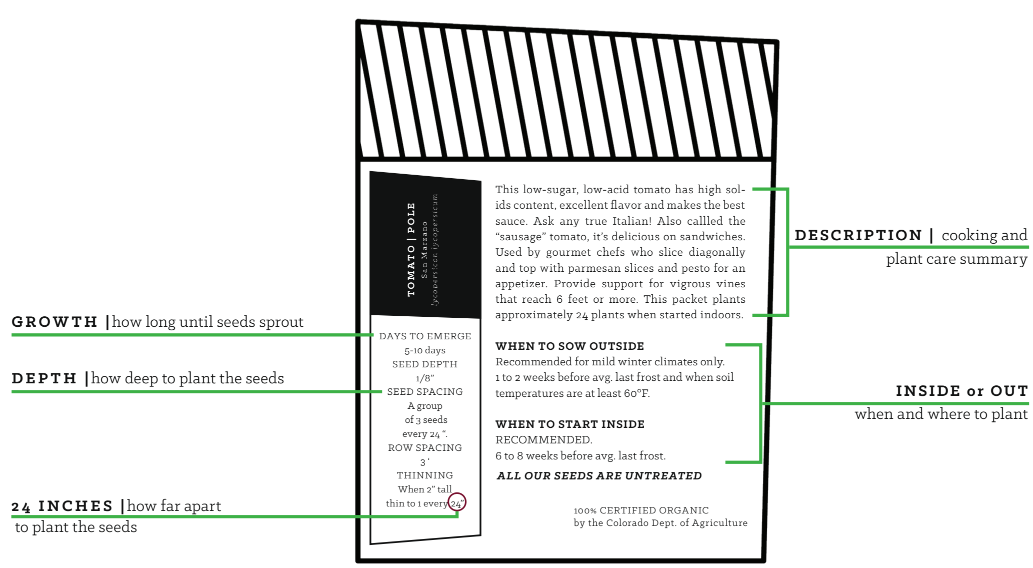
Choosing Plants

Florida school gardeners are extremely fortunate to have a nearly year-round growing season that conforms very well to the school year. Florida gardens can be planted in both warm and cool seasons. Throughout the year, you may have multiple harvests, with the final one conveniently planned for the week before summer vacation. Check the recommended planting dates for your region and the "days to harvest" in the Florida Vegetable Gardening Guide (See Appendix of *Grow to Learn*) to see what will work for your garden. Keep in mind that "days to harvest" is from seed to harvest; if you are using transplants instead, the time period will be shorter. Selecting vegetable varieties that are resistant or tolerant of pests is important for the health of your garden. Seed catalogs, seed packets, and transplant labels often indicate if pest resistance is a characteristic through statements or letter designations. For example, a tomato variety name may be followed with VFNTA indicating that it is resistant (in this case) to Verticillium (V) and Fusarium (F) wilt diseases, Nematodes (N), Tobacco Mosaic Virus

HOW TO READ A SEED PACKET | FRONT



HOW TO READ A SEED PACKET | BACK



(T), and Alternaria fungus (A). Choosing the right plant at the outset can eliminate a lot of future problems. For a list of the "Top Twenty Vegetables for Florida School Gardens" see Appendix of *Grow to Learn*.

Seeds or Transplants?

There are two ways to get plants started in your garden– seeds or transplants. Some plants do much better when they are directly seeded (planted right into the garden soil where they will be growing). For direct-seeding, follow the directions on the seed package or in the garden guide. Plant at the required depth and spacing and be sure to water regularly, until they begin to sprout. Root crops like carrots, radishes, turnips, and beets do best when directly seeded. There are a number of advantages to using transplants (baby plants you can grow from seed or purchase from garden stores). If you are raising your own, you can care for them in a protected environment until they are strong enough to go out into the garden; there will be fewer disappointments and setbacks from unexpected freezes, heavy rainfalls or hungry insects. There is also a shorter wait between planting and harvesting. There are two other advantages: If you've delayed planting and have missed the window of planting from seeds, transplants allow you a 4–6 week catch up. Also, for plants that are picked over an extended period (like peppers) you really only need a limited number of plants, not all the potential plants from a seed packet. Buying them is even easier! Large chain stores don't always carry vegetable varieties that perform well in Florida. You may have better luck shopping at small retail nurseries or feed-and-seed stores that stock locally-grown transplants. Often your local UF/IFAS County Extension Agent can recommend good varieties for each region.

HOW TO SOW A SEED | Refer to the seed packet or gardening guide for tips on how deep to bury the seeds and how far apart to sow them. A good rule of thumb is to plant a seed no deeper than twice its size. Once sown, be sure and mark the spot. Water gently to avoid washing them away and keep the soil moist until they germinate. If you have good germination, you may need to thin seedlings to get the correct spacing. You can either pull extra plants or you can snip or pinch them off close to the roots if it seems like pulling them might disturb the roots of adjacent seedlings. Very small seeds, like carrots and lettuce can be mixed with sand to make it easier to plant them shallowly and a reasonable distance apart. Large seeds like beans and peas are especially easy for small fingers to handle and can be planted one to a hole.

HOW TO TRANSPLANT A SEEDLING | It is important to carefully remove transplants from their pots. Gently lift soil from the pot with the handle of a plastic utensil, trying to keep as much soil as possible attached to the roots. The soil level of the formerly potted plant should be even with the ground level around the hole, so dig your hole with that in mind. (Tomatoes are an exception to this; tomato roots will sprout along the buried portion of the stem, so it's best to plant them deeply). Gently press the soil around the plant and water immediately.

HOW TO MAKE TRANSPLANTS | Some plants are best put into the garden as transplants and are very easy to grow from seed in a container. Seed trays can be filled with a very fine growing medium. Both trays and soil are usually available at garden stores. Seeds should be sown at the same depth indicated for sowing outdoors. They should be placed in a sunny, but protected area outdoors, in a sunny window with southern exposure, or under grow lights.

Best Practices for Starting Your Plants

TOP 19 VEGETABLES	DIRECT SEED	TRANSPLANT
Beans | Green	•	
Beets	•	
Broccoli		•
Brussels Sprout		•
Carrots	•	
Chard, Swiss		•
Corn	•	
Cucumber	•	
Eggplant		•
Greens | *collards, kale etc.*		•
Lettuce		•
Peppers		•
Pumpkins | *Seminole*	•	
Onions | *Sweet*		• *(sets)*
Peas | *Sweet*	•	
Potatoes	• *(from seed potatoes)*	
Radishes	•	
Roselle	•	•
Tomatoes		•

MULCHING | Mulch is any material placed on the soil surface around plants. Mulch provides many benefits, including conserving soil moisture, conserving nutrients, reducing soil erosion, reducing crop loss from nematodes, reducing weed growth, providing a barrier between fruit and soil, and moderating soil temperature. Organic mulch can attract many insects, including beneficial spiders and ground beetles, but may also attract organisms like slugs or snails that can damage crops. Organic materials most commonly used for mulching are oak leaves, grass clippings, Bahia hay, pine straw, and mature cover crops, which have been cut and returned to the garden as mulch. Apply mulch before or after seeding or transplanting, being sure mulch does not touch plant stems, which may cause them to rot. Generally, 2–4 inches of moderately packed mulch is recommended to prevent weeds. Hardwood or pine mulch chips, underlaid with newspaper, are best used in walkways and border areas around the garden where they can provide a surface to walk on when the garden is wet and will reduce weeds. Do not use these mulches in the garden. Woody mulches are slow to break down, and the process can rob plants of nutrients.

Arranging Crops

The careful placement of plants in an in-ground or raised bed garden is important. Consider the following when deciding how to arrange your plants in your garden area.

OPTIMAL SUNLIGHT | Run rows north and south so that exposure to sunlight is even for all rows. Also place tall plants and trellised crops at the north side of the garden so they will not shade smaller plants. Remember the sun will be low in the southern sky during winter.

WALKWAYS | Allow adequate space between rows so that groups of students can walk through without stepping on plants or tripping on raised bed supports.

PLANT LIFESPAN | Crops that span more than one season, such as strawberries or perennial crops that persist through many seasons, should be placed to one side of the garden so they do not interfere with seasonal preparation of the garden.

SPACE & INTERPLANT | Be sure to use proper spacing so plants have room to grow. Interplant fast-growing crops like radish among slower-growing ones (like carrots). Fast-growing crops are out of the way before the slower-growing crop needs the space.

POLLINATION | Plant sweet corn in blocks rather than in single rows so that ample pollen is present in the air around the corn stalks. This practice should result in better pollination and full, mature corn cobs.

CROP ROTATION | Design your garden so that crop rotation is practiced, and that vegetables from the same family are not planted in the same location more often than once every three years. Vegetables belong to plant families. For example tomatoes, peppers, and potatoes all belong to the same family.

Simply divide your growing space into a number of distinct areas, identify the crops you want to grow and then keep plants in the same family together in one area. Every year the plants grown in each given area are changed, so that each family (with its own requirements, habits, pests and diseases) can have the advantage of new ground. Many gardeners find it helpful to draw a sketch of the garden and the succession of crops to be planted. Try to plan at least 2 years in advance; 3–5 years is

CROP ROTATION CATEGORIES

NIGHTSHADES → CUCURBITS → CRUCIFERS → LEGUMES

then start over!

CROP CATEGORY EXAMPLES

NIGHTSHADES | tomato, potato, eggplant, pepper
CUCURBITS | watermelon, cucumber, squash, zucchini, cantaloupe, pumpkin
CRUCIFERS | cabbage, kale, broccoli, turnips, cauliflower, collards
LEGUMES | beans, peas, southern peas

Chapter 1: Grow to Learn

even better. Refer to the Florida Vegetable Gardening Guide in the Appendix of *Grow to Learn* for planting dates and plant families to help plan crop succession.

Maintaining the Garden

CONTRIBUTORS from UF/IFAS John McLaughlin | Eva Worden | Danielle D. Treadwell | Sydney Park Brown | James Stephens | Susan Webb | Amanda Gevens | R.A. Dunn | G. Kidder | D. Short | G.W. Simone | Wendy Wilbur

Setting out plants is exciting and fun for everyone involved, but it's in the day-to-day care and observation of the garden that your students will learn the most. Learn together how to nurture your growing plants and look for signals of what they need. This section provides information on how to maintain your garden throughout the school year by watering, weeding, fertilizing, composting, checking for pests and diseases, and "putting it to bed" for the summer. The work you put into the garden will result in a bountiful harvest as well as a crop of budding scientists.

Watering

Watering may be the most important factor in the long-term success of your garden. How much and how often depends on the growth stage of the plants, the type of soil, and how much natural rain the garden has received. Giving the plants enough water –but not too much– is vital for the success of your garden. During the period immediately following planting or sowing, frequent irrigation, one or more times per day, is required to maintain soil moisture. Ideally, soil should feel similar to a wrung-out sponge (not soaking wet). But for established plants, irrigation is best done on a schedule, with a reliable, measurable amount of water being applied on a regular basis. Young plants need frequent, but light irrigation. It's important that enough water is applied to reach the root zone, but not so much that the water washes nutrients through it. Established plants need more water in order to penetrate their root system, but do not need to be watered as often. Sandy soils demand more frequent irrigation than clay, muck or organic soils. Using a rain gauge will help you determine if the rain your garden has received is sufficient, or if additional water is required.

There are a number of ways to irrigate your garden, from hand-watering to more complex built-in systems. Most school gardens incorporate some hand-watering into the irrigation plan even if they have an alternate system. Hand-watering allows students of all ages to directly care for and observe a plant while they water it. A hose or a watering can can be used. With either one, students can be taught to direct the spray or stream to the soil at the base of the plant where it can filter down to the roots and avoid wetting the leaves as much as possible. Since youger students will often water only until the soil looks moist, you can show them how to poke their finger into the soil to see how deep the water has reached. A more accurate way of measuring the amount of water your plant is receiving is to make marks every inch on a small can, like a tuna fish can, near the plant you are watering with a hose and nozzle or watering can. Time this process and you will have a guide for future watering. Water until the shallow can is filled to the 1 inch mark; divide the time it took into two and this will be the amount of time you water twice a week.

Except for the smallest gardens, you will need to consider other sources of irrigation as well. Sprinklers are designed for broadcasting water over a large area. While inexpensive, a sprinkler wastes water and in many instances encourages disease by unnecessarily wetting foliage.

As a rule of thumb, vegetables should receive a total of 1"–2" of water per week, spread out if possible to deliver one-half inch at a time. Another indicator of water need is the condition of the soil, where the upper 1"–2" should be allowed to dry out before providing additional water. Approximately 65 gallons of water will be needed to provide 1" of water for every 100 square feet of plant bed.

INSTALLED IRRIGATION SYSTEMS | There are a number of efficient, installed irrigation systems that supply water directly where it is needed - at the roots of the plants. As a result, water is not wasted on leaves or soil, and evaporation and run-off are greatly reduced. The least expensive and simplest hose to install for a very small garden is a soaker hose, which can be purchased at a garden supply store. "Micro-irrigation", a more complex system that uses tiny sprinklers, drip emitters, or drip tape are more complicated to install, but highly recommended for the school garden. Any of these can be put on a timer at the water source, thus saving time and weekend trips to the garden for watering. Your local UF/IFAS County Extension agent or irrigation company can advise you on their installation and practicality for your particular garden.

COLLECTING WATER | Cisterns and rain barrels can be a great way to save water by rain collection, but due to potential contamination by wildlife, it is best to use this water on ornamental plantings rather than on edible crops.

TROUBLESHOOTING | Too much or too little soil moisture and inappropriate methods of applying water can all cause visible signs of plant damage and disease. Too little soil moisture causes wilting. Too much water can increase mold, fungi, weeds, and pests. Too much soil moisture encourages root and stem rot. When roots aren't functioning, nutrients and water aren't absorbed. Foliage turns pale in color and the plant wilts and dies. Again, regular scouting for problems in the garden will alert you to irrigation problems as well as other concerns and will also be a good way for your students to hone their observation and diagnostic skills.

Weeding

Weeds are simply plants growing in the wrong place. Unfortunately, they will compete with your plants for water, sun, and root space. While mulching will cut down on the number of weeds, their seeds are lying just below the surface waiting to sprout under the right conditions. It's best to keep a close eye out for them and pull them when they are young. Never let weeds grow to the point of flowering and producing seed, or you will find more among your plants. Mowing around the outside edges of the garden where weeds grow will help prevent their seeds from drifting into the garden beds.

Keep adding mulch as the season progresses to reduce the need to weed. As the garden season wears on, the mulch you added initially around seedlings will begin to break down, improving soil structure and adding nutrients like a slow release of fertilizer. Adding mulch to maintain a depth of at least 2"–3" will continue to aid in weed suppression and water retention and continue the cycle of soil improvement. More information on mulching is found in the previous section.

Fertilizing

Plants, like people, need the proper nutrition to help them grow well. Fertilizers are composed of minerals, and many of the same minerals that are important for human health are also important for plant health. Too much, or too little, fertilizer will have a negative impact on your garden's growth and development. Commercial fertilizer comes in a number of different formulations, or combinations of nutrients and their relative concentrations in the mix. The top three essential nutrients for plants are nitrogen, phosphorus, and potassium, or N, P, and K, as they are known by their chemical element abbreviation, and are found in nearly all fertilizer formulations. Several curricula address crop nutrition in greater detail.

Most plant nutrients are provided by the soil and will increase their availability by fertilizing. You are ahead of the game if you have made an effort to incorporate organic material into your garden and had your soil tested for additional nutrient needs. Similarly, carefully choosing and mixing a growing medium for raised beds or containers will help your plants get off to a good start. Soil with plenty of organic material can increase water holding capacity and help retain nutrients in soil. As your garden grows and the plants take up some of these nutrients, they will need to be replenished.

Both organic and synthetic fertilizer can contribute to plant health. Good results can be obtained by using one or the other, or a combination of both. No matter what fertilizer you use, it's very important to use the recommended amount. Over-fertilizing can encourage excessive growth, often at the expense of the edible portion of the plant, and in extreme cases, can kill plants by interfering with metabolism. In addition, nutrient leaching and surface run-off are significant contributors to water pollution. Under-fertilization slows growth and development and leaves plants weak. Purchase only the amount needed for a season to avoid degradation, pest-management, and child safety concerns associated with long-term fertilizer storage.

More information on reading a fertilizer bag and calculating nutrient contact can be found on page 43 of *Grow to Learn*.

Tips from the Experts

SOIL | REGULAR TESTING

Regular soil testing enables you to find out the makeup of your soil and determine how much lime and fertilizer you may need to amend it. It's important to know your soil and to keep improving this crucial component in your landscape and garden. To find out what you need to do to ensure optimal plant growth, you should know each of the following attributes of the soil.

++ CURRENT pH LEVELS | pH is measured on a scale of 1–14. If your soil is below 7, it is acidic and if it is above 7, it is alkaline. Certain essential elements for plant growth are most available for absorption when the soil is close to neutral. Generally speaking, most plants and vegetables do best at a pH of 6.5, but there are exceptions. Blueberries prefer pH of 5.5–4.0.

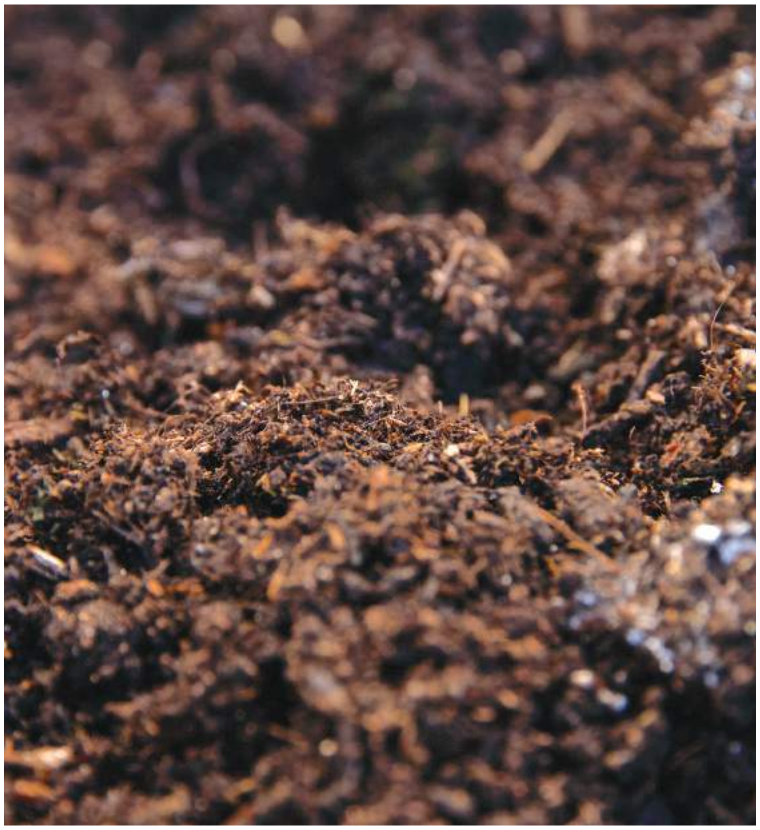
++ FERTILITY LEVELS OF PRINCIPLE NUTRIENTS | Our Florida soils naturally have nutrients. A soil test report will include recommendations regarding soil amendments.

Soil tests are relatively inexpensive ($7). Contact your UF/IFAS County Extension agent for directions on how to take a sample and where to have it tested.

– Wendy Wilbur, UF/IFAS Alachua County Extension

Amending with Organic Materials

Plant nutrient deficiencies can often be diagnosed by symptoms that affect the plant's appearance, such as leaf color and



shape, as well as abnormalities in the developing fruit. Careful, regular observation of plants by students can help spot problems early before the plant is weakened. Your UF/IFAS County Extension agent can help you diagnose diseases caused by nutrient deficiencies and help you put together a nutrient/fertilizer program for your garden.

In nature, earthworms, pillbugs, snails, mushrooms, bacteria, and fungi decompose dead plants and animals, breaking them into smaller particles and releasing nutrients back into the soil. Compost is produced by biological decomposition under controlled conditions. Compost is made from garden waste and other materials high in carbon (leaves, straw) or nitrogen (grass clippings). When the organic materials are managed to ensure optimum moisture and airflow through the pile, the decomposers use the organic matter as an energy source and break it down into smaller compounds collectively called humus. The decomposition process produces heat which furthers additional decomposition. After the material is broken down, the compost can be added into the garden to improve soil structure and increase the nutrient content. Research has shown that compost applied on the surface of the garden can reduce weeds, but because of the many benefits compost imparts to soil, it is probably best to incorporate it into the soil. Apply a 1–3 inch layer of compost to the soil surface and mix it to a depth of 6–8 inches. Compost can also be used in potting media mixes at a rate of one part compost to 3 or 4 parts of other media ingredients.

Composting is easy and affordable in the presence of readily available raw materials. It also helps to reduce waste by making use of leaves, grass clippings, and other plant refuse. Florida is one of several states that have banned yard waste from landfills.

If you choose to compost, it's important to do it properly to reduce odor, to avoid attracting rodents and other scavenging animals, and to ensure food safety. Compost can be made in freestanding piles (between 3 and 5 feet, cubed) or contained in bins that allow for proper air movement.

VERMICOMPOSTING | Vermicomposting is the process of using worms and microorganisms to break down paper and vegetable scraps into rich compost. One pound of worms can turn 65 pounds of trash into vermicompost in 110 days. In a school setting, vermicomposting can set the stage for a variety of fun, interdisciplinary activities. Worms are easy to care for, produce no offensive odors, and worm castings can be used

Tips from the Experts

RULES FOR SAFE COMPOST

++ A general rule of thumb is to layer "browns" (materials high in carbon) and "greens" (materials high in nitrogen) in equal layers 3"–4" deep.

++ Avoid stocking the pile with materials larger than 3" long or 1" in diameter.

++ Keep the pile moist, but not wet to the point of dripping when squeezed.

++ Never add cooked food.

++ Never add animal products—meat, dairy, fat, etc.

++ Always ensure your pile has attained the proper internal temperature between 130–170˚F (depending on the composting methods used) to reduce the risk of plant and human disease-causing organisms. These organisms are killed when temperatures are maintained over a period of several days. Compost thermometers can be ordered online or found at many garden stores.

++ Finished compost should smell like damp soil, have a consistent and cool temperature throughout the pile and be uniform in particle size.

++ Always apply finished compost at beginning of growing season and no more than one month before harvesting.

Additional advice and published materials on composting, including the construction of composting bins, is available from your UF/IFAS County Extension service and in the "Digging Deeper" section of *Grow to Learn.*

to improve the fertility and water retention of soil or potting media in your garden. Apply vermicompost at similar rates to field soil or containers as compost. Information on how to build an inexpensive worm bin that will produce compost for your garden can be obtained from your local UF/IFAS County Extension agent or found in the "Digging Deeper" section on page 49 in *Grow to Learn*.

Best Practices

Integrated Pest Management
Integrated Pest Management (IPM), an effective and environmentally sensitive approach to pest management, is recommended for schools. The principles of IPM include monitoring for pests and learning to identify them, using cultural methods in the garden like crop rotation and careful plant selection, and, when necessary, using the least toxic pesticide possible (chemical pesticides are prohibited in the school garden).

Frost Protection

For schools in Central and North Florida, you are likely to contend with frost and below-freezing temperatures. Planting crops that are cold-hardy in the fall is wise and will usually alleviate the need for protection as long as the temperature does not stay below freezing for more than a few hours. For other plants, and for tender spring plants that are threatened by a late frost, protection must be considered. In most cases, the best option is frost cloth. This keeps the plants protected from the cool temperatures while allowing air circulation around the plants. Since most cloth allows a degree of sunlight through, plants can continue photosynthesis and the cloth can be left on for 2–3 days if needed.

Managing Pests & Disease

When it comes to keeping your garden healthy, an ounce of prevention is worth a pound of cure. Good cultural practices from the outset, as described in previous sections–observing planting dates, amending the soil, having a crop rotation plan, using mulch, and providing appropriate irrigation–will give your plants the best opportunity to thrive. The Florida Vegetable Gardening Guide in the Appendix of *Grow to Learn* provides an extensive list of practical approaches to controlling pests that do not include synthetic pesticides, including a table that provides a list of pesticides with formulations that are approved by the United States Department of Agriculture's National Organic Program. These products are generally available at national retail outlets and are deemed to have minimal risk to human and animal health by the Environmental Protection Agency. According to the USDA, no synthetic pesticides should be used in school gardens. Many schools have banned the use of any and all pesticides on school grounds, unless applied by a licensed pesticide applicator when students are absent from school grounds.

IDENTIFYING & MANAGING INSECT PROBLEMS IN THE GARDEN | A healthy garden is home to a number of insects, the great majority of which will not harm your plants. Even when potentially harmful bugs are present, they are not necessarily a threat to your garden. Healthy, well-established plants, like healthy human beings, can manage some stress and damage and still perform well overall.

Students can help scout the garden at least twice a week to look for possible damage to plants. Learning to identify insects and other crawling creatures in the garden is a fun scientific pursuit. There are a number of resources online, in the bookstore, and in the library that can help you identify common garden pests as well as beneficial insects. Students often need to be reminded not to jump to conclusions about bugs. Many pests have natural predators and if you take away the pest, you will never get to see the beneficial predator in action. Below-ground fauna is present too, and some of the biggest threats to a healthy garden in Florida are nematodes. Nematodes cannot be seen with the naked eye. Some signs of nematodes are stunted roots, or galls, on roots that do not easily fall off when rubbed. Plants with nematode damage will often have yellow leaves and not reach expected size. A healthy garden has a diversity of organisms all contributing something positive toward a stable ecology. Students, volunteers, and teachers will benefit from getting to know the garden's inhabitants and their roles as predators, pollinators, decomposers, and yes, the occasional pest.

BIG PESTS | Deer, rabbits, groundhogs, and other four-legged pests can devastate vegetable gardens. Birds, squirrels, mice, and raccoons can also become troublesome pests and can leave droppings and waste behind that can become contaminants. Do not feed wildlife near your garden, and if possible, secure permission, funding, and assistance to erect a fence with a gate. If deer are a problem, the fence needs to be 8 feet tall. If deer are not a problem, a 4-foot-high fence will suffice. Many types of woven wire and vinyl netting fencing materials are available. Bird netting is a soft fine mesh netting often used to protect tender fruit such as blueberries and strawberries from birds and other small animals. Bird neetting can be left on until the fruit is harvested.

DISEASE DIAGNOSIS & TREATMENT | Plant disease, like insect problems, can also be greatly abated by using sound gardening practices from the outset. Choosing healthy transplants, ensuring there will be adequate space between plants at maturity and watering in the morning are additional measures to take. Disease-resistant varieties have genetic characteristics that allow them to tolerate biological disease-causing organisms and are particularly important to use in our warm, humid climate. Diseases can also be abiotic (not biological in origin), but caused by a nutrient deficiency or some other environmental imbalance.

If you notice signs of plant disease, yellowing or curling leaves, sudden wilting, spots on the leaves or fruit, or flower or fruit drop, remove the affected part, if possible, to help keep it from spreading. Research with your students the possible diagnosis and its treatment. There are a number of identification guides under "resources" in this section of *Grow to Learn*. If you run into problems, your UF/IFAS County Extension agent will be happy to help.
*Page 52-53 of *Grow to Learn* has great information on what to do with your school garden over school breaks and holidays.

Harvesting

The best part of growing a school garden is the joy of harvesting the fruits of your labor! Knowing when and how to harvest your produce for maximum quality will ensure that you and your students will have a great experience. This phase of the gardening experience will also provide a wonderful opportunity for experiential learning. There are many resources to help you develop a curriculum that meets your needs and offers fun, interactive activities to integrate academics and nutrition from the garden into your classroom.

When to Harvest

It is important to consider the amount of time you will need to grow and harvest the bounty of your garden! You want to choose plants that have "days to harvest" that match your timeline for the classroom so that you can be sure your students will get to experience as much of the plant's lifecycle as possible The approximate planting and harvesting dates for many common vegetables for North, Central and South Florida can be found in the Appendix of *Grow to Learn*.

If you are new to vegetable gardening, it may not be obvious what vegetables look like when they are ready for harvest. Using the guide mentioned above is a great start, but that can all change based on the weather: more heat or cold, sun or shade, and rain or drought. Check seed packets for additional information as there are many differences based on varieties.

Harvest Safety

A few simple steps will ensure you have a fun, safe harvest to enjoy with your class. Before and during harvest use clean and sanitized tools, gloves, harvest containers, and work surfaces.

Be aware of what hands and tools have touched before moving to another task that involves edible plants, especially picking. Clean and sanitize tools and containers in an area well separated from your vegetable garden.

- Diluted bleach (1 teaspoon in 4 cups water) or pure white vinegar are safe for sanitizing tools and containers.
- Always use clean and sanitized containers that are made from materials designed specifically to safely hold food for harvesting. Examples include paper grocery bags, 5-gallon food-grade buckets (use only new food-grade buckets or food-grade buckets that held only food items, such as pickles), colanders or plastic kitchen bowls. Never use plastic garbage bags, trash cans, or any containers that originally held chemicals such as household cleaners or pesticides.
- Wash hands before and after picking produce. If using gloves, be sure they are cleaned and stored properly.
- Brush, shake, or rub off any excess garden soil or debris before putting the produce into the harvest container or bringing produce into the kitchen. It is not recommended to wash fruits and vegetables before refrigerating, but to wash them immediately before eating or preparing for cooking. Refrigerating fruits and vegetables with moisture from washing can encourage microbial growth.
- When washing produce, use cool, running, potable water. Produce with thick skins, like potatoes, can be scrubbed with a vegetable brush to remove excess dirt and bacteria.

- Fruits and vegetables stored at room temperature (like onions, potatoes) should be kept in a cool, dry, pest-free, well-ventilated area separate from chemicals.
- Handle produce gently to avoid bruising and always cut away damaged parts of fruits and vegetables before eating or preparing. Throw moldy produce away. Always cover and refrigerate cut fruit and vegetables when preparing them in advance.
- Do not serve cut fruit and vegetables if they have been held for longer than 2 hours at room temperature or longer than 1 hour at temperatures above 90°F (32°C).
- If possible do not mix root crops with above ground crops; keep leafy greens, especially those eaten raw, separate from other vegetables.

Best Practices

Safe Surfaces for Post Harvest Storage & Food Preparation

After following good food safety in the garden and at harvest, it is important to minimize opportunities for contamination during food preparation.

+ Diluted bleach (1 teaspoon in 4 cups water) or pure white vinegar is safe for sanitizing surfaces, utensils and containers.

+ Avoid cross-contamination when preparing fruits and vegetables. Clean work surfaces, utensils, and hands before and after handling fruits and vegetables. Let utensils and surfaces air dry.

+ Keep fruit and vegetable bins in the refrigerator clean. Wash and sanitize bins before re-using them. If you store fruits and vegetables in the refrigerator, use a thermometer to check that your refrigerator is at the proper temperature (40°F or less).

Expanding Your Garden

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While it is wise to start simple and small, you may want to expand your garden as you grow in experience. Adding pollinator-attracting plants and perennial food crops are two interesting ways to add beauty and depth to your vegetable garden, as well as a number of new learning experiences for your students.

Gardening for Native Pollinators

A pollinator is an animal or insect that transfers pollen from flower to flower. Butterflies, bees, beetles, flies, tiny wasps, hummingbirds and even some species of bat are all pollinators. Plants, which are rooted to the ground and can't go look for a mate like animals do, depend on pollinators to unwittingly transfer pollen from the male anther of one flower to the female stigma of another. Successful pollination results in the production of seeds and fruit – plant reproduction. Pollinators are vital to food production in your garden and in the world over.

In addition to their agricultural value, pollinators are also essential components in other plant systems. In the wild, pollinators increase biodiversity and create more food for wildlife. The presence of pollinators is as important as water, sun, and soil to the success of many of the world's flowering plants. During the last century, pollinator species have been on the decline. Loss of habitat, exotic parasites, and overuse and misuse of pesticides have contributed to the loss. By adding pollinator-attracting plants to the school garden, students can provide an oasis for pollinators while investigating the fascinating process of pollination – learning about both the animals that visit the garden and their showy flower partners. While this section will focus on butterflies and bees, other pollinators will be attracted to many of the same plants.

Butterflies

Florida is home to 180 native butterfly species, boasting the highest number east of the Mississippi River, 40 of which are either unique to the state or occur mainly within its boundaries. Attracting butterflies to your school garden can aid in pollination and provide opportunities to learn about these fascinating creatures as they progress through their life stages from egg to larvae (caterpillar) to pupa (chrysalis) to adult butterflies. With the right plants, your Florida school garden is almost bound to attract butterflies.

A butterfly garden is most successful when it provides food for both adult butterflies and their larvae (caterpillars). Most adult butterflies feed on flower nectar and will be attracted to a wide variety of different flowers. Caterpillars, though, rely on specific plants called host plants for food and these are much more limited. Host plants may also provide shelter and camouflage, as well as chemicals used for protection, courtship, and reproduction. It is not necessary to include larval host plants to attract butterflies, but adults tend to stay fairly close to the areas where their larval food plants can be found. If you do use larval host plants, remember that, unlike other plants in your garden, these will be eaten by caterpillars if all goes well.

You can learn more about the butterflies that inhabit your area of the state, their food sources and larval plants in the UF/IFAS document, "Butterfly Gardening in Florida," found in the Appendix of *Grow to Learn*.

Best Practices

Pollinator Gardens

+ Allow a few vegetable plants to bolt (go to seed) to attract pollinators.

+ Choose plants that flower at different times of the year to provide nectar and pollen sources throughout the growing season.

+ Plant in clumps, rather than single plants, to better attract pollinators.

+ Provide a variety of flower colors and shapes to attract different pollinators.

+ Whenever possible, choose native plants.

Fun Facts | Pollinators

+ Male bees cannot sting!

+ Pollination services to U.S. agricultural crops are valued at $10 billion annually.

+ Of the 1,400 crops grown, almost 80 percent depend on pollinators, including coffee, almonds, and apples.

+ Numerous animal species, from birds to bears to humans, include fruit and seeds as an important part of their diets.

+ Plants provide egg laying and nesting sites for many insects.

+ There are 20,000 different species of bees.

Growing Perennial Fruit Crops

Perennial fruit crops can be added to almost any school garden. They have many of the same requirements that annual vegetable plants do: 6–8 hours of sun, fertile soil, adequate water, etc. However, unlike annuals, which complete their life cycle in one season, perennial crops continue to grow year after year. Adding them to your garden creates a more permanent landscape element which also bears delicious fruit.

Perennial fruit crops also have some additional requirements. They usually grow much larger than annuals and need more space. They also require occasional pruning to optimize fruit production. Perennial fruit have temperature limits that are necessary to produce an abundant harvest. Some crops, like blueberries and peaches, require a certain number of hours of low temperatures. Other crops, like citrus, must be protected from the cold in order to produce harvestable fruit. With some planning, almost any school garden can include at least one perennial fruit crop.

If you have the good fortune to have plenty of sunny space in your school yard, you might consider designing an orchard into your overall plans. For schools that are more limited in space, fruit crops might replace landscape ornamentals as a hedge along a fence, or on a free-standing trellis or arbor. Many fruit crops can also be grown in containers.

The type of crop you can grow will also be limited by the climate in your region of the state. For fruit plants, there are two concerns with cold hardiness. The first is whether the plant will survive the winter. Florida falls into zones 8b–10b on the USDA Plant Hardiness Zone Map (see page 26 of 'STEMming Up Gardening for Grades'). While temperate-zone fruits, which are fairly cold-hardy when dormant, can survive North Florida winters, some tropical fruits cannot. Further south, subtropical and tropical fruit crops are divided by their cold tolerance.

On the other side of the coin, some fruit crops have a chilling requirement. They require exposure to cool temperatures during their dormant period in order to produce flowers and begin active growth again in the spring. It is important to choose the right type of fruit and the best variety for your particular region and climactic zone.

Oranges, of Course

The orange is synonymous with Florida. However, it is a subtropical fruit and most types are limited to areas that do not regularly experience frost. Pollination, spacing, and pest control are common issues. Also, before planting citrus, be sure to speak with your County Extension agent regarding citrus greening and other diseases that might restrict planting citrus in your area. Gardens in Central Florida and South Florida can grow almost any type of orange. Growers in North Florida should choose cold-hardy types like Satsuma and Kumquat that can withstand the region's occasional cold snaps. Cold-hardy varieties should still be planted in a protected area, like the south side of a building, to ensure fruit production for years to come. Citrus can also be grown in pots in the northern part of the state and brought indoors during occasional freezes. Almost any Florida school garden can grow some version of our state fruit.

Pollination, spacing and pest damage are other considerations to keep in mind when planning an addition of oranges to your garden. A few varieties (for example, mandarins) will produce very little fruit unless another tree is planted nearby to provide cross-pollination. It is also recommended that there be a minimum of 15 feet between trees as citrus trees grow rapidly when they are given good care. Septic tanks and drain fields should be avoided to prevent drains from being clogged by deep roots. Most varieties can be grown successfully without synthetic pesticides. The fruit may have blemishes on the outside, but it will still be juicy and sweet on the inside. These conditions can be met by many school gardens.

Blueberries

Blueberries are another good fruit crop to consider for your school garden. Regional climate, soil pH and pollination need to be considered in addition to the basic needs they share with other plants in your vegetable garden. South Florida may have a better climate for citrus, but Central and North Florida are just right for blueberry growing. There are two types of blueberries that grow well in our state, rabbiteye and southern highbush. However, only certain lowchill cultivars of each are adapted to Florida. Generally, rabbiteye blueberries grow best from Ocala north. The southern highbush cultivars that are commonly grown in Florida are better adapted to areas

south of Ocala and north of Sebring. New cultivars developed by breeding programs often aim to extend the southern and northern most limits of production to expand commercial markets.

Another important factor to consider is that blueberries require acidic soil with a pH of 4.0–5.5. A soil test is vital, and your UF/IFAS County Extension agent can advise you on whether your soil will support blueberry plants, and what amendments might be necessary. In general, the more organic matter, the better. Peat moss and pine bark are commonly used to reduce soil pH and also increase organic matter as they break down. Peat and pine bark are also good growing mediums for growing blueberries in pots.

Space is an issue with this perennial as well, although the two different varieties have different requirements. A mature rabbiteye blueberry plant can reach up to 15 feet in height with canes sprouting over an area of 8–10 feet in diameter; southern highbush plants are somewhat smaller. Allow at least a 7' x 7' area for rabbiteyes and a 4' x 4' area for southern highbush. Plants may be set 3 feet apart (southern highbush) or 5 feet apart (rabbiteye) for a hedgerow effect.

Pollination is an important consideration. Rabbiteye requires cross-pollination to produce fruit, and southern highbush benefits from cross-pollination. To ensure cross-pollination, select at least two of cultivars of each type which flower at the same time (two or more rabbiteyes or two or more southern highbush), and plant them together. Encourage bees by ensuring other garden plants are in flower ahead of and during the early part of the perennial fruit season. A steady provision of flowers will provide a consistent food source for pollinators that will benefit all aspects of the garden. Growing several cultivars will also expand the harvest season. Many native Floridians remember picking blueberry relatives in the wild as children. Adding these hardy plants to your garden will allow another generation of Floridians to enjoy this tradition.

Muscadine Grapes

Muscadine grapes can be grown in most areas of Florida, although most varieties do best in the central and northern parts of the state. The muscadine is native to the southeastern United States and was the first native grape species to be cultivated in North America. Muscadines are tolerant of insect and disease pests and can be grown in a wide range of soil conditions. Muscadine grapes can be planted vineyard-style with traditional post-and-wire trellises. They can also be grown on an overhead arbor providing shade for classroom gatherings, or over an archway as an entrance to your garden. They are fast growers, and after only three years, a grape vine can easily cover a 6-foot by 15-foot horizontal area. Several cultivars could be planted together to prolong the ripening period and also to provide a variety of grape sizes, colors, and flavors.

Shiitake Mushrooms

And now for something completely different! You can take your garden in a whole new direction by cultivating mushrooms. Shiitake mushrooms have been enjoyed for centuries in Asia. Growing mushrooms is a great opportunity for your students to learn more about fungi. They can also be grown in shadier areas of your garden. You can find more information on growing Shiitake in the "Digging Deeper" section on page 71 of *Grow to Learn*. Ask your UF/IFAS County Extension agent for recommendations for your school garden.

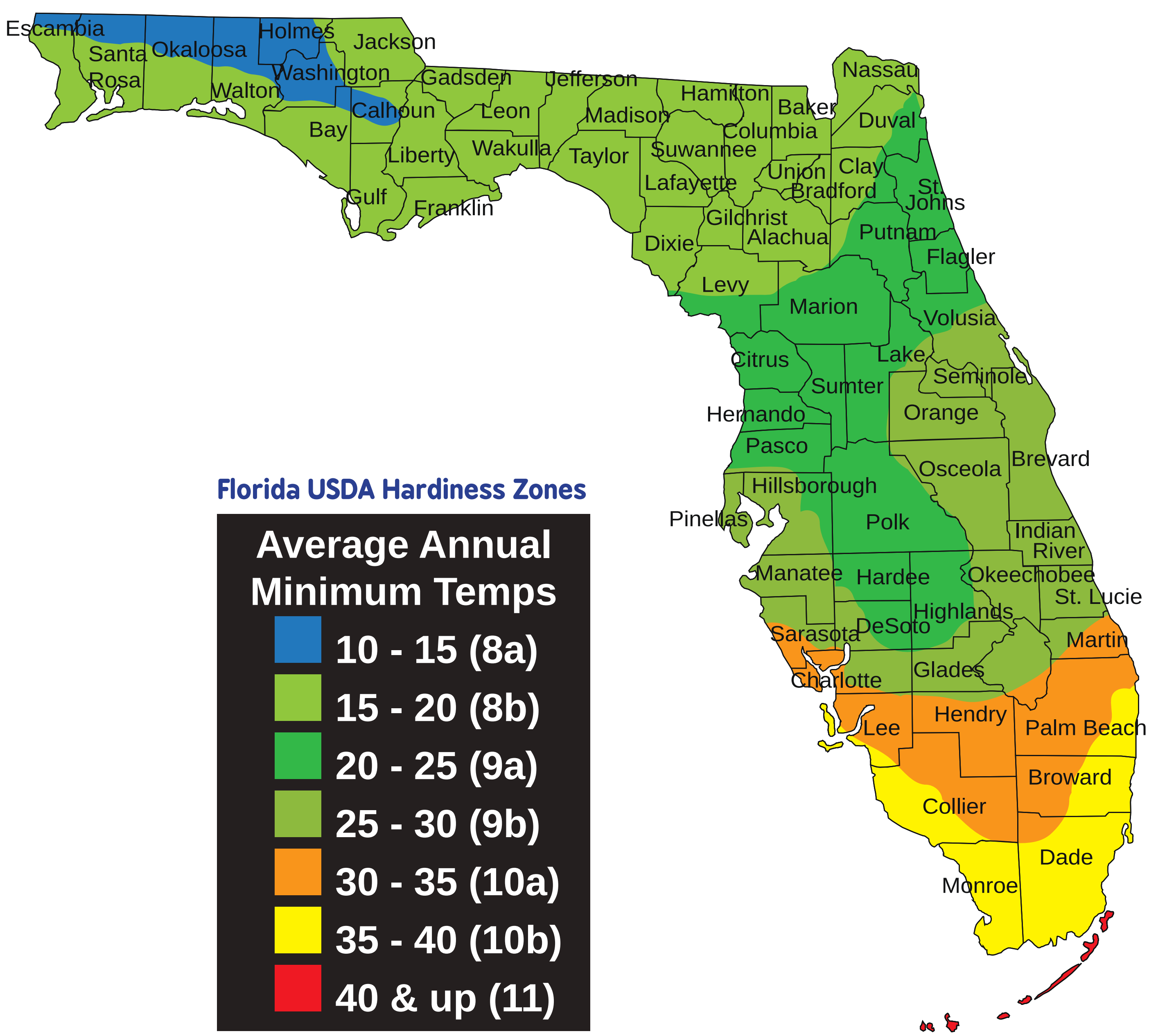
Treadwell, D., S. Park-Brown, K. Brew, and A. Prizzia (Eds.). 2014. Grow to Learn: A Garden Guide for School and Community Gardens. 112 pp. Revised 2015. Published by Florida Department of Agriculture and Consumer Services and the University of Florida-IFAS. Available at: http://uffnp.org/wordpress1/wp-content/uploads/2015/09/FDACSFNW_Grow-to-Learn_Book-LOW-RES.pdf

Chapter 2
Planting and Growing Tips

Welcome to Your Region!

Florida is different from any other state. While we commonly say Florida has four growing zones — Northwest, Northeast, Central and South — there are sub-zones within each, so referring to a zone chart can assist you with understanding the nuances of your area. Florida's six-degree latitude difference from the northern to the southern tip creates 1 ½ more hours of sunlight in Miami than in Jacksonville each day (www.edis.ifas.ufl.edu). These different latitudes create different climate zones throughout the state, from 8a to11 (see chart below), which translates to different planting times in each zone. It is important to know what region the school is in to help guide you in planting the right plants at the right time.

The zones should be used as a planting guideline, and are a factor you should consider, particularly in areas where freezing temperatures are likely certain times of the year. Novice gardeners should stick with crops labeled for their zone, and expert gardeners can venture out and plant crops for neighboring zones.



Search for your zone by zip code at *www.plantmaps.com/interactive-florida-usda-plant-zone-hardiness-map.php*

How to Plant a Pizza Garden

Pizza is a favorite food of many so the pizza garden is a fun layout to try in the schoolyard. This garden should be started in the spring to take advantage of Florida's unique growing season.

Regions: All Florida regions

Space needed: Gardens can be 10 to 50 feet in diameter

Plant list:

Tomato seedlings
Basil seeds
Pepper seedlings
Scallion sets (small onions; green stems are edible)
Oregano plants in small pots

Supplies:

One foot stakes (enough to mark the perimeter every five feet)
String
Mallet
Pine straw for walkways
Hay for mulch inside planting beds
Shovels
Fertilizer
Clear plastic

1. Remove any grass or unwanted vegetation from the site before getting started.
2. Hammer a one-foot stake into the center of the garden. Attach a string and measure to the outside edge of the garden space (typically 10 feet).
3. Holding the string, walk a circle along the outside-edge of the garden and hammer a stake into the ground every two steps (or five feet).
4. Connect the stakes with string to mark the boundaries of the garden.
5. Connect the stakes across the circle to make the "slices" or wedge-shaped beds.
6. The garden should be divided into eight pieces of equal size.
7. With a shovel, mark a walkway along each of the radiating strings as wide as needed.
8. With a shovel, mark an observational circle around the middle stake.
9. Shovel dirt from the walkway into the pizza beds to help define a boundary between the two areas.
10. Add fertilizer to pizza bed soil.
11. Add pine straw to walkways and hay to pizza beds (except in basil area).

Sample timeline (Central Region):

January: Prepare the site and build the beds.
February: Check Farmer's Almanac or Extension Office for last frost date. Plant peppers, scallions and basil after that.
March: Plant oregano and tomatoes. Add fertilizer to pepper and tomato plants. Water regularly (an automatic sprinkler on a timer works well).
April: Continue to water regularly, and enjoy the harvest!
May: Cover garden with clear plastic to "solarize," or sterilize the soil during the summer.

Chapter 2: Planting and Growing Tips

How to Plant a Salsa and Soup Garden

Soup gardens can be created from any combination of cool or warm season vegetables. Each of these can be grown in a container or in the ground. A common recipe for a soup garden follows the story *Recipe to Make Stone Soup*, by Joseph Moser, and includes:

Cool Season Stone Soup

(If planted at beginning of season, should be ready by January.)

- Cabbage
- Carrots
- Kale
- Onions

Warm Season Stone Soup

(If planted at beginning of season, should be ready by May.)

- Beans
- Corn
- Peppers
- Tomatoes
- Summer squash

...then add:

- Basil, thyme, bay leaf
- Vegetable broth
- Rice
- One large, clean stone

Chop vegetables, place in a crock pot with vegetable broth to cover, cook until tender.

Salsa Garden

The salsa garden can be grown in containers and is one of the simplest to grow and prepare.

Plant list:

Tomato plants (Determinant cherry tomatoes work well.)
Bell pepper plants
Jalapeño or sweet pepper plants
Cilantro seeds

Supply list:

Potting mix
Proper diameter (dependent on recommended plant spacing) container per tomato plant
10-inch diameter container per pepper plant
Paint stirrers or popsicle sticks
China marker

Timeline:

January: Sow cilantro seeds
February: Plant peppers
March: Plant tomatoes
April: Enjoy harvest

Edible Commodities in Florida: An Introduction

Florida farmers grow nearly 300 different crops to sell across the country. These crops are called commodities. Out of these crops, grapefruit, oranges, tangerines, snap beans, sugarcane, tomatoes, melons, cucumbers, peanuts, sweet corn and bell peppers made the most money in 2013, according to *2014 Florida Agriculture by the Numbers*. More than 9.5 million acres of Florida land is farmed, according to the 2014 guide. About 13,000 of those acres are being farmed organically, according to the Census of Agriculture 2012. Organic farms in Florida use natural fertilizer and pest control methods to keep their plants healthy. When studying economics or Florida history, it may be interesting to create a Commodity Garden at the school. Each region produces a variety of commodities such as:

South: Citrus, corn, beans, cucumbers, herbs, lettuce, peppers, squash, sugarcane, tomatoes, tropical fruit, watermelon

Central: Citrus, corn, blueberries, herbs, peaches, strawberries, tomatoes, watermelon

North: Blueberries, cabbage, corn, herbs, peaches, peanuts, potatoes

Comprehensive guides to vegetable and herb gardening can be found at the UF/IFAS repository of publications (http://edis.ifas.ufl.edu) which include the "Florida Vegetable Gardening Guide" and "Herbs in the Florida Garden."

Seed Sources

Southern Exposure Seed Exchange
www.southernexposure.com

Tomato Growers Supply Company
www.tomatogrowers.com

Baker Creek Heirloom Seeds
www.rareseeds.com

Seeds of Change – Certified Organic
www.seedsofchange.com

Johnny's Selected Seeds
www.johnnyseeds.com

Burpee Seeds
www.burpee.com

What to Grow in Florida

Herbs

Overview
Herbs grown in pots, or in the ground, need well-drained soil and full sun to thrive. This means the soil in the pot should have plenty of sand, bark pieces and other matter to let the water drain quickly out of the soil.

Basil

What it is used for: A sweet herb. Leaves used in pizza sauce, pesto and other Italian cooking.
Days to sprout: Seven to 10
Seed to plant: One month
Spacing: Six inches apart, or it can be grown hydroponically.

How do I harvest it? Basil is an annual plant, so once it flowers, it's finished. To keep it from "finishing," find the second bunch of leaves from the bottom of the plant, and snip off the entire stalk — this keeps the plant growing. Use the leaves in cooking. Flowers, when they appear, are edible, too.

Chives

What it is used for: Spicy flavor in fresh salads, and as a garnish
Days to sprout: Five to 14
Seed to plant: Six weeks
Spacing: Eight to 12 inches
How do I harvest it? Snip off at the base; the plant is a bulb and will grow back. Flowers are also edible. To spread to other pots, divide in half and replant any time of year.

Cilantro

What it is used for: Salsa, garnish
Days to sprout: 10 to 15
Seed to plant: Six weeks
Spacing: 12 inches
How do I harvest it? Cut off a few sprigs, or remove individual leaves as needed. Cilantro is an annual plant. Once the plant "bolts," or makes flowers, the flavor of the leaves changes and is not usually used anymore. Cilantro seeds are coriander, a spice commonly used in Indian cooking.

Dill

What it is used for: Garnish, salads
Days to sprout: 20 to 25
Seed to plant: Six weeks
Spacing: Three to 12 inches
How do I harvest it? Cut off a few leaves at the base of plant, or cut the entire plant. Flowers, leaves and seeds are edible.

Fennel

What it is used for: Garnish, soups
Spacing: Three to five inches
How do I harvest it? Cut off a few leaves at the base of plant, or cut the entire plant. Flowers and leaves are edible.

Mint

Types: Chocolate mint, peppermint, spearmint, pineapple mint
What it is used for: Garnish, desserts, teas
Days to sprout: 10 to 16
Seed to plant: Six weeks
Spacing: 18 inches
How do I harvest it? Cut off a few stems at the base of plant. Flowers and leaves are edible.

Nasturtium

What it is used for: Edible flowers used as garnish or in salads
Days to sprout: Seven to 14
Seed to plant: Four to six weeks
Spacing: Six to 12 inches
How do I harvest it? Pick off flowers where stem meets flower.

Oregano

What it is used for: In sauces for Italian cooking
Days to sprout: Eight to 14
Seed to plant: Eight weeks
Spacing: Eight to 12 inches
How do I harvest it? Take outer stems, with leaves, and cut from plant at base. Most gardeners dry this herb by hanging it upside down for a few weeks, then harvesting leaves. To pull leaves off, hold stem from tip and pull towards roots. Oregano is a perennial plant and will grow to fill whatever size pot you put it in.

Parsley

What it is used for: Garnish, salads
Days to sprout: 11 to 27
Seed to plant: Four to six weeks
Spacing: Six inches
How do I harvest it? Cut off a few sprigs, or remove individual leaves as needed. Parsley is an annual plant, meaning you'll plant new seeds every fall.

Rosemary

What it is used for: To flavor soups and stews, breads, meat dishes
Days to sprout: Usually transplanted from plants.
Spacing: Six to 24 inches
How do I harvest it? Cut off a few sprigs to the base of the stem, or remove individual leaves as needed. Most gardeners dry this herb by hanging it upside down for a few weeks, then harvesting leaves. To pull leaves off, hold stem from tip and pull toward roots. Rosemary is a perennial herb, and depending on the variety, can be kept in a well-drained pot for many years.

Sage

Varieties: Pineapple sage, silver-leafed sage
What it is used for: To flavor soups and stews, breads, meat dishes
Days to sprout: 14 to 21
Seed to plant: Four weeks
Spacing: 12 inches
How do I harvest it? Remove individual leaves as needed. Flowers are also edible. Pineapple sage is a butterfly attractant.

Thyme

Varieties: Lemon thyme, creeping thyme
What it is used for: To flavor soups and stews
Days to sprout: 20 to 30
Seed to plant: Eight weeks
Spacing: Six to12 inches
How do I harvest it? Cut off a few stems as needed; flowers are also edible. To pull leaves off, hold stem from tip and pull towards roots.

Beans

History and fun facts: Beans are originally from Central America.

Time of year to plant:
North: March–April and August–September
Central: February–April and September
South: September–April
Type of planting: Seeds
Florida-friendly varieties:
Bush beans – Bush Blue Lake, Contender
Pole beans – Dade, McCaslan, Kentucky Wonder, Blue Lake

Sun: At least six hours per day
Water: One cup per week, per plant
Nutrient needs: Beans benefit from monthly fertilizer applications of a standard 5-10-10 fertilizer, sprinkled into the soil at time of planting and again each month.

Planting tips: Beans can be planted directly into the ground, or in cups to transplant later. If planting in a garden, beans do well planted near tomatoes. Bush beans were developed for commercial growers that wanted all the beans ready at one time. Pole beans bear fruit longer.

Time from seedling to harvest: Eight weeks

How to harvest: Carefully clip bean from the stalk. Harvest when you can see the beans through the pods (and still green).

Nutritional value: Good source of vitamins C, K

Blueberries

History and fun facts: Florida farmers produce 20 million pounds of blueberries a year. Florida has some native varieties of blueberries that grow on the edges of wet pine forests, blanketed by pine needles. This is a clue that the natural environment for blueberries to thrive is in moist, acidic, nutrient-rich soils. Many home gardeners have trouble reproducing these conditions in their own yard as most of Florida's sandy soils are not naturally as acidic as blueberries prefer (4.0-5.5pH; see www.edis.ifas.ufl.edu for more specific growing information). Seek the volunteer expertise of a local blueberry grower to assist in planning your school blueberry garden.

Time of year to plant: Mid-December through mid-January
Type of planting: Seedlings
Florida-friendly varieties:
Northern counties: Rabbiteye (Vaccinium ashei)
Central and Southern counties to Sebring: Southern highbush

Sun: At least six hours full sun per day
Water: Likes moist soil
Nutrient needs: High, but specific — use a 12-4-8 fertilizer (Those formulated for azaleas would work well.)
Planting tips: Plant blueberries in mid-December through mid-January, and incorporate peat moss into planting area. Plant at least 20 feet from building foundation as this can make the soil even less acidic. Cover plants with three inches of pine bark mulch to provide acidic conditions. Once the soil is moist, fertilize lightly. Repeat every two months.

Time to harvest: Late April to June, depending on variety

How to harvest: Pick berries from stem.

Nutritional value: Good source of vitamins C and K, and manganese

Cabbage

History and fun facts: The first cabbage was native to the British Isles and Mediterranean Europe. Cabbage is also related to broccoli, cauliflower, collard greens, kale, Brussels sprouts and radishes. It contains many vitamins, including vitamin C.

Time of year to plant:
North: September–February
Central: September–January
South: September–January
Type of planting: Seedlings
Florida-friendly varieties: Bravo, Gourmet, King Cole

Sun: At least six hours full sun per day
Water: Likes moist soil
Nutrient needs: High

Planting tips: Although some caterpillars will eat outer cabbage leaves, it is rarely serious enough to hurt the plant, and little insect control is needed. Be sure to maintain a regular watering and fertilization schedule.

Time from seedling to harvest: Three months

How to harvest: Cut bottom of cabbage off at the root when inner cabbage head is large enough (four to six inches wide); peel off outer leaves.

Nutritional value: Good source of vitamins C, K

Citrus

History and fun facts: It is important to note that citrus trees available for sale in plant nurseries have been grafted. One plant provides the root, and another plant provides the branches and fruit for the plant. The two have been combined together. Citrus trees are grown on sour citrus root stock, which makes them healthier and more disease resistant. For this reason, starting citrus plants from seed will not result in the same tree the fruit came from.

Time of year to plant:
North: Recommended to grow in containers so they can be moved inside during cold weather.
Central and South: Transplant nursery trees after the last frost (usually mid-late February)
Type of planting: Three gallon plant

Sun: At least six hours per day
Water: One inch of water per week
Nutrient needs: Citrus fertilizer should be applied every two months, March through September.

Planting tips: Dig a hole that's twice as wide, but no deeper than the rootball. Gently remove the tree from the container, and place in center of hole. Fill in with soil, build three to four inch berm of soil around edge of rootball, and then fill with water.

Time to harvest: Different varieties ripen at different times, but most ripen in December or January.

How to harvest: Citrus ripens on the tree, so leave it on the tree until it's needed. The acidity drops and sugars increase the longer it stays on the tree (for example, grapefruit is best when harvested in March).When ready to harvest, hold the fruit and twist while pulling down.

Nutritional value: Good source of vitamins A, C (tangerine, grapefruit, orange)

Sweet Corn

History and fun facts: Corn is in the grass family. Corn was first grown for food in South and Central America, and is now a major food crop throughout the world. It is wind-pollinated, which means it needs ample space (at least four rows) to pollinate itself. Corn needs a lot of tender, loving care to grow and produce well and may not be suitable for amateur growers.

Time of year to plant:
North: March–April and August
Central: February–March and September
South: September–March
Type of planting: Seed, or transplants
Florida-friendly varieties: Silver Queen, Supersweet

Sun: At least six hours per day
Water: Maintain even soil moisture
Nutrient needs: High. Use lawn fertilizer at least once a month.

Planting tips: Corn needs at least 20 square feet of growing space for the rows of corn to cross-pollinate and form the ears of corn, or fruit, that we eat. Planting corn in a block is recommended.

Plant seedlings 15 inches apart. If growing from seed, plant a seed every two inches and thin to 15 inches when corn is several inches tall. Corn can be planted with pole beans (which use cornstalk as the pole), and grows well with potatoes and cucumbers.

Time from seedling to harvest: Eight to 12 weeks

When to harvest: Harvest when juices in the seeds are halfway between clear and milky and tassels are brown.

Nutritional value: Good source of thiamin

Cucumbers

History and fun facts: Cucumbers originated in India, and are related to cantaloupe, summer squash, pumpkins and watermelons.

Time of year to plant:
North: February–April and August
Central: February–March and September
South: September–March
Type of planting: Seeds or transplants
Florida-friendly varieties: Poinsett, Ashely, Dasher

Sun: At least six hours per day
Water: One inch per week
Nutrient needs: Fertilize once a month, using standard 5-10-10 formulation.
Planting tips: Plant seedlings 12 inches apart, and bury up to the first two leaves. Cucumbers grow well next to beans and corn.

Time from seedling to harvest: Six weeks for seeds; five weeks for plants

How to harvest: Harvest when fruit is smooth and green (before they turn yellow). Cut from stem.

Lettuce

History and fun facts: Lettuce is in the Aster family, and is related to artichokes and dandelions. Lettuce is the world's most widely used salad crop. It originated in the eastern Mediterranean basin and was cultivated by the Egyptians as early as 4,500 years ago. Over time, people selectively cultivated the varieties that were less bitter, had fewer spines and less milky latex sap. There are four main forms — crisphead, butterhead, romaine and loose leaf. Lettuce is a cool-season crop, and grows and tastes best when grown between 46°F and 75°F.

Time of year to plant:
North: February–March and September
Central: September–March
South: September–January
Type of planting: Seeds or transplants
Florida-friendly varieties:
Crisp: Floricrisp, Minetto, Ithatca, Fulton
Butterhead: Bibb, White Boston, Tom Thumb
Leaf: Simpson, Red Sails, Salad Bowl
Romaine: Parris Island Cos, Valmaine, Floricos

Sun: Four to six hours per day
Water: Keep soil evenly moist
Nutrient needs: Fertilize once a month with standard 5-10-10 fertilizer.
Planting tips: Lettuce seeds are sown in the top quarter inch of soil. To make a lettuce row, take the handle of a digging tool and lay it on the ground, pressing lightly. This will make a small furrow in which to scatter the seeds. Tip the seed packet and let the seeds scatter from the corner of the packet along the row. Use the edges of the furrow to cover the seeds lightly, and water regularly until seeds sprout. When the first two leaves of the plants are visible, pinch plants in between until plants are at recommended spacing on the seed packet. As lettuce matures, daytime temperatures will reach above 75°F and the lettuce will start to grow taller in the middle. This is called "bolting." As soon as the lettuce begins to put energy into bolting and making a flowerhead, its leaves become bitter. Be sure to harvest the lettuce before it bolts, or let the lettuce go to seed to collect for next season.

Time from seed to harvest: Six to seven weeks for seeds, five to six weeks for seedlings

How to harvest: Remove individual outer leaves, or cut off entire plant. To save seed, allow lettuce to bolt up and form flowers. When seeds are fuzzy, pull the plant and hang it upside down in a paper bag to dry. When the seeds completely dry, rub them between your hands to separate seeds from chaff, and store in a cool, dry place.

Peanuts

History and fun facts: Florida farmers grow 200,000 acres of peanuts each year. Peanuts form underground. After the yellow flower is fertilized, it extends the ovary in the form of a "peg," growing downward for about 10 days until the fertilized ovary is beneath the soil. The pods then form the shell and the nut that we recognize as a peanut.

Time of year to plant: May
Type of planting: Seed, two to four inches apart and in two-foot rows

Sun: Full sun
Water: Peanuts can be planted as school is finishing, and will not need irrigation until August. Do not water past September to keep fungal diseases down.
Nutrient needs: Peanuts grow well in sandy soil with minimal organic matter. As part of the pea family, they fix nitrogen from the air as a main source of fertilizer.

Planting tips: Peanuts must have loose, weed-free soil around them to form the pegs that penetrate the ground. Flowers will start to form a month after planting, and pegs form as the flowers are fertilized. It takes nine to 10 weeks for the seeds (or peanuts) to mature once pegs reach the soil.

How to harvest: Peanuts are ready to be harvested when the leaves turn yellow. Remove entire plant with a pitchfork and shake off soil. Hang in a warm, dry place (like a garage) for one to two weeks, remove remaining soil, then cure for one to two weeks more.

Nutritional value: Good source of protein, niacin, folate, thiamin, vitamin E

Peppers

History and fun facts: Peppers are originally from Mexico and Central America. They are related to tomatoes, potatoes and eggplant.

Time of year to plant:
North: February–April and July–August
Central: January–March and August–September
South: August–March
Type of planting: Seedling
Florida-friendly varieties: Various, depending on type of pepper

Sun: Six hours per day
Water: Consistently moist soil
Nutrient needs: Fertilize monthly

Planting tips: Peppers need sulfur to set fruit. The first settlers of Florida dropped a few matchsticks in each hole before planting peppers to provide the nutrient. If the first leaves turn yellow, apply sulfur in powdered form to the soil. Apply a two-inch layer of mulch after planting.

Time from seedling to harvest: 12 weeks

How to harvest: Cut the pepper from the plant using scissors or a knife, leaving one inch of stem on the fruit to help it keep longer.

Nutritional value: Good source of vitaimin C

Potatoes

History and fun facts: Potatoes originally came from Peru's mountainous regions. They are related to tomatoes, eggplant and peppers — the edible part is the tuber located below the ground. Americans eat 125 pounds of potatoes per person, per year. White potatoes need warm days and cool nights to flourish and are grown as a cool season crop. Sweet potatoes are warm season crops, but because they take at least four months to produce, they are not ideal for school gardens unless planted at the very start of the season.

Time of year to plant:
North: January–March
Central: January–February
South: September–January
Type of planting: From seed potato
Florida-friendly varieties: Sebago, Red Pontiac, Atlantic, Red LaSoda, LaRouge, Superior

Sun: Six hours per day
Water: Potatoes grow during the dry season in Florida, and may rot if too much water is applied. Keep soil moderately moist.

Nutrient needs: Apply a 5-10-10 fertilizer at planting, and again each month through the season.

Planting tips: Purchase seed potatoes from a local nursery. This will minimize disease in the new plants. Each small "eye" of a potato is a potential sprout. Use a paring knife to slice a one-inch section around each eye, and dip in wood ash to prevent disease. Plant four inches deep, spaced eight inches apart, in rows spaced at least three feet from each other. In 10 days, leaves should begin to sprout above the surface. When potatoes have grown about 10 inches, use a hoe to mound soil up around each stem, which will produce more potatoes.

Time from seedling to harvest: 12 weeks

How to harvest: Plant will turn yellow and die. Wait two weeks and then dig potatoes out of soil by digging below them, lifting the entire root mass out of the ground. This way, potatoes are not damaged in digging process.

Squash

History and fun facts: Squash originated in Mesoamerica, and was cultivated heavily by the North American indigenous tribes. Along with beans and corn, squash is the third of the "three sisters" that indigenous people often planted together. Squash would shade out weeds while the beans grew on the cornstalk and shaded the plant.

Time of year to plant:
North: March–April and August–September
Central: February–March and August–September
South: January–March and September–October
Type of planting: Seed or seedling
Florida-friendly varieties:
Cool: Sweet Mama, Table Queen, Butternut, Spaghetti
Warm: Summer crookneck, Dixie, Zucchini, Peter Pan

Sun: Six hours per day
Water: One inch per week. Keep leaves dry when watering
Nutrient needs: Apply fertilizer monthly

Planting tips: Train vines up vertical trellis for good production. To pollinate using a paint brush, transfer pollen from male flowers (bright yellow) to female flowers (green, with a small, swollen part at the stem).

Time from seedling to harvest: Eight weeks

How to harvest: Cut fruit stem to harvest. Harvest at six to nine inches.

Nutritional value: Good source of vitamins A, C

Strawberries

History and fun facts: Strawberries are in the Rose family, and are related to apples, peaches, plums and nectarines. Botanically speaking, strawberries are an aggregate accessory fruit, meaning that the fleshy part is derived not from the plant's ovaries but from the receptacle that holds the ovaries. They are native to North and South America. The strawberry was originally named "strew-berry" because of its runners and berries that run along the ground (Jones, 2005). Honeybees pollinate strawberry plants.

Time of year to plant: October to November for all regions
Type of planting: Seedling
Florida-friendly varieties: Florida 90, Candler, Dover, Florida Belle, Oso Grande, Sweet Charlie, Selva

Sun: Six hours per day
Water: One inch per week, keeping water off leaves and fruit

Nutrient needs: Fertilize monthly

Planting tips: Directions for creating a strawberry tower are given in the *How to Plant a Fruit Garden for Small Spaces* in this book. Be sure to heavily mulch around plants to prevent fungal diseases.
Time from seedling to harvest: 12 weeks, then continuously through May

How to harvest: Pick berries from stems.
Nutritional value: Good source of vitamin C, manganese

Sugarcane

History and fun facts: Sugarcane is native to Asia, and has been grown in gardens for more than 4,000 years. It was the first staple crop brought by the Spanish to Florida in 1537.

In 1763, when Spain turned over Florida to the English, sugarcane production took off. Many of the English farmers converted old missions into sugarcane plantations. During the second Spanish occupation, settlers from different countries were encouraged to come and stake land, and many were interested in growing sugarcane.

In 1821, when Florida became a United States territory, the industry flourished. "Canaveral" means cane fields. Loads of sugarcane were shipped north from ports in Cape Canaveral. By the late 1800s, canals were draining new land for sugarcane production south of Lake Okeechobee, and Florida's sugarcane industry continued to thrive.

Today, Florida produces more sugarcane than any other state, growing approximately 410,000 acres of the crop. While all areas of the state can grow sugarcane, it is produced commercially in the counties below Lake Okeechobee because of the rich, fertile soils of that area. One sugarcane stalk weighs an average of three pounds, and contains .3 pounds of raw, granular sugar.
Time of year to plant: August - January
Type of planting: Cuttings, or clones, from other plants

Florida-friendly varieties: Since the sugargrown in school gardens won't be made into crystallized sugar, "chewing" varieties are recommended. These are: Yellow Gal; CP57-603; CP80-1837; CP80-1907; NG57-258 and White Transparent.

Sun: Full sun
Water: Moist soil
Nutrient needs: Rich, mucky soil with a lot of organic matter. Use an 8-8-8 fertilizer when planting sugarcane.

Planting tips: Plant sugarcane in furrows, or trenches, in rows approximately seven to eight inches deep and five feet apart. Loosely spread fertilizer in furrows. Cover with two inches of soil and plant canes.

How to harvest: Sugarcane is ready for harvest in late October, and before the first freeze. Caution: The blades of the grass are sharp. Use a knife to cut off stalk at base. The sugar is sweetest at the stalk. Also, remove top leaf blades, then slice for chewing.

Nutritional value: Carbohydrates (one teaspoon of granulated sugar cane contains four grams of carbohydrates). Carbohydrates are a source of energy for the brain and muscles. Use it in moderation. Sugar adds a boost of flavor to food, gives baked goods color and texture, and acts as a preservative.

Tomatoes

History and fun facts: Tomatoes were originally grown in South America, Peru and Ecuador. Florida now grows 42 percent of America's tomato crop, more than any other state.

Time of year to plant:
North: February–April and August
Central: January–March and September
South: August–March
Type of planting: Seedlings
Florida-friendly varieties: Two types of tomato plants: determinant (will stop growing at a certain height), or indeterminant (will keep vining). When shopping for plants, keep in mind that hybrid plants offer improved disease resistance, but their seeds cannot be saved for planting next season.

Sun: Six hours per day
Water: One inch per week
Nutrient needs: Fertilize monthly

Planting tips: The Florida weave for planting indeterminant tomatoes: Hammer two, four-foot stakes at either end of the row. When tomato plants are four to six inches tall, run a string in between the stakes. At every tomato plant, run the string the opposite way around it from the last plant, directly under the nearest branch. This string will support the branch as it bears fruit. Then run a string the opposite way, forming a "figure 8" around each stem at the branch point. Repeat every four to six inches all the way up the stake as the plants continue to grow. Determinant cherry varieties perform well in containers. Pile up mulch around each plant to keep soil moist and leaves healthy. Keep soil evenly moist. Do not let it dry out. Blossom end rot happens when not enough calcium, or too little then too much water, is applied. Pinch off new leaves that grow in between the branch and the main stem to help plants produce larger fruit.

Time from seedling to harvest: 10 to 12 weeks

How to harvest: Pick tomato right before it ripens and allow it to ripen afterwards. To save seed from non-hybrid tomatoes, squeeze seeds and pulp into an open jar and add water. Leave uncovered for four days until white mold appears. Pour seeds and pulp into a strainer and wash with clean water, then put seeds on a paper towel to dry. Store in a cool, dry place.

Nutritional value: Good source of fiber, vitamins A, C

Tropical Fruit

History and fun facts: The Southern region of Florida produces over 30 varieties of tropical fruit. Scientists began breeding tropical fruit trees and plants in the 1930s to create varieties suited to Florida's growing conditions. This research yielded many important results. Today, around 13,000 acres produce tropical fruit worth (www.edis.ifas.ufl.edu/document_ag210.) An interesting project within a classroom would be to assign students to interview their relatives and discover which fruit trees they remember from their childhood. A map of tropical fruit trees, and the regions they are from, could be compiled from this information. A complete list of growing instructions for tropical fruit can be found at www.edis.ifas.ufl.edu.

Nutrient needs: Fertilize once in the fall and once in the spring with a 6-6-6 blend.
Nutritional value: Good source of vitamin C

Fruit	Type	Height	Region	Harvest Time
Banana	Perennial tree	12-15 feet	Central, South	Year-round
Blackberry	Perennial shrub	4-6 feet	North, Central, South	April-May
Carambola	Medium tree	25-35 feet	Central, South	June-October
Fig	Small tree	10-15 feet	North, Central, South	June-August
Lychee	Large tree	35-45 feet	South	June-July
Mango	Large tree	40-50 feet	Central, South	May-October
Papaya	Tree-like	15-20 feet	Central, South	Year-round
Pineapple	Perennial	2-3 feet	Central, South	Year-round

Watermelon

History and fun facts: Watermelon first came to the United States from Central Africa. Florida scientists began experimenting with fungus-resistant varieties in the 1930s and have developed some improved varieties since then.

Time of year to plant:
North: March–April and July–August
Central: January–March and August
South: January–March and August–September
Type of planting: Seed or seedling
Florida-friendly varieties: Large — Charleston Gray, Jubilee, Crimson Sweet, Dixielee. Small — Sugar Baby, Minilee, Mickylee. Seedless — Fummy

Sun: Six hours per day
Water: Likes moist soil, but is susceptible to fungal problems. Be sure to mulch heavily under the watermelon plants with coastal hay to keep fungal problems at bay, and water beneath leaves.
Nutrient needs: Fertilize monthly.

Planting tips: Seedlings should be planted 18 inches apart, buried up to the first leaves to establish a strong root structure. Watermelon is susceptible to a variety of fungal, bacterial and viral diseases. See this publication to diagnose a problem: www.edis.ifas.ufl.edu.

Time from seedling to harvest: 11 to 13 weeks
How to harvest: Harvest when watermelon makes a "PLUNK!" sound when you hit it with a knuckle.
Nutritional value: Good source of vitamin C

Chapter 3

STEMming Up Your Garden Lessons

Soil Moisture and Soil Temperature

Brief Description:
The lesson entails having students measure, record, chart, and evaluate the soil moisture and temperature of school gardens.

Objectives:
Students will:
1. Measure and evaluate which parts of the garden soil or planter soil are retaining moisture and heat during the day.
2. Evaluate which plants would be most appropriate for planting based on the soil moisture and temperature level.
3. Research and engineer the ideal soil for the school garden.

Materials:
- Soil temperature and soil moisture meters
- Atmospheric thermometers
- Clip boards
- Graphing paper
- Pencils
- Tissues for cleaning the meters
- Calculators are optional

Preparation:
1. If a soil health and properties lesson has not been taught it is suggested to do that before this lesson. Suggested lessons are *Gardening for Grades* 'It all Begins with Soil' and Nutrients for Life Foundation's Properties of Soil and/or Plant-Soil Interaction.
2. Obtain soil temperature and soil moisture meters from your county UF/IFAS office, local gardening club, garden store, or order on-line or through catalogues. One soil temperature and soil moisture meter per four students facilitates an orderly lab in which each student has multiple chances to use each kit.
3. It is recommended that students have clip boards while recording temperature and moisture, and calculators are optional for tabulating the total, mean and range.
4. This lab can be performed on any soil-based plant, whether growing in raised garden beds, raised herb beds, or in planters. It is suggested to have students measure soil temperature in two different growing mediums or containers. If you only have a garden in the ground, a container, gutter or hydroponics garden is recommended to get a good comparison.
5. Suggest breaking the garden into sections and numbering them (see Soil Moisture Table on page 45) to be able to more easily assign groups to an area. There are five Garden columns on the table. This is for those schools that have large gardens or multiple gardens and would like to take samples from all garden areas.

Time:
Each lab, the soil temperature and soil moisture, will take approximately two to four classes to complete, depending on the length of each class.

Vocabulary:
mean, mode, range, moisture, insulation, infer, predict, optimum, evaluate, variable, independent variable, dependent variable, x-axis, y-axis, atmospheric temperature, photosynthesis, germinate, saturated, inundated, retain, absorb, organic matter, compost, silt, clay and sand

Background:
Soil Moisture: All life is dependent, in some form, on water. For plants, it is water (H_2O) that enables plants to create their own food through a process known as **photosynthesis**. Water is separated along with carbon dioxide and converted into glucose (sugar), and excess is oxygen is released into the air and is represented by the chemical equation:

$$6(H_2O) + 6(CO_2) \rightarrow C_6H_{12}O_6 + 6(O_2)$$

Most of the plants grown in gardens require between one to two inches of water a week. One to two inches of rain and/or water from irrigation keeps the soil moist but not **saturated** or **inundated** with water. Dry soil will not allow plants to grow to their full potential nor produce delicious, healthy fruits, roots, stems and leaves. Roots growing in waterlogged soil may die because they cannot absorb the oxygen needed to function normally. The longer the air is cut off, the greater the root

Florida Standards:
SC.6.N.1.5, SC.6.N.1.3, SC.7.N.1.5, SC.7.L.17.2, SC.7.L.17.3, SC.8.N.1.5, LAFS.6.SL.1.2, LAFS.6.SL.1.3, LAFS.6.SL.2.4, LAFS.68.RST.1.1, LAFS.68.RST.1.2, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, MAFS.7.SP.2.4, VA.68.C.2.1, VA.68.C.2.2, VA.68.C.2.3, SS.7.C.2.12, SS.7.C.2.13, and SS.7.C.2.14

damage. The dying roots decay and cannot supply the plants with nutrients and water.

Soil types dictate the ability of a garden to retain and drain water. Soils that have a high amount of **sand**, as most do in Florida's school yards, drain water quickly and do not retain moisture well. Soils that have a high amount of **clay** retain water so well that the clay doesn't allow the plants to uptake the water. **Silt** and **organic matter** in the form of **compost** help to balance the sand and clay so that soil is able to retain and slowly drain water as it flows through the garden soils.

A moisture meter provides information on the moisture level of the soil two to six inches (five-10cm) below the surface, where the root hairs absorb water. By using a moisture meter, a gardener or farmer can determine the effectiveness of the irrigation system and the ability of the soils to drain and/or retain water. Moisture levels below three indicate dry soil and moisture levels above eight indicate inundated, waterlogged soil. The ideal soil moisture level is between three and eight on the moisture-meter-scale.

Soil Temperature: Many seeds will not **germinate**, or begin to grow, when soil temperatures are too cool, such as tomatoes and watermelons. Other plants, such as lettuce or cilantro, will not germinate when the soil is too hot. Some plants stop growing when the soil temperature becomes too cool, and some stop growing when the soil temperature becomes too hot.

For example, St. Augustine grass stops growing when the soil temperature is below 55°F, and Rye Grass stops growing when the soil temperature is above 75°F.

Many insects and fungi thrive in certain soil temperatures, generally warm soil temperatures over 80°F. For this reason, very few farmers grow plants outdoors between late July and early September in Florida. The soil is too hot during those months in Florida to grow healthy plants. Thus, knowing the soil temperature allows a farmer or home gardener to make the best choices for which plants to grow for changing seasons and weather conditions.

Generally, soil between 40°F-55°F is considered the coolest soil in which plants will grow. Soil between 56°F-78°F is considered the **optimum** or best soil temperature for growing plants. Finally, soil between 79°F-90°F is the highest soil temperature at which plants will grow.

Introduction:

*It is recommended that this lesson is performed before planting, but it can just as well be performed while plants are growing. Additionally, it is more effective to compare temperature and moisture across different classes and times of the schoolday.

1. Begin class with a starter or warm-up question, such as: "Watermelons will grow fruit at soil temperatures as low as 70°F and as high as 85°F. What is the range of the soil temperature at which watermelons will grow fruit?"
   Answer: 85°F-70°F = 15°F or
   "The optimum or best soil temperature for growing cucumbers is 64°F, cantaloupe 68°F, okra 73°F, pumpkin 75°F, squash 70°F and watermelons 72°F. What is the mean or average soil temperature in degrees Fahrenheit for growing the above fruits and vegetables?"
   Answer: 64°F + 68°F + 73°F + 75°F + 70°F + 72°F = 422°F/6 = 70.3°F
2. Allow students time to answer starter or warm-up questions. Discuss solving for the **range** and **mean** and why those forms of data analysis are important and useful for gardening.
3. Read orally, or discuss the background information on soil temperature and soil moisture. Discuss temperature and moisture based on the time of the year and which plants are most appropriate for temperature and moisture/rainfall averages for that season. Also, discuss how soil temperature does NOT change as dramatically as the atmospheric or outside temperature due to the **insular** properties of the soil.

Activity 1:

1. Using a document projector, display the soil moisture and soil temperature meters on the screen and demonstrate how to properly use, read and clean each meter.
2. Pass out one copy of each of the following handouts to every student; *Soil Moisture Data Table* and *Soil Temperature Data Table*. Display the sheet using an overhead or computer projector. Group students in groups of four and emphasize that each student will have multiple opportunities to use each meter and that each group is responsible for recording the information while in the garden.
3. Tell students that they are going to be taking soil temperatures in the garden and in another location of your choice, such as a different growing medium like the hydroponics garden or container garden.
4. Upon returning from the garden, review the data recorded for each class. Next, as a class, solve a data column to demonstrate how to solve the total, mean, mode and range for each column.
5. For the soil moisture lab, demonstrate using an overhead or computer projector, how to properly label the graph for the moisture of different parts of each garden.
6. For the soil temperature lab, post the mean soil temperatures for each class and time on the overhead or computer projector. Next, demonstrate how to properly label and plot the data points on a graph.
7. Once students have completed the data tables, assign the *Extension/Comprehension Questions for Soil Moisture and Extension/Comprehension Questions for Soil Temperature*. Allow students to work collaboratively in answering the questions, but each student is responsible for completing their own paper. When all students are finished, discuss the answers.

Extensions:

1. After collecting temperature and moisture data, have students research which plants are most appropriate for planting. Be sure to have students include the recommended amount of water and optimal soil temperature for each plant.
2. As a group have students design their “ideal” garden including measurements, number of plants, spacing of plants and irrigation, and submit for approval. Depending on space, each group can create their own garden or each class can decide which design they like the best and plant one for the whole class.
3. Unless soil amendments were added to your garden, the soil moisture is probably not ideal. There are different soil amendments that help retain moisture for better plant health. Have students research the amendments and engineer the best soil for your school garden. They will have to design an experiment similar to the soil moisture lab to test their engineered soil.

Evaluation:

1. Assess student performance in completing the assigned lab measurements and completed graphs for soil moisture and soil temperatures, as well as cooperation in completing the group work.

Soil Moisture Data Table

Directions: Correctly use the moisture meter to determine the moisture level of soil in each box and fill in the chart to document the moisture level in each part of the different gardens.

Section of the Garden	Garden 1	Garden 2	Garden 3	Garden 4	Garden 5
NE corner					
SE corner					
NW corner					
SW corner					
Center					
Total					
Mean					
Mode					
Range					

Extension/Comprehension Questions for Soil Moisture

Directions: Using the completed Soil Moisture Data Table, answer the following questions.

1. Which garden had the **highest** Mean for moisture?

2. Which garden had the **lowest** Mean for moisture?

3. What **variables** could account for a moisture **difference** between the gardens? (one to two sentences)

4. What **variables** could account for a moisture difference between different **sections** (NE, NW, SE, SW and Center) of each garden? (one to two sentences)

5. Which garden had the **highest range** of moisture between the **sections**? What variable or variables might explain the high range of moisture between the sections?

6. Which garden had the **lowest range** of moisture between the **sections**? What variable or variables might explain the low range or moisture consistency of the sections?

7. What changes and/or additions would you suggest to create a consistent moisture level in each garden?

8. Explain how using a moisture meter could save a farmer or gardener money.

9. Create a graph that shows the different gardens as the independent variable (x-axis) and the **mean** moisture level as the dependent variable (y-axis).

10. What patterns became apparent on **your graph** in reference to mean soil moisture level in each garden?

Soil Temperature Data Table

Directions: In this lab you will use the soil thermometers to measure the mean, average soil temperature of each of the main gardens and solve for the range between the soil's temperatures to the atmospheric or outside temperature. Next, you will use your information to infer and predict patterns that occur between outside temperature and the soil temperature.

Time of data collections:___________

	Garden 1	Garden 2	Garden 3	Garden 4	Garden 5	Mean
Outside Temperature ˚F						
Soil Temperature ˚F						
Alternative Growing Medium Temperature ˚F						
Range between Soil & Outside Temperature.						
Range between Soil & Alternative Temperature						

Extension/Comprehension Questions for Soil Temperature

Directions: Use the soil temperature chart/table to answer the following questions.

1. Which garden, if any, had the **highest** soil temperature?

2. What variables might account for a **high** soil temperature or the reason for no change between the garden soils?

3. Which alternative garden/growing medium had the **highest** soil temperature?

4. What variables might account for a **high** alternative garden/growing medium temperature?

5. Which garden had the greatest **range** or difference between the outside temperature and the soil temperature? **Explain** what variables might account for a **high range** between the outside and soil temperatures?

6. Which garden had the greatest **range** or difference between the soil temperature and the **alternative garden/growing medium** temperature? **Explain** what variables might account for a **high range** between the soil temperature and alternative garden/growing medium temperature in that garden?

7. Using the information from your chart, which gardens would you plant plants that thrive in **cooler** soil and which garden would you put plants that thrive in **warmer** soil?

8. Using the data from your chart, **explain** the **numerical pattern** that developed between the outside/atmospheric temperature, the soil temperature and the alternative garden/growing medium temperature.

9. Looking at your chart, what could be **inferred** about the relationship between the soil temperature and the atmospheric or outside temperature?

10. Using the **mean** outside temperature, soil temperature and alternative garden/growing medium temperature data from your class **plus** two other classes, create a line graph that shows the relationship between the time of day, the atmospheric temperature, soil temperature and alternative garden/growing medium temperatures between different class periods. On the x-axis, place the time of data recordings and on the y-axis place the temperature in ascending order from 40°F to 90°F. Be sure to **title** your graph and **label** BOTH axes!!!

11. Looking at your graph, what **patterns and relationships** developed between the outside temperature, soil temperature, alternative garden/growing medium temperature AND the time of day?

Soil Moisture and Temperature

Sample Pre-Post Test Assessment

Directions: Answer each question using precise terms.

1. What material in soil is best for allowing water to drain and move through the soil?

2. Explain why water is vital to the health and survival of plants.

3. How does soil temperature control the germination or sprouting of plants?

4. What material in the soil is best for retaining water in the soil?

5. What causes plants to die if the roots are inundated or receive too much water?

6. Why is it difficult to grow fruits and vegetables in extremely warm soil temperatures?

Learn About Decomposition by Creating Compost

Brief Description:
Students, working in groups, will create a small composter, monitor and record the decomposition process, and reflect on the final product of decomposition in their composter.

Objectives:
Students will:

1. Understand what compost is and how it compares to nature.
2. Create compost bottles in order to record, measure, observe and evaluate the decomposition process of plants, vegetables and fruit.

Time:
Initial set up for the compost bottle lab takes one class, and the monitoring of the compost bottles should be done during each class over three to four weeks allowing 15 to 20 minutes for measurements and observations each class period. The final compost analysis/evaluation will take one class.

Preparation:

1. A lesson on soil health, components and organic versus inorganic materials is suggested. Suggested lessons are *Gardening for Grades*: It all Begins with Soil and Nutrients for Life Foundation's Properties of Soil and/or Plant-Soil Interaction.

2. This tactile/inquiry lab on composting/decomposition requires that the teacher collect enough plant and vegetable scraps to fill at least 30 two-liter bottles.
3. A five-gallon bucket with a lid is recommended for collecting plant and vegetable scraps. Depending on the size of the school, enough fruit and vegetables can be collected through three to four lunch shifts. Be careful NOT to collect meat or dairy products in the bottle, such as ranch dressing or hot dogs and hamburgers.

Materials:

- Two-liter plastic bottles
- Scissors
- Masking tape
- Permanent marker
- Balances for measuring mass
- Metric rulers
- Beakers that measure in milliliters (mL)
- Plant and vegetable wastes, such as leaves, stems, tomatoes, banana peels, orange peels and apple cores
- Red wiggler worms (earthworms)
- Soil
- Water
- Tongs for placing plant and vegetable waste in the two-liter bottles

Vocabulary:
compost, compostable, decomposition, decomposer, micro-organism, organic, inorganic, bacteria, fungi, aerobic, anaerobic, humus, nutrient, symbiosis, symbiotic, mutual, quantitative, qualitative, biodegradable, non-biodegradable, prediction, evaluate, matter, elements, biotic, abiotic, biogeochemical cycle and Law of Conservation of Matter

Background:
Composting, often described as nature's way of recycling, is the biological process of breaking up of **organic** waste such as food waste, leaves, grass trimmings, paper, worms and coffee grounds into an extremely useful humus-like substance by various **micro-organisms** (including **bacteria** and **fungi**) in the pres-

Florida Standards:

SC.6.N.1.5, SC.6.N.1.3, SC.7.N.1.5, SC.7.L.17.2, SC.7.L.17.3, SC.8.N.1.5, LAFS.6.SL.1.2, LAFS.6.SL.1.3, LAFS.6.SL.2.4, LAFS.68.RST.1.1, LAFS.68.RST.1.2, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, MAFS.7.SP.2.4, VA.68.C.2.1, VA.68.C.2.2, VA.68.C.2.3, SS.7.C.2.12, SS.7.C.2.13, and SS.7.C.2.14

ence of oxygen. **Humus** refers to natural decay or decomposition. **Compost** is created when organic materials such as leaves, grass, eggs, coffee grounds, and fruit and vegetable peelings are mixed with soil, water and **decomposers** such as fungi, bacteria and earth worms. The decomposers consume the organic material and reduce it to simple **nutrients**, such as nitrogen, phosphorus and potassium that can once again be used by plants for growth and health. Compost is an excellent fertilizer because the nutrients that comprised the leaves, grass, eggs, and fruit and vegetable peelings are returned to the soil.

Compost energizes the soil food web, which is made up of microscopic bacteria and fungi, along with earthworms, crickets, and many other life forms. Many fungi in compost form **symbiotic**, or **mutually** rewarding, partnerships with plant roots, making it possible for vegetables to feed themselves more efficiently. Research shows (Ohio University) that compost enhances the ability of tomatoes and other vegetables to stand up to common diseases and may also improve their flavor and nutrition. Compost also helps the soil retain moisture. Through composting you enhance your garden's ability to grow healthy plants while reducing your volume of trash.

A compost bin is an efficient way of making rich compost and results in the use of fewer yard-trash and garbage bags. A compost bin allows for control of the four factors that affect the speed of decay: oxygen, water, food and temperature. By managing these factors, the naturally slow process of decay can progress much faster. To work well, the compost container needs to be moist, and should be stirred in order to better promote air circulation and fresh oxygen.

Carbon-rich material is known as "brown" matter. Nitrogen-rich material is known as "green" matter. There needs to be a good balance of these two materials to form good quality compost. Too much of either one will result in poor compost. A healthy compost contains a balance of one-quarter green stuff such as vegetable scraps, coffee grounds, or grass clippings —to three-quarters brown stuff such as leaves, straw, grass clippings, shredded paper, coir fiber, wood pellets, or sawdust. In other words, ¼ green matter to ¾ brown matter.

Compost ingredients are broken down by microorganisms, which require aerobic conditions (the presence of oxygen) to thrive. Frequent turning of the compost pile provides this necessary oxygen. Meat and dairy products, such as cheese, yogurt, milk and some salad dressings, however, attract microorganisms requiring **anaerobic** (the absence of oxygen) conditions for decomposition. When meat and dairy products are put in a compost pile, the aforementioned anaerobic microorganisms generate foul-smelling byproducts. This, in turn, attracts flies and their maggots, vermin, (such as cockroaches, mice, rats, raccoons, opossums and skunks) and neighborhood dogs and cats. It also slows down the composting process. Thus, it is highly recommended to keep compost bins and containers free of meat (chicken, pork, deli-meats, hot dogs and hamburgers) and dairy products.

Composting is an excellent vehicle to witness the **biogeochemical cycle** and the **Law of Conservation of Matter**. In terms of composting, the biogeochemical cycle is the process where materials are cycled through living organisms and returned back to the earth or soil. The Law of Conservation of Matter states that matter cannot be created nor destroyed. Matter elements can only change form.

*There are food safety concerns when using compost in schools. Compost must be created correctly. Please see "Tips from the Experts: Rules for Safe Compost" on page 47 of *Grow to Learn School Gardening Guide*. Additional advice and published materials can be found at your local UF/IFAS County Extension Office.

Introduction:

1. Begin class with a "starter" or "warm-up" question such as: "In the NE Florida woods, a banana peel will decompose in one month, an apple two months, a leaf five months, and a cigarette butt will take two years. What is the average time, in **months** that the above products will decompose?" **Answer:** 32 months/4 products = 8 months per product.
2. Allow students time to answer starter question and discuss the process of decomposition. Next, discuss how nature naturally recycles products through the process of decomposition. Ask students to name decomposers and/or scavengers from their environment such as vultures, crabs, worms, maggots, fungi and bacteria.
3. Discuss with students that soil takes a very long time to be created naturally. Inorganic material is slowly created by the parent material breaking down and moving to the surface. Organic material is slowly created by once living items dying and decomposing. Both of these processes take time and therefore we need to often fabricate these soils.
4. Read aloud, the "Background" on compost and decomposition. Possible discussion questions:
   "What is the difference between organic and inorganic material?"
   "What benefits do the different materials have for plants?"
   "What organisms aide in the decomposition of waste?"

"How does compost benefit plants?"
"What is the difference between "aerobic" and "anaerobic?"
"Why is it NOT recommended to put meat and dairy products in compost?"

5. Next, place students in groups of four, and pass out the materials for creating a compost bottle: two-liter bottle, scissors (you may want to pre-cut the bottle), masking tape, permanent marker, 500 mL beaker, water, soil, metric ruler and balance for measuring mass in grams.

Activity 1:

1. Have students remove label and cut at the top of the bottle where the bottle widens. Instruct students to leave about one inch of plastic and do not cut the entire top off. (Again, you may want to pre-cut and remove labels before class.)
2. Have students put the bottle cap in the recycle bin and then place masking tape across the top instead of a bottle cap and poke three to four holes with a pen in the masking tape.
3. Fill the bottle with 500 mL of soil (can be dirt from outside the classroom) and then pour 20 mL of water on top of the soil in the bottle.
4. Using tongs, add the plant and vegetable compost to the bottle, filling to the top of cut area of bottle.
5. Now place one or two earthworms in the bottle.
6. Have students reattach the top part of the bottle to the main body of the bottle using masking tape.
7. Have students write their names on the masking tape where they reattached the bottle.
8. Pass out *Compost Evaluation Worksheet*, have students complete question one and collect the papers. At the end of the forth week pass, the worksheet back out and have students complete the rest of the questions.
9. Now pass out the *Compost Bottle Monitoring Chart* to each student and have students write their names at the top of paper. Remind students that they will be responsible for monitoring and recording their measurements and observations for three to four weeks on their own paper.
10. Have students measure the mass and height of the bottle and record their measurements, along with day's date, on their *Compost Bottle Monitoring Chart*.
11. Students need to describe the appearance of their compost pile under the "Qualitative Observations/Description of Contents" column on the chart.
12. Finally, students are to predict which product they believe will decompose fastest and which the slowest and explain why they choose those products in the Evaluation Questions #1.
13. Students are to place their bottle in the same location in the classroom each day as they leave the class. **If possible**, have some groups place their bottle in area that receives sunlight in the classroom and other groups in shadier or dark areas of the classroom. (Also, maybe add one Cheetos, cheese puff, or Frito to each bottle.)
14. For the next three to four weeks, students should measure the mass and height of the compost pile, and write down their qualitative observations.
15. Students should **GENTLY** stir the contents of the bottle **AFTER** measuring the bottle each class in order to allow more oxygen to flow through the compost pile.

Extensions:

1. Allow students to compost different items to determine if some items create a more nutrient-rich compost.
2. In compost, high temperatures are essential for destruction of pathogenic organisms and undesirable weed seeds. Have students check temperatures of the compost pile using a compost thermometer throughout the school year to make sure it is maintaining safe temperatures. Have students keep a journal that is accessible by all students to keep accurate data of the class compost pile. For more information on compost temperature students can visit http://whatcom.wsu.edu/ag/compost/fundamentals/needs_temperature.htm.
3. Students can take samples throughout the composting process to check for bacterial levels.
4. Students should now understand that many things have to be thought about for optimal plant growth. Students will need to take soil samples in the current school garden to determine nutrient content. Next students need to complete soil moisture activity to determine the moisture content in the school garden. Students will choose which plants they would like to plant in the garden and research soil requirements and engineer soil for their garden. They need to think about water holding capabilites, permeability, soil structure and nutrient content. Once designed they will need to devise experiments to test the effectiveness.

Evaluation:

1. Assess student performance in completing the assigned lab measurements.
2. Grade *Compost Evaluation Worksheet* for accuracy.

Compost Bottle Monitoring Chart

Name ___________________

Date ________ Per. ______

Directions: After creating your compost bottle, record the date, measure the mass and height, and describe the contents of the bottle. Repeat these steps for each class until the contents in the bottle have turned to compost.

Quantitative Observations			Qualitative Observations
Day/Date	Mass in grams (g)	Height in centimeters (cm)	Description of contents
Day 1 Date ____			
Day ____ Date ____			
Day ____ Date ____			
Day ____ Date ____			
Day ____ Date ____			
Day ____ Date ____			
Day ____ Date ____			
Day ____ Date ____			

Compost Evaluation Worksheet

1. **Predict** which product in your bottle you believe will decompose the fastest and which product will decompose the slowest. Explain in detail why you chose each product.

2. Was your prediction as to which product would decompose the fastest and slowest supported? Explain.

3. Did the mass of your bottle change over time? Explain why you believe it changed or why it did not change?

4. Did the height of your compost pile change? Explain why it changed or why it did not.

5. Did the items decompose at the same rate? Explain why they did or did not decompose at the same rate.

6. What was the role of the earthworm in your bottle? Explain in detail.

7. What other organisms would have aided in the decomposing of the materials in your bottle?

8. What items do you consume at home **and** at school that are compostable?

9. How does the compost bottle model the **biogeochemical** cycle? Explain in detail.

10. How does the compost bottle model the **Law of the Conservation of Matter**? Explain in detail.

11. Observe a group whose bottle was in a dramatically different location than yours. Did it decompose at different rate? Why or why not?

Compost/Decomposition

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. Name two organisms that aid in the decomposition of plant matter.

2. Name three products found in and around your home that would be suitable for composting.

3. How is mixing compost into garden soil beneficial to plants growing in the garden?

4. What factors affect how fast or slow compost decomposes?

5. How is composting a demonstration of the biogeochemical cycle?

What's Bugging Me?: Integrated Pest Management Part 1

Brief Description:
Pest management is required for all types of gardens. Integrated Pest Management (IPM) is using more than one practice to control and prevent pests. In this lesson students will learn about the different practices that can and are being used in agriculture today. Students will test the effectiveness of some of the practices by designing their own bioassay experiments.

Objectives:
Students will be able to:

1. Understand the types and benefits of integrated pest management strategies.
2. Learn the concept of bioassays and how to set up a protocol for a bioassay.
3. Design and set up a bioassay experiment.

Time:
Part A. Integrated Pest Management: two hours
  Introduction: 45 minutes
  Activity 1: 60 minutes
  Activity 2: 50 to 75 minutes
Part B. Least Toxic Chemicals: two and a half hours
  Introduction: 10 minutes
  Activity 1: 45 minutes
  Activity 2: 90 minutes

Materials:
- Dish soap
- Vegetable oil
- Soluble fertilizer
- Sugar water
- Salt water
- Different water sources (distilled, deionized, tap, spring or ocean)
- Seeds
- Plants

Part A. Integrated Pest Management

Vocabulary:
beneficial insects, cover crop, cultural practices, integrated pest management, intercropping, limiting factors, parasitoids, pathogens, pests, plant density, population growth curves, scouting, soil solarization and symbiotic relationship

Background:
Pests:
Garden pests are generally considered insects, but also include caterpillars, nematodes (parasitic round worms) and weeds.

Florida Standards for IPM Part 1-3:

SC.7.N.1.1, SC.7.N.1.4, SC.7.N.3.2, SC.7.L.17.1, SC.7.L.17.2, SC.7.L.17.3, MAFS.7.RP.1.2, SC.8.N.1.1, SC.8.N.1.2, SC.8.N.1.3, SC.8.N.1.4, SC.8N.3.1, SC.8.N.4.2, MAFS.8.F.1, MAFS.8.F.2, SC.912.L.14.10, SC.912.L.14.7, SC.912.14.9, SC.912.L.15.6, SC.912.L.17.1, SC912.L.16.12, SC.912.L.17.12, SC.912.L.17.15, SC.912.L.17.16, SC.912.L.17.17, SC.912.L.17.6, SC.912.L.17.9, SC.912.N.1.2, SC.912.N.1.3, SC.912.N.1.4, SC.912.N.1.5, SC.912.N.2.1, SC.912.N.2.4, SC.912.N.2.5, SC.912.N.3.5, SC.912.N.1.1, SC.912.N.1.6, SC.912.N.1.7, MAF.912.F-LE, MAFS.912.A-REI, MAFS.912.S-ID, MAFS.912.S-IC, MAFS.912.S-MD.2

Pests feed on plant roots, leaves and fruit. In all cases, infestation reduces yield. Pathogens include bacteria and fungi that that infect roots, tissue and fruit, also reducing yield. Many IPM strategies can discourage the growth of pathogens. For example, proper water management includes supply and drainage of water, preventing long-lasting soaked soil conditions. This tends to discourage fungal growth which can rot roots, and algal growth which can prevent gas exchange between the soil and atmosphere. (There is one important example of a beneficial symbiotic relationship between *Mycorrhizae* fungi and plant roots. *Mycorrhizae* helps extend the surface area for nutrient absorption in plant roots, while the plant provides food for the *Mycorrhizae*.)

Integrated Pest Management (IPM):
Integrated pest management involves using a variety of techniques to reduce pest populations in an environmentally sound and cost efficient manner. Such techniques include:

1. Use cultural practices to discourage pests. Plan to rotate crops and intercrop to break up high plant density. Between seasons, sterilize soil with the heat of the sun. Cover plant beds with plastic mulch to reduce weeds and water use (if using with drip irrigation). Use pest-free plants or transplants at planting time.
2. Monitor for pest outbreaks by scouting. Walk the garden frequently (Monday, Wednesday, Friday) and look at plants for signs and symptoms. Carry a spray bottle of diluted soap solution (two tablespoons/gallon) to spot-treat problems.
3. Do not kill beneficial insects and parasitoids. They are the natural ecosystem at work to keep pest numbers down.
4. Use proper water management to reduce fungal growth and to encourage strong, healthy plants.

Soil solarization:
During the months of June, July and August, you can cover garden soil with clear plastic. Not only are these the most effective months to solarize soil, but it is also during summer break of the school year— *perfect timing*! The heat of the sun will cause high temperatures in the soil, killing pathogens and insects. The plastic will need to be completely buried along the edges to prevent heat escape. Plastic must be clear, not opaque, and remain in place for at least six weeks. If small holes appear, seal with duct tape. If no weeds are present under the plastic, then soil solarization is successful. If green weeds appear, remove plastic and start again.

Natural predators:
In a food web, one organism eats another as a food source. This can be used to our advantage in the garden. Predators of garden pests are referred to as beneficial insects, and may occur naturally in the garden ecosystem. Predatory insects, usually mites, can also be purchased and placed in the garden to eat insect pests. A special group, called parasitoids (usually parasitic wasps), lay eggs in pests, and then the larvae eat the pest before hatching.

Intercropping:
Marigolds have the ability to reduce nematodes, which are small roundworms that can infect plant roots. Planting marigolds in between plant types can help prevent nematode populations from spreading in the soil. Another use would be to plant the entire garden with marigolds once the final harvesting is complete. Any area not used for cold season crops can be planted with marigolds as a cover crop to lower soil nematode populations.

Choosing the desired plants to be grown, as well as available space, may dictate how much intercropping can be accomplished (Ratnadass et. al., 2012).

Special example – IPM for whiteflies:
Whiteflies are a VERY common plant pest, and some interesting techniques have been developed to discourage their presence. First, whiteflies are attracted to yellow, and bright yellow sticky traps are commercially available. The idea is that the whitefly will be attracted to the yellow, and then become stuck to the sticky glue. Second, whiteflies are confused by metallic or reflective surfaces, which may be offered in plastic mulch. In this case, the shiny surface causes whiteflies to become disoriented in relation to the location of the sky.

Special example – IPM for other insect pests:
Depending how big your gardening project will be, you can construct a screened, polypropylene, polyester, or polyvinyl alcohol, cheesecloth enclosure using PVC as the structure support. This will provide a barrier to insects, such as the leaf miner, to enter the garden. Cutworm collars can protect young plants from cutworms. Tar paper shields can prevent cabbage root maggots from laying eggs. Slugs can be monitored with a pie tin filled with beer. Pheromone (sex hormone for a specific insect) and feeding attractant traps can assist in controlling specific insects.

Introduction:

1. Ask students, "Why do we need pesticides?" **Answer:** To control pests and allow plants to grow and provide a higher yield.
2. Ask students, "What would happen if a farmer didn't use pesticides?" **Answer:** Their entire crop could be wiped

out quickly by one insect or disease. It would be very costly to the farmer.

3. Teach the PowerPoint (found at www.faitc.org/teachers/STEMming-Up) in class to ensure students understand the concept of integrated pest management.
4. Ask students about their gardening experiences, or if they have seen IPM strategies in use (i.e., farm experiences, seeing raised beds with plastic mulch, screened gardens, etc.).

Activity 1: Intercrop Plan

1. Have students work in groups of three to four. Ask them to choose four vegetables, two herbs and two annual ornamental plants.
2. Research together as a class or lead a discussion on Section 4: Pest Deterrence or Repellence and Section 6: The "Push-Pull" Strategy from "Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review" (Ratnadass, A et al. Agron. Sustain. Dev. (2012) 32: 273. doi:10.1007/s13593-011-0022-4). http://link.springer.com/article/10.1007/s13593-011-0022-4). This should prompt the students to think about what they could plant in and around their garden and when.
3. Using the *Intercropping Worksheet*, have students design a garden plan using intercropping and push and pull plants to help control insects. Students will present their designs and defend why they chose the plants for their garden.

Activity 2: IPM Calendar

1. Integrated Pest Management is a yearlong plan; it is management of your garden. Explain to students that in order for the garden to stay as pest-free as possible, it is best to stay ahead to prevent the pests. This can be done by making a monthly calendar for your garden. Things to think about: weather, temperature, what crops will be in the ground and school vacations.
2. Provide students with an *IPM Calendar Worksheet*. Allow students time to research and ask them to list IPM strategies by the appropriate month for your area of Florida (North, Central and South Florida may differ due to temperature). The UF/IFAS Extension Office in your county is a great place to start. See example below for a completed IPM calendar for Central Florida.

Evaluation:

1. Grade *Intercropping Worksheet* for completion and accuracy.
2. Grade *IPM Calendar Worksheet* for completion and accuracy.
3. Based on your initial presentation of information ask students to:
   a. Make a list of IPM strategies and write them on the board. The list should include: soil solarization, marigold planting, intercropping, identifying beneficial insects and natural preditors, plastic mulch, fertilizing and watering to keep plants healthy, drainage methods, etc.
   b. List what insects are expected? What insects are common?

Intercropping Worksheet

Research whether the plants are compatible with other plants, and if they serve as hosts to different insects. If so, this can break up high plant densities, which are attractive to pests.

ROW 1	ROW 2	ROW 3	ROW 4	ROW 5	ROW 6	ROW 7	ROW 8

IPM Calendar Worksheet

Using the list of strategies on the board, create a calendar for the garden that shows when to implement Integrated Pest Management techniques.

Month	IPM
May	
June	
July	
August	
September	
October	
November	
December	
January	
February	
March	
April	

Example of a Completed IPM Calendar for Central Florida

Month	IPM
May	Manage water and apply fertilizer to maintain strong, healthy plants. Finish harvesting. Remove plants. Cover soil with clear plastic for soil solarization.
June	Maintain soil solarization for at least six weeks.
July	Soil solarization. Possibly plant a legume, a nitrogen fixing cover crop.
August	School starts, remove solarization plastic, make beds. Cover beds with plastic mulch (if using drip irrigation). Start transplants. Plastic mulch can be painted silver or use white on black plastic.
September	Plant garden. Manage water and apply fertilizer to maintain strong, healthy plants. Look for cutworms. Monitor for pests. Start marigold transplants.
October	Monitor for pests. Manage water and apply fertilizer to maintain strong, healthy plants.
November	Manage water and apply fertilizer to maintain strong, healthy plants. Harvest complete by Thanksgiving. Remove plants. Plant with marigolds.
December	Winter break and marigold blooming. Manage water and apply fertilizer to maintain strong, healthy plants.
January	Start transplants.
February	Remove marigolds. Make beds. Use black or silver-painted plastic mulch. Plant by February 15.
March	Monitor for pests. Manage water and apply fertilizer to maintain strong, healthy plants.
April	Monitor for pests. Manage water and apply fertilizer to maintain strong, healthy plants.

Part B. Least Toxic Chemicals

Vocabulary:

bioassay, conclusion, control, data, hypothesis, introduction, least toxic chemicals, question or problem, replication, results, treatment, dependent variable, independent variable and controlled variable

Background:

A bioassay involves use of a biological organism to test for chemical toxicity. Perhaps the oldest and most commonly known example is the canary in the coal mine. Traditionally, coal miners have taken caged canaries down into the mines to help ensure a safe air supply. Canaries are more sensitive than humans to methane, an odorless gas released during the mining process, so they were used to provide an advanced warning of when methane was building up to dangerous levels in the mines. If the canary died, it meant the miners should leave the mine as quickly as possible.

A bioassay is the use of a living organism to test for the presence of a compound or to determine the amount of the compound that is present in a sample. The organism used is sensitive to the compound for which the test is conducted. Thus, the effect observed is typically the death or deteriorated health of the test organism. Depending on the test organism, soil, air, or liquid samples can be assayed.

Read more: Bioassay - Test, Bioassays, Organism, and Compound - JRank Articles http://science.jrank.org/pages/855/Bioassay.html#ixzz4Dp97JU00

Introduction:

1. Pesticides are chemicals that are not allowed to be used by students, and adults need a pesticide license to appropriately apply certain pesticides. Therefore it is important to know what can be used in a school garden.
2. Discuss with students some of the "least toxic chemicals" available to gardeners:
   - Mild dish soap solution (two tablespoons/ gallon water)
   - Vegetable oil solutions (two tablespoons/gallon water)
   - Diatomaceous earth for control of ants
   - Bacillus thuringiensis – a bacteria which prevents soft-bodied caterpillars and insect larvae from digesting food. B. thuringiensis only affects caterpillars and larvae, so it is considered a selective, narrow spectrum insecticide.
   - Sulfur or copper ingredients in fungicides can be the least toxic option as well
3. Explain that scouting identifies a pest or pathogen problem and that sometimes physical removal of a plant or leaf can stop the problem. If not, least toxic chemicals are the first choice.

Activity 1:

1. Explain Bioassay: A bioassay can use a plant, leaf tissue, seed, or a population of insects. Any of these may be subjected to a chemical solution or mixture at different concentrations or different volumes, and affects measured or deaths recorded.
2. Show images of bioassay experiments (images can be found PM power point www.faitc.org/STEMming-Up). Use the notes section in the PowerPoint as a guide to explain the slides.
3. Below are suggested articles for students to read. Each student chooses one article and summarizes the protocol for bioassay.
   - 'Bioassay Test for Toxicity': http://www.hometrainingtools.com/a/bioassay-test-toxicity-project
   - 'Insect Bioassay Workshop' PowerPoint by Murray B. Isman: http://projects.nri.org/adappt/docs/M_Isman_bioassays.pdf
   - 'Environmental Inquiry: Authentic Scientific Research for High School Students': http://ei.cornell.edu/toxicology/bioassays/Duckweed/
4. Divide students into three groups, depending on class size with no more than four students per group. The goal is to use an existing scientific experiment to extract the procedure. Using the *Bioassay Article Review Worksheet*, assign each group to research a bioassay journal article on the internet, and ask each group to identify:
   a. The problem
   b. The hypothesis
   c. The test organism
   d. The dependent variable
   e. The independent variable
   f. Data collected
   g. The results
   h. Whether or not the hypothesis was supported
5. Have students design and conduct a bioassay experiment. The easiest bioassay would be using seed or small, whole plants grown in paper cups. Detached plant leaves may also be used, but will be more difficult to keep alive and healthy. To use insects, the teacher may contact a Master Gardener at the local UF/IFAS Extension Office for help with collecting. After choosing seed, plant, leaf or insect, the student needs to choose a test solution that can be mixed to different concentrations. Examples of solutions

include: dish soap, vegetable oil, soluble fertilizer (plant food), sugar water, salt water, or compare water sources (distilled, deionized, tap, spring or ocean). Bioassays should be completed before other factors could cause seed or plant death (i.e., lack of water).

6. Math instructors may continue this lesson using statistics and algebraic functions. Students can create data tables of averages, look for outliers and create graphs. Three common models used in horticulture are the quadratic, logarithmic (called quadratic plateau) and linear plateau functions.

Evaluation:

1. Using the *Bioassay Lab Report Worksheet*, have the students complete a Lab Report on their experiment.

Bioassay Article Review Worksheet

Article Title:

The problem:

The hypothesis:

The test organism:

The dependent variable:

The independent variable:

Data collected:

The results:

Whether or not the hypothesis was supported:

Bioassay Lab Report Worksheet

INTRODUCTION

Question or Problem – This describes what the general purpose for an experiment is.

Introduction – What is known about a problem? Search the internet using credible websites (.edu, .gov, .org). Why do you think your hypothesis will be correct?

HYPOTHESIS

The prediction you want to test. Usually, the hypothesis is written as an "If…, then…" statement.

MATERIALS AND METHODS

Variable (dependent) – The response measured from the seed, leaf tissue, whole plant, or insect.

Variable (independent) – The variable changed by the student (I change); for example, salt concentration.

Variable (controlled) – Variables which are kept consistent to make sure the response is from the treatment (temperature, time, water source, etc.).

Replication – Experiments are repeated to ensure that the results are consistent.

RESULTS

Data – Measurements made (quantitative) or observations (qualitative). It is best to create a scoring system for qualitative data, such as on a scale of 1-10, how dark is the green color, or how strong is a smell? Then the qualitative data can be graphed.

Results – the part of a Lab Report that shows data in tables and graphs, and the mean is calculated from each treatment.

CONCLUSION

After conducting the experiment and evaluating results, was the hypothesis correct? The conclusion should contain a sentence restating the hypothesis, one or two sentences about the experiment procedure, one or two sentences on the measured response, and a sentence stating whether or not the hypothesis was supported.

Integrated Pest Management

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. Define pest.

2. What is integrated pest management?

3. Why is it important to have a pest management plan?

4. What are two ways to manage pests?

Pest Management Safety: Integrated Pest Management Part 2

Brief Description:

Pest management is needed in order to have a healthy and productive garden. There are many options for pest control. This lesson will show students the importance of reading a pesticide label and what information they can find. Students will also be exposed to safety equipment that may need to be used when applying a pesticide.

Objective:

Students will:

1. Be introduced to Personal Protection Equipment, pesticide regulating government agencies and parts of a pesticide label.
2. Identify and understand Personal Protective Equipment used during pesticide application.
3. Learn parts of the pesticide label.

Time:

Introduction: 15 minutes
Activity 1: 20 minutes to one hour
Activity 2: 30 to 50 minutes

Vocabulary:

chemical resistant, fungicide, herbicide, insecticide, Material Safety Data Sheet (MSDS), personal protective equipment, pesticide, pesticide label, restricted entry interval, restricted use, pesticides and signal word

Background:

Personal protection equipment:

Garden chemicals for sale are required to have a label. The label will specify the types of Personal Protective Equipment (PPE) required. PPE may include: chemical resistant gloves, respirator, long sleeves, protective eyewear, and in some cases, a chemical resistant spray suit. Before applying a store-bought chemical to a school garden, find out which chemicals can be used at your school and seek the advice of your local UF/IFAS Extension Agent. There are many laws regarding the application of chemicals to property that you do not own (such as school grounds), who purchases the chemical and if the applicator has the required certification or license.

Parts of a Pesticide Label:

Pesticides may be sold as concentrate or ready to use. Concentrates are much more dangerous than ready to use. It is always recommended to have the Material Safety Data Sheet within reach. Visit http://pest.ca.uky.edu/PSEP/2labels.html to see an example of a pesticide label with interactive labels.

1. Type of pesticide – the type of pest(s) controlled; i.e., herbicide (weeds), fungicide, insecticide. Also the label will indicate what plants the chemical can be used on.
2. Name of product – Tradename and chemical name
3. Name and address of manufacturer
4. Net contents
5. EPA Reg. No. – EPA Registration number
6. EPA Est. No. – EPA Establishment number
7. Ingredient statement
8. Signal word (based on lethal dose 50%)
   - Danger/ Poison – highly toxic
   - Warning – moderately toxic
   - Caution – slightly to relatively low toxicity
9. Warning or caution statements
10. First aid – what to do if there is an exposure
11. Directions for use – how to mix with water and how much area can be covered
12. Personal protective equipment required
13. Environmental hazards – i.e., wind, runoff, cleaning equipment, time of day, bee activity, high water table, surface water nearby
14. Hazards to wildlife – i.e., toxic to bees, fish or other wildlife

Introduction:

1. Show image 1, image 2 and image 3 (images are on IPM Power Point, found at www.faitc.org/teachers/STEM-ming-Up), and then ask students, "If your employer asked you to spray a pesticide, what would you want to know?" Make a list of student responses on the board.
2. Ask students, "Do you know what a pesticide is?"
3. Ask students, "Are all pesticides dangerous?" This is where most people will say yes because that is what social media has led everyone to believe. If appropriately applied on the right crop, using the right application rate and right application method, then pesticides are safe. This is a great time to ask a pesticide company representative to come in and talk with the students about the science behind pesticides.

Image 2

Activity 1: Personal Protection Equipment and the Pesticide Label

1. Display Personal Protection Equipment which is used with both least toxic chemicals (chemicals available to consumers in the plant and garden department) as well as pesticide handlers. Examples can be found at http://edis.ifas.ufl.edu/pi061
2. For better understanding show the video (suggest only parts) of "Pesticide Handler and the Worker Protection Standard." https://www.youtube.com/watch?v=ArfBQvs_zLE

Image 1

Image 3

Activity 2: Pesticide Label

1. Students will be comparing pesticide labels. Find one pesticide that contains synthetically made Bt toxins and one that contains natural Bt toxin. Print the labels for those pesticides and make copies for the students.
2. Use the label with the synthetic-made Bt toxin to model how students will answer the questions in the activity described below:
   - Safety: What is the signal word? What PPE is required? What are first aid instructions in the event of an exposure?
   - Chemical use: What crops can the chemical be used on? What pests will be treated?
   - Application: How is the chemical applied? How soon until harvest can the chemical be applied?
   - Environmental effects/considerations: What are environmental hazards? What are the effects on wildlife?
3. Provide students with two different pesticide labels. A suggestion: Print one organic and one non-organic pesticide label for students to be able to compare and contrast. Use the Jigsaw Method to divide students into five separate teams to study parts of a pesticide label(s). Have each group of students answer questions about <u>one</u> topic below for both pesticides:
   - Safety: What is the signal word? What PPE is required? What are first aid instructions in an exposure?
   - Chemical use: What crops can the chemical be used for? What pests will be treated?
   - Application: How is the chemical applied? How soon until harvest can the chemical be supplied?
   - Environmental effects/considerations: What are environmental hazards? What are the effects on wildlife?
   - MSDS Sheets: What does this tell you? Why is it important to have accessible by applicator?
4. Have groups share their answers.

Evaluation:

1. Provide the students with a pesticide label for an insecticide that is made to mimic nicotine.
2. Ask students to complete the *Pesticide Labels and PPE Worksheet*.

Pesticide Labels and PPE Worksheet

1. **Safety:** What is the signal word? What PPE is required? What are first aid instructions in the event of an exposure?

2. **Chemical use:** What crops can the chemical be used for? What pests will be treated?

3. **Application:** How is the chemical applied? How soon until harvest can the chemical be applied?

4. **Environmental effects/considerations:** What are environmental hazards? What are the effects on wildlife?

Pest Management Safety

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. Describe what a pesticide is.

2. Name two safety items you may need when using pesticides.

3. Name two signal words.

Genetically Modified Plants: Integrated Pest Management Part 3

Brief Description:

Genetically Modified Organisms, or GMOs, are a very hot topic, but how much do you really know about the science behind them? Through science, farmers have been able to reduce the amount of pesticides used, increase yields and improve flavor. This lesson will explore what a GMO is and why we are using them in today's agriculture.

Objective:

Students will:

1. Be guided in a conversation about genetically modified organisms, ethics and decision making, educating themselves on a topic and analyzing the issues.

Time:

Introduction: 30 to 50 minutes
Activity 1: 50 to 75 minutes
Activity 2: 60 to 120 minutes, depending on how much in-class time is given for writing

Vocabulary:

claim, cloning, ethics, fact, genetically modified organism, genetically modified plant as a pesticide, genetically modified plant for higher plant quality and transgenic organism

Background:

What is a Genetically Modified Organism?
From http://www.bt.ucsd.edu/gmo.html University of California San Diego

When a gene from one organism is purposely moved to improve or change another organism in a laboratory, the result is a genetically modified organism (GMO). It is also sometimes called "transgenic" for transfer of genes.

There are different ways of moving genes to produce desirable traits. For both plants and animals, one of the more traditional ways is through selective breeding. For example, a plant with a desired trait is chosen and bred to produce more plants with the desirable trait. More recently, with the advancement of technology, another technique has been developed. This technique is applied in the laboratory where genes that express the desired trait are physically moved or added to a new plant to enhance the trait in that plant. Plants produced with this technology are transgenic. Often, this process is performed on crops to produce insect or herbicide resistant plants, and they are referred to as Genetically Modified Crops (GM crops).

Genetically engineered products are not new. Insulin used in medicine is an example of genetic engineering; the insulin gene from the intestines of pigs is inserted into bacteria. The bacterium grows and produces insulin; this insulin is then purified and used for medical purposes. Thyroid hormones, until recently, were derived only from animals; now the hormone can be cultured from bacteria. Other genetically engineered products include the chemical Aspartame used in sugar-free foods, and the drug used for the hepatitis B vaccine.

Genetically Modified Organisms (GMOs) as pesticides:
The recent public awareness about GMOs and no-label-necessary has sparked many debates. Most GMOs in food crops include inserted genes for resistance to the weed killer (herbicide) Round-up™ or the gene for the Bacillus thuringiensis toxin (Bt toxin). Fields of plants containing the "Round-up ready" gene can be sprayed for weeds without harming the crop. This keeps weeds down, which compete with crops and can harbor insects, requiring additional pesticides. Common crops containing the Round-up ready gene are alfalfa, canola, corn, cotton, sorghum, soybeans, sugarbeets and wheat. The Bt toxin is produced naturally from the bacteria Bacillus thuringiensis. This toxin affects the ability of caterpillars to digest food and leads to their death. Common crops containing the Bt toxin gene are corn, potato and cotton. Plants containing this gene would not need pesticides that target caterpillars.

Genetically Modified Organisms in plant breeding:
It is common for plant breeders to identify a gene for a desirable characteristic such as flavor, fungal resistance, shelf life, or skin texture in a plant that has other undesirable characteristics that make it a poor choice for growing commercially. For example, the fruit may have a great flavor, but a short shelf life. If the breeder can identify the gene that causes great flavor, and adds it to a fruit with long shelf life, then the result would be a great tasting fruit with a long shelf life. First, the breeder identifies a desirable gene. Next, the breeder isolates the gene and makes copies of the gene. Then, using biotechnology techniques, the breeder can insert the gene into another variety of fruit (transgenic), one that is currently on the market, to improve fruit quality.

*Throughout this lesson reinforce the importance of a science-based, reputable source. There is as much incorrect information as there is correct information. This is a scientific subject, not an emotional one.

Suggested websites for research:

- http://www.nytimes.com/2016/05/18/business/genetically-engineered-crops-are-safe-analysis-finds.html?_r=0
- http://www.ers.usda.gov/media/1282246/err162.pdf
- http://learn.genetics.utah.edu/content/science/gmfoods/
- http://isaaa.org/resources/publications/pocketk/1/default.asp

Introduction:

1. Introduce the topic of genetically modified organisms. Discuss with students what they are and why they are produced, keeping opinion out of the discussion.
2. Introduce the concept of gene insertion with one of the following videos. For an animation of gene insertion, view: https://www.dnalc.org/view/15476-Mechanism-of-Recombination-3D-animation-with-with-basic-narration.html. For more information on gene mutation view Bozeman Science video: https://www.youtube.com/watch?v=eDbK0cxKKsk&t=223s.
3. After showing the video, explain to students that gene insertion is part of genetically modifying organisms. Ask students, "What are some reasons for modifying a plant?" *Possible answers could be: GMO as a pesticide or GMO in plant breeding.*

Activity 1:

1. Discuss with students the definition of scientific fact and claims. Ask students to give examples of each, and relate them back to the definitions.
2. Separate students into groups of three. Each group will need access to the internet.
3. Each student needs a copy of the *Evaluating Claims about GMOs Worksheet.*
4. Each group will put the phrase "Genetically Modified Organism" into the search field. They will choose five webpages to quote. At least two websites need to be .edu or .gov. Remind students they should find agriculture-related GMO articles or websites.
5. Each group will write down a statement from the website next to Statement 1 and fill out the information below. Repeat for all five websites.
6. Have each group present one statement they think is a scientific fact and one statement they think is a claim. As a class ask, "Was this group correct? Was that a claim or proven fact?"
7. Continue the discussion with students using *Group Discussion Questions*. You can have the students research the answers as an assignment or discuss as a class. The discussion will lead into the essay assignment.

Activity 2:

1. Students will be researching and writing an opinion essay.
2. Each student needs the *GMO Essay Worksheet*. Students will write an essay about their opinion about using GMOs. Students can use the *GMO Essay Worksheet* for guidance.

Activity 3:

1. Students now have a better understanding of how GMOs are used in agriculture and the important role they play.
2. Put students into groups of three and inform them that they are going to be designing a public service announcement campaign.
3. The average American consumer does not understand the science behind GMOs and therefore assumes they are unsafe. You have discovered in Activity 1 that social media and the Internet do not always state fact. Your job is to design a public service announcement to convey truths about GMOs and why they are necessary for our growing population.
4. Once you have designed your approach you will submit it to your teacher for approval. You will redesign it if necessary.
5. As a group you will create a poster that will educate the "average" American and present it to the class.
6. If allowed, the cafeteria is a great place to hang the posters.

Evaluation:

1. Grade groups based on completion of *Evaluating Claims about GMOs Worksheet* and cooperation as a group.
2. Essays are graded by support of the opinion and structure of the essay, not the actual opinion. Encourage students to not worry about right or wrong. They can even write the essay opposing their true opinion.
3. Grade groups based on completion and accuracy of their public service announcement posters.

Evaluating Claims about GMOs Worksheet

Choose Five statements from the web search and evaluate.

Statement 1:
Made by:
Website = .com, .edu, .gov, .org etc.:
Claim or Fact?
What motives may this person or entity have?

Statement 2:
Made by:
Website = .com, .edu, .gov, .org etc.:
Claim or Fact?
What motives may this person or entity have?

Statement 3:
Made by:
Website = .com, .edu, .gov, .org etc.:
Claim or Fact?
What motives may this person or entity have?

Statement 4:
Made by:
Website = .com, .edu, .gov, .org etc.:
Claim or Fact?
What motives may this person or entity have?

Statement 5:
Made by:
Website = .com, .edu, .gov, .org etc.:
Claim or Fact?
What motives may this person or entity have?

Group Discussion Questions

1. What kind of research has been conducted to evaluate the safety of GMO food?
2. What government agencies have approved GMO food and feed for human and animal consumption?
3. Just because we can do something, should we?
4. How can we do it correctly and safely?
5. What are the issues of ethics with respect to GMOs?
6. How do other countries feel about GMOs (European countries, Haiti, China)?
7. What are the conflicts in patenting a gene and the concept of owning life?
8. If GMOs reduce pesticide use, why are people not more supportive?
9. How could GMOs serve to end hunger?
10. What if GMO pollen from Bt plants spread to plants nearby? How do we evaluate the effect on wildlife?
11. Should GMO food be labeled as such?
12. How have GMO vegetables helped supply desirable fruit all year round?
13. Should we value species integrity (the organism is essentially the same species after the new gene is added)?

GMO Essay

1. Using your class notes, make a list of the positive things about GMO crops.
2. Using your class notes, make a list of the negative things about GMO crops. Make sure to separate feeling from scientific evidence. For example, "GMO food is unhealthy" – Is there scientific proof of that, or is that just a feeling. ***Answer:*** *Feeling. There is now scientific proof they are just as healthy as non-GMO food.*
3. What do you think? Choose a question to answer:
   a. Should we create GMO food?
   b. Should we label GMO food?
   c. Should we label meat and dairy products that come from GMO-fed animals?
4. Choose a position and support the opinion with three pieces of evidence.
   Yes, because 1, 2, 3.
   No, because 1, 2, 3.

<u>Introduction (Five sentences)</u>
"Hook"
Describe GMO crops
Introduce thesis statement
Thesis statement

<u>Support Paragraph 1 (Four sentences)</u>
Topic sentence, 1st support of thesis
Detail
Closing sentence

<u>Support Paragraph 2 (Four sentences)</u>
Topic sentence, 2nd support of thesis
Detail
Closing sentence

<u>Support Paragraph 3 (Four sentences)</u>
Topic sentence, 3rd support of thesis
Detail
Closing sentence

<u>Conclusion (Four sentences)</u>
Restate thesis
Summarize supports
Closing essay

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Florida Irrigation

Brief Description:

This lesson and associated experiments will introduce students to the reasons why irrigation is needed to feed the world and the different types of irrigation being used.

Objective:

Students will be able to:

1. Learn about some of the unique characteristics of rainfall in Florida.
2. Explore the different types of irrigation practices.
3. Create their own drip irrigation system.

Materials:

- PowerPoint presentation software
- Projector/Smart-board
- Activity Sheets
  - Materials for each activity are listed out on the sheets

Time:

Two to three 45-minute class periods

Vocabulary:

aquifer, best management practices (BMP), drip irrigation, control valve, fertigation, fittings, flow, flow meter, irrigation, precipitation, pressure and pressure regulator

Background:

Taken from USGS Water School (http://water.usgs.gov/edu/wuir.html)

Throughout the world, irrigation (water for agriculture or growing crops) is probably the most important use of water (except for drinking and washing a smelly dog, perhaps). Estimates vary, but about 70 percent of all the world's freshwater withdrawals go toward irrigation uses (http://www.globalagriculture.org/report-topics/water.html). Large-scale farming could not provide food for the world's large populations without the irrigation of crop fields by water gotten from rivers, lakes, reservoirs and wells. Without irrigation, crops could never be grown in the deserts of California, Israel or my tomato patch.

Irrigation has been around for as long as humans have been cultivating plants. Man's first invention after he learned how to grow plants from seeds was probably a bucket. Ancient people must have had strong backs from having to haul buckets full of water to pour on their first plants. Pouring water on fields is still a common irrigation method used today—but other, more efficient and mechanized methods are also used. One of the more popular mechanized methods is the center-pivot irrigation system, which uses moving spray guns or dripping faucet heads on wheeled tubes that pivot around a central source of water. The fields irrigated by these systems are easily seen from the air as green circles. There are many more irrigation techniques farmers use today, since there is always a need to find more efficient ways to use water for irrigation.

When we use water in our home, or when an industry uses water, about 90 percent of the water used is eventually returned to the environment where it replenishes water sources (water goes back into a stream or down into the ground) and can be used for other purposes. But of the water used for irrigation, only about one-half is reusable. The rest is lost by evaporation into the air, evapotranspiration from plants, or is lost in transit, by a leaking pipe, for example.

Florida Standards:

SC.6.E.6.1, SS.6.G.3.1 SC.7.N.1.1, SC.7.L.17.3, SC.8.N.1.1, SC.8.N.4.2, SC.912.E.7.1, SC.912.L.17.1, SC.912.L.17.12, SC.912.L.17.15, SC.912.L.17.16, SC.912.L.17.17

Introduction:

1. Teach the PowerPoint (found at www.faitc.org/teachers/STEMming-Up) in class to ensure students understand rainfall, soil irrigation and its importance in agriculture.

Activity 1:

1. Students will conduct a soil moisture experiment to show the importance of controlled irrigations.
2. See *Soil Moisture Experiment* handout for instructions, materials and discussion questions.

Activity 2:

1. Students will conduct a drip irrigation experiment to demonstrate irrigation in action.
2. See *Drip Irrigation Experiment* handout for instructions and materials.

Activity 3:

1. Students now have a basic understanding of how water moves through soil and how to set up drip irrigation. It is time to design. Problem - The school garden does not have irrigation.
2. Have students measure the current school garden or the area where the school garden will be placed to determine the square footage.
3. Once the square footage of the garden is determined, students will work in groups to design an irrigation plan and devise the most cost effective form of drip irrigation. Designs and cost estimates have to be turned into the teacher for approval.
4. Students will set up the garden and test the effectiveness of the irrigation by setting up a soil moisture test in multiple points in the garden.

Evaluation:

1. Grade students on cooperative group work for Soil Moisture and Drip Irrigation experiments.
2. Grade students on thoroughness and effectiveness of garden irrigation design.

Soil Moisture Experiment

Objectives:
Students will learn about the importance of controlled irrigation.

Materials:
- Dry sponges (two per set of students)
- Dixie cups (two per set of students)
- Small spray bottles (one per set of students)
- Measuring cups (optional)
- Water
- Aluminum baking pans (one per set of students)
- Book
- Markers
- Ruler

Procedure:
1. Divide the students into pairs and pass out the materials.
2. Have the students use a ruler to draw lines every half inch on the Dixie cups and fill them equally with water. Make sure the students note how much water is in both cups (i.e., two inches of water).
3. Place one edge of the pan on the book, so that it tilts to one side.
4. Place one of the dry sponges on the elevated side of the pan.
5. Take the Dixie cup of water and pour all of the water on top of the sponge.
6. Have the students work together to pour the water that has collected in the low side of the pan back into the Dixie cup.
7. Have the students make observations about what happened with the first sponge.
8. Now, ask the students to replace the first sponge with the dry sponge.
9. Pour the other cup of water into a spray bottle and use the bottle to spray the water onto the new sponge.
10. Once the students have used all of the water from the spray bottle, have them repeat the step of collecting the water at the lower side of the pan and measuring the water.
11. Have the students compare the results from both of the sponges and methods for distributing the water.

Discussion Questions:
1. Why do you think the water was absorbed so quickly?
2. Give an example of how this experiment would appear in nature.
3. What would happen if you had applied fertilizer to the first sponge?

Drip Irrigation Experiment

Adapted from TinkerCrate: https://www.youtube.com/watch?v=aUUcq-DGKPQ

Objectives:
Students will create their own drip irrigation systems in the classroom and begin growing plants from seeds to take home.

Materials:
- Water bottles (one per three to four students)
- Peat pots (pack of 26 is $2 at local hardware/garden stores)
- Seeds (herbs, flowers, vegetables)
- Plastic tubing
- Pushpin
- Scissors
- Planting soil
- Clay
- Water
- Syringe
- Plastic cups (10 ounce)
- Markers
- Small binder clips

Procedure:
1. Cut a 18- to 24-inch length of tubing and a hole in the top of the water bottle, large enough so the tubing can be put inside of the bottle. Set these aside for now.
2. Put together the plant pots. Attach a small binder clip to the edge of a plastic cup.
3. Put one of the peat pots inside the plastic cup and fill the peat pot with soil (about a little more than half full).
4. Make sure to follow the instructions for planting the individual seeds your class/students have chosen to grow.
5. Stretch out the tubing in front of the cups and poke a hole in the tubing with the pushpin. Make sure not to push the pin all the way through the tubing.
6. Fill the water bottle with water and put one end of the tubing into the bottle. You can seal this opening using some clay. Thread the other end of the tubing through the opening of the clips, making sure that the holes in the tubing line up over the plants.
7. Using a syringe, place it at the end of the tubing (not in the bottle) and pull water into the tube until it is outside of the bottle and has started down the curve. Water should begin to flow through the rest of the tube. Remove the syringe and use clay to stop up the end of the tubing.
8. Water should slowly drip from the tubing and into the pots. If not, use the pushpins to make the hole slightly bigger.

Florida Irrigation

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. Define irrigation.

2. Name two types of irrigation.

3. How is rainfall important to irrigation?

4. What is an aquifer?

5. How does the soil type/texture affect the type of irrigation needed?

Improving Mother Nature: Maximize Storm Water Runoff for Irrigation

Brief Description:

In this lesson, students will learn about the specific needs of plants, design a rainwater irrigation system and test the effectiveness of the system. A standard plot of garden plants will be exposed to the rain water delivery systems designed by students. Students will then measure the growth of their plants irrigated by different systems.

Objective:

Students will be able to:

1. Use scientific techniques to determine the effectiveness of rain delivery systems by measuring plant growth.
2. Apply measurement techniques, evaluate data, make comparisons and report on the implications based on their results.

Time:

Introduction: 30 minutes
Activity 1: 60 minutes
Activity 2: 120 minutes
Activity 3: 30 minutes
Activity 4: Depends on if in-class or at-home assignment

Materials Needed:

The supplies needed for this activity will vary from project to project. Below is a list of useful items students might want to obtain. Recycled or upcycled materials should be used whenever possible. Hardware stores often offer donations for school garden projects.

- Plastic containers (milk jugs, juice containers, salad containers, soda bottles, laundry soap containers, etc.)
- PVC pipe
- Plumbers tape
- Funnels
- Duct tape
- Nails
- Screws
- Garden string
- Gravel
- Hoses
- Tubing
- Zip ties
- Wicking material (cotton, twine, felt)
- Plastic net baskets
- Rain gutters
- Garden stakes
- Plastic bags
- Buckets
- Plastic/wooden/metal barrels/tanks
- Soil
- Plastic straws
- Screens (for filtering)
- And any other landscaping materials available to improve aesthetics and elevate apparatus to allow for gravitational design enhancements
- For advanced projects, consider plumbing supplies as well

Chapter 3: STEMming Up Your Garden Lessons

Florida Standards:

SC.912.N.1.1, SC.912.N.1.3, SC.912.N.1.4, SC.912.N.1.6, SC.912.N.1.7, SC.912.N.3.5, SC.912.E.6.6, SC.912.E.7.1, SC.912.L.14.7, SC.912.L.14.53, SC.912.L.17.16, SC.912.L.17.17, SC.912.L17.20, SC.912.L.18.2, SC.912.L.18.7, SC.912.L.18.12, SC.912.L.18.7. (SC.7.N.1.3, SC.7.N.1.4, SC.8.L.18.1, SC.8.N.1.2, SC.8.N.1.3, SC.8.N.1.4), LAFS.910.RST.1.3, LAFS.910.WHST.2.6, LAFS.910.WHST.3.7, LAFS.910.WHST.3.8, LAFS.910.WHST.4.10, LAFS.1112.RST.1.3, LAFS.1112.WHST.2.6, LAFS.1112.WHST.3.7, LAFS.1112.WHST.3.8, LAFS.1112.WHST.4.10 (LAFS.68.RST.1.3, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, LAFS.68.WHST.3.8, LAFS.68.WHST.4.10)

Tools:

Scissors, power drill, screw driver, saw, shovels, rake and hammer

Preparation:

- Determine the resources available for this activity. Will this be implemented on an existing school garden? Will temporary containers be used or will the school grounds be altered? What supplies, technology and donations are available? Can other departments such as physics, engineering or vocational be involved? If the Water Quality Extension Activity is implemented, how will the water quality tests be performed and paid for?
- Solicit students and parents as soon as possible for supplies: hoses, tubing, PVC pipe, plastic containers, other recyclables (egg cartons for seeds, salad containers, plastic milk jugs, or others scrap items for decoration).
- Determine the type of plant(s) you will be using for this activity (see Considerations and Safety Guidelines if a food crop will be used).

Background:

Difficulties in gardening are diverse, but the challenge of irrigation is foremost in planning and maintaining crops. Besides the challenge of delivering water to plants, fresh water is a valuable resource that must be conserved whenever possible. Maximizing rainwater runoff for irrigating plants saves money, reduces the runoff into storm water systems and conserves fresh water. School buildings are equipped with rainwater diversion systems, which can be converted into an irrigation system for a garden. Designs for rainwater irrigation will focus on recycling/upcycling scrap materials and can range from a simple tube adjacent to a drain pipe or more complicated tanks storing runoff for future use. The data on the effectiveness of the different systems will be collected over a month (or more) and the most effective system will be determined. Students will present their findings in a formal lab report which includes graphical data, comparisons between irrigation systems, and an analysis focusing on conservation of resources and the long-term recommendations for the irrigation systems of the school garden.

Considerations and Safety Guidelines:

No alterations should be made to school property (even temporary) without first gaining permission from school administration and grounds maintenance personnel. When using recycled/upcycled materials, ensure proper sanitary measures are taken and none of the materials are procured from unsafe or unsanitary conditions. Additionally, if these techniques are to be implemented on food crops, students and teachers should carefully read *Rain Barrels Part IV: Testing and Applying Harvested Water to Irrigate a Vegetable Garden*, published by Rutgers, the State University of New Jersey (2013) and make proper determinations (see also Water Quality Extension Activity*). If water quality is questionable, use decorative non-food plants for this experiment. Students can design a rainwater catch system that does not come from any school structure roofs.

Introduction:

Introduce the project to the students and provide examples to get them interested in what they will be doing. Small scale examples can be brought into the classroom, students can read articles, or the class can be shown a video. If there is a school garden on site, ensure students are familiar with its location and proximity to drain spouts. There are numerous YouTube videos and instructional websites but below are a few examples:

Video examples:
This Old House rain collections installation: http://www.thisoldhouse.com/toh/video/0,,20794278,00.html
Rain Gutter Grow System: https://www.youtube.com/watch?v=GRQzhFBCot4
Rain barrel collection system: http://www.grownyc.org/openspace/rainwater-harvesting

Web articles:
'Gardening with Rainwater': http://www.bbg.org/gardening/article/gardening_with_rainwater
'How to Harvest Rainwater': http://www.gardengatemagazine.com/52droughttolerant/

Activity 1: Background Knowledge

1. Discuss with the class, plant structure and function. Use the *Plant Anatomy and Physiology Background Worksheet* to enable the students to organize this information. Depending on the scope and sequence of a particular county, this material will consist of some review and some new material for a biology or environmental science class. Students should work in groups to complete as much as possible on their own following a lecture, reading, or video.

Plant structure video:
https://www.youtube.com/watch?v=zHp_voyo7MY

Capillary action videos:
https://www.youtube.com/watch?v=y-h_qGhgtno,
https://www.youtube.com/watch?v=VXo-wLR8Aic

Plant Nutrition and Transport:
https://www.youtube.com/watch?v=bsY8j8f54I0

Activity 2: Research and Planning

1. Place students into groups. Each group will construct a small container self-watering system as shown in the pictures below. This will give students an idea of what is needed when designing their own system. Note: You can give the students the supplies and let them design their own small-scale self-watering system, but this activity is just to give them an idea of possible larger versions.
2. In groups give students time in class to research and plan their own designs for rainwater irrigation systems.

Improving Mother Nature: Rainwater Irrigation System Proposal is a suggested format for students to organize their plan. By the end of this activity they should have established the following:

- Type of plant(s) they will be using
- A hypothesis stating how they think their system will aid in plant growth
- Location and scale of irrigation system (small containers or large systems using school roof run off)
- Supplies they will need to build their system and how they will obtain their supplies

Figure 1: Supplies for a small scale container planter: strawberry baskets, seeds, three salad containers, scissors, marker, cheese cloth and twine. Not pictured are the green straws used to connect the wicking twine from the reservoir container to the plant container.

Figure 2: Assembled system has twine woven in the basket under the cheese cloth and up into the basket to serve as an automatic watering system.

Figure 3: Upper container serves as the catchment from a spout. A large hole in the lid below allows water to drain from the catchment which has small holes to filter debris.

Figure 4: Soil and seeds have been added to the baskets.

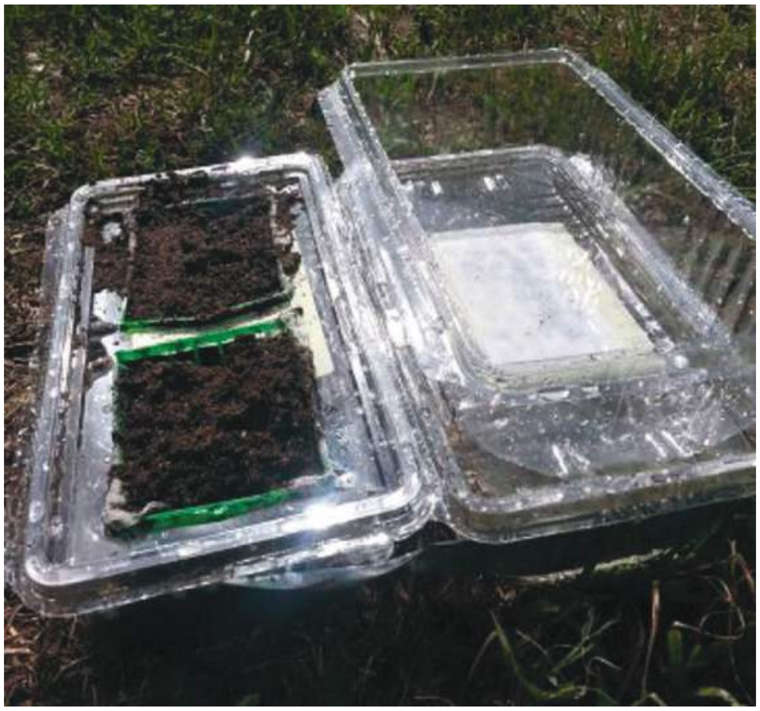


Figure 5: Water is poured into the catchment to ensure proper operation.

Figure 6: Seeds have sprouted and growth can be measured

- A diagram or model of their system
- A procedure for setting up their system and measuring the growth of their plants
- A schedule and data table for their measurements
- Description of methods for control comparison
- List of safety precautions

Activity 3: Construction

1. After the design has been approved, instruct the students to assemble their systems in class or at the locations where they will be implemented.
2. Have students bring extra supplies and tools in case they need to modify their irrigation systems.
3. Provide students with access to water so they can test the functionality of their design.
4. If they need to make modifications, remind them to update their proposal diagram, procedure and material list to reflect their modifications.
5. Ensure the control replicates are established at the same time and given the same amount of water as the experimental ones.
6. Instruct the students to take initial measurements of their plants (if seedlings are used). If they are planting seeds, wait until they have sprouted and the students have something to measure.

Data Collection Recommendations:

1. Control replicate plants can be used for more than one group of students. These plants should be in the same location as the experimental plants but with no rain water irrigation system applied. If the test plants are in a container then the control plants should be in a similar container. If test plants are in the ground then control plants should also be in the ground in a similar location.
2. When taking measurements of plant growth, students can use a piece of string to trace the length from the base of the stem above ground to the tallest/longest portion of the plant. They will then measure the string to ensure accuracy and minimize damage to the plant.
3. Weather conditions should be noted so students can analyze their results based on weather patterns.
4. The data collection frequency will vary depending on the type of plant and if they started as seeds or small plants. Depending on how fast the plants grow, data collection will be more or less frequent. Suggested collection times might be the last 20 minutes of class every Friday.
5. Each group member needs to keep a copy of the data sheet. If a person is absent, the other members of the group should still be able to collect data.

Activity 4: Report Writing

1. The students' final product will be a report comparing the growth of their experimental plants to the growth of the control as well as the growth of the other groups' plants. When data collection has finished, each group will share their results with the class and create a lab report on their findings. The reports should include:
   - **Hypothesis:** An hypothesis indicating how their irrigation system will aid in plant growth.
   - **Materials:** A list of all materials used.
   - **Procedure:** A detailed, step-by-step procedure of their experiment.
   - **Data:** A data table of the experimental and control plant measurements, and a line graph comparing the experimental and control plants' growth. Data tables and graphs comparing the plant growth of each group. Replicate plant growth measurements should be averaged.
   - **Results:** A description of the results indicating how the experimental plant growth compares to that of the control as well as comparisons between different irrigation systems.
   - **Analysis:** Using reference material, the results should be explained and rationalizations for outcomes should be made based on research data and the obtained experimental data.
   - **Discussion:** Students should make recommendations for improving their designs and indicate large-scale benefits of using recycled materials to conserve natural resources.
   - **References:** All resource material should be cited in APA format including in-text citations.

Water Quality Extension Activity:

When food plants are used, water quality issues must be considered. It has been determined that toxic substances may be present in rainwater runoff from roofs and other surfaces (Bakacs, et al., 2013).

This presents an opportunity for students to learn about the importance of water quality. This extension would be ideal to conduct along with irrigation system experiments or on an existing rainwater reclamation system. Opportunities for advanced science fair projects focusing on risk assessment could be implemented by students. The EPA published guidelines for water reuse in EPA, Guidelines for Water Reuse 2012. These guidelines include acceptable limits for toxicants and recommendations for filtering and safety.

Considerations and Safety Guidelines:

Fecal coliform tests must be performed within eight hours of collection for accurate results. Schools equipped with microbiology labs would be ideal to analyze samples. Alternatively, samples could be transported to a local college microbiology lab for analysis. If samples are not analyzed by the school or a collaborating college, they could be sent to a private lab. However, the cost for a private lab analysis is substantial and fecal coliform samples would have to be hand delivered.

Once toxicity levels of rainwater are determined, students could use the EPA guidelines to make recommendations for filtration systems and advise the school on the use of rainwater for food plants. A study of this nature would be at a college or professional level.

Extension Activity Resources:

- Commercial labs in FL: http://www.flenviro.com/fsestemp3.html
- EPA Guidelines for Water Reuse: http://www.lacsd.org/civicax/filebank/blobdload.aspx?blobid=2184
    - EPA documents online: http://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf

Extension Activity Standards:

- SC.912.N.1.1, SC.912.N.1.3, SC.912.N.1.4, SC.912.N.1.6, SC.912.N.1.7, SC.912.N.3.5, SC.912.L.17.13, SC.912L.17.14, SC.912.L.17.15, SC.912.L.17.16, SC.912.L.17.17, SC.912.L.4.1, SC.912.4.2, SC.912.P.8.11, SC.912.P.8.13, SC.912.P.8.7, SC.912.P.8.9.

References:

Bakacs, M., Haberland, M., & Yergeau, S. (2013, December). Rain Barrels Part IV: Testing and Applying Harvested Water to Irrigate a Vegetable Garden. Retrieved from https://njaes.rutgers.edu/pubs/fs1218/

Improving Mother Nature: Maximize Storm Water Runoff for Irrigation

Sample Pre-Post Test Assessment

Directions: Choose the best answer for each of the questions below.

1. In order to make a determination about the effectiveness of a garden system, which of the following should take place?
   a. Different methods of gardening are implemented and the best looking system is considered the most effective.
   b. Data in the form of measurements collected over time is compared and a determination about the effectiveness of a system is made based on the results.
   c. Students and teachers vote on the garden system they think is the most effective and the one with the most votes will be determined to be the best.
   d. The system that is the cheapest will be considered the most effective because cost is always an issue.

2. Which of the following statements correctly describes the function of the transport system in plants?
   a. The transport system in plants moves water and nutrients throughout the plant's structure to facilitate growth.
   b. The transport system in plants moves water only to the leaves.
   c. The transport system in plants moves nutrients only from the roots to the rest of the plant.
   d. The transport system in plants moves sunlight from the leaves to the roots.

3. The general formula for photosynthesis is:
   a. sunlight + water + carbon dioxide -→ oxygen + methane
   b. sunlight + water + carbon dioxide -→ oxygen + water
   c. sunlight + nitrogen + carbon dioxide -→ oxygen + sugar
   d. sunlight + water + carbon dioxide -→ oxygen + sugar

4. Chose the phrase below that correctly describes the movement of water through plants.
   a. Active transport moves water from the leaves to the stems.
   b. Diffusion is the movement of water from the leaves to the atmosphere.
   c. Water moves through osmosis into the roots and through capillary action is transported to the rest of the plant.
   d. Osmotic pressure is only present when nutrients are not present in the soil.

5. The cells of a plant are rigid due to the presence of water. Chose the term describing this.
   a. Osmotic pressure
   b. Active transport
   c. Photosynthesis
   d. Transpiration

Plant Anatomy and Physiology Background Worksheet

Name ____________________

Plant Structure:

1. What are the three principal organs of plants?

   a. __________________________ b. ______________________________ c. ________________________________

Stem Structure and Function:

2. What are the two important functions of stems?

   a. __________________________ b. ______________________________

3. What is transpiration?

4. What does the transport system of stems do?

Roots:

5. Circle the letter of each sentence that is true about a function that roots perform.
   a. They anchor plants in the ground.
   b. They compete with other plants for sunlight.
   c. They absorb water and nutrients from soil.
   d. They hold plants upright.

6. Water enters the plant through the large **surface area** provided by the ________________________

7. What are two functions of a plant's roots?

   a. ____ b. ____

8. True or False? The ingredients of a soil can determine what kinds of plants grow in it.

9. Circle the letter of each sentence that is true about **active transport** of minerals in roots.
   a. Water molecules move into the plant by active transport.
   b. ATP is the source of energy used to pump mineral ions from the soil into the plant.
   c. The cell membranes of root hairs contain active transport proteins.
   d. Using active transport, a root actually pumps water into the plant.

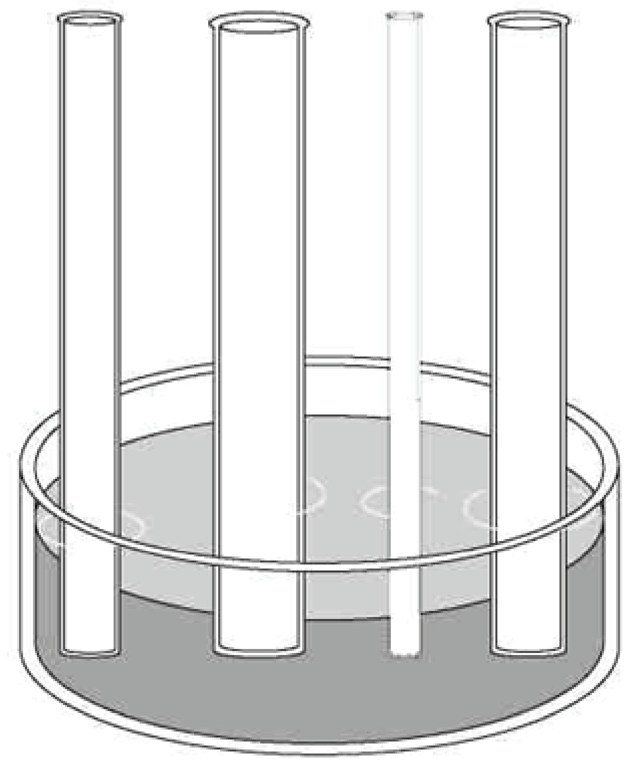
Transport in Plants - Water Transport:

10. How can water move from the roots to the rest of the plant?

11. What combination of factors provides enough force to move water through the tissue of even the tallest plant?

12. The tendency of water to rise in a thin tube is called ________________________

13. How does the thinness of a tube affect how high water will rise because of **capillary action**? Show your answer by drawing how high water would rise in each of the tubes on the illustration.



14. What keeps a plant's leaves and stems rigid?

____

15. How does the loss of **osmotic pressure** in leaves slow down the rate of transpiration?

Leaves and Nutrient Transport:

16. The principal organs in which plants carry out **photosynthesis** are the ____________________

17. How do the carbohydrates produced in photosynthesis get to the rest of the plant?

18. How is the water content of a leaf kept constant?

Define the following vocabulary terms:

19. **surface area**

20. **active transport**

21. **capillary action**

22. **osmotic pressure**

23. **photosynthesis**

24. Draw and label a diagram of a plant including **roots**, **leaves** and **stems**. Use a blue arrow to show how water moves from the soil into the plant. Use a red arrow to show how carbohydrates created during photosynthesis move from the leaves to the rest of the plant.

Plant Anatomy and Physiology Background Worksheet: Answer Key

Plant Structure:

1. What are the three principal organs of plants?
   a. **Roots** b. **Stems** c. **Leaves**

Stem Structure and Function:

2. What are the two important functions of stems?
   a. **Transport materials throughout the plant** b. **Hold the leaves up to the sun**

3. What is transpiration?
   Loss of water from the leaves of the plants through evaporation, helping to cool the plant

4. What does the transport system of stems do?
   Moves water and nutrients from the roots to the rest of the plant

Roots:

5. Circle the letter of each sentence that is true about a function that roots perform.
   (a.) They anchor plants in the ground. b. They compete with other plants for sunlight.
   (c.) They absorb water and nutrients from soil. (d.) They hold plants upright.

6. Water enters the plant through the large **<u>surface area</u>** provided by the **roots**

7. What are two functions of a plant's roots?
   Anchoring to the ground, food storage, nutrient and water absorption

8. True or False? The ingredients of a soil can determine what kinds of plants grow in it. **True**

9. Circle the letter of each sentence that is true about **<u>active transport</u>** of minerals in roots.
   (a.) Water molecules move into the plant by active transport.
   (b.) ATP is the source of energy used to pump mineral ions from the soil into the plant.
   (c.) The cell membranes of root hairs contain active transport proteins.
   (d.) Using active transport, a root actually pumps water into the plant.

Transport in Plants - Water Transport:

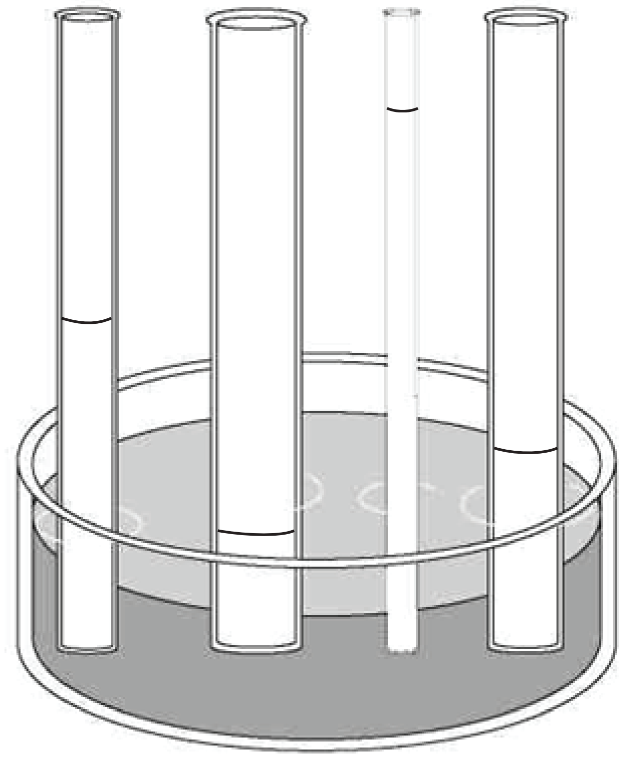
10. How can water move from the roots to the rest of the plant?
    Capillary action combined with active transport causes water to move from the roots to the rest of the plant

11. What combination of factors provides enough force to move water through the tissue of even the tallest plant?
    Water cohesion and adhesion

12. The tendency of water to rise in a thin tube is called **<u>capillary action</u>**

Chapter 3: STEMming Up Your Garden Lessons

13. How does the thinness of a tube affect how high water will rise because of **capillary action**? Show your answer by drawing how high water would rise in each of the tubes on the illustration.



14. What keeps a plant's leaves and stems rigid?
    osmotic pressure

15. How does the loss of **osmotic pressure** in leaves slow down the rate of transpiration?
    With less pressure from water at the surface of the leaves, less water will evaporate

Leaves and Nutrient Transport:

16. The principal organs in which plants carry out **photosynthesis** are the
    leaves

17. How do the carbohydrates produced in photosynthesis get to the rest of the plant?
    Active transport

18. How is the water content of a leaf kept constant?
    Active transport in the roots and transpiration in the leaves

Define the following vocabulary terms:

19. **surface area** – **the area of a structure in contact with the surrounding environment**

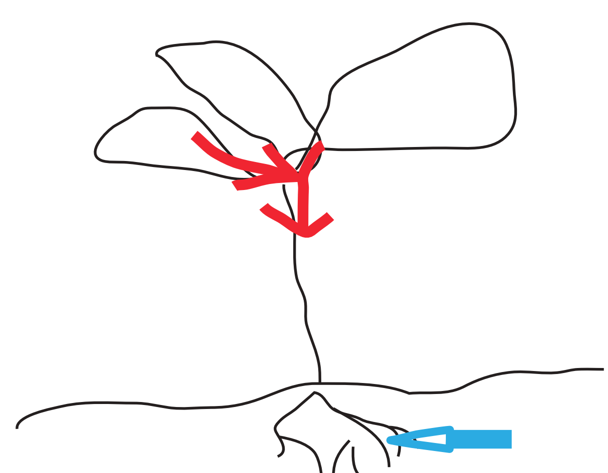
20. **active transport** – **an energetic process (using ATP) that moves ions and nutrients across cell membranes**

21. **capillary action** – **the combination of adhesion and cohesion allowing water to move against gravity through a tube**

22. **osmotic pressure** – **The pressure exerted by water on the cell membrane maintained by the osmotic movement of water form areas of high concentration to areas of low concentration**

23. **photosynthesis** – **The process of transforming carbon dioxide, sunlight, and water into carbohydrates and oxygen**

24. Draw and label a diagram of a plant including **roots**, **leaves** and **stems**. Use a blue arrow to show how water moves from the soil into the plant. Use a red arrow to show how carbohydrates created during photosynthesis move from the leaves to the rest of the plant.



Improving Mother Nature: Rainwater Irrigation System Proposal

Name(s) ___

Plant Information:

Type of Plant(s)	Grown from seed?	Ideal light conditions	Ideal moisture conditions	Number of replicate plants for experiment / control

Hypothesis: How will your rainwater system aid in plant growth?

Test Plot Area Information:

Container?	Size of standard plot (meters)	Approximate hours of sunlight daily	Description of drainage at this location	Soil type (sand, clay, rocky)

List of supplies needed to construct rainwater irrigation system:

Procedure for set up and planting:

Description of control conditions and location:

Diagram (on a separate sheet of paper or on the back of this paper) of irrigation system (include measurements using meters), including drawings of plants.

Growth Data

(attach additional sheets if necessary)

Date / time									
Weather									
Experimental Replicate 1 height (m)									
Experimental Replicate 2 height (m)									
Experimental Replicate 3 height (m)									
Experimental Replicate 4 height (m)									
Experimental Replicate 5 height (m)									
Control Replicate 1 height (m)									
Control Replicate 2 height (m)									
Control Replicate 3 height (m)									
Control Replicate 4 height (m)									
Control Replicate 5 height (m)									

Safety Concerns: When experimenting on food crops, consider water quality issues associated with roof water runoff. Ensure all building materials are sanitary and do not present any hazards. List any precautions necessary for constructing irrigation system (gloves, eye protection, etc.).

STEMming Up Plant Nutrients

Brief Description:

In this lesson students will identify and describe the functions of essential plant nutrients. This material assumes a basic knowledge of plant biological functions and fertilizer. If you feel your students need more background information see: www.nutrientsforlife.org

Objectives:

Upon completion of this lesson students will be able to:

1. Interpret fertilizer labels for proper application
2. Define nutrient leaching
   a. Identify the different categories of fertilizer and how they are relevant to nutrient leaching
3. Define the 4Rs of nutrient stewardship
4. Interpret possible plant nutrient deficiencies based on observable symptoms
5. Diagnose plant nutrient deficiencies
6. Apply the 4Rs of nutrient stewardship
7. Defend their application of the 4Rs of nutrient stewardship using a test garden

Materials:

The supplies needed for this activity will vary from project to project. Below is a list of useful items students might want to obtain. Recycled or upcycled materials should be used whenever possible. Hardware stores often offer donations for school garden projects.

- Copies of blank fertilizer label
- Copies of periodic table
- Bag of fertilizer (check your local feed and farm stores)
- Highlighters or colored pencils
- Fertilizer Labels
- Fertilizer Labels worksheet
- Live plants with different nutrient deficiencies or pictures of nutrient deficient plants (found on page 113)
- IFAS Soil Test Information Sheet and Analytical Services Lab Sheet
  - www.soilslab.ifas.ufl.edu

Time:

This time allotment does not account for the inclusion of the final enrichment activity.

Introduction: 45 minutes or one class period
Activity 1: 45 minutes or one class period
Activity 2: 40 minutes
Activity 3: 50 minutes (time may vary depending on time allowed to percolate)
Activity 4: 90 minutes

Preparation:

Teacher should read and understand all background material before beginning.

Vocabulary:

plant nutrients, 4Rs, fertilizer, nutrient leaching and plant nutrient deficiency

Background:

- Essential Plant Nutrient Functions (Nutrients for Life's Nourishing the Planet in the 21st Century Teacher Background, pp 20-21)
  - Scientists have identified 17 elements essential for plants. An element qualifies as being essential to a plant if the following conditions are met:
    - The element must be required by the plant to complete its life cycle.
    - The element cannot be replaced by another element.
    - The element is required for essential plant functions.
    - The element is required by a substantial number of different plant species.
  - Essential elements can be classified as mineral or non-mineral nutrients. Carbon, hydrogen and oxygen are classified as non-mineral because they are obtained through the atmosphere and water. Mineral nutrients can be further classified as macro or micronutrients. Macronutrients are needed in relatively large amounts. Nitrogen, phosphorus and potassium are called primary macronutrients; while calcium, sulfur and magnesium are called secondary macronutrients. The

Florida Standards:

SC.7.N.1.1, SC.7.N.1.4, SC.7.L.17.3, SC.8.N.1.1, SC.8.N.1.3, SC.912.L.17.1, SC.912.L.17.12, SC.912.L.17.15, SC.912.L.17.16, SC.912.L.17.17, MAFS.7.SP.1.1, MAFS.7.SP.1.2, MAFS.912.S-ID.2.5

remaining essential elements are called micronutrients because they are needed in relatively small amounts. Despite their name, however, micronutrients are just as essential to plant health as macronutrients.

Element Taken into the Plant	Symbol	Classification	Chemical Form
Hydrogen	H	Nonmineral nutrient	H_2O
Oxygen	O	Nonmineral nutrient	O_2 and CO_2
Carbon	C	Nonmineral nutrient	CO_2
Nitrogen	N	Primary macronutrient	NH_4+ and NO_3-
Phosphorus	P	Primary macronutrient	H_2PO_4- and HPO_{42}-
Potassium	K	Primary macronutrient	K+
Calcium	Ca	Secondary macronutrient	Ca_2+
Magnesium	Mg	Secondary macronutrient	Mg_2+
Sulfur	S	Secondary macronutrient	SO_{42}-
Boron	B	Micronutrient	$B(OH)_3$
Chlorine	Cl	Micronutrient	Cl-
Copper	Cu	Micronutrient	Cu_2+
Iron	Fe	Micronutrient	Fe_2+ and Fe_3+
Manganese	Mn	Micronutrient	Mn_2+
Molybdenum	Mo	Micronutrient	MoO_{42}-
Nickel	Ni	Micronutrient	Ni_2+
Zinc	Zn	Micronutrient	Zn_2+

- Fertilizer Labels-
  - The Florida Fertilizer Label- *Information for this section was derived from the edis article (http://edis.ifas.ufl.edu/ss170) unless otherwise stated. (Sartain.J)*
    - Fertilizer is responsible for approximately 50 percent of our world's food production. It is a vital ingredient used to grow strong and healthy plants – both in the garden and in the farm field. The connection between fertilizer and population is evident. As Nobel Peace Prize Winner Dr. Norman Borlaug explains, "This is a basic problem, to feed 6.6 billion people. Without chemical fertilizer, forget it. The game is over." *(Nutrients for Life)*
    - In order to protect its consumers, the Florida legislature enacted the first fertilizer law in 1889. These laws regulate the manufacture and sale of fertilizer in the state of Florida. While each state has autonomy over their fertilizer labeling laws, they must comply with Federal Fertilizer Regulations governed by the Environmental Protection Agency. The Association of American Plant Food Control Officials (AAPFCO) is the national organization of fertilizer control officials from each state, Puerto Rico and Canada responsible for administering fertilizer law and regulation. *(The Fertilizer Institute)*

- Information on the Fertilizer Label
  - Florida License Number
    - Identified as a capitol "F" preceding the license number.
  - Brand Name
    - Name used by the licensee to identify the product.
    - Grade
      - Percentages of total nitrogen (N), phosphate (P_2O_5) and soluble potassium (K_2O) in fertilizer. Stated in whole numbers in that order.
  - Net weight
    - Actual weight present in package or container.
  - Name and street address of the manufacturer.
  - "Organic"
    - If used, this term indicates that water-insoluble nitrogen must not be less than 60 percent of the total guaranteed nitrogen stated.
  - "Guaranteed Analysis"
    - Divided into the percentage of total nitrogen (sum of all forms present), available phosphate, soluble potassium and a statement of each secondary plant nutrient present.
- Total Nitrogen
  - Potential Forms of Nitrogen included- a statement of percentage of each form must be present.
    - Nitrate nitrogen
      - Includes all of the nitrate forms in the fertilizer mixture (NO_3^-).
    - Ammoniacal nitrogen
      - All of the ammonium forms of nitrogen.
    - Water-soluble nitrogen
    - Urea nitrogen
      - Urea, a white crystalline solid containing 46 percent nitrogen *(Overdahl.C)*
    - Water-insoluble nitrogen
      - Any water-insoluble source is used in this figure
        - Urea-formaldehyde, isobutylidene diurea, magnesium ammonium phosphate and other similar sources.
      - Many of these sources are treated in order to continually release nitrogen.
  - Without fertilizer, nitrogen becomes available to plants through the nitrogen cycle: (Nourishing the Planet in the 21st Century, www. Nutrientsforlife.org) See Figure 1. The Nitrogen Cycle.
    - Nitrogen fixation

        - Process by which atmospheric nitrogen is converted to nitrogen containing compounds usable by plants. Fixation is accomplished through the action of lightning or microbial action in the soil.
    - Ammonification
        - Bacteria and fungi convert decomposed nitrogen-containing compounds into ammonium cations.
    - Nitrification
        - Process by which bacteria converts ammonium ions into nitrite. Still other bacteria convert nitrite into nitrate.
    - Denitrification
        - Bacteria converts nitrates back to N2.

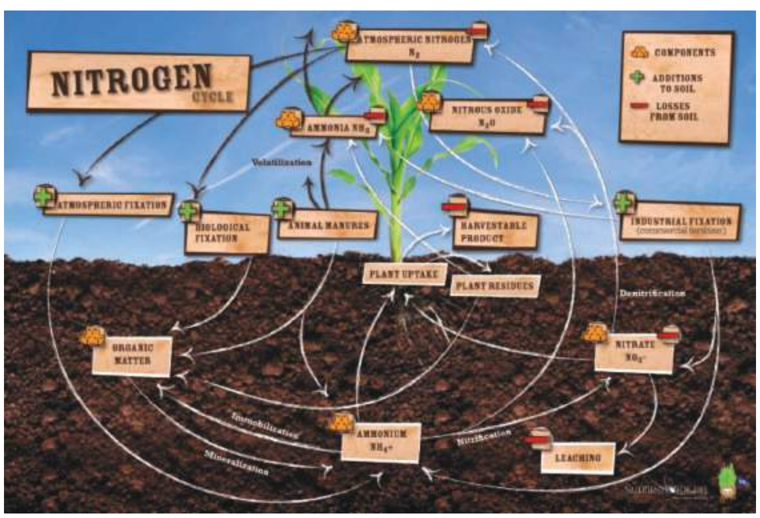


Figure 1: The Nitrogen Cycle (Nutrients for Life Foundation)

    - Available Phosphoric Acid
        - Water soluble phosphorus plus a weak acid (citrate). Available as mono-basic phosphate ion (H2P4-) which is water soluble, or the dibasic phosphate ion (HPO42-) which is soluble in the weak acid citrate.
        - Other terms used: available phosphorus or available phosphate.
    - Soluble Potash
        - The form of potassium in fertilizer is the potassium ion, K+. All of the potassium guaranteed on a fertilizer label is immediately available for plant uptake when applied to the soil.
        - Other terms used: soluble potassium
    - Total Available Primary Plant Nutrients
        - Sum of the total nitrogen, available phosphate, and soluble potash. Exhibited in three figures accordingly: 10-20-10, known as the guaranteed analysis. The sum of these figures (40 in the case of the numbers used above) makes up the grade of the mixture.
    - Chlorine- stated as "not more than" because of tendency toward toxicity toward many plants.
    - Derived From- states the actual source materials for primary and secondary nutrients.
    - Micronutrients:
        - Specifies secondary nutrients are present in elemental form.
        - Stated as "total"/ "water-soluble"/ "soluble" depending on source.
            - Magnesium (Mg)
            - Iron (Fe)
            - Zinc (Zn)
            - Copper (Cu)
            - Manganese (Mn)
        - Sulfur must be stated as "combined" or "free" unless product is classified as "Specialty Fertilizer."
- Nutrient Leaching and the 4Rs
    - As defined by Lehman and Schroth in "Chapter 7 Nutrient Leaching;" nutrient leaching is the downward movement of dissolved nutrients in the soil profile with percolating water. Nutrients moving below the rooting zone are (at least temporarily) unavailable to the plant. Leached nutrients have the potential to contribute to groundwater contamination. *(Lehman)*
    - Controlling nutrient loss means identifying its sources and implementing management practices that limit the loss of nutrients to the environment. Nutrient pollution, in part, caused by the excessive used of plant nutrients can cause algal blooms. These blooms damage waterways when the algae dies off and decomposing algae depletes the dissolved oxygen in the water used by marine species. (Nourishing the Planet in the 21st Century, *Nutrients for Life Foundation*)
    - According to the Natural Resource Conservation Service's Leaching Index (LI) *(Hurley)*.
        - To see step-by-step nutrient management plans visit www.nrcs.usda.gov
            - LI > 10 inches indicates a HIGH risk of leaching below the rootzone.
            - LI of five to 10 inches indicates a MODERATE risk of leaching below the rootzone.
            - LI < five inches indicates a LOW risk of leaching below the rootzone (Pierce et al, 1991).
    - 4Rs descriptions listed below are from *Nourishing the Planet in the 21st Century* (Nutrients for Life Foundation)

Chapter 3: STEMming Up Your Garden Lessons

- The fertilizer industry endorses a best management practice (BMP) known as 4R Nutrient Stewardship. *(The Fertilizer Institute)*
  - Right Source: The type of fertilizer used matches the crop's needs.
  - Right Rate: Fertilizer is applied at a rate that the plant can use. If the rate it too slow then optimal yields will not result. If the rate is too fast, fertilizer (and money) will be wasted and nutrients will possibly leak into the environment.
  - Right Time: Fertilizer should be applied when the crop needs the nutrients.
  - Right Place: Ensure nutrients are applied where plant roots can most easily access them. The goal is to limit nutrient losses. Avoid environmentally sensitive areas such as those close to surface waters so nutrients will not run off or leach into surface/groundwater.
- Nutrient Deficiencies (derived from Nourishing the Planet in the 21st Century, *Nutrients for Life Foundation*) unless otherwise stated.
  - Plants grown in depleted soils may display a wide variety of symptoms and limit the quantity and quality of harvested crops. Fertilizers or plant nutrients, are essentially "plant food." When added to soil in the proper amounts, fertilizer replenishes nutrients people indirectly extract from the soil when harvesting plants. The essential components of most fertilizers are the macronutrients nitrogen (N), phosphorus (P) and potassium (K). Each of these play a key role in allowing plants to access the free energy of the sun through photosynthesis; and must be present in adequate amounts to ensure healthy crop growth.
    - Nitrogen (N)-
      - The primary building block for all organisms, nitrogen is a component of every amino acid and is vital in protein manufacture. As part of the chlorophyll molecule, nitrogen helps keep plants green; and along with magnesium is the only element in the chlorophyll molecule plants obtain from the soil.
      - Vigorous plant growth is associated with adequate nitrogen nutrition, in part, because nitrogen plays a key role in cell division. Of course, cell division is essential to adequate leaf surface area; without which photosynthesis would be limited and crop yields greatly reduced.
      - Nitrogen deficient plants will present leaves that are light green to yellow, they will have low protein levels and poor fruit development.
    - Phosphorus (P)-
      - Can be found in every living cell. Serves as both a structural element and a catalyst for biochemical reactions. Phosphorus is the main component of DNA and ATP (the cell's energy molecule). It also plays vital roles in capturing sunlight during photosynthesis, helping with seed germination and the efficient use of water in the plant. Phosphorous also aids in overall plant hardiness and susceptibility to disease.
      - Phosphorus deficient plants will exhibit purple colored leaves, stunted growth and delay in development, increased disease and reduced drought tolerance.
    - Potassium (K)-
      - While not crucial to any important plant structure, it plays critical roles in several physiological functions: activates enzymes that catalyze chemical reactions involved in growth; balances water by regulating the opening and closing of the stomates; and assists in the regulation of rate of photosynthesis through its role in the production of ATP. Other aspects of plant health influenced by potassium include growth of strong stalks, protection from extreme temperatures, and the ability to survive stressors such as weeds and insects.
      - Potassium deficient plants will show yellowing edges of older leaves and dead leaves. A potassium deficiency will also result in irregular fruit development and reduced drought tolerance.

Introduction:

1. Students will use a periodic table to identify nutrients needed by plants and then discover what impact each nutrient has on the plants. Start with the periodic table and identify macro, secondary, non-mineral and micro nutrients plus the function of each of the 17 in growing plants.

a. Ask students, "What do plants need to live?" and record their answers somewhere everyone can see. Possible responses are carbon dioxide, water, sunlight, sugar (a product of photosynthesis).
b. Hold up a fertilizer bag and ask, "What about this? What is this? What does it do?" Possible responses are plant food, fertilizer, compost. It feeds the plants -> use guiding questions to elicit responses along the line of "plant food."
c. Ask students, "Do plants eat?" Make sure that students understand that plants do NOT eat. Plants absorb nutrients from the soil as they take in water.
d. If not previously discussed, talk with students about plant structures, including phloem and xylem, and capillary action.

2. Placing students into groups, instruct them that they are going to be designing an experiment to demonstrate how a plant carries water and nutrients from the bottom to the top. Suggested materials given to groups are: celery, white flower such as carnation, water, glass or jar, food coloring or similar item, measuring cups. Or you can just use celery as a demonstration with the entire class.
3. Use celery to demonstrate how plants carry water and nutrients from bottom to the top. You will need to cut a piece of celery off the stalk, leaving the leaves. Place ¾ to one cup of water in a clear glass and add food coloring and stir. Place the celery in the colored water. Have students observe what is happening.

a. Directions for Celery Demonstration:
  i. Pour 215 mL (approximately seven ounces) of water into a glass jar.
  ii. Add six to eight drops of food coloring (blue or red work best).
  iii. Cut one stalk of celery so it is 20 centimeters in length
  iv. Be sure to leave the leaf end on.
  v. Place cut stalk into jar with food coloring and water.
  vi. Observe results the next day.
  vii. This quick demonstration shows that plants take water (along with nutrients) UP from the roots to the rest of plant, explaining why we add nutrients to the soil.

b. Ask students, "How and why is the colored water moving up the celery?" The xylem is a pipeline that moves water and nutrients up into the plant and to the leaves. This is how plants "eat" and why fertilizer must be soluble.

Activity 1: Essential Plant Nutrient Funtions

1. Begin by giving each student a copy of the *Blank Florida Fertilizer Label* (Sartain. J) and *Simple Periodic Table of Elements*.
2. Have students highlight or use colored pencils to color in the elements on their periodic tables they find on their blank fertilizer labels. Be sure to point out the similarities. Discuss with students that any element found in the periodic table is natural and "from the earth." When different elements are put together they are called compounds.
3. Ask, "Given what you've just seen, what is fertilizer?"
   - Possible responses: elements, compounds, molecules, chemicals (if students say chemicals point out that any combination of elements on the periodic table is considered a chemical, some chemicals are beneficial to humans, some are harmful).
4. Students are going to focus on the three key nutrients: nitrogen (N), phosphorus (P) and potassium (K).
   - Jigsaw or divide students into home groups of three to six students. Then divide each home group into three expert groups for N, P and K (more than one student from a home group can go to the same expert group as long as there is at least one person from each expert group). When students come back to their home groups from their expert groups they will teach everyone else in their group what they learned about N, P or K.
   - Expert groups should visit the following sites (The Fertilizer Institute): If internet is not available there is information for each group at the end of the lesson.
     - Nitrogen: https://www.tfi.org/introduction-fertilizer/nutrient-science/nitrogen
     - Phosphorus: https://www.tfi.org/introduction-fertilizer/nutrient-science/phosphorous
     - Potassium: https://www.tfi.org/introduction-fertilizer/nutrient-science/potassium
   - Use the table below as a guide: Expert Tip! Have each home group complete one chart as a team. Flipchart paper or large copy paper works best. Be sure to encourage students to use lots of color!

	Nitrogen	Phosphorus	Potassium
What is it?			
Where does it come from?			
How is it helpful to plants?			

Chapter 3: STEMming Up Your Garden Lessons

Activity 2: Fertilizer Labels

1. In this activity students will interpret fertilizer labels for proper application rates.
   - Fertilizer Label Scavenger Hunt
     - The teacher will need to have at least four different fertilizer bags, boxes or bottles all with a label that can easily be read by the student. If this is not possible the teacher can use the four pictures of fertilizer labels found on pages 110 and 111. Sample fertilizer labels should be placed around the classroom to allow students to move around freely. After explaining the assignment, allow students to circulate around the classroom collecting information from the fertilizer labels. Expert Tip! A great way to have fertilizer labels around the room is to either enlarge them using your copy machine or recreate them on flipchart paper.
       - Each fertilizer label needs to be colored coded blue, orange, green or purples. Each student needs a *Fertilizer Label Scavenger Hunt Worksheet*. Students will write information on the worksheet for the label that matches the information. For example, Brand Name is in blue so student will write the brand name for the fertilizer coded blue.

Activity 3: Nutrient Leaching and the 4Rs

1. In this activity students will be able to understand nutrient leaching through a hands-on experiment. Students will also be able to identify the different categories of fertilizer and how they are relevant to nutrient leaching.
2. Students will be conducting a "Blue Dye Test" that will allow them to see how soil permeability relates to nutrient leaching. You can allow students to design their own experiment or conduct the one below. (Hochmuth, G.)
   - Materials
     - One cup quartz sand (clean sandbox sand is a good option)
     - ¼ cup dye (iodine or food coloring) mixed with ¼ cup water
     - Clear glass jar (volume of at least eight ounce)
   - Procedures
     - Measure one cup of clean, dry quartz sand and place it into clear glass jar. DO NOT compact the sand; leave it loose.
     - Slowly pour approximately one tablespoon of the dye solution over the sand.
       - Make initial observations.
       - Let sit for 10-20 minutes.
         - Make observations.
       - "Make it rain:" pour a small amount one to two tablespoons of clean water over sand.
         - Make observations.
3. Explain to students that this test shows the permeability of sand, which is the main particle size of most soil orders in Florida. They can add other particle sizes such as clay to compare. Students should observe that when the dye solution (representing fertilizer solutions) are added to sand they permeate past the rooting zone rather quickly. When it "rains," that percolation of solution only speeds up.
4. Finish up the "Blue Dye Test" with a discussion centering around the following:
   - Define the 4Rs of nutrient stewardship (see page 102)
     - Right Source
     - Right Rate
     - Right Time
     - Right Place
   - Guiding Questions
     - Where was the dye relative to the root system?
     - What environmental challenges might be presented when the blue dye (i.e., fertilizer) moves beyond the rooting zone?
     - How does soil texture and other qualities (slope, vegetation, surface permeability, etc.) affect water and nutrient movement through the soil?
     - How does that movement impact plant growth and productivity?

- Expert Tip! Helps students remember the 4Rs. After your discussion, assign students to groups of three to four. Give them seven-10 min to create a song, skit, newscast or commercial that helps other members of the class remember the 4Rs.

Activity 4: Nutrient Deficiencies

Expert Tip! If resources are limited Sub Activities 2 and 3 can be done as stations.

1. Introduce Plant Nutrient Deficiencies (amended from Nutrients for Life Foundation's H.S. Lesson 4). In this activity students will:
   - Recognize that like people, plants require essential nutrients present in the right amounts in order to be healthy.
   - Diagnose plant nutrient deficiencies using reference material.
   - Define fertilizer as a type of "food" for plants.
   - Explain that fertilizers are used to replenish nutrients in agricultural soils.
2. Sub Activity 1: When a Plant Needs Food (10 minutes)
   - When a Plant Needs Food Discussion
     - Ask, "How do plants get the nutrients they need for growth?"
       - If necessary, reference introduction celery absorption activity and use that as an anchor to this concept). Two important points should result from this question:
         - Plants require elements that are not supplied by photosynthesis.
         - Essential elements are found in the soil and absorbed by the plant through the root system.
     - Remind students that plants and people are both made of cells and those cells need nutrients in order to be healthy.
     - Ask, "What happens to us if we don't get enough of an essential nutrient?"
       - Answers will vary, but most should be able to point out that if we have a nutrient deficiency then we will likely get sick.
     - Think-Pair-Share
       - Say, "Predict what would happen to plants if they do not get the nutrients they need."
         - Accept all reasonable answers, but use probing questions to assess whether the students think the plant's response would be the same for all missing nutrients or whether there might be differences for different nutrients.
           - Think about your answer.
           - Pair up with the person next to you and compare answers. Formulate an answer that is as detailed as possible.
           - Share your answers with the rest of the class. Create a "super answer" and write it on the board or flipchart.
3. Sub Activity 2: Humanity Against Hunger (30 minutes) https://nutrientsforlife.org/for-students
   - Divide the class into groups of three. Each group will evaluate three case studies.
     - If computers are available, allow each student to work individually. See the Expert Tip! at the beginning of this activity for another option on splitting the class.
   - Students should access the "Humanity Against Hunger" activity at: https://www.nutrientsforlife.org/games/humanity/.
   - At the homepage, instruct students to begin by clicking on "The Food Crisis in Africa," and ask volunteers to read parts of the article.
   - Ask, "Can you think of ways to help solve Africa's food shortage problem?"
   - Instruct students to return to the home page and select "Your Assignment for Humanity Against Hunger." At this point, students will complete the web activity either in assigned groups or individually, following the directions given on the website.
   - When students have completed the assignment, you can have them print out their reports and turn them in as a form of evaluation.
   - As students finish, encourage them to explore the "Additional Resources/Links" Section.
4. Sub Activity 3: Plant Deficiencies (30 minutes)
   - In this activity students will evaluate plants (pictures at end of lesson) and determine which nutrient they believe the plant is deficient in. Using their knowledge from activity 1, students will be diagnosing nutrient deficiencies.
   - Extension Activity – Have students take soil samples from different areas of campus and ask your UF/IFAS Extension Office, listed on pages 174-177, to analyze the soil. This will allow the students to find out if the soil is deficient in nitrogen, phosphorus or potassium. If all analyses comes back with zero deficiencies then you have healthy soil around your campus and can complete this activity having students review which plant is showing a deficiency. If the soil samples come back with different deficiencies, have students match the deficiency pictures with the soil analysis.
   - Students will determine which fertilizer (1, 2, 3 or 4)

would best fit the deficient plants and explain why.

Extensions:

If you are looking for an additional agricultural experience for your students, consider doing a test garden. Use the following model (the Fort White Agriscience Program) as a guide.

1. Divide students into "gardening groups" (no more than four per group is recommended).
2. Tell students, "We are going to do an agricultural experiment to find out what effect plant spacing and fertilizer use has on plant health and productivity (using biomass)."
   - Biomass: For the purposes of this experiment, we are going to use "harvest weighed" as the biomass.
3. Develop a hypothesis in the form of an "if/then" statement. Example: If the population density of tomato plants is greater and fertilizer is added, then more tomatoes will be harvested.
4. Determine Variables:

   - **Independent Variables** (x values):
     - Plant Treatments: Spacing/Population Density
       1. Closer spacing (teacher determined)
       2. Further spacing (teacher determined)
       3. Closer spacing with fertilizer (same spacing as treatment one, add recommended amount of fertilizer)
       4. Further spacing with fertilizer (same spacing as treatment two, add recommended amount of fertilizer)

   - **Dependent Variables** (y values): Note: Each group should keep a record book showing regular measurements of the dependent variables they have been assigned (recommended daily/every other day).
     1. Plant Health and Productivity
     2. Height
     3. Leaf Production (how many leaves)
     4. Viability/Mortality Rate per Row
     5. Biomass (harvest weight)

   - **Control:** Note: It is recommended that only one group per class OR teacher be in charge of the control plot so as to minimize disturbance and potential damage. The group or teacher will share regular measurements with the rest of the class.
     1. Recommended plant spacing as stated on the seed packet; no fertilizer.

Example Group Data Record Keeping

Names & Group Number

Class Period & Date

Treatment Group: 3

Hypothesis (*hypothesis should correspond with treatment group assignment; you do not have to agree with your group's statement*): **If bell pepper plants are planted 16 inch apart and recommended amounts of fertilizer applied, then more peppers will be harvested.**

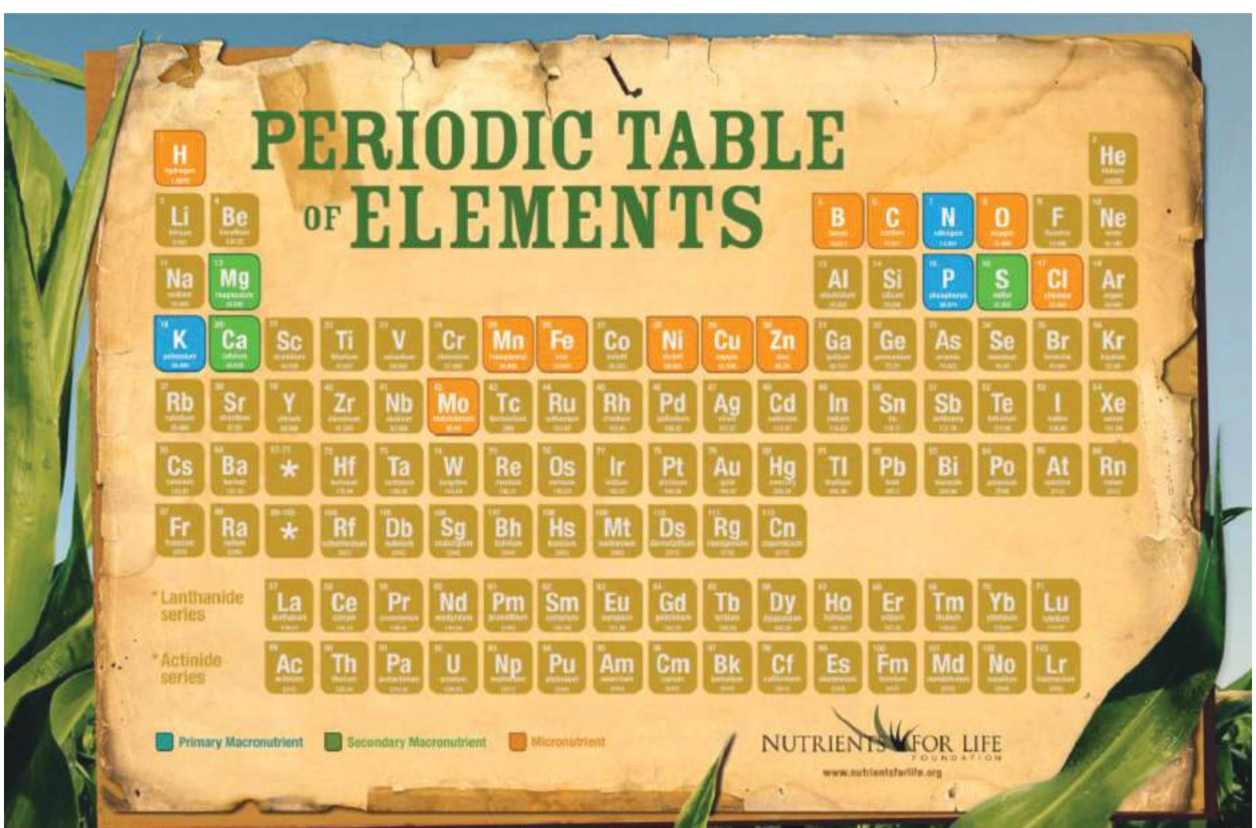
Daily/Bi-Daily Data:

- Number of plants originally planted: 10
- Number of plants still viable: 8
- Average height of plants: 7.6 inch
- Average leaf count: 26 leaves per plant
- Average Fruiting: 2 per plant

Data Graphs *(Graphs can/should be done to illustrate comparisons of all relevant, measurable data collected)*
Example:

***Note: As a class, make final recommendations. Which treatment was the most effective? Which was the least effective? Use a table like the one below to show the class sets of data and then insert that data into the graphs. Students can further extend this activity by presenting their findings and recommendations.

Group	Treatment	# Plants Planted	# of Plants Harvested	Harvest weight (Biomass) (lbs)	Average Height of Harvested Plants (HP)	Average Leaf Count of HP	Average Fruiting of HP
Control	Control						
A	1						
B	2						
C	3						
D	4						



Expert Group Nitrogen Information Sheet

- Nitrogen (N)-
  - The primary building block for all organisms. As a component of every amino acid it is vital in protein manufacture. As part of the chlorophyll molecule, nitrogen helps keep plants green and along with magnesium, is the only element in the chlorophyll molecule plants obtain from soil.
  - Vigorous plant growth is associated with adequate nitrogen nutrition, in part, because nitrogen plays a key role in cell division. Of course, cell division is essential to adequate leaf surface area without which photosynthesis would be limited and crop yields greatly reduced.
  - Nitrogen-deficient plants will present leaves that are light green to yellow, they will have low protein levels and poor fruit development.

Expert Group Phosphorus Information Sheet

- Phosphorus (P)-
  - Can be found in every living cell and serves as both a structural element and a catalyst for biochemical reactions. Phosphorus is the main component of DNA and ATP (the cell's energy molecule). It also plays vital roles in capturing sunlight during photosynthesis, helping with seed germination and the efficient use of water in the plant. Phosphorous also aids in overall plant hardiness and susceptibility to disease.
  - Phosphorus-deficient plants will exhibit purple colored leaves, stunted growth and delay in development, increased disease and reduced drought tolerance.

Expert Group Potassium Information Sheet

- Potassium (K)-
  - While not crucial to any important plant structure, it plays critical roles in several physiological functions: activates enzymes that catalyze chemical reactions involved in growth, balances water by regulating the opening and closing of the stomates, and assists in the regulation of rate of photosynthesis through its role in the production of ATP. Other aspects of plant health influenced by potassium include growth of strong stalks, protection from extreme temperatures and the ability to withstand stressors such as weeds and insects.
  - Potassium-deficient plants will show yellowing on the edges of older leaves and dead leaves. A potassium deficiency will also present as with irregular fruit development and reduced drought tolerance.

Blank Fertilizer Label

BRAND NAME		
GRADE X-X-X		
Guaranteed Analysis		
Total Nitrogen (N)		________%
________%	Nitrate Nitrogen	
________%	Ammoniacal Nitrogen	
________%	Other / Water Soluble Nitrogen	
________%	Urea Nitrogen	
________%	Water Insoluble Nitrogen	
Available Phosphate (P_2O_5)		________%
Soluble Potash (K_2O)		________%
Chlorine, (Cl) Not More Than..		________%
________%	Water Soluble Magnesium as (Mg)	
________%	Chelated Magnesium as (Mg)	
________%	Manganese as (Mn)	
________%	Water Soluble Manganese as (Mn)	
________%	Chelated Manganese as (Mn)	
________%	Copper as (Cu)	
________%	Water Soluble Copper as (Cu)	
________%	Chelated Copper as (Cu)	
________%	Iron as (Fe)	
________%	Water Soluble Iron as (Fe)	
________%	Chelated Iron as (Fe)	
________%	Zinc as (Zn)	
________%	Water Soluble Zinc as (Zn)	
________%	Chelated Zinc as (Zn)	
________%	Combined Sulfur as (S)	
________%	Free Sulfur as (S)	
Derived from: (Actual materials and in forms used in the fertilizer mixture; e.g., diammonium phosphate, urea, potassium chloride, magnesium sulfate, manganese nitrate, etc.........		
Manufactured by: Name (FXXXX) City, State & Zip		
Net Weight - ________lb		

NPK Home Group Collaboration Table

	Nitrogen	Phosphorus	Potassium
What is it?			
Where does it come from?			
How is it helpful?			

Fertilizer Label Sample #1

Formulated with Urea for better uptake

Griffin 300

Griffin Fertilizer Company

GUARANTEED ANALYSIS

• Total Nitrogen	3.000%
• Available Phosphorous as P_2O_5	0.000%
• Soulble Potassium as K_2O	0.000%
• Iron as Fe (Chelated)	0.375%
• Manganese as Mn (Chelated)	3.000%
• Zinc as Zn (Chelated)	3.000%
• Boron as B	0.150%
• Copper as Cu	0.347%
• Molybdenum as Mo	0.006%

DERIVED FROM:

Urea, Iron, Manganese & Zinc Glucoheptonate, Copper Sulfate, Sodium Borate, Sodium Molybdate

Weight Per Gallon - 11.48 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN 300 is formulated with urea along with a balanced combination of essential micronutrients. These elements are in the correct ratios to provide the building blocks for the complex enzymatic reactions essential to overall plant health, production and disease resistance.
GRIFFIN 300 includes **Agro-Mos®** by **Alltech®**. **Agro-Mos®** is designed to enhance the natural systemic resistance within crops to crop-born challenges that limit production.

Foliar Nutritional Spray - **GRIFFIN 300** may be applied by air or with all types of ground spraying equipment.

Compatibility - **GRIFFIN 300** is compatible with most common foliar pesticides. USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES - CITRUS CROPS

Mature Citrus - Apply 2-4 quarts of per acre.

Young Trees - Mix 2-4 quarts per one hundred gallons of spray solution and apply to runoff.

Fertilizer Label Sample #2

Griffin Dual Phos™ 3-18-18

Griffin Fertilizer Company

GUARANTEED ANALYSIS

• Total Nitrogen	3.00%
• Available Phosphorus as P_2O_5	18.00%
• Soluable Potassium as K_2O	18.00%

Statement of Secondary Plant Food

• Boron as B	.10%

DERIVED FROM:

Urea, Ammonium Hydroxide, Dipotassium Phosphate, Phosphorus Acid, Potassium Hydroxide, Sodium Borate

Weight Per Gallon - 11.72 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN DUAL PHOS™ 3-18-18 is a proprietary nutrient solution containing highly soluble forms of elements essential to plant growth, crop development, crop quality and yield.
DUAL PHOS™ is formulated with Dipotassium Phosphate (DKP).

- **DKP** has a very low salt index and can be safely applied at higher rates than many other products
- **DKP** provides readily available phosphorous as PO_4. At critical stages of plant growth, DKP enables the grower to bypass certain soil & environmental conditions that limit phosphorous uptake.
- **DKP** is much more soluble than potassium nitrate, therefore the DKP stays in solution on the leaf much longer - an essential requirement for foliar potassium uptake.

Patented **DUAL PHOS ™** includes phosphorous and phosphoric acid. The patent was granted after research proved that combining phosphates and phosphites in a single application is an innovative and superior method. The dual application provides a synergistic effect in which the inherent qualities of both products are amplified.
Foliar Nutritional Spray - **DUAL PHOS™** may be applied by air or with all types of ground spraying equipment.
Compatibility - **DUAL PHOS™** is compatible with most common foliar pesticides and nutrients. However, USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES - CITRUS CROPS

Mature Citrus - Apply 3 - 4 gallons per acre. Each gallon supplies 0.50 pounds of Phosphorous Acid.

Young Trees - Apply 3 - 4 gallons per one hundred gallons of spray mix and apply to run-off.

Fertilizer Label Sample #3

Dual Phos™ & AGRO MOS® inside

Griffin GREEN

Griffin Fertilizer Company

GUARANTEED ANALYSIS

· Total Nitrogen	
· Available Phosphorus as P_2O_5	4.000%
· Soluable Potassium as K_2O	14.000%
· Borom as B	10.000%
· Copper as Cu (Chelated)	.200%
· Iron as Fe (Chelated)	.161%
· Manganese as Mn (Chelated)	.110%
· Molybdenum as Mo	.110%
· Zinc as Zn (Chelated)	.001%
	.200%

DERIVED FROM:

Urea, Dipotassium Phosphate, Phosphorous Acid, Sodium Borate, (Copper, Iron, Manganese & Zinc EDTA), Sodium Molybdate

Weight Per Gallon - 10.95 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN GREEN contains Dual Phos™, a proprietary nutrient solution containing two highly soluble forms of phosphorus - Dipotassium Phosphate and Phosphorous Acid.

- **Dipotassium Phosphate** has a very low salt index and can be safely applied at higher rates than many other products.
- **Dipotassium Phosphate** provides readily available phosphorus and potassium that remain in solution on the leaf longer - an essential requirement for foliar phosphorus uptake.

GRIFFIN GREEN contains 1/2 pounds of pure phosphorous acid per gallon. Research has demonstrated that combining phosphates and phosphites (from phosphorous acid) in a single application is an innovative and superior method. The dual application provides a syngeristic effect in which the inherent qualities for both products are amplified.

GRIFFIN GREEN also includes **Agro-Mos®** from Alltech® Crop Science. **Agro-Mos®** is designed to enhance the natural systemic resistance within crops to crop-born challenges.

GRIFFIN GREEN includes a full complement of essential, soulble micronutrients. These elements are in the correct ratio to provide the building blocks for the complex enzymatic reactions essential to overall plant health, production and disease resistance.

Compatibility - GRIFFIN GREEN has a neutral pH and is compatible with most common foliar pesticides and nutrients. However, USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products. It may be applied by air or ground equipment.

SUGGESTED USES

Fruit Trees and Landscape Ornamentals - Apply 1-2 gallons in a minimum of 100 gllons of water per acre, or for dilute sprays, 1-2 gallons per 100 gallons of water and spray to full coverage.
Turf and Field Grown Ornamentals - Apply 1-3 gallons per acre (3-9 ounces per 1000 square feet) in a minimum of 100 gallons of water per acre, or inject through properly equipped irrigation system.
Greenhouses and Field Nurseries - Mix 1-2 quarts in 100 gallons of spray solution and spray to runoff every 14-21 days. Transplant Drench - Mix one quart per 100 gallons of water.

Fertilizer Label Sample #4

Griffin CA 825

Griffin Fertilizer Company

GUARANTEED ANALYSIS

• Total Nitrogen	7.000%
• Available Phosphorous as P_2O_5	0.000%
• Soulble Potassium as K_2O	0.000%
• Calcium as Ca	8.250%

DERIVED FROM:

Calcium Nitrate, Sodium Glucoheptonate

Weight Per Gallon - 11.86 LBS.

Manufactured by:
Griffin Fertilizer Company
3201 South Scenic Hwy Frostproof, FL 33843
Phone: 863-635-2281

GENERAL INFORMATION

GRIFFIN CA 825 is a liquid foliar fertilizer containing a soluble and safe chelated calcium. It is formulated to aid in supplementing calcium levels in crops, especially during critical periods of growth.

Foliar Nutritional Spray - GRIFFIN CA 825 may be applied by air or with all types of ground spraying equipment.

Compatibility - GRIFFIN CA 825 is compatible with most common foliar pesticides. USER ASSUMES FULL RESPONSIBILITY to ensure compatibility when tank mixing with other products.

SUGGESTED USES

Mature Citrus - Apply 2 - 3 quarts per acre.
Young Trees - Mix 2 - 3 quarts per one hundred gallons of spray solution and apply to runoff.
Vegetables - Apply 1 - 2 quarts per acre
Turf, Lawns, Sod - Apply 6 - 8 ounces per 1000 sq. ft.

Fertilizer Label Scavenger Hunt Worksheet

(the colors correspond to the different fertilizer labels)

- Brand Name: ______________________
- Grade: ______________________
- Guaranteed Analysis of this product: ______________________
- Total Nitrogen: ______________________
- Available Phosphorus: ______________________
- Soluble Potassium: ______________________
- Name at least two micronutrients along with their respective percentages: ______________________
- Derived From: ______________________
- Manufactured By: ______________________
- Net Weight: ______________________
- Application Instructions
    - o Calculate how much of this fertilizer you would use on a six-acre plot.
    - o How long would this product last if you fertilized weekly on your six-acre plot?

Picture of Nitrogen-Deficient Plant

Picture of Phosphorus-Deficient Plant

Picture of Potassium-Deficient Plant

Photos courtesy of Nutrients for Life Foundation.

STEMming Up Plant Nutrients

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. List three essential nutrients plants need.

2. Describe how plants "eat."

3. List and explain the 4Rs of nutrient stewardship.

4. Explain the relationship between soil particle size and water movement through soil.

5. Explain the relationship between the need for plant nutrients and feeding the world.

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Plant Hormones and Tropic Responses

Brief Description:

There are many hormones in plants and they all play different roles. In this lesson students will learn about hormones such as ethylene, gibberellins, cytokinin, absiscic acid and the application of hormones in commercial horticulture.

Tropic responses in plants are those responses to light, gravity and touch. In this lesson students will learn about the different tropic responses and set up experiments to demonstrate hormone effects and plant responses to stimulus. Data will be collected and summarized in tables and graphs.

Objective:

Students will be able to:

1. Grow a plant from a seed.
2. Identify parts of a plant and plant cells.
3. Understand the role plant hormones play in plant growth.
4. Understand what plant tropisms are.
5. Work in groups to design and conduct an experiment to demonstrate a plant hormone or tropic response.

Time:

Part I. Plant Structure
Introduction: 15 to 20 minutes
Activity 1: Up to three 50 minute class periods

Part II. Plant Hormones and Tropisms
Introduction: Up to one 50 minute class period
Activity 1: Up to four 50 minute class periods

Materials:

- Microscope(s)
- Iodine
- Onion skin
- Elodea (sometimes referred to as Anacharis) water plant
- Slides
- Cover slips, or prepared plant tissue slides
- Seeds (lima bean or cucumber)
- Potting soil
- Polystyrene cups
- Scissors
- Aluminum tray
- Fertilizer
- Water

Vocabulary:

apical bud, branch, cell, cell wall, cell membrane, chloroplast, flower, fruit, internode, lateral bud, leaf blade, nucleus node, organelle petiole, root, root cap, stem, tissue, vacuole, abscisic acid, auxin, cytokinin, ethylene, geotropic, gibberellin, hormone, phototropic, tropism and thigmotropic

Background:

Plant Tissues and Structure: Plants are composed of cells which together with other similar cells make tissues. Groups of tissues form plant organs such as roots, stems, leaves and flowers (if present).

Hormones and Tropisms: The distribution and concentration of plant hormones occur on a cellular level. The presence, absence, or balance of hormone in a tissue affects a tropism in the whole organ.
Tropisms are movements of a plant organ in response to an environmental stimulus, such as lights, gravity or touch.

Three Major Types of tropisms:

- Phototropism – Plant growth towards the sun or light.
- Geotropism or Gravitropism – Plant growth in response to gravity.
- Thigmotropism – Plant responses to touch.

Hormones are signaling molecules that are produced in small amounts and sent to other parts of the plant body, like tiny messengers running around. Plant hormones affect both plant growth as well as plant response to the environment. Plant growth and response may occur because a hormone is present, absent, or the balance between hormones is changed. Concen-

Florida Standards:

SC.7.N.1.1, SC.7.N.1.4, SC.7.L.17.3, SC.8.N.1.1, SC.8.N.1.2, SC.8.N.1.3, SC.8.N.1.4, SC.8.N.4.2, SC.912.L.14.1, SC.912.L.14.10, SC.912.L.14.2, SC.912.L.14.31, SC.912.L.14.7, SC.912.N.1.1, SC.912.N.1.6, SC.912.N.1.7, MAFS.7.RP.1.2, MAFS.7.SP.1.1, MAFS.7.SP.1.2, MAFS.8.SP.1.1, MAFS.8.SP.1.2, MAFS.8.F.2.5, MAFS.912.A-REI.1.1, MAFS.912.S-ID.1.1, MAFS.912.S-MD.2.5

trations of plant hormones cause regulation in the growth and metabolism of the plant as a whole.

Major Types of Plant Hormones:

- Auxins – Plant hormone produced in the stem tip that promotes cell elongation. Causes all tropisms by collecting in one side of the plant stem, causing the stem to bend. Auxin is used in rooting plant hormones. A stem that is cut and then dipped into powdered auxin will develop roots in as little as ten days. Auxin is also a source of apical dominance which causes the growing tip to continue to grow rather than the lateral buds.
- Cytokinins – Plant hormone that promotes mitosis (cell division) in the growing tip of the plant, as well as the roots. Without this hormone cells will not divide.
- Abscisic Acid – Plant hormone that slows down growth and water use when the environment is dry. Causes the stomata to close when the environment is dry to prevent water loss. Abscisic acid also promotes seed dormancy.
- Ethylene – Plant hormone that is released as a gas by ripened fruit. It will cause other fruit to ripen. Often fruit is picked unripe, shipped and then in the distribution warehouse it will be exposed to ethylene gas to ripen before going to the store.
- Gibberellins – Plant hormone that encourages seed growth and breaks the seed from dormancy. It increases stem growth and fruit size, as well as induces flowers.

Part I: Plant Structure

Introduction:

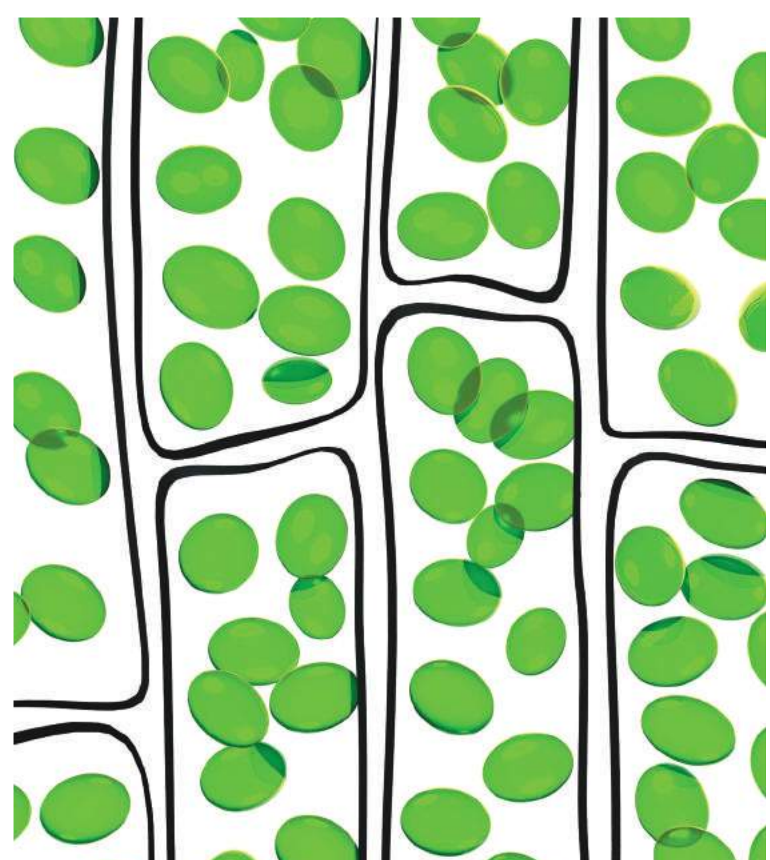
1. Review information on how to prepare wet mount versus stained mounted slides. If you have not already gone over this with students in class do it now.
2. It is important to understand the parts of plants for this lesson to understand how different responses are elicited.

Activity 1:

1. Separate students into groups of three to four students.
2. Three weeks before starting the lesson each group will plant lima bean seeds into 10 Styrofoam cups.
   a. Using scissors, make a slit on the cup bottom.
   b. Cups should be filled with packed potting soil to one inch from top of 16 ounces Styrofoam cup (i.e. three groups = 30 plants).
   c. Plant two seeds per cup, pressing them into the soil one inch.
   d. Place plants in an aluminum tray.
   e. Keep plants in an area of good light and water as needed.
   f. After seven days, or plant emergence, ask students to thin plants to one per cup by pinching off the weaker plant with fingers.
   g. Using soluble fertilizer, fertilize and water plants at seven days.
   h. Water plants as needed and on Fridays for the weekend.
   i. At the end of two weeks of growth, have students each pick a "best grown" lima bean plant and use it for drawing and labeling of the plant parts.
3. Take students outside to show the different parts of landscape plants. Ask, "Do landscape plants have different parts than edible plants?" "How are the plants similar and how are they different?"
4. Have students pick a plant and label the plant parts without damaging the plant or landscape.
5. Have students prepare and look at slides of plant cells.
   a. Prepare a wet mount of an elodea water plant leaf. Students can observe the cell membrane, chloroplast and vacuole space.
   b. Prepare a stained slide of onion skin with a cover slip. Iodine is a safe, effective stain.

Evaluation:

1. Have students draw elodea and onion skin cells from microscope and label parts.
2. Have students retrieve one grown lima bean plant, remove the soil, and draw and label the plant parts.



Part II. Plant Hormones and Tropisms
Introduction:

1. Teach the PowerPoint (found at www.faitc.org/teachers/STEMming-Up) in class to ensure students understand the concept of hormones and tropisms and their relationship to plant growth.
2. Review the scientific method: Problem, Hypothesis, Procedure, Experiment, Results and Conclusion. Review the need for controls and three or more replications.

Activity 1:

1. Divide students into groups. There are nine tropic responses and hormones to experiment.
2. Assign each group a tropic response or plant hormone. Groups will research their hormone or tropism for more detailed information about function.
3. Students will design an experiment to demonstrate their plant's response. Teacher can choose to give students a list of materials available. Experiment and list of items needed must be presented to teacher for approval.
   a. Controls should be used for comparison.
   b. Measurements should be taken in metric units.
   c. Ethylene is a gas, so an enclosed environment, such as a sealed bag or a large jar, will be required. Ethylene is produced by ripe and/or damaged fruit.
4. If students design experiments that use several concentrations of hormone, a mathematical model can be applied to the response curve (this would extend into an algebra lesson).

Evaluation: Plant Hormones and Tropisms

1. Students submit a lab report.

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Plant Hormones and Tropic Responses

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. What are hormones?

2. What effects do hormones have on plants?

3. What is a tropic response in plants?

4. How does the agriculture industry use plant hormones?

Plant Propagation

Brief Description:

Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs and other plant parts. There are several methods of plant propagation used in commercial horticulture besides planting seeds. This lesson will introduce the industry skills of plant propagation, such as grafting, budding, rooting cuttings, seed scarification, air layering and tissue culture. Students will also research on the internet about several types of plant industries, and gain an appreciation for how economically important they are.

Objective:

Students will:

1. Be introduced to the different methods of plant propagation.
2. Understand the importance of plant propagation in agribusiness.
3. Explore plant propagation techniques through teacher demonstration and hands-on trials.

Time:

Introduction: 30 to 60 minutes
Activity 1: 60 to 90 minutes (depending on how much at-home time)
Activity 2: One to two hours to demonstrate methods (One hour to create a manual and multiple class periods depending on how many propagation methods are attempted).

Materials:

Will vary depending on propagation method used.

- Budding tape
- A lab hood with positive pressure for sterile technique (preferred for best tissue culture results)
- A spray bottle of 70 percent alcohol to sterilize
- A spray bottle of 10 percent bleach to sterilize
- Pruners
- Budding knife
- Grafting clips
- Aluminum foil
- Plastic wrap
- Plant material: Many schoolyard shrubs can be used for budding, grafting and rooting cuttings. *Avoid oleander as these plants are VERY poisonous!
  - Budding – hibiscus or shrub
  - Rooting cuttings – coleus, geraniums, crepe myrtle, woody ornamentals
  - Grafting – tomato seedlings
  - Scarification seeds – morning glory or birds of paradise

Vocabulary:

air layering, asexual propagation, budding, cloning, fungicide, genetically modified organism, grafting, rooting cuttings, rootstock, scarification, scion, seeding, sterile, tissue culture and transplant

Background:

Vegetable plants, such as tomato and bell pepper, are often started in a greenhouse, where they are seeded in trays and allowed to grow for four to six weeks. In Florida, one reason this is done is to get the harvested fruit to the market as early as possible. Florida's advantage is early season. It is not long before other large vegetable producing states, such as California and Texas, flood the market with their produce. This causes prices to become lower for Florida farmers.

Some vegetables, notably tomatoes, are grafted while young transplants. This involves taking a Florida hearty root system of one tomato, and using it to grow a very tasty tomato fruiting plant, whose roots may not be suited for Florida's soil diseases.

Some vegetables, such as cucumber, are directly seeded. Cucumber, in particular, is a very fast growing crop, and transplanting does little to make the crop grow faster. Grains, such as corn and soybean, are also seeded. Soybean is often a cover

Florida Standards:

SC.7.L.16.3, SC.7.L.16.4, SC.7.L.16.2, SC.8.N.4.2, SC.912.L.14.1, SC.912.L.14.10, SC.912.L.14.33, SC.912.L.14.7, SC.912.L.16.10, SC912.L.16.12, SC.912.L.17.16, LAFS.68.RST.1.3, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, LAFS.68.WHST.3.8, LAFS.68.WHST.4.10, LAFS.910.RST.1.3, LAFS.910.WHST.2.6, LAFS.910.WHST.3.7, LAFS.910.WHST.3.8, LAFS.910.WHST.4.10, LAFS.1112.RST.1.3, LAFS.1112.WHST.2.6, LAFS.1112.WHST.3.7, LAFS.1112.WHST.3.8, LAFS.1112.WHST.4.10

crop which can also be harvested. The legume nature of the crop is good for fixing nitrogen in the soil as well as preventing soil erosion.

Most seeds will not germinate if the seed coat is scratched or damaged. Entry of disease-causing bacteria or fungi may make the seed unviable. However, there are a few kinds of seeds, like Morning Glory, a flowering plant, that require seed coat scratching in order for water to enter the seed. This is called scarification.

Citrus is budded using scion wood from trees that already produce high quality fruit. This allows for genetically identical fruit on the new tree as on the initial tree. Root stock is chosen based on disease resistance and strong adaption to Florida soils. Budding also shortens time-until-fruit from eight to10 years from a seeded tree to two to three years on a budded tree.

Orchids and hibiscus are cloned by tissue culture using a medium of nutrients. Once a beautiful flower is bred or the plant is genetically modified for a trait, tissue culture allows clones, or genetically identical plants, to be produced from a few cells of the initial plant on a large scale.

Leaf and rooting cuttings is also a method of producing genetically identical plants by asexual propagation. This may be done to avoid the lengthy process of pollination, fruit/seed production and then seedling. This may be done to clone plants, or may be done just to reproduce plants more rapidly.

Lychee trees are predominantly air-layered. This method produces genetically identical, great tasting fruit from the parent plant. Air-layering is also used for shrubs that do not root easily from cuttings.

For more information on different propagation methods check out the following websites: https://ag.arizona.edu/pubs/garden/mg/propagation/asexual.html, http://aggie-horticulture.tamu.edu/ornamental/a-reference-guide-to-plant-care-handling-and-merchandising/propagating-foliage-flowering-plants/

Introduction:

1. Show the PowerPoint (found at www.faitc.org/STEMming-Up), using embedded notes as a guide. Be sure to play the YouTube video links. Using Safesharetv.com will remove all comments and screen pictures except for the desired video. (Instructions for this are on slide three of the PowerPoint.)

Activity 1:

1. Explain that presenting posters is an important way that scientists communicate their research at national and international conferences. Scientific posters contain the steps of the scientific procedure for an experiment, just like they may have seen at science fairs.
2. Although this assignment does not have an experiment, designing a poster will be a great exercise in scientific communication.
3. Divide students into groups and assign each group a method of plant propagation. If using the *Worksheet Evaluation: Propagation Industry Research*, give each group a copy. There is an example poster at the end of the lesson that you can show students. Students should research on the internet examples of how plant propagation is used in industry. For example:
   - Grafting roses
   - Budding citrus
   - Tissue culture of orchids
   - Rooting cuttings such as geranium, coleus, and woody ornamentals, such as crape myrtle.
   - Air layering of lychee, house plants or ficus trees
   - Transplant vegetables (tomatoes)
4. As a group students will design a presentation on poster board using the information from *Worksheet Evaluation: Propagation Industry Research* provided.
5. Students present their poster to the class as a group.

Activity 2:

1. Research all the different propagation techniques and decide which one will be appropriate for your classroom setting and demonstrate each of them for the students or have students research the methods and design a demonstration.
2. In groups students will create a step-by-step procedure manual for the propagation techniques demonstrated by the teacher. Example procedure manuals are included at the end of the lesson.
3. Groups will then switch manuals with another group and follow the step-by-step instructions and propagate a plant.
4. Make weekly observations of plant propagations to determine plant growth and find out which method works best for the classroom environment.

Alternative or Extensions:

1. Tissue culture is a difficult propagation method to attempt in a classroom, especially if you do not have a way to create a sterile environment. You can have students get into groups and complete the Plant Tissue Culture (found at www.faitc.org/STEMming-Up) activity that has information, step-by-step procedures and questions.

Evaluation:

1. Grade group scientific poster for neatness, completeness and teamwork on the use of each plant propagation technique in industry.
2. Create a rubric for the procedure manual describing the steps of each technique, along with hand drawn pictures. See example assignments provided. This will be an excellent opportunity for students to write a step-by-step procedure, such as used in scientific writing. If accommodation is needed, written steps can be printed out and students could add drawings.
3. Grade students on the cooperative effort in the manual writing and the plant propagation.
4. Have students draw pictures on the step-by-step manual to show how well they understand how the method works.

References:

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Cornell University. Top Wedge Grafting. Retrieved July 25, 2015 from http://www.hort.cornell.edu/grafting/methods.alpha/TWGMeth.html [GRAFTING]

Crane, J.H., C. Balerdi, and I. Maguire. 2013. Lychee growing in the Florida home landscape. Retrieved July 25, 2015 from https://edis.ifas.ufl.edu/mg051 [AIR-LAYERING]

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McAvoy, G. and Ozores-Hampton, M. 2015. Commercial Transplant Production in Florida. Retrieved July 25, 2015 from http://edis.ifas.ufl.edu/cv104 [TRANSPLANT]

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University of Florida. (2015). Electronic Data Information Source. https://edis.ifas.ufl.edu/

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Wright, G. 200. Budding Citrus Trees. Retrieved July 25, 2015 from http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1146.pdf [BUDDING]

Worksheet Evaluation: Propagation Industry Research

Method of propagation: ______________________________

Plant industry studied: ______________________________

Statistics:

How many plants sold annually in the US? ______________________________

What is the dollar value? ______________________________

How many plants sold worldwide? ______________________________

What is the dollar value? ______________________________

History of industry: ______________________________

____

Three to five interesting facts about the plant industry: ______________________________

____

____

Three companies in industry: ______________________________

____

____

Description/ Procedure of technique/ Materials used: ______________________________

____

____

What are the growth requirements for a plant? Go from initial propagation to store: ______________________________

____

____

Names of group members: ______________________________

____

References (use at least three to five): ______________________________

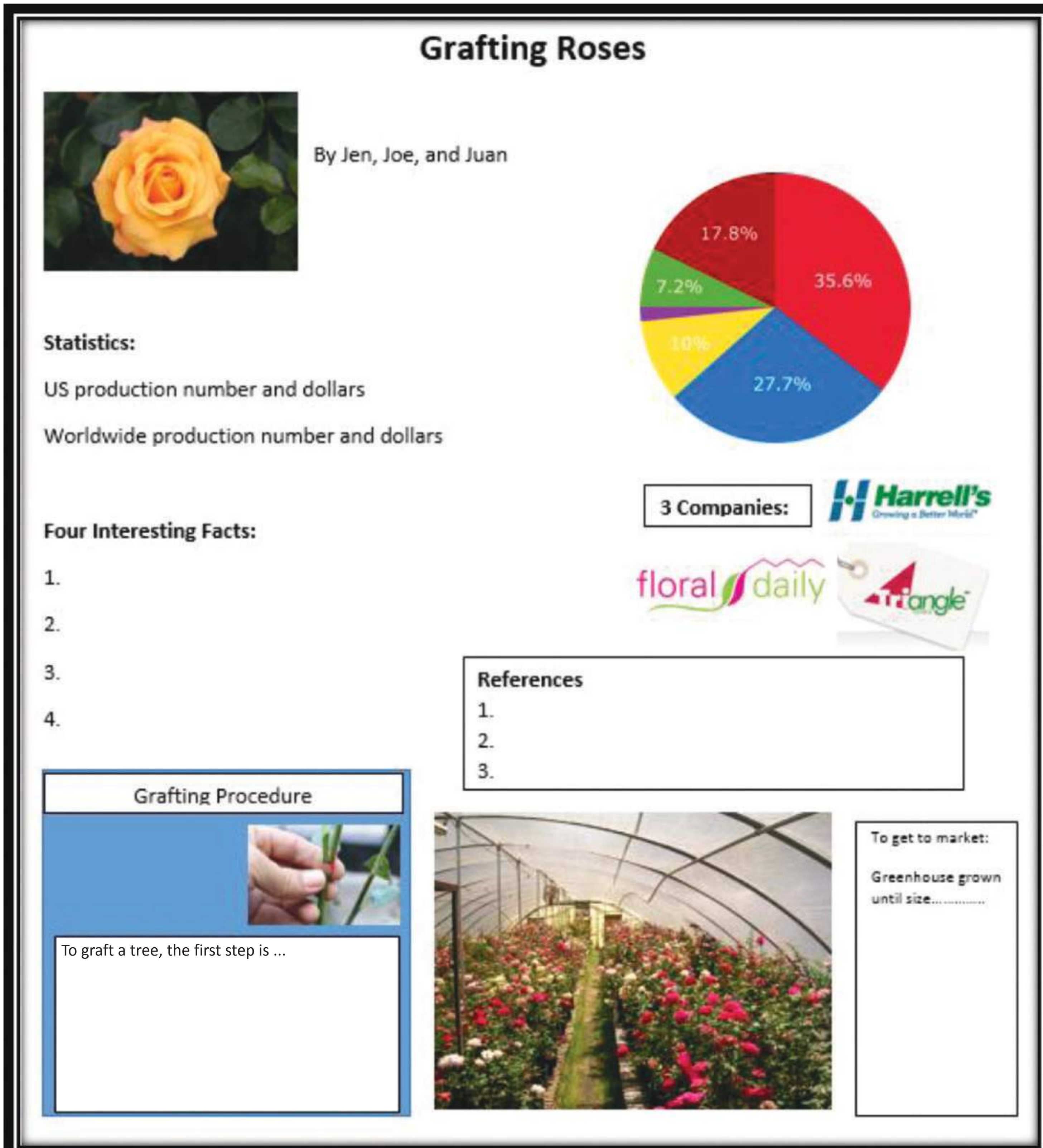
____

____

____

Picture of plant:

Example of Student Poster Presentation:



How to Root a Cutting

Name: ___________________________

1. Pick a plant. Cut off a branch.
   Make sure there are four to five nodes.

2. Cut off some of the leaf.

3. Dip the bottom of the cutting into rotting hormone.

4. Plant bottom two nodes in soil.

5. Keep misted or under clear plastic to trap humidity.

6. Check for roots after 10 days.

7. When there are good roots, the plant doesn't have to be misted or kept under plastic.

How to Scarify Seeds

Name: ________________________

1. Research on the internet if seeds need scarification.

2. Obtain seeds and choose method:

    a. Sandpaper

    b. Metal file

    c. Nail clipper

    d. Other (such as boiling in water briefly)

3. Plant seeds in potting soil.

How to Bud onto a Rootstock

Name: ________________________

1. Obtain certified bud wood from the state of Florida.
   -Or-
   Go outside in the school yard and choose a woody plant.
   * Using a schoolyard plant is just for practice.

2. Pick a place where the branch wood is young, but mature.
   It may be green with a little browning, but NOT tender.

3. Using a budding knife, slice the lateral bud off, cutting away from yourself.

4. In the rootstock (or the same shrub in the schoolyard), cut a "T" in the bark and peel the bark back. It may help to water the plant the day before.

5. Tuck the bud in the "T" slit.

6. Wrap with budding tape.

7. Check the bud in two weeks, and if not healed, re-wrap.
   If the bud is healed, prune the rootstock branch and bend back.

How to Graft a Tomato

Name: ___________________________

1. Get six egg cartons and cut a small slit in the bottom of each egg holder.

2. Get three packets of tomato seeds.

3. Plant ten seeds every two days for eight days. This is to get plants of different sizes so they can be matched up to fit each other.

4. After seedlings are three to four inches tall, choose a seedling to be the bottom rootstock. Cut off the leaves from the stem.

5. Choose a different variety seedling to be the top scion of the graft. It should have the same diameter stem as the rootstock. Cut the stem to obtain the leaves.

6. Place the top tomato on the cut of the bottom tomato, and attach with a grafting clip.

7. Keep the plant misted or under clear plastic to collect humidity.

8. Check the graft after 10 days for healing.

How to Air Layer

Name: ____________________________

1. Choose a woody plant. Choose a branch of mature wood. A few branches may be attempted, using older wood and newer wood.

2. Cut the bark in a one-inch-thick band and strip away the bark.

3. Soak a clump of Spanish moss in water and squeeze out the excess water.

4. Place the moss around the one-inch band of stripped bark.

5. Wrap tightly with plastic wrap.

6. Cover with aluminum foil to keep out light and encourage root growth.

7. Check for root growth after four weeks. Repot in a container for further growth.

Plant Propagation

Sample Pre-Post Test Assessment

Directions: Answer each question to the best of your ability.

1. What does it mean to propagate a plant?

2. Name two different methods used to propagate a plant.

3. Why would a grower pre-treat seeds before planting?

4. What is the benefit of transplanting a seedling versus planting a seed directly into the garden?

"Phun" with Photosynthesis

Brief Description:

Students will use light-sensitive beads to observe how sunlight can cause rapid physical and chemical changes in what it strikes. They will calculate the total surface area of leaves exposed to the sun on a saw palmetto plant. They will calculate how many photoelectric cells would equal the solar energy capturing ability of the saw palmetto plant they measure. The students will then design and make a tree using photoelectric cells as leaves.

Objective:

Students will be able to:

1. Explain that photosynthesis is a crucial process for all living things on earth.
2. List the steps in the process of photosynthesis by making a flow chart.
3. Produce measurable electricity by placing photoelectric cells into a tree form.
4. Explain why photoelectric cells are an environmentally sound way to produce electricity.

Time:

Lesson: up to 50 minutes
Lab/Field Observation: up to 100 minutes
Solar Project: 100 to150 minutes

Materials:

- Photoelectric cells (12)
- Graph paper in centimeters squared
- Light-sensitive beads
- Scissors
- Materials to make tree frame: wooden base, dowels, tape, wire, etc.

Vocabulary:

element, atom, ion, nucleus, electron, catalyst, enzyme, NADP, ADP, ATP, rubisco, energy levels and photoelectric cells

Photosynthesis Equation:

Carbon Dioxide + Water $\xrightarrow{\text{(Light)}}$ Sugar + Oxygen

$$6CO_2 + 6H_2O \xrightarrow{\text{(Light)}} C_6H_{12}O_6 + 6O_2$$

Procedure:

1. The students will go outside where they can readily observe the green world around them. The green is reflected because red and blue are absorbed in the light spectrum and therefore we see green.
2. The steps of photosynthesis will be reviewed and the importance of this process for all living things on the surface of the earth will be expressed.
3. Use light-sensitive beads to show students ultraviolet (UV) light. The beads will remain white while indoors because incandescent and flurescent lights will not affect them. The beads will turn a bright color when exposed to UV light. This allows the students to see a reaction to UV light other than a sunburn on their skin.
4. Students will complete a *Pre-Lab* assignment to reinforce their knowledge needed for the photoelectric tree build project.
5. Give each student a copy of the *Field Observations/Lab*. The class will look at a saw palmetto plant, determine the total number of leaves on the plant, calculate the surface of a leaf using graph paper, and calculate the total surface area of the leaves on the entire plant. This is the total area of the plant exposed to light.
6. Give each student a copy of the *Solar Project* handout. Students will look at the similarities of energy changes involved in the palmetto plant capturing sunlight and sunlight hitting photoelectric cells. The students will make a tree using photoelectric cells and compare the electric energy produced.
7. Optional: Take students on a photosynthesis walk. Look at the advantages of different leaf shapes and sizes, how all plants strive to get their leaves exposed to the sun, and what happens to plants when they are deprived of sunlight.

*Lesson created by The Savanna Preserve State Park Life Program in collaboration with the St. Lucie School System.

Florida Standards:

SC.7.P.11.2, SC.7.P.10.1, SC.7.L.15.2, SC.8.L.18.1, SC.8.N.3.1, LAFS.68.WHST.3.7, LAFS.68.WHST.4.10, SC.912.L.17.19, SC.912.L.17.20, SC.912.L.18.7, SC.912.P.10.1, LAFS.910.WHST.3.7, LAFS.910.WHST.4.10, LAFS.1112.WHST.3.7, LAFS.1112.WHST.4.10

"Phun" with Photosynthesis

Pre-Lab

Name: ______________________________ Date: ______________

1. What is the difference between a lead blade and a frond?

2. How does a photoelectric cell compare with photosynthesis?

3. How do you think the surface area of plant leaves will compare with the surface area of photoelectric cells in their ability to capture solar energy?

"Phun" with Photosynthesis

Field Observations/Lab

Take students outside to observine saw palmetto plants. Place students into groups.

How many leaf blades are on one palmetto frond?

How many fronds are on a palmetto plant?

What is the total number of leaf blades on the palmetto plant?

Remove one leaf blade from the palmetto plant per group to take to the classroom to use on assessment questions.

Aim the photoelectric cell array directly at the sun and record the meter reading in milliamperes.

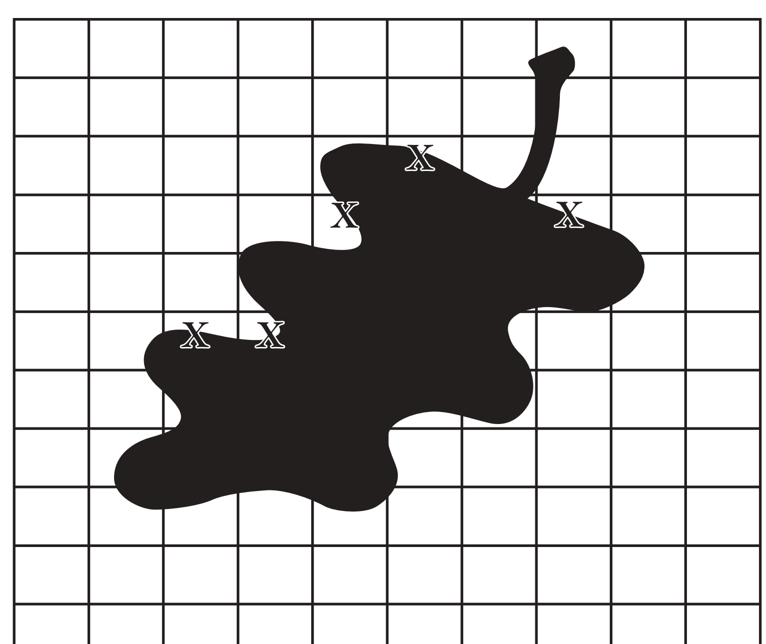
Aim the photoelectric cell array so it is pointing away from the sun and record the meter reading in milliamperes.

Position the photoelectric cell array so it is at a right angle to the sun and record the meter reading in milliamperes.

What is the average of your three milliamperes readings?

Lab Assessment:

- Cut the palmetto leaf blade into pieces so that each person in your group has a piece.
- Each person in the group will lay their piece on graph paper.
- Outline the leaf part with a marker, then remove the leaf part.
- Count the squares the leaf part covered on the graph paper. (Count partially-covered squares that are more than half covered as one square and ignore the squares that are less than half covered.)



1. Record the number of squares covered on your sheet: ________________

2. Record the number of squares covered on each of your team member's sheets:
___________, ___________, ___________, ____________, ___________

3. Record the total number of squares covered by one leaf blade (add the answers from questions 1 and 2): _____________

4. Record the area of the leaf blade in centimeters squared (cm^2). Remember that each square is one cm^2. (should be the same answer as question 3): ______________________

5. Record the total leaf blade area exposed to sun (both sides of leaf are exposed to sun): _______________________

6. Total cm^2 of leaf area in the entire palmetto plant exposed to the energy of the sun (multiply answer to question 5 by the number of leaf blades found on the entire plant): _________________________________

7. A table top covers an area of 13,859 cm^2. How many table tops of saw palmetto plants were exposed to energy of the sun? (Divide the answer to question 6 by 13,859): ___________________________________

8. A photoelectric cell does only one thing: it uses the energy of the sun to produce electricity and it needs less sun to do that one task. Photosynthesis within a plant lead is much more complex. The energy of sunlight is used to power eighty differential chemical reactions.

   Divide the answer to question 7 by the answer to question 6 to determine how many table tops an array of photoelectric cells would have to cover to capture the same amount of solar energy as one palmetto plant:

9. Now multiply the answer to question 8 by 13,859 (this is the number of tables times the area of a table top in cm^2):

10. Now multiply the answer to question 9 by 13, 859. ____________________

11. Divide the answer to question 10 by area of the photoelectric cell used: ____________________

Hint: The answer to question 11 is how many photoelectric cells it would take to capture the same amount of the sun's energy as your saw palmetto plant can capture!

"Phun" with Photosynthesis

Solar Project

1. Design and create a solar tree. The leaves will be photoelectric cells. Consider the following:
   - How many photoelectric panels you will need to model the energy captured by the class average calculated for the typical saw palmetto plant. Is that possible with your given materials?
   - If it takes 600 photoelectric cells to equal the one typical plant, what is your ratio for using six cells, or five?
   - The observations you gathered of the movement and placement of the fronds from sunrise to sunset.
   - The arrangement you observed of the saw palmetto frond on your plant.

2. Your tools available are: wooden base, dowels, tape, wire and photoelectric cells.

3. Draw your design and get approval from teacher. Once you gain approval to build, start working together to create your model using the materials given.

4. When ready ask for permission to take your model to a testing station:
   - Position the lamp above your model to represent the sun at the time of day your class meets.
   - Place your model on counter in direct path of light waves and turn on light.
   - Connect milliamp meter to circuit, take measurement and record.

5. Compare your model with those of other classmates and discuss.

Questions:

How many amperes of electric current did your solar tree produce? ____________________

How well did your tree capture energy of the sun compared to the other solar trees made by your classmates?

____

____

Explain how you might alter yours or what made it so successful: ______________________________

____

____

"Phun" with Photosynthesis

Assessment Questions

1. What was the size of one square on the graph paper you used to measure your saw palmetto leaf blade? ____________________

2. What relationship between leaf blades and fronds on a saw palmetto plant helped you to calculate the number of leaves on one plant?____
____

3. Why did you have to multiply the measured area of the palmetto leaf by two?______________________________
____

4. Describe how you would calculate the surface area of the needles on a pine tree:____________________________
____
____
____

5. How would planting a large number of trees in a city benefit the people of that city? ______________________
____
____
____
____

Journal Prompt:
Carbon dioxide and other gases in the air enter and exit through the stomata within the leaves of plants. Photoelectric cells can take the place of other sources of electric power. In your journal, record your ideas about how both plants help and how photo-electric cells might help to make the air and thus our whole planet a cleaner place to live.

Greenhouse Technology

Brief Description:
Students will use a greenhouse to germinate seeds and grow plants to better understand the science and dynamics of a greenhouse. For schools without greenhouses students will research, design and create a cost analysis of building a greenhouse at school.

Objective:
Students will be able to:
1. Prepare seeds to germinate and grow in a greenhouse.
2. Document the atmospheric and greenhouse temperatures and observe the growth of their plants in order to understand the science of how a greenhouse operates.

Time:
Activity 1: The preparation of the potting mix and seeds will take approximately one class. The monitoring, recording, and observation of plant growth and greenhouse temperatures will be done the first 15 to 20 minutes of each class for up to a month, depending on the type of seeds planted. The final greenhouse evaluation will also take one class.
Extension Activity: One to two weeks depending on how much in-class work is done.

Materials:
- A greenhouse (if possible)
- Thermometer that measures both the **high and low** atmospheric/outside temperatures, as well as the **high and low** of the greenhouse temperatures
- Potting mix or sand, compost, peat moss, perlite
- 500mL (cm^3) beakers
- Calculator
- Metric ruler centimeters (cm)
- Plastic tub for mixing potting mix
- Mixing shovel
- Potting tray
- Newspaper
- Masking tape
- Markers
- Microgreen seeds or seeds of your choice
- Clip boards for recording information

Vocabulary:
UV spectrum, solar wavelengths, shorter wavelengths, longer wavelengths, infrared, thermal energy, convection, conduction, radiation, converted, quantitative, qualitative, range, mean, ratio and inundated

Background:
How Does a Greenhouse Work?
Greenhouses are designed to germinate seeds and grow plants when the conditions for germination and the growth of plants is not possible in the natural environment. Fruits and vegetables, such as blueberries and tomatoes, are not naturally available at all times of the year, in all climates, and in all geographical locations. Greenhouses create a controlled environment in which seeds can germinate and grow even when the outside environment is inhospitable to plant growth.

In order to grow, plants need sunlight, water and nutrients. Greenhouses are built to provide all of those needs at all times. At its most basic, greenhouses collect the sunlight and convert it to heat. The heat is stored by preventing it from escaping back into the outside, colder air. Thus, the temperature and humidity are stable by keeping the cold air outside, preventing too much rainwater from inundating plants, and protecting plants from pests and diseases.

Short and Long Wavelengths
Glass (as well as other transparent materials such as plastic) allows most of solar (sun) shorter wavelengths to pass through, with the exception of the long (thermal infrared) wavelengths. So, solar radiation can come into the greenhouse, where the plants convert it into thermal, long wavelengths (heat). Since the glass is not transparent to the thermal wavelengths, they get trapped in the greenhouse, heating the air, plants, soil and the greenhouse structure itself.

When heated by the sun, soil warms up, whether it is in the greenhouse or outside of it. The air around the soil warms up as well and, as it is less dense than the cool air, starts expanding and raising. Outside of the greenhouse, the warm air goes into

Florida Standards:

SC.6.N.1.5, SC.6.N.1.3, SC.7.N.1.5, SC.7.L.17.2, SC.7.L.17.3, SC.8.N.1.5, LAFS.6.SL.1.2, LAFS.6.SL.1.3, LAFS.6.SL.2.4, LAFS.68.RST.1.1, LAFS.68.RST.1.2, LAFS.68.WHST.2.6, LAFS.68.WHST.3.7, MAFS.7.SP.2.4, VA.68.C.2.1, VA.68.C.2.2, VA.68.C.2.3, SS.7.C.2.12, SS.7.C.2.13, and SS.7.C.2.14

the atmosphere, where it eventually cools off. In the greenhouse, hot air is trapped, so the temperature in the greenhouse keeps rising throughout the day. The heat causes water to evaporate, creating high humidity making the greenhouse atmosphere better for plants' growth.

Heating and Cooling

Of course, we cannot stop the sun from shining and heating the greenhouse, so the temperature can become too high for plants. It is up to us to design a system to control the amount of heat that remains in the greenhouse. Well-designed greenhouses have vents that automatically open when the air temperature reaches a certain point, and close when the temperature drops below the one desired. Fans help to keep the temperature within the entire greenhouse even by circulating the air – moving the hot air higher up and mixing it with the cooler air at the lower parts of the greenhouse. Automatic misting systems can also help with keeping the temperature and humidity stable. During the night, the temperature can drop too low and the greenhouse sometimes has to be heated in order to keep the temperature optimal for plants' growth.

Thermal Mass

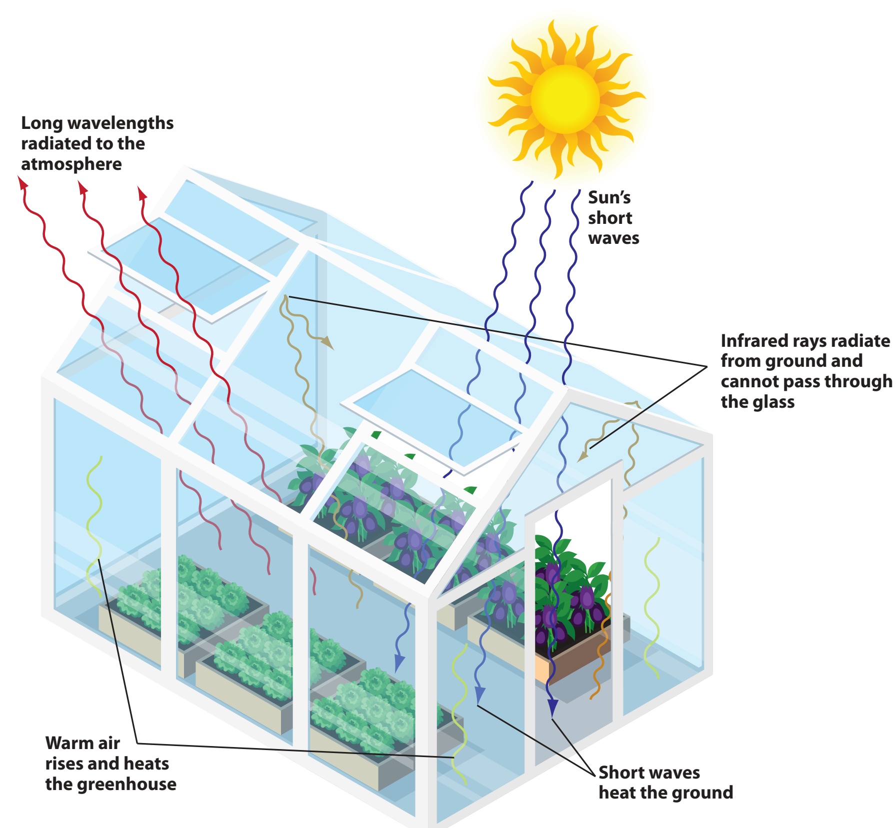
Of course, the air is not the only thing that gets heated by the sun. Everything else in the greenhouse gets heated to a different extent. Wood, water, soil and bricks get heated slowly and release heat slowly. Iron and aluminum warm up fast, and release heat fast. This is particularly important at night when the stored heat or 'thermal mass' slowly releases the heat, keeping the temperature in the greenhouse warm even when the sun is not there to heat it up. That is why it is so important to design the greenhouses carefully, using materials that have the ability to store and release a large quantity of heat slowly. Wooden frame, brick greenhouse floor, open plant trays full of soil, all store and release heat slowly, and are more useful to keeping the greenhouse temperature optimal at night than iron or aluminum, which heat fast, but lose the heat fast as well.

Water

Plants in the greenhouse get a fair amount of needed water through water vapor, but it is not enough for a fast growing process. An automatic watering system provides water to plants when it is needed, and the greenhouse structure prevents too much water, such as excess rain, from inundating plants. A well-designed greenhouse will have a system or gutters and drainage for managing the excess water inside and out.

Protection

A greenhouse also acts as a 'house' for plants – it keeps them protected from insects, pests, domestic pets, hail, strong wind, falling debris, flying baseballs and anything else that can damage your precious buds and seedlings. Keep in mind that pollinators, like bees, are also kept outside, so choose self-pollinating plants or introduce a few bees inside.



Introduction:

1. Begin by having students answer a starter/challenge question that relates to outside temperatures and plant growth, such as:
"The record low temperature ever recorded in Florida was -2°F which occurred on February 13, 1899, in Tallahassee. The record high for Florida in February was 90°F which occurred in Orlando in 1962. What is the range in temperatures for the record high and low in Florida?"
Answer: 90°F-(-2°F)= 92°F
2. Discuss the extreme weather fluctuations that occur in parts of Florida (especially in the north) from late December until early March and how these fluctuations make it very difficult and risky to plant many types of fruits and vegetables, such as tomatoes, lettuces, sweet basil and oranges. Prompt with questions such as "How can people grow fruits or vegetables if the climate is not supportive?"
3. Distribute the background materials on "How Does a Greenhouse Work" and read aloud with the class. Discuss the advantages and disadvantages of growing in a greenhouse. Discuss the type of greenhouse that you will be using at your school.

Procedure:

1. Students will engineer their own potting mix, referring to the *Seed and Potting Mix Preparation* sheet on creating a potting mix for microgreens. The preparation of the potting mix takes one class. Generally, four students per tray of mix and seeds works best.
2. Once the tray of seeds is placed in the greenhouse, distribute the *Greenhouse Observation Lab* and review the key components of the chart on an overhead projector. Remind students that they can work with the people at their table, but each person is responsible for recording temperatures and plant growth. Ten to fifteen minutes should be spent during each class recording and observing the plants in the greenhouse.
3. When the plants have reached full growth, complete the *Greenhouse Evaluation* sheet. Encourage students to write complete sentences when creating the captions for the science of a greenhouse.

Extensions:

1. Students can design experiments to see if changing the ratio of perlite or fertilizer impacts plant growth.
2. If your school does not have a greenhouse have students (in groups) design an ideal greenhouse for the space available at your school. Make sure to include building materials, irrigation, heating, cooling and possible tables or shelves.
3. After the greenhouse is designed, students will research the cost to create their "ideal" greenhouse.
4. You can set a budget and space availability for students before groups begin their designs or let students decide.

Seed and Potting Mix Preparation

Name: ______________________________ Date: ______________ Per. ________

Background Information: Seeds remain dormant or inactive until conditions are right for **germination**, the sprouting of a seed into a plant. All seeds need are water, oxygen and proper temperature for germination to occur. Some seeds need specific amounts of sunlight, too. In this lab you will prepare the medium (materials in which a seed is placed), and monitor the temperature and the amount of time it takes your seeds to sprout. When growing **microgreens** in a container, you need to ensure that the container has a depth of at least five centimeters (two inches). It needs to be filled with excellent quality potting mix, as well as compost for root growth. The soil needs to be smoothened. Scatter the seeds at least one centimeter (¼ inch) apart and cover them with at least .5 cm (1/8 inch) of soil. Place the container in a place where it gets at least three to four hours of sunlight each day. It is best to place it in a south-facing window.

Materials: 500mL (cm^3) beakers, calculator, metric ruler centimeters (cm), plastic tub, mixing shovel, potting tray, newspaper, sand, store-bought compost, peat moss, perlite and microgreen seeds

Directions: Follow each step in order to place the correct amounts of potting mix in your potting tray.

1. Find the **volume** of your potting tray. Do not measure higher than **five centimeters for the height** of your tray. Show the formula for the volume of your tray, show your work, and be sure your answer is written in **cm^3**.

Answer ______________________________

2. Your tray will need equal amounts of sand, compost and peat moss. How will you divide the volume of your potting tray into three equal parts? Explain how you complete this step mathematically and list the appropriate amount of sand, compost and peat moss in **cm^3 or mL**.

Sand________________ Compost________________ Peat Moss ________________

3. Once your work is **approved** by your teacher, you may prepare your potting mix in a plastic tub using a shovel or spoon.

4. All groups need to add perlite to the potting mix to help aerate the potting mix and trap in needed moisture. The ratio of perlite to potting mix is 1:25 or 1/25. In other words, for every one part of perlite, 25 parts of potting mix is needed. With that ratio in mind, show how much perlite will be needed if you have 6,500mL or cm^3 of potting mix.

5. Some of the groups will receive fertilizer for their potting mix. The ratio of fertilizer to potting mix is 1:50 or 1/50. In other words, for every one part of fertilizer, 50 parts of potting mix is needed. With that ratio in mind, show your work to solve how much fertilizer in mL or cm^3 will be needed if you have 6,500mL or cm^3 of potting mix.

6. Describe how your group decided to spread the seeds most evenly throughout the tray in order to achieve at least one seed per cm^2? What method worked the best?

Greenhouse Observation Lab

Name: ______________________________ Date: ______________ Per. ________

Directions: Over the next few weeks, you will observe your tray of microgreens that are growing in the greenhouse. Additionally, you will observe other trays, the high/low temperature of the greenhouse, and the high/low of the outside temperature.

Materials: Pencil, clipboard, calculator, thermometer and metric ruler

1. Use the table below and the temperature monitor in the greenhouse (GH) to record quantitative data about the greenhouse temperatures, the outside temperatures and the height of your tray of microgreens.

Date	GH-High Temp. ˚F	GH-Low Temp. ˚F	**Range** in GH Temp. ˚F	Outside High Temp. ˚F	Outside Low Temp. ˚F	**Range** in Outside Temp. ˚F	Microgreen Height in cm
Mean (average)							

2. **Qualitative data:** On the lines below and on the back side of this paper, record qualitative data about your tray of microgreens and other trays of microgreens, both in your class and in the other classes.

Date ________________

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Date ______________________

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Date ______________________

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Date ______________________

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Date ______________________

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Date ______________________

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Date ______________________

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Date ______________________

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Greenhouse Evaluation

Name: ______________________________ Date: ______________ Per. __________

Directions: Using your data and observations from the *Greenhouse Observation Lab*, complete the following questions.

1. Which had a higher mean (average) temperature **range**, the greenhouse or the outside temperature?

2. How might you explain why the greenhouse or the outside temperature had a greater range?

3. What was the difference between the mean greenhouse **high** temperature and the mean outside **high** temperature? Show your work.

4. What was the difference between the mean greenhouse **low** temperature and the mean outside **low** temperature? Show your work.

5. Use your data to support the advantages of using a greenhouse in the winter months in North Florida. Cite your data as evidence while explaining the reasons for using a greenhouse in the winter.

6. Using handouts and online sources, create a simple sketch with **captions** that explains how a greenhouse is heated and how it traps heat. Your sketch should illustrate the flow of the sun's energy into the greenhouse and the movement of energy in the greenhouse. Your captions, (at least two) should explain how the sun's energy enters the greenhouse and how the sun's energy is trapped and converted into heat in the greenhouse.

Greenhouse

Sample Pre-Post Test Assessment

Directions: Answer each questions as thoroughly as possible.

1. What type of solar (sun) wavelengths are able to pass through the glass or plastic of a greenhouse?

2. What type of solar (sun) wavelengths become trapped in the glass or plastic of a greenhouse?

3. Name two advantages of using a greenhouse.

4. What is a possible disadvantage of a greenhouse?

5. What objects in a greenhouse will conduct the heat from the sun?

Alternatives to Traditional Gardening

Brief Description:

In this project-based learning lesson, students will read articles and view digital media to gather information about plant growth. They will learn about the nutrients plants need and the environmental factors that contribute to healthy plant growth. They will explore how people who live in urban areas get their food as well as learn alternative gardening methods including hydroponics, aquaponics, container gardening and vertical gardening. The students will research at least two of the gardening methods that interest them using multiple sources such as interviews, articles and videos. They will compare and contrast the gardening methods they research and then write an opinion essay on the gardening method they prefer, using evidence from their sources to support their position. The students will then work in teams to design and construct an alternative garden using recycled materials. Using the rubric, they will organize their information and use digital resources to prepare a presentation.

Objective:

Students will:

1. Learn about the nutrients and environmental factors that contribute to healthy plant growth and what factors prevent some people and communities from gardening.
2. Design and plan an alternative (non-traditional) garden and present their findings to the class.

Time:

Introduction: one class period
Activity 1: 50 minutes to create a survey; one week - daily data collection
Activity 2: 50-100 minutes to research information; one week to complete presentation in class or after school

Background:

Anytime is a great time to try a different approach to traditional vegetable gardening! If you don't have the proper resources, the physical ability, or the space for a large garden there are alternatives. Limited space and light can also be a good reason to try something different. There are many different types of alternative gardens; some do not require soil, some require less space, some use different methods of supplying nutrients to the plants, some are specific to a culture or geography and some are themed. Examples of theme gardens include salsa, pizza or soup gardens (see pages 27-28).

Examples of alternative gardens that require less space and in some cases no soil are:

Container gardening is a good option for apartments, rooftops, balconies, terraces and other small spaces. Almost all vegetables can be grown in a variety of containers as long as they are big enough and provide adequate drainage.

Florida Standards:

SC.6.N.1.1, SC.7.N.1.3, SC.7.L.17.3, SC.8.N.1.4, LAFS.6.RI.1.1, LAFS.6.RI.1.2, LAFS.6.RI.2.6, LAFS.6.RI.3.8, LAFS.6.RI.3.9, LAFS.6.SL.1.2, LAFS.6.SL.2.4, LAFS.6.SL.2.5, LAFS.6.W.1.1, LAFS.6.W.2.6, LAFS.6.W.3.9, LAFS.7.RI.1.1, LAFS.7.RI.1.2, LAFS.7.RI.2.6, LAFS.7.RI.3.8, LAFS.7.RI.3.9, LAFS.7.SL.1.2, LAFS.7.SL.2.4, LAFS.7.SL.2.5, LAFS.7.W.1.1, LAFS.7.W.2.6, LAFS.7.W.3.9, LAFS.8.RI.1.1, LAFS.8.RI.1.2, LAFS.8.RI.2.6, LAFS.8.RI.3.8, LAFS.8.RI.3.9, LAFS.8.SL.1.2, LAFS.8.SL.2.4, LAFS.8.SL.2.5, LAFS.8.W.1.1, LAFS.8.W.2.6, LAFS.8.W.3.9, MAFS.6.G.1.4, MAFS.6.SP.2.5, MAFS.7.RP.1.1, MAFS.7.RP.1.2, MAFS.7.RP.1.3

Hydroponics gardening is a method of growing plants without soil but instead using mineral nutrient solutions in water.

Aquaponics gardening is a food production system that combines conventional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water) in a symbiotic environment.

Vertical gardening can use trays stacked against a wall or containers attached to a vertical structure. Whether it's because of limited space or to cover an unattractive wall, this is great way to cultivate and grow small plants and herbs.

Introduction:

1. Conduct class discussion about what plants need to grow. Students should have an understanding of what nutrient are available in the soil (nitrogen, potassium and phosphorous) as well as environmental factors such as sunlight and space. See lesson "Feed Me-Nutritional Building Blocks" from *Gardening for Grades* or "In Search of Essential Nutrients" from *Gardening for Nutrition* for more about NPK.
2. Brainstorm the factors that might prevent people in various communities or dealing with challenging conditions (urban areas, deserts, limited water or soil) from vegetable gardening.
3. Brainstorm or discuss different type of gardens from different methods to different designs and themes.

Activity 1:

1. Students will work in groups to design a survey method to gather more information about the drawbacks to traditional gardening in their community.
2. They will survey their community about what prevents them from vegetable gardening or how they are able to garden at their homes using various resources (blogs, pencil/paper survey, interviews). Possible survey questions are:
   a. Do you have a vegetable garden?
   b. If yes, what does your garden look like? Is it a traditional bed, hydroponics, container, etc.?
   c. Why did you choose that gardening method?
   d. If no, why don't you garden?
   e. What, if anything, would encourage you to garden?

Activity 2:

1. In groups, students will explore two alternatives to traditional gardening that meet the needs of the community they selected. If the surveys showed that people in the community were not gardening due to lack of space, then have students choose the best two methods that grow the most food in the least amount of space. If the survey showed that it was not lack of space, then other methods can be chosen based on either cultural or theme.
2. Students (as a group or individually) will write an opinion essay (one page typed, double-spaced or two pages handwritten) using evidence from the resources they use to explain the alternative gardening methods they chose. At least three sources must be used; two of them being government- or education-based and one can be a personal opinion or blog. The parameters of this part of the activity can change with the teacher and class.
3. Each group will prepare a multimedia presentation (PowerPoint, Prezi, infographic, etc.) that documents the results of their research. They will explain which non-traditional method they chose that best meets the needs of a particular community and include the pros and cons of the methods. Students will design and determine the resources (including costs) needed to construct the alternative garden, as well as prepare a scaled-down model of what the garden will look like once completed. Suggest that presentations be at least five minutes long and include the how-to model.
4. A sample rubric is included on page 152 to assist with planning and organizing presentation.

Extensions:

1. Seek funding and volunteers to assist with constructing and maintaining the alternative garden.
2. Each team can construct the alternative garden and compare the results.
   For instance…
   How long did it take the seeds to germinate?
   How much did each garden yield?
   What was the cost of each garden?
3. Use Google Earth to determine places in the community where gardens could be created.
4. Discuss the drawback(s) to each alternative garden.
5. Have students brainstorm ideas for other forms of alternative gardens.
6. Create an infomercial for one of the alternative gardening methods.

Evaluation:

1. Grade students on the thoroughness of their surveys and ability to work in a group.
2. Use sample rubric on page 152 to grade multimedia presentation.

Resources:

https://app.discoveryeducation.com/search?Ntt=what+plants+need+to+grow (video)

https://afsic.nal.usda.gov/education-and-research/classroom-and-curricula

http://www.globalgardenfriends.com/2013/01/everything-you-need-to-know-about-hydroponics/

http://www.growingpower.org/education/what-we-grow/aquaponics/

https://www.youtube.com/watch?v=-z1kozprw8Y

http://www.rodalesorganiclife.com/garden/container-gardening

http://containergardening.about.com/od/vegetablesandherbs/ss/10-Great-Vegetables-to-Grow-In-Containers.htm

http://www.woollypocket.com/vegetable-herb-gardening?gclid=CKi5yq3tnMcCFcEUHwod23EKAg

http://www.diynetwork.com/how-to/outdoors/gardening/how-to-grow-a-vertical-vegetable-garden

Project-Based Learning: Alternatives to Traditional Gardening

Sample Pre-Post Test Assessment

List three advantages and three disadvantages to:

1. Hydroponics gardening

2. Container gardening

3. Vertical gardening

4. Aquaponics gardening

Alternative Gardening - Multimedia Presentation Rubric

Criteria	4	3	2	1
Research of Community	☐ Use of three or more sources ☐ Factual information is accurate ☐ Narrow focus of topic	☐ Use of two sources ☐ Most information can be confirmed ☐ Topic could be more narrowly focused	☐ Use of one Internet source ☐ Some errors in information ☐ Topic somewhat broad	☐ Use of only one source ☐ Numerous errors in information ☐ Topic too general
Organization (Outline or Storyboard for Planning)	☐ Logical sequencing ☐ Menus and paths are clear ☐ Original; inventive; creative	☐ Somewhat logical sequencing ☐ Menus and paths are mostly clear ☐ Original	☐ Sequencing is poorly planned ☐ Menus and paths are sometimes confusing ☐ Little originality	☐ Sequencing is confusing ☐ Menus and paths are confusing ☐ Inconsistent ☐ Rehash of other people's ideas
Gardening Graphic/ Design Method	☐ Covers topic completely and in depth ☐ Accurate list of materials ☐ Effective combination of multimedia and persuasive design elements	☐ Covers topic ☐ List of most materials ☐ Good combination of multimedia and design elements	☐ Barely covers topic ☐ Some materials ☐ Some use of multimedia and design elements	☐ Does not adequately cover topic ☐ Very few materials listed ☐ Zero to one media used
Mechanics	☐ Correct grammar, usage, mechanics and spelling ☐ All sources are correctly cited	☐ Few grammar, usage, mechanics or spelling errors ☐ Most sources are correctly cited	☐ Several grammar, usage, mechanics or spelling errors ☐ Some sources are incorrectly cited	☐ Obvious grammar, usage, mechanics, or spelling errors ☐ Sources are not cited
Teamwork (optional)	☐ Work load is divided and shared equally	☐ Some members contribute	☐ Few members contribute	☐ One or two people do all of the work

Name: ______________________ Team: ______________ Final Score: __________

Hydroponic Vertical Farming: Helping Feed Our Growing Population

Brief Description:

By 2050, it's estimated that 80 percent of the world's 9.2 billion population will live in urban areas. In this lesson students will gain an understanding of what a seed needs in order to grow into a healthy plant, and what a vertical farm is by comparing and contrasting this method of food production with conventional farming methods. Students will design their own rubric; research best practices; create blueprints; and modify and build a working model of an indoor vertical hydroponic farm through collaborative efforts using recycled materials. This closed system should last six or more months, which allows students time for reflection, entertainment and a healthy snack.

Objective:

Students will:

1. Understand what a seed needs to grow into a healthy plant.
2. Know what a vertical farm is and compare and contrast that method of food production with traditional farming methods.
3. Design and build a working model of a hydroponic vertical farm.

Time:

Up to two weeks
Activity 1: 30 to 60 minutes
Activity 2: 30 to 60 minutes
Activity 3: 60 to 90 minutes
Activity 4: 60 to 120 minutes
Activity 5: 30 to 60 minutes
Activity 6: 60 to 90 minutes

Materials Needed:

- Recycled materials such as plastics bottles
- Soilless growing medium
- Wire
- String
- Metal chain
- Five gallon aquarium/reservoir
- Water pump, hydroponic hose
- Barbed valves
- Plastic flex net cups
- Seeds or seedlings
- Hydroponic fertilizer
- Optional: grow lights, pH test kit, thermometer

Background:

The impact that humans have had on Earth include deforestation, urbanization, desertification, erosion, poor air and water quality, and changing the flow of water. Through innovative techniques such as hydroponic vertical gardening, we can mitigate some of the effects of urban sprawl.

Hydroponics is a method of growing edible crops in soilless, nutrient-rich water. Advantages of hydroponic gardening include: reduction in runoff; less water usage; crops can be grown indoors year-round; plants require less space, and can have higher yields.

Florida Standards:

SC.7.E.6.6, LAFS.6.SL.1.1, LAFS.6.SL.2.4, LAFS.7.SL.1.1, LAFS.7.SL.2.4, LAFS.8.SL.1.1, LAFS.8.SL.2.4, LAFS.68.RST.3.7, LAFS.68.RST.3.9, SC.912.E.6.6, SC.912.L.17.12, SC.912.L.17.15, SC.912.L.17.16, SC912.L.17.18, SC.912.L.17.20

Possible Sequencing Calendar

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Science	**Engage:** Introduce project and vertical farming to students.	**Engage:** Facilitate a lesson on traditional farming.	**Explore:** Students research vertical farming and learn the requirements of their project.	**Explore:** Students build their model.	**Elaborate/Extend:** Students test their model and make changes to their model based on their test and findings.	**Evaluate:** Students present their project to the class.
Math	**Engage:** Introduce project and facilitate a lesson on proportions with Gizmo activity.	**Explore:** Students learn about scale drawings.	**Explore:** Students brainstorm ideas about how their vertical farm can look and make a sketch of their farm to scale.	**Explain:** Students learn about budgets and create a budget for their vertical farm.		

Activity 1:

1. Introduce the project to the students by explaining to them that the end goal will be for them to make a hydroponic vertical farm with specific requirements. They will get their rubric on day three of project.
2. Show students two pictures, one picture of vertical farming and the other of conventional farming (see page 154). Ask students to analyze the pictures and consider what they see in the picture, what they think about the pictures and what they wonder about the pictures, and fill in the *See-Think-Wonder Handout*. Lead the students in a class discussion by having them share.
3. As a class, complete a *KWL: Farming* chart (K-what the student knows, W-what the student wants to know, L-what the student has learned). Students should complete a class *KWL: Farming* chart for their personal notebooks. Students will add to the chart as they continue to go through the activity.
4. Play Windowfarms Project video or locate your own hydroponic vertical video (https://www.youtube.com/watch?v=PkCuPrsPn_I). This video provides students with information on vertical farming.
   - Ask students the following questions:
     - "What are the advantages of vertical farming?"
     - "What are some of the difficulties with vertical farming?"
     - "How is vertical farming different from conventional farming?"
     - "What are some reasons that vertical farming would be preferred over conventional farming?"
     - "If you were a politician being asked to vote on the issue of whether to approve a vertical farm in your neighborhood, would you be in favor of it? Why or why not?"
5. Facilitate a lesson with the students on proportions and common multipliers. As students complete the examples, have them explain their thought process for the solution. At the end of the lesson, have students write a real-world problem that involves a proportion.

Activity 2:

1. Students will need to research factors involved in conventional and hydroponic farming such as space needed on average for a set amount of plants, amount of water needed/used, nutrients needed, costs, etc. Students will complete a Venn diagram comparing and contrasting vertical/hydroponic and conventional farming.
2. Discuss with students the feasibility of vertical/hydroponic farming feeding the world. Have students think about countries with less available water, no power and the cost of shipping food grown on hydroponic farm. After discussion, ask students to write an opinion paper titled "Can hydroponics feed the world?"
3. Introduce the design build aspect of this lesson by giving students an example of a big figure, for example, the blueprint of a home and the actual home. Explain the importance and process of forming a scale. Create scale models of classroom objects such as tables or desks. Assign students the task of creating a scale model of a textbook from your classroom. Students will complete this task using graph paper.

Activity 3:

1. Provide students time for research on the internet to learn more about vertical farming, what it fully entails and possible design options. If you do not have time for research find multiple articles from reputable websites to print out for the students.

2. Have students assign point values to the *Blue Print Rubric*.
3. Explain to the students their task by saying:
   - By 2050, the world's population is expected to reach 9.1 billion or more.
   - Local crops could reduce the costs of transporting food from distant places.
   - As the world population grows, soil is being used increasingly to create housing while continuing to produce crops used to feed livestock.
   - Alternative farming methods will also be needed such as hydroponic farming.
   - Using provided materials, design a model of a vertical farm that meets the following criteria:
     - Must be a minimum of three levels.
     - Light must reach all seedlings.
     - Water must be able to move from each level to the lower levels, while still allowing saturation for each seedling.
     - Students determine their needs based on the list of materials provided.
4. Students will work together in teams of three to four students. Teams will design a system from recycled materials in which their plant will fit into a grid of their classmates' plants, all benefiting from the communal nutrient rich water. The teacher will assist in setting up communal nutrient-rich water using an aquarium. All designs and inventions are acceptable as long as all plants have access to water, sunlight and are in a closed system. Once set up, your vertical hydroponic garden should need very minimal care. If growing indoors, collard greens, lettuces, celery and herbs grow very well.

Activity 4:

1. Once the model has been approved by the teacher, students will build their model to satisfy the construction criteria of their model.
2. Provide students an example of a budget and have them create a budget for their vertical garden design, including a shared nutrient tank and distribution supplies. Students should include the unit price of each resource. Have students prepare their presentation on the cost of using their system to produce crops equivalent to five acres.

Activity 5:

1. Students will test their design with water to see if it meets all four of the design criteria requirements.
2. Students reflect on their testing of their model and determine how they can make any changes.

Activity 6:

1. Students present their designs to the class. The students and teacher complete a rubric on their peers as they are watching the presentation.

Resources:

Text Reference(s)

Silverman, Jacob. "Will there be farms in New York City\u0027s skyscrapers?" 26 June 2007. HowStuff Works.com. <http://science.howstuffworks.com/environmental/conservation/issues/vertical- farming.htm> 24 January 2013.

Ogden, Andy. "The Vertical Farm" 31 December 2010. < http://eatinggoodly.com/2010/12/31/the-vertical-farm/> 24 January 2013.

Electronic References

(web sites, Gizmo, other, paste hyper-links or URLs here)

http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=615

http://www.florida-agriculture.com/

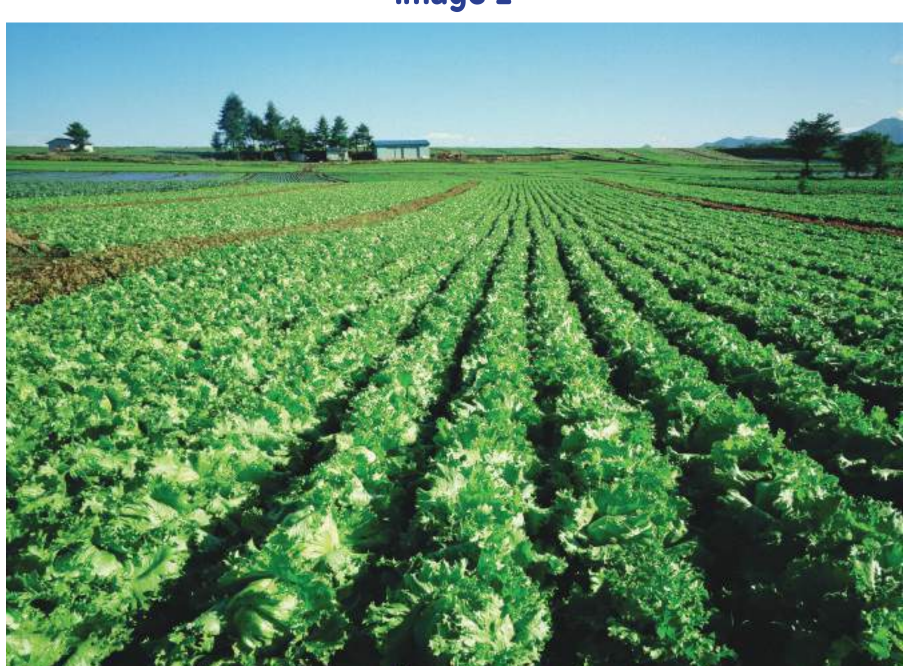
http://en.wikipedia.org/wiki/agriculture

http://www.ms.uky.edu/algebracubed/lessons/ScaleDrawingLessonPlan.pdf

The windows farm project https://www.youtube.com/watch?v=PkCuPrsPn_I

Image 1

Image 2



See-Think-Wonder Handout

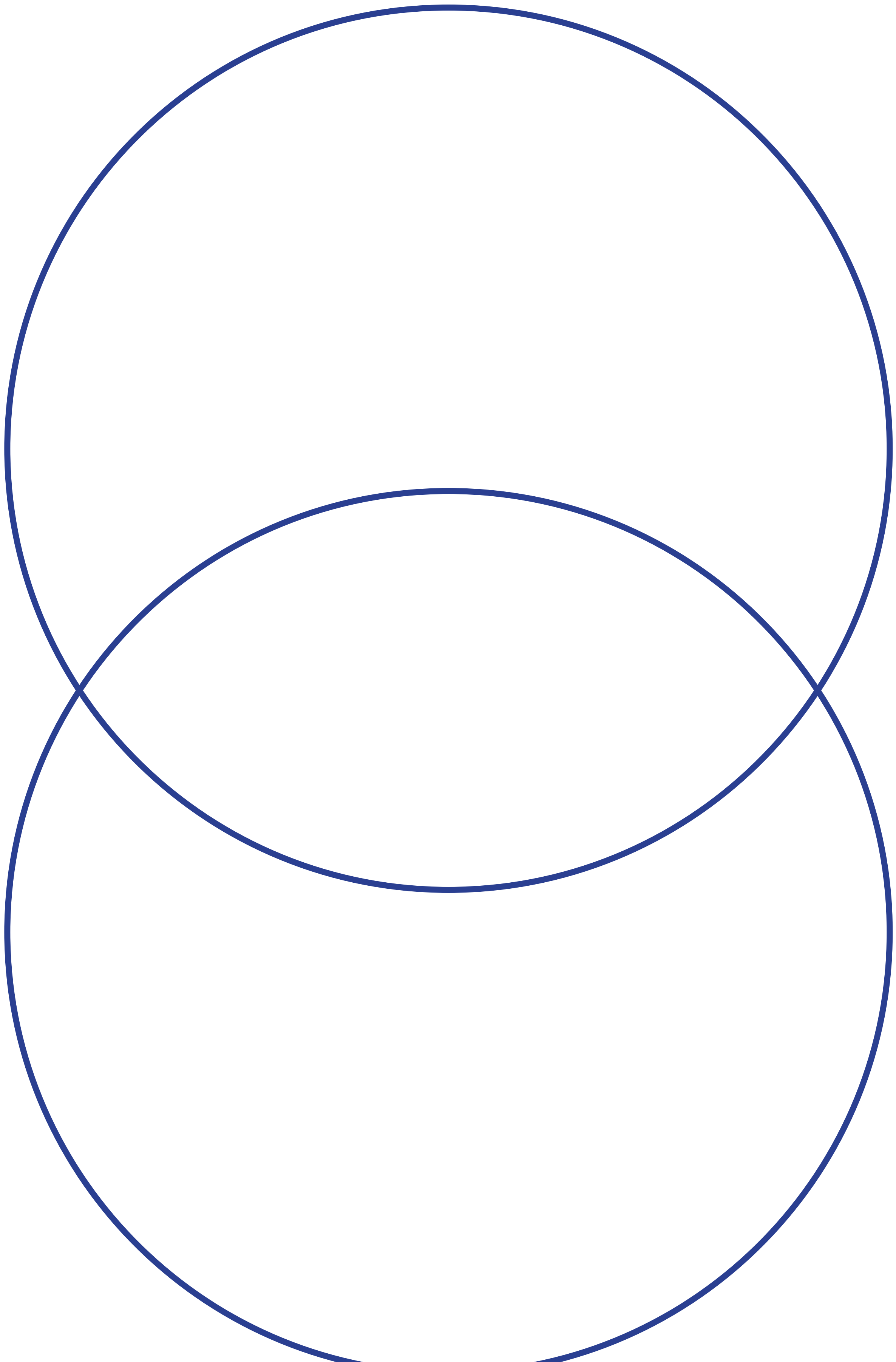
Directions: Examine the two images of farming and record what you see, think and wonder about.

Image #1	Image #2
I See:	I See:
I Think:	I Think:
I Wonder:	I Wonder:

KWL: Farming

Know What I know	**W**onder What I want to know	**L**earn What I've learned

Directions: Read the articles provided by your teacher. Use the Venn diagram to compare and contrast traditional farming and vertical farming.



Blue Print Rubric

RUBRIC	Possible Points	Self - Assessment	Teacher Assessment
Design solution has three levels			
Light is able to reach all seedlings			
Water is able to move through all levels leaving each seedling saturated			
Team showed effective collaboration with everyone participating equally			
Total			

Hydroponic Vertical Farming

Sample Pre-Post Test Assessment

Directions: Answer each question as thoroughly as possible.

1. Why may it be necessary to grow produce vertically in the future?

2. Pure water has a neutral pH. What is the pH of pure water?

3. What are some benefits of growing vertically?

4. What is the benefit of a hydroponic system that is closed?

5. Compare and contrast conventional farming methods and vertical farming methods.

Activity: Creating a Plastic Tote Hydroponic Garden

Brief Description:

To educate students about the hydroponic system where they will be able to compare and contrast the various aspects to traditional gardening.

Materials Needed:

- Container with removable lid (Dark colored containers are recommended to eliminate algae growth. A clear container will work; just spray-paint the outside of the container black before starting. The size may vary depending on your needs, but it should have minimal depth. Dimensions of container in pictures are 23 ½ inches x 16 7/8 inches x 5 7/8 inches which holds 27 liters of liquid.)
- Liquid fertilizer (9-4-9 which is designed for fruits and vegetables)
- Small syringe to measure fertilizer amounts
- Drill, hole saw, or tin snips to cut holes in the lid
- Seedlings (Recommend "vine" plants such as cucumbers, watermelon or cantaloupe.)
- A protected area with six to eight hours of direct sunlight. Protection from the elements is very important for this project because your plants will not have the support of the soil. Rain storms and wind can very easily damage these plants. Pay attention to the temperature requirements of the selected plants and make sure that you will be able to keep them at the recommended temperature for growth.

Approximate budget for this project is $35.

Project:

1. Identify the area for the hydroponic garden. Have students monitor and record the amount of sunlight for this area. Varying amounts of sunlight will aide in plant selection. If your area has four hours or less of sunlight, then focus on succulent plants. The best place would be a table indoors next to a window. This will eliminate the worry of strong rain storms damaging the plant since it will not have the support of the soil as well as any loss due to frost. If you do not have a window, placement under an awning can also work. The system can be moved from place to place but this is not recommended due to the weight of the container as well as sloshing of water and possible damage to the root system of plant.
2. Obtain materials. When searching for your container, remember that you want a larger surface area with minimal depth.

3. Select your plants. Vine plants are ideal for outdoor areas because they require the least amount of support. Tomatoes, bell pepper and okra are also good choices, but they will need support for vertical growth.
4. If you select seedlings, you will need to wash off all dirt before placing them in your container. If time allows, have students grow their own seedlings. Students would be able to monitor and record the growth process from seed to seedling. You can start this process with seeds and a clay pot.
5. Next, you will need to cut holes (using a drill, small hole saw, or tin snips) in the lid to allow the plants to "sit" on top of the lid while their root systems are submerged in the water/fertilizer mixture that you will be adding to the container. Holes for the plants should be cut two inches apart. If you cut the holes bigger than the plants need, then you can add Styrofoam into the hole to aid in support. As long as the roots are submerged in water and the

stem and leaves are above water, they will be fine. Another option is to buy net cups and place them in the holes to keep the plants out of the water. You will need to buy growing media which will cost more. You will also need to cut a single hole that will be used to add your water/ fertilizer mixture without disturbing the plants.

6. Place the seedlings in their respective holes and begin filling with water. Leave one inch of space from water level to lid to keep water from spilling. You can even drill a small drainage hole one inch down so that you cannot overfill.
7. Measure surface area of the lid and container (Area = Length x Width). Read fertilizer packaging to find recommended dosage amounts. Add the recommended amount of fertilizer to the water already in the container. For example, if the fertilizer bottle selected reads "one bottle (16 ounces) will feed 400 ft^2" and the area of the container is about 2.75 ft^2, we should use 0.11 ounces per week or 3.25 ml. (1 ounces = 29.573 ml).
8. Continue fertilizing your hydroponic garden until desired plant production is reached. Fruits and vegetables will produce in approximately eight-12 weeks. Students should see growth within the first week.

Activity: Design on a Dime

Objective:

Students will be able to utilize reusable or biodegradable materials to create sustainable gardening systems.

Materials:

- Empty toilet paper rolls
- Duct tape
- Paper towels
- Toilet paper
- Water
- Soil or other growing mediums
- Used egg cartons, k-cups or water bottles
- Seeds packets such as radish, beets
- Glue
- Meter stick
- Markers

Essential Questions:

1. What are three advantages of using the seed tape versus planting seeds directly in the ground?
2. Explain the importance of using biodegradable materials for planting.
3. Justify how the use of the two design systems supports a sustainable garden.

Directions:

1. Divide students into groups of three to five students. Start by having students in their group either create the seed tape or the seed starter (directions below) to show them an example of a possible item that would help with the school garden.
2. Students will research different ways to start, grow or plant seeds for their school garden. As a group the students will decide what they are going to design and create using as many recycled items as possible. Some examples are waterers, irrigation, self-watering systems, planting tools, planters/containers, germinating tools, or greenhouses. Students will submit design and supply list to the teacher for approval.

Seed Tape:

1. Measure a 24-inch length of toilet paper using the meter stick
2. Cut toilet paper in half lengthwise
3. Read seed packet for the recommended spacing
4. Use marker to mark each spot for seed on toilet paper (larger seeds are easier for this)
5. Add a dot of glue to each mark
6. Using tweezers, place seed on glue, allow to dry
7. Roll seed tape onto spool
8. Tape can be placed in garden and then covered with soil

Seed Starter:

1. Cut toilet paper roll in half using scissors
2. Cut four slits on one end and then fold into each other to secure the bottom of the pot
3. Secure with tape
4. Place soil inside tube
5. Add desired seed according to required seed depth
6. Repeat for several planters needed
7. After a few weeks when seeds have sprouted, remove the bottom of toilet paper roll
8. Place in soil

Extensions:

1. Create a machine to drop seed into the ground using recycled materials.
2. Explore different seed starting media. Is there any recycled material that can be used? Which is the most cost effective?
3. Is there a better product than toilet paper that can be used to create seed tape? Compare alternate methods with the toilet paper method.
4. Students can do a comparison of using the seed tape versus planting in the ground. Which method has a better plant yield?

Chapter 4

Florida Standards Spelled Out

By Lessons

Florida Standards Spelled Out: by Lessons

Correlated using Florida Standards at *www.cpalms.org*.

Soil Moisture and Soil Temperature

SC.6.N.1.3	Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.
SC.6.N.1.5	Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.
SC.7.N.1.5	Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
SC.7.L.17.2	Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.
SC.7.L.17.3	Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.8.N.1.5	Analyze the methods used to develop a scientific explanation as seen in different fields of science.
LAFS.6.SL.1.2	Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
LAFS.6.SL.2.4	Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.
LAFS.68.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts.
LAFS.68.RST.1.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
LAFS.68.WHST.2.6	Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.
LAFS.68.WHST.3.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
MAFS.7.SP.2.4	Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.
VA.68.C.2.1	Assess personal artwork during production to determine areas of success and needed change for achieving self-directed or specified goals.
VA.68.C.2.2	Evaluate artwork objectively during group assessment to determine areas for refinement.
VA.68.C.2.3	Examine artworks to form ideas and criteria by which to judge/assess and inspire personal works and artistic growth.
SS.7.C.2.12	Develop a plan to resolve a state or local problem by researching public policy alternatives, identifying appropriate government agencies to address the issue, and determining a course of action.
SS.7.C.2.13	Examine multiple perspectives on public and current issues.
SS.7.C.2.14	Conduct a service project to further the public good.

Learn About Decomposition by Creating Compost

SC.6.N.1.3	Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.
SC.6.N.1.5	Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.
SC.7.N.1.5	Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
SC.7.L.17.2	Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.
SC.7.L.17.3	Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.8.N.1.5	Analyze the methods used to develop a scientific explanation as seen in different fields of science.
LAFS.6.SL.1.2	Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
LAFS.6.SL.2.4	Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.
LAFS.68.RST.1.1	Cite specific textual evidence to support analysis of science and technical texts.
LAFS.68.RST.1.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
LAFS.68.WHST.2.6	Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.
LAFS.68.WHST.3.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
MAFS.7.SP.2.4	Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.
VA.68.C.2.1	Assess personal artwork during production to determine areas of success and needed change for achieving self-directed or specified goals.
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VA.68.C.2.3	Examine artworks to form ideas and criteria by which to judge/assess and inspire personal works and artistic growth.
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SS.7.C.2.13	Examine multiple perspectives on public and current issues.
SS.7.C.2.14	Conduct a service project to further the public good.

Integrated Pest Management Parts 1-3

SC.7.N.1.1	Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
SC.7.N.1.4	Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.
SC.7.N.3.2	Identify the benefits and limitations of the use of scientific models.
SC.7.L.17.1	Explain and illustrate the roles of and relationships among producers, consumers, and decomposers in the process of energy transfer in a food web.
SC.7.L.17.2	Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.
SC.7.L.17.3	Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
MAFS.7.RP.1.2	Recognize and represent proportional relationships between quantities. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships. Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as $t = pn$. Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate.

SC.8.N.1.1 Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.1.2 Design and conduct a study using repeated trials and replication.

SC.8.N.1.3 Use phrases such as “results support” or “fail to support” in science, understanding that science does not offer conclusive ‘proof’ of a knowledge claim.

SC.8.N.1.4 Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data.

SC.8.N.3.1 Select models useful in relating the results of their own investigations.

SC.8.N.4.2 Explain how political, social, and economic concerns can affect science, and vice versa.

MAFS.8.F.1.1 Understand that a function is a rule that assigns to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.

MAFS.8.F.2.4 Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

SC.912.L.14.10 Discuss the relationship between the evolution of land plants and their anatomy.

SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes.

SC.912.14.9 Relate the major structure of fungi to their functions.

SC.912.L.15.6 Discuss distinguishing characteristics of the domains and kingdoms of living organisms.

SC912.L.16.12 Describe how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, polymerase chain reaction, ligation, and transformation) is used to construct recombinant DNA molecules (DNA cloning).

SC.912.L.17.1 Discuss the characteristics of populations, such as number of individuals, age structure, density, and pattern of distribution.

SC.912.L.17.12 Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

SC.912.L.17.15 Discuss the effects of technology on environmental quality.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC.912.L.17.17 Assess the effectiveness of innovative methods of protecting the environment.

SC.912.L.17.6 Compare and contrast the relationships among organisms, including predation, parasitism, competition, commensalism, and mutualism.

SC.912.L.17.9 Use a food web to identify and distinguish producers, consumers, and decomposers. Explain the pathway of energy transfer through trophic levels and the reduction of available energy at successive trophic levels.

SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following:

1. **Pose questions about the natural world,** (Articulate the purpose of the investigation and identify the relevant scientific concepts).
2. **Conduct systematic observations,** (Write procedures that are clear and replicable. Identify observables and examine relationships between test (independent) variable and outcome (dependent) variable. Employ appropriate methods for accurate and consistent observations; conduct and record measurements at appropriate levels of precision. Follow safety guidelines).
3. **Examine books and other sources of information to see what is already known,**
4. **Review what is known in light of empirical evidence,** (Examine whether available empirical evidence can be interpreted in terms of existing knowledge and models, and if not, modify or develop new models).
5. **Plan investigations,** (Design and evaluate a scientific investigation).
6. **Use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs),** (Collect data or evidence in an organized way. Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration, technique, maintenance, and storage).
7. **Pose answers, explanations, or descriptions of events,**
8. **Generate explanations that explicate or describe natural phenomena (inferences),**
9. **Use appropriate evidence and reasoning to justify these explanations to others,**
10. **Communicate results of scientific investigations, and**
11. **Evaluate the merits of the explanations produced by others.**

SC.912.N.1.2 Describe and explain what characterizes science and its methods.

SC.912.N.1.3 Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.

SC.912.N.1.4 Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

SC.912.N.1.5 Describe and provide examples of how similar investigations conducted in many parts of the world result in the same outcome.

SC.912.N.1.6 Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

SC.912.N.1.7 Recognize the role of creativity in constructing scientific questions, methods and explanations.

SC.912.N.2.1 Identify what is science, what clearly is not science, and what superficially resembles science (but fails to meet the criteria for science).

SC.912.N.2.4 Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific argumentation. Because of these frequent examinations, scientific knowledge becomes stronger, leading to its durability.

SC.912.N.2.5 Describe instances in which scientists' varied backgrounds, talents, interests, and goals influence the inferences and thus the explanations that they make about observations of natural phenomena and describe that competing interpretations (explanations) of scientists are a strength of science as they are a source of new, testable ideas that have the potential to add new evidence to support one or another of the explanations.

SC.912.N.3.5 Describe the function of models in science, and identify the wide range of models used in science.

MAF.912.F-LE.1.1
Distinguish between situations that can be modeled with linear functions and with exponential functions.

Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.

MAFS.912.A-REI.1.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

MAFS.912.S-ID.1.1
Represent data with plots on the real number line (dot plots, histograms, and box plots).

MAFS.912.S-IC.2.3
Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

MAFS.912.S-MD.2.5
Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.

Florida Irrigation

SC.6.E.6.1 Describe and give examples of ways in which Earth's surface is built up and torn down by physical and chemical weathering, erosion, and deposition.

SS.6.G.3.1 Explain how the physical landscape has affected the development of agriculture and industry in the ancient world.

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

SC.8.N.1.1 Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.4.2 Explain how political, social, and economic concerns can affect science, and vice versa.

SC.912.E.7.1 Analyze the movement of matter and energy through the different biogeochemical cycles, including water and carbon.

SC.912.L.17.1 Discuss the characteristics of populations, such as number of individuals, age structure, density, and pattern of distribution.

SC.912.L.17.12 Discuss the political, social, and environmental consequences of sustainable use of land.

SC.912.L.17.15 Discuss the effects of technology on environmental quality.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC.912.L.17.17 Assess the effectiveness of innovative methods of protecting the environment.

Improving Mother Nature: Maximizing Storm Water Runoff for Irrigation

SC.7.N.1.3 Distinguish between an experiment (which must involve the identification and control of variables) and other forms of scientific investigation and explain that not all scientific knowledge is derived from experimentation.

SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

SC.8.L.18.1 Describe and investigate the process of photosynthesis, such as the roles of light, carbon dioxide, water and chlorophyll; production of food; release of oxygen.

SC.8.N.1.2 Design and conduct a study using repeated trials and replication.

SC.8.N.1.3 Use phrases such as "results support" or "fail to support" in science, understanding that science does not offer conclusive 'proof' of a knowledge claim.

SC.8.N.1.4 Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data.

SC.912.N.1.1 Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following:

1. **Pose questions about the natural world,** (Articulate the purpose of the investigation and identify the relevant scientific concepts).
2. **Conduct systematic observations,** (Write procedures that are clear and replicable. Identify observables and examine relationships between test (independent) variable and outcome (dependent) variable. Employ appropriate methods for accurate and consistent observations; conduct and record measurements at appropriate levels of precision. Follow safety guidelines).
3. **Examine books and other sources of information to see what is already known,**
4. **Review what is known in light of empirical evidence,** (Examine whether available empirical evidence can be interpreted in terms of existing knowledge and models, and if not, modify or develop new models).
5. **Plan investigations,** (Design and evaluate a scientific investigation).
6. **Use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs),** (Collect data or evidence in an organized way. Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration, technique, maintenance, and storage).
7. **Pose answers, explanations, or descriptions of events,**
8. **Generate explanations that explicate or describe natural phenomena (inferences),**
9. **Use appropriate evidence and reasoning to justify these explanations to others,**
10. **Communicate results of scientific investigations, and**
11. **Evaluate the merits of the explanations produced by others.**

SC.912.N.1.3 Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented.

SC.912.N.1.4 Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

SC.912.N.1.6 Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

SC.912.N.1.7 Recognize the role of creativity in constructing scientific questions, methods and explanations.

SC.912.N.3.5 Describe the function of models in science, and identify the wide range of models used in science.

SC.912.E.6.6 Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

SC.912.E.7.1 Analyze the movement of matter and energy through the different biogeochemical cycles, including water and carbon.

SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes.

SC.912.L.14.53 Discuss basic classification and characteristics of plants. Identify bryophytes, pteridophytes, gymnosperms, and angiosperms.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC.912.L.17.17 Assess the effectiveness of innovative methods of protecting the environment.

SC.912.L17.20 Explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

SC.912.L.18.2 Describe the important structural characteristics of monosaccharides, disaccharides, and polysaccharides and explain the functions of carbohydrates in living things.

SC.912.L.18.7 Identify the reactants, products, and basic functions of photosynthesis.

SC.912.L.18.12 Discuss the special properties of water that contribute to Earth's suitability as an environment for life: cohesive behavior, ability to moderate temperature, expansion upon freezing, and versatility as a solvent.

SC.912.L.18.7 Identify the reactants, products, and basic functions of photosynthesis.

LAFS.68.RST.1.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

LAFS.68.WHST.2.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

LAFS.68.WHST.3.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

LAFS.68.WHST.3.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

LAFS.68.WHST.4.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

LAFS.910.RST.1.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

LAFS.910.WHST.2.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

LAFS.910.WHST.3.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

LAFS.910.WHST.3.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

LAFS.910.WHST.4.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

LAFS.1112.RST.1.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

LAFS.1112.WHST.2.6
Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

LAFS.1112.WHST.3.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

LAFS.1112.WHST.3.8
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

LAFS.1112.WHST.4.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

STEMming Up Plant Nutrients

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

SC.8.N.1.1 Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.1.3 Use phrases such as “results support” or “fail to support” in science, understanding that science does not offer conclusive ‘proof’ of a knowledge claim.

SC.912.L.17.1 Discuss the characteristics of populations, such as number of individuals, age structure, density, and pattern of distribution.

SC.912.L.17.12 Discuss the political, social, and environmental consequences of sustainable use of land.

SC.912.L.17.15 Discuss the effects of technology on environmental quality.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC.912.L.17.17 Assess the effectiveness of innovative methods of protecting the environment.

MAFS.7.SP.1.1 Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

MAFS.7.SP.1.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

MAFS.912.S-ID.2.5
Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

Plant Hormones and Tropic Responses

SC.7.N.1.1 Define a problem from the seventh grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.7.N.1.4 Identify test variables (independent variables) and outcome variables (dependent variables) in an experiment.

SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

SC.8.N.1.1 Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.1.2 Design and conduct a study using repeated trials and replication.

SC.8.N.1.3 Use phrases such as “results support” or “fail to support” in science, understanding that science does not offer conclusive ‘proof’ of a knowledge claim.

SC.8.N.1.4 Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data.

SC.8.N.4.2 Explain how political, social, and economic concerns can affect science, and vice versa.

SC.912.L.14.1 Describe the scientific theory of cells (cell theory) and relate the history of its discovery to the process of science.

SC.912.L.14.10 Discuss the relationship between the evolution of land plants and their anatomy.

SC.912.L.14.2 Relate structure to function for the components of plant and animal cells. Explain the role of cell membranes as a highly selective barrier (passive and active transport).

SC.912.L.14.31 Describe the physiology of hormones including the different types and the mechanisms of their action.

SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes.

SC.912.N.1.1 Define a problem based on a specific body of knowledge; for example: biology, chemistry, physics, and earth/space science, and do the following:

1. **Pose questions about the natural world,** (Articulate the purpose of the investigation and identify the relevant scientific concepts).
2. **Conduct systematic observations,** (Write procedures that are clear and replicable. Identify observables and examine relationships between test (independent) variable and outcome (dependent) variable. Employ appropriate methods for accurate and consistent observations; conduct and record measurements at appropriate levels of precision. Follow safety guidelines).
3. **Examine books and other sources of information to see what is already known,**
4. **Review what is known in light of empirical evidence,** (Examine whether available empirical evidence can be interpreted in terms of existing knowledge and models, and if not, modify or develop new models).
5. **Plan investigations,** (Design and evaluate a scientific investigation).
6. **Use tools to gather, analyze, and interpret data (this includes the use of measurement in metric and other systems, and also the generation and interpretation of graphical representations of data, including data tables and graphs),** (Collect data or evidence in an organized way. Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration, technique, maintenance, and storage).
7. **Pose answers, explanations, or descriptions of events,**
8. **Generate explanations that explicate or describe natural phenomena (inferences),**
9. **Use appropriate evidence and reasoning to justify these explanations to others,**
10. **Communicate results of scientific investigations, and**
11. **Evaluate the merits of the explanations produced by others.**

SC.912.N.1.6 Describe how scientific inferences are drawn from scientific observations and provide examples from the content being studied.

SC.912.N.1.7 Recognize the role of creativity in constructing scientific questions, methods and explanations.

MAFS.7.RP.1.2 Recognize and represent proportional relationships between quantities.

a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
c. Represent proportional relationships by equations. *For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as t = pn.*
d. Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points (0, 0) and (1, r) where r is the unit rate.

MAFS.7.SP.1.1 Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

MAFS.7.S.P.1.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

MAFS.8.SP.1.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

MAFS.8.SP.1.2 Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

MAFS.8.F.2.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph. Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

MAFS.912.A-REI.1.1
Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

MAFS.912.S-ID.1.1
Represent data with plots on a real number line.

MAFS.912.S-MD.2.5
Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.

Plant Propagation

SC.7.L.16.3 Compare and contrast the general processes of sexual reproduction requiring meiosis and asexual reproduction requiring mitosis.

SC.7.L.16.4 Recognize and explore the impact of biotechnology (cloning, genetic engineering, artificial selection) on the individual, society and the environment.

SC.7.L.16.2 Determine the probabilities for genotype and phenotype combinations using Punnett Squares and pedigrees.

SC.8.N.4.2 Explain how political, social, and economic concerns can affect science, and vice versa.

SC.912.L.14.1 Describe the scientific theory of cells (cell theory) and relate the history of its discovery to the process of science.

SC.912.L.14.10 Discuss the relationship between the evolution of land plants and their anatomy.

SC.912.L.14.33 Describe the basic anatomy and physiology of the reproductive system.

SC.912.L.14.7 Relate the structure of each of the major plant organs and tissues to physiological processes.

SC.912.L.16.10 Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues.

SC.912.L.16.12 Describe how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, polymerase chain reaction, ligation, and transformation) is used to construct recombinant DNA molecules (DNA cloning).

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

LAFS.68.RST.1.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

LAFS.68.WHST.2.6
Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

LAFS.68.WHST.3.7
Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

LAFS.68.WHST.3.8
Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

LAFS.68.WHST.4.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

LAFS.910.RST.1.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

LAFS.910.WHST.2.6
Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

LAFS.910.WHST.3.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

LAFS.910.WHST.3.8
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.

LAFS.910.WHST.4.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

LAFS.1112.RST.1.3
Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

LAFS.1112.WHST.2.6
Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

LAFS.1112.WHST.3.7
Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

LAFS.1112.WHST.3.8
Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

LAFS.1112.WHST.4.10
Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

"Phun" with Photosynthesis

SC.7.P.11.2 Investigate and describe the transformation of energy from one form to another.

SC.7.P.10.1 Illustrate that the sun's energy arrives as radiation with a wide range of wavelengths, including infrared, visible, and ultraviolet, and that white light is made up of a spectrum of many different colors.
SC.7.L.15.2 Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms.
SC.8.L.18.1 Describe and investigate the process of photosynthesis, such as the roles of light, carbon dioxide, water and chlorophyll; production of food; release of oxygen.
SC.8.N.3.1 Select models useful in relating the results of their own investigations.
LAFS.68.WHST.3.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
LAFS.68.WHST.4.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
SC.912.L.17.19 Describe how different natural resources are produced and how their rates of use and renewal limit availability.
SC.912.L.17.20 Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability.
SC.912.L.18.7 Identify the reactants, products, and basic functions of photosynthesis.
SC.912.P.10.1 Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.
LAFS.910.WHST.3.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LAFS.910.WHST.4.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.
LAFS.1112.WHST.3.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LAFS.1112.WHST.4.10 Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Greenhouse Technology

SC.6.N.1.3 Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.
SC.6.N.1.5 Recognize that science involves creativity, not just in designing experiments, but also in creating explanations that fit evidence.
SC.7.N.1.5 Describe the methods used in the pursuit of a scientific explanation as seen in different fields of science such as biology, geology, and physics.
SC.7.L.17.2 Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.
SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.8.N.1.5 Analyze the methods used to develop a scientific explanation as seen in different fields of science.
LAFS.6.SL.1.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
LAFS.6.SL.2.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.
LAFS.68.RST.1.1 Cite specific textual evidence to support analysis of science and technical texts.
LAFS.68.RST.1.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
LAFS.68.WHST.2.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.
LAFS.68.WHST.3.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
MAFS.7.SP.2.4 Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.
VA.68.C.2.1 Assess personal artwork during production to determine areas of success and needed change for achieving self-directed or specified goals.
VA.68.C.2.2 Evaluate artwork objectively during group assessment to determine areas for refinement.
VA.68.C.2.3 Examine artworks to form ideas and criteria by which to judge/assess and inspire personal works and artistic growth.
SS.7.C.2.12 Develop a plan to resolve a state or local problem by researching public policy alternatives, identifying appropriate government agencies to address the issue, and determining a course of action.
SS.7.C.2.13 Examine multiple perspectives on public and current issues.
SS.7.C.2.14 Conduct a service project to further the public good.

Alternatives to Traditional Gardening

SC.6.N.1.1 Define a problem from the sixth grade curriculum, use appropriate reference materials to support scientific understanding, plan and carry out scientific investigation of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.
SC.7.N.1.3 Explain the difference between an experiment and other types of scientific investigation, and explain the relative benefits and limitations of each.
SC.7.L.17.3 Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.
SC.8.N.1.4 Explain how hypotheses are valuable if they lead to further investigations, even if they turn out not to be supported by the data.
MAFS.6.G.1.4 Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.
MAFS.6.SP.2.5 Summarize numerical data sets in relation to their context, such as by:

a. Reporting the number of observations.
b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.
c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
d. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

MAFS.7.RP.1.2 Recognize and represent proportional relationships between quantities.

a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
c. Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as $t = pn$.
d. Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate.

LAFS.6.RI.1.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
LAFS.6.RI.1.2 Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.
LAFS.6.RI.2.6 Determine an authors point of view or purpose in a text and explain how it is conveyed in the text.
LAFS.6.RI.3.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.

LAFS.6.RI.3.9 Compare and contrast one authors presentation of events with that of another (e.g., a memoir written by and a biography on the same person).

LAFS.6.SL.1.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

LAFS.6.SL.2.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.6.SL.2.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

LAFS.6.W.1.1 Write arguments to support claims with clear reasons and relevant evidence.

a. Introduce claim(s) and organize the reasons and evidence clearly.
b. Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.
c. Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.
d. Establish and maintain a formal style.
e. Provide a concluding statement or section that follows from the argument presented.

LAFS.6.W.2.6 Use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of three pages in a single sitting.

LAFS.6.W.3.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

a. Apply grade 6 Reading standards to literature (e.g., "Compare and contrast texts in different forms or genres [e.g., stories and poems; historical novels and fantasy stories] in terms of their approaches to similar themes and topics").
b. Apply grade 6 Reading standards to literary nonfiction (e.g., "Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not").

LAFS.7.RI.1.1 Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

LAFS.7.RI.1.2 Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.

LAFS.7.RI.2.6 Determine an author's point of view or purpose in a text and analyze how the author distinguishes his or her position from that of others.

LAFS.7.RI.3.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.

LAFS.7.RI.3.9 Analyze how two or more authors writing about the same topic shape their presentations of key information by emphasizing different evidence or advancing different interpretations of facts.

LAFS.7.SL.1.2 Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.

LAFS.7.SL.2.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.7.SL.2.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

LAFS.7.W.1.1 Write arguments to support claims with clear reasons and relevant evidence.

a. Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically.
b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text.
c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), reasons, and evidence.
d. Establish and maintain a formal style.
e. Provide a concluding statement or section that follows from and supports the argument presented.

LAFS.7.W.2.6 Use technology, including the Internet, to produce and publish writing and link to and cite sources as well as to interact and collaborate with others, including linking to and citing sources.

LAFS.7.W.3.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Apply grade 7 Reading standards to literature (e.g., "Compare and contrast a fictional portrayal of a time, place, or character and a historical account of the same period as a means of understanding how authors of fiction use or alter history").

Apply grade 7 Reading standards to literary nonfiction (e.g. "Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims").

LAFS.8.RI.1.1 Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.

LAFS.8.RI.1.2 Determine a theme or central idea of a text and analyze its development over the course of the text, including its relationship to the characters, setting, and plot; provide an objective summary of the text.

LAFS.8.RI.2.6 Determine an author's point of view or purpose in a text and analyze how the author acknowledges and responds to conflicting evidence or viewpoints.

LAFS.8.RI.3.8 Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

LAFS.8.RI.3.9 Analyze a case in which two or more texts provide conflicting information on the same topic and identify where the texts disagree on matters of fact or interpretation.

LAFS.8.SL.1.2 Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.

LAFS.8.SL.2.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.8.SL.2.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

LAFS.8.W.1.1 Write arguments to support claims with clear reasons and relevant evidence.

a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
b. Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text.
c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.
d. Establish and maintain a formal style.
e. Provide a concluding statement or section that follows from and supports the argument presented.

LAFS.8.W.2.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas efficiently as well as to interact and collaborate with others.

LAFS.8.W.3.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

a. Apply grade 8 Reading standards to literature (e.g., "Analyze how a modern work of fiction draws on themes, patterns of events, or character types from myths, traditional stories, or religious works such as the Bible, including describing how the material is rendered new").
b. Apply grade 8 Reading standards to literary nonfiction (e.g., "Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced").

Hydroponic Vertical Farming: Helping Feed Our Growing Population

SC.7.E.6.6 Identify the impact that humans have had on Earth, such as deforestation, urbanization, desertification, erosion, air and water quality, changing the flow of water.

MAFS.7.RP.1.2 Recognize and represent proportional relationships between quantities.

a. Decide whether two quantities are in a proportional relationship, e.g., by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.
b. Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.
c. Represent proportional relationships by equations. For example, if total cost t is proportional to the number n of items purchased at a constant price p, the relationship between the total cost and the number of items can be expressed as $t = pn$.
d. Explain what a point (x, y) on the graph of a proportional relationship means in terms of the situation, with special attention to the points $(0, 0)$ and $(1, r)$ where r is the unit rate.

LAFS.6.SL.1.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.
c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.
d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing.

LAFS.6.SL.2.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.7.SL.1.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
b. Follow rules for collegial discussions, track progress toward specific goals and deadlines, and define individual roles as needed.
c. Pose questions that elicit elaboration and respond to others' questions and comments with relevant observations and ideas that bring the discussion back on topic as needed.
d. Acknowledge new information expressed by others and, when warranted, modify their own views.

LAFS.7.SL.2.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.8.SL.1.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed.
c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.

LAFS.8.SL.2.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

LAFS.68.RST.3.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

LAFS.68.RST.3.9- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

SC.912.E.6.6 Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

SC.912.L.17.12 Discuss the political, social, and environmental consequences of sustainable use of land.

SC.912.L.17.15 Discuss the effects of technology on environmental quality.

SC.912.L.17.16 Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

SC912.L.17.18 Describe how human population size and resource use relate to environmental quality.

SC.912.L.17.20 Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability.

Chapter 5
Additional Resources

County Farm Bureau Offices • University of Florida/IFAS County Extension Offices

County Contacts

For help with school garden questions or additional resources, contact your local county Farm Bureau or UF/IFAS Extension Office.

Alachua County
Alachua County Farm Bureau
14435 NW US Hwy 441, Suite 20
Alachua, FL 32615-8812
(386) 418-4008

Alachua County Extension
2800 NE 39 Avenue
Gainesville, FL 32609-2658
(352) 955-2402

Baker County
Baker County Farm Bureau
539 South Sixth St.
Macclenny, FL 32063-2605
(904) 259-6332

Baker County Extension
1025 W Macclenny Avenue
Macclenny, FL 32063-4433
(904) 259-3520

Bay County
Bay County Farm Bureau
303 Mosley Drive
Lynn Haven, FL 32444-5605
(850) 872-2077

Bay County Extension
2728 E 14th St.
Panama City, FL 32401-5022
(850) 784-6105

Bradford County
Bradford County Farm Bureau
2270 N Temple Ave.
Starke, FL 32091-1612
(904) 964-6369

Bradford County Extension
2266 N. Temple Ave.
Starke, FL 32091-1612
(904) 966-6224

Brevard County
Brevard County Farm Bureau
111 Virginia Ave.
Cocoa, FL 32922-8655
(321) 636-4361

Brevard County Extension
3695 Lake Drive
Cocoa, FL 32926-4219
(321) 633-1702

Broward County
Broward County Farm Bureau
2121 North State Road 7
Margate, FL 33063-5713
(954) 972-2525

Broward County Extension
3245 College Ave.
Davie, FL 33314-7719
(954) 357-5270

Calhoun/Gulf County
Calhoun County Farm Bureau
17577 Main Street North
Blountstown, FL 32424-1768
(850) 674-5471

Calhoun County Extension
20816 Central Avenue E, Suite 1
Blountstown, FL 32424-2292
(850) 674-8323

Desoto/Charlotte County
Charlotte County Farm Bureau
1278 SE US Highway 31
Arcadia, FL 34266
(863) 494-3636

Charlotte County Extension
25550 Harbor View Road, Unit 3
Port Charlotte, FL 33980-2503
(941) 764-4340

Citrus/Hernando County
Citrus County Farm Bureau
617 Lamar Ave.
Brooksville, FL 34601
(352) 796-2526

Citrus County Extension
3650 W Sovereign Path, Suite 1
Lecanto, FL 34461-8070
(352) 527-5700

Clay County
Clay County Farm Bureau
3960 Lazy Acres Road
Middleburg, FL 32068-4908
(904) 282-0644

Clay County Extension
PO Box 278
Green Cove Springs, FL 32043-0278
(904) 284-6355

Collier County
Collier County Farm Bureau
1011 W Main St., Ste. 2
Immokalee, FL 34142-3651
(239) 657-6500

Collier County Extension
14700 Immokalee Road
Naples, FL 34120-1468
(239) 252-4822

Columbia County
Columbia County Farm Bureau
605 SW State Road 47
Lake City, FL 32025-0452
(386) 752-4003

Columbia County Extension
164 SW Mary Ethel Lane
Lake City, FL 32025-1597
(386) 752-5384

Dade County
Dade County Farm Bureau
1850 Old Dixie Highway
Homestead, FL 33033-3212
(305) 246-5514

Dade County Extension
18710 SW 288 St.
Homestead, FL 33030
(305) 248-3311

Desoto/Charlotte County
Desoto County Farm Bureau
1278 SE US Highway 31
Arcadia, FL 34266-7737
(863) 494-3636

Desoto County Extension
2150 NE Roan St.
Arcadia, FL 34266-5025
(863) 993-4846

Duval County
Duval County Farm Bureau
5542 Dunn Ave.
Jacksonville, FL 32218-4332
(904) 768-4836

Duval County Extension
1010 N McDuff Ave.
Jacksonville, FL 32254-2031
(904) 255-7450

Escambia County
Escambia County Farm Bureau
153 Highway 97
Molino, FL 32577-5553
(850) 587-2135

Escambia County Extension
3740 Stefani Road
Cantonment, FL 32533-7792
(850) 475-5230

Flagler County
Flagler County Farm Bureau
1000 Palm Coast Parkway SW,
Suite 202
Palm Coast, FL 32137
(386) 447-5282

Flagler County Extension
150 Sawgrass Road
Bunnell, FL 32110-4325
(386) 437-7464

Franklin County
Franklin County Extension
66 Fourth Street
Apalachicola, FL 32320-1775
(850) 653-9337

Gadsden County
Gadsden County Farm Bureau
2111 W. Jefferson St.
Quincy, FL 32351-1909
(850) 627-7196

Gadsden County Extension
2140 W Jefferson St.
Quincy, FL 32351-1905
(850) 875-7255

Gilchrist County
Gilchrist County Farm Bureau
306 W. Wade St.
Trenton, FL 32693-4150
(352) 463-2298

Gilchrist County Extension
125 E Wade St.
Trenton, FL 32693-0157
(352) 463-3174

Glades/Hendry County

Glades County Farm Bureau
PO Box 1365
LaBelle, FL 33975
(863) 675-2535

Glades County Extension
PO Box 549
Moore Haven, FL 33471-0549
(863) 946-0244

Calhoun/Gulf County

Gulf County Farm Bureau
17577 Main Street North
Blountstown, FL 32424-1768
(850) 674-5471

Gulf County Extension
200 N. 2nd St.
Wewahitchka, FL 32465-0250
(850) 639-3200

Hamilton County

Hamilton County Farm Bureau
1117 US Hwy 41 NW
Jasper, FL 32052-5856
(386) 792-1458

Hamilton County Extension
1143 US Hwy 41 NW
Jasper, FL 32052-5856
(386) 792-1276

Hardee County

Hardee County Farm Bureau
1017 US Highway 17 N
Wauchula, FL 33873-8751
(863) 773-3117

Hardee County Extension
507 Civic Center Drive
Wauchula, FL 33873-9460
(863) 773-2164

Glades/Hendry County

Hendry County Farm Bureau
PO Box 1365
LaBelle, FL 33975-1365
(863) 675-2535

Hendry County Extension
PO Box 68
LaBelle, FL 33975-0068
(863) 674-4092

Citrus/Hernando County

Hernando County Farm Bureau
617 Lamar Ave.
Brooksville, FL 34601-3211
(352) 796-2526

Hernando County Extension
1653 Blaise Dr.
Brooksville, FL 34601
(352) 754-4433

Highlands County

Highlands County Farm Bureau
6419 US Highway 27 S
Sebring, FL 33876-5712
(863) 385-5141

Highlands County Extension
4509 W George Blvd.
Sebring, FL 33875-5837
(863) 402-6540

Hillsborough County

Hillsborough County Farm Bureau
100 S. Mulrennan Road
Valrico, FL 33594-3934
(813) 685-9121

Hillsborough County Extension
5339 S. County Road 579
Seffner, FL 33584-3334
(813) 744-5519

Holmes County

Holmes County Farm Bureau
1108 N. Waukesha Street
Bonifay, FL 32425-1406
(850) 547-4227

Holmes County Extension
1169 E Hwy 90
Bonifay, FL 32425-6012
(850) 547-1108

Indian River County

Indian River County Farm Bureau
7150 20th Street, Suite A
Vero Beach, FL 32966
(772) 562-4119

Indian River County Extension
1028 20th Place, Suite D
Vero Beach, FL 32960-5360
(772) 770-5030

Jackson County

Jackson County Farm Bureau
4379 Lafayette Street
Marianna, FL 32446-3367
(850) 482-5751

Jackson County Extension
2741 Pennsylvania Ave., Suite 3
Marianna, FL 32448-4022
(850) 482-9620

Jefferson County

Jefferson County Farm Bureau
105 W. Anderson St.
Monticello, FL 32344-1301
(850) 997-2213

Jefferson County Extension
275 N Mulberry St.
Monticello, FL 32344-1423
(850) 342-0187

Lafayette County

Lafayette County Farm Bureau
PO Box 336
Mayo, FL 32066-0336
(386) 294-1399

Lafayette County Extension
176 SW Community Circle, Ste D
Mayo, FL 32066-4000
(386) 294-1279

Lake County

Lake County Farm Bureau
30241 State Road 19
Tavares, FL 32778-4239
(352) 343-4407

Lake County Extension
1951 Woodlea Road
Tavares, FL 32778-4407
(352) 343-4101

Lee County

Lee County Farm Bureau
14180 Metropolis Ave. Suite 1
Fort Myers, FL 33912-4449
(239) 561-5100

Lee County Extension
3406 Palm Beach Blvd.
Fort Myers, FL 33916-3736
(239) 533-7400

Leon County

Leon County Farm Bureau
3375 Capital Circle NE, Bldg. C
Tallahassee, FL 32308
(850) 671-3276

Leon County Extension
615 Paul Russell Road
Tallahassee, FL 32301-7060
(850) 606-5200

Levy County

Levy County Farm Bureau
PO Box 998
Chiefland, FL 32644-0998
(352) 493-4780

Levy County Extension
PO Box 219
Bronson, FL 32621-0219
(352) 486-5131

Liberty County

Liberty County Farm Bureau
17577 Main Street North
Blountstown, FL 32424-1768
(850) 674-5471

Liberty County Extension
10405 NW Theo Jacobs Way
Bristol, FL 32321-0369
(850) 643-2229

Madison County

Madison County Farm Bureau
233 W. Base St.
Madison, FL 32340-2409
(850) 973-4071

Madison County Extension
184 NW College Loop
Madison, FL 32340
(850) 973-4138

Manatee County

Manatee County Farm Bureau
5620 Tara Blvd., Ste. 101
Bradenton, FL 34203-8865
(941) 746-6161

Manatee County Extension
1303 17th St. West
Palmetto, FL 34221-2934
(941) 722-4524

Marion County
Marion County Farm Bureau
5800 SW 20th St.
Ocala, FL 34474-9360
(352) 237-2124

Marion County Extension
2232 NE Jacksonville Road
Ocala, FL 34470-3615
(352) 671-8400

Martin County
Martin County Farm Bureau
506 SW Federal Highway, Suite 102
Stuart, FL 34994-2827
(772) 286-1038

Martin County Extension
2614 SE Dixie Highway
Stuart, FL 34996-4007
(772) 288-5654

Monroe County
Monroe County Extension
1100 Simonton St., Room 2-206
Key West, FL 33040-3110
(305) 292-4501

Nassau County
Nassau County Farm Bureau
PO Box 5007
Callahan, FL 32011-5007
(904) 879-3498

Nassau County Extension
543350 U.S. Highway One
Callahan, FL 32011-6486
(904) 879-1019

Okaloosa County
Okaloosa County Farm Bureau
921 W James Lee Blvd
Crestview, FL 32536-5136
(850) 682-3536

Okaloosa County Extension
3098 Airport Road
Crestview, FL 32539-7124
(850) 689-5850

Okeechobee County
Okeechobee County Farm Bureau
401 N.W. Fourth St.
Okeechobee, FL 34972-2550
(863) 763-3101

Okeechobee County Extension
458 Highway 98 North
Okeechobee, FL 34972-6303
(863) 763-6469

Orange County
Orange County Farm Bureau
PO Box 1329
Christmas, FL 32709
(407) 637-7727

Orange County Extension
6021 S Conway Rd.
Orlando, FL 32812-3604
(407) 254-9200

Osceola County
Osceola County Farm Bureau
1680 E Irlo Bronson Memorial Hwy
Kissimmee, FL 34744-3729
(407) 847-5189

Osceola County Extension
1921 Kissimmee Valley Lane
Kissimmee, FL 34744-6107
(321) 697-3000

Palm Beach County
Palm Beach County Farm Bureau
13121 North Military Trail
Delray Beach, FL 33484-1107
(561) 498-5200

Western Palm Beach Farm Bureau
3019 State Road 15
Belle Glade, FL 33430
(561) 996-0343

Palm Beach County Extension
559 North Military Trail
West Palm Beach, FL 33415
(561) 233-1712

Pasco County
Pasco County Farm Bureau
12445 US Highway 301
Dade City, FL 33525-6018
(352) 567-5641

Pasco County Extension
36702 State Road 52
Dade City, FL 33525-5138
(352) 521-4288

Pinellas County
Pinellas County Farm Bureau
1165 Lakeview Road
Clearwater, FL 33756-3586
(727) 466-6390

Pinellas County Extension
12520 Ulmerten Road
Largo, FL 33774-3602
(727) 582-2100

Polk County
Polk County Farm Bureau
1715 Highway 17 South
Bartow, FL 33830-6634
(863) 533-0561

Polk County Extension
PO Box 9005, Drawer HS03
Bartow, FL 33831-9005
(863) 519-8677

Putnam/St. Johns County
St. Johns County Farm Bureau
147 South US Highway 17
East Palatka, FL 32131-6070
(386) 325-5822

St. John's County Extension
3125 Agriculture Center Drive
St. Augustine, FL 32092-0572
(904) 209-0430

St. Lucie County
St. Lucie County Farm Bureau
3327 Orange Ave
Fort Pierce, FL 34947-3561
(772) 465-0440

St. Lucie County Extension
8400 Picos Road, Suite 101
Fort Pierce, FL 34945-3045
(772) 462-1660

Santa Rosa County
Santa Rosa County Farm Bureau
PO Box 490
Jay, FL 32565-0490
(850) 675-4572

Santa Rosa County Extension
6263 Dogwood Drive
Milton, FL 32570-3500
(850) 623-3868

Sarasota County
Sarasota County Farm Bureau
7289 Palmer Blvd.
Sarasota, FL 34240-9404
(941) 371-2043

Sarasota County Extension
6700 Clark Road
Sarasota, FL 34241-9328
(941) 861-9900

Seminole County
Seminole County Farm Bureau
PO Box 585694
Orlando, FL 32858-5694
(407) 889-9705

Seminole County Extension
250 W. County Home Road
Sanford, FL 32773-6189
(407) 665-5560

Sumter County
Sumter County Farm Bureau
7610 State Road 471
Bushnell, FL 33513-8734
(352) 793-4545

Sumter County Extension
7620 State Road 471, Ste. 2
Bushnell, FL 33513-8716
(352) 793-2728

Suwannee County
Suwannee County Farm Bureau
407 Dowling Ave, SE
Live Oak, FL 32064-3222
(386) 362-1274

Suwannee County Extension
1302 11th Street SW
Live Oak, FL 32064-3611
(386) 362-2771

Taylor County
Taylor County Farm Bureau
813 S Washington St.
Perry, FL 32347-3372
(850) 584-2371

Taylor County Extension
203 Forest Park Drive
Perry, FL 32348-6340
(850) 838-3508

Union County
Union County Farm Bureau
325 SE Sixth St.
Lake Butler, FL 32054-2627
(386) 496-2171

Union County Extension
25 NE First St.
Lake Butler, FL 32054-1701
(386) 496-2321

Volusia County
Volusia County Farm Bureau 3090 E. New York Ave. DeLand, FL 32724-6408 (386) 734-1612 Volusia County Extension 3100 E New York Ave. Deland, FL 32724-6410 (386) 822-5778

Wakulla County
Wakulla County Farm Bureau 2468 Crawfordville Highway Crawfordville, FL 32327-2157 (850) 926-3425 Wakulla County Extension 84 Cedar Ave. Crawfordville, FL 32327-2063 (850) 926-3931

Walton County
Walton County Farm Bureau 684 N. Ninth St. DeFuniak Springs, FL 32433-3802 (850) 892-5512 Walton County Extension 732 N. Ninth St., Suite B DeFuniak Springs, FL 32433-3804 (850) 892-8172

Washington County
Washington County Farm Bureau 1361 Jackson Ave. Chipley, FL 32428-1774 (850) 638-1756 Washington County Extension 1424 Jackson Avenue, Suite A Chipley, FL 32428-1602 (850) 638-6180