

Minnesota Agriculture in the Classroom

Fall 2013



Minnesota

School Gardens: **A Guide to Gardening and Plant Science**

*Featuring 31 K-12 lessons linked to
the Minnesota Academic Standards*





Developed by the Minnesota Department of Agriculture's
Agriculture in the Classroom Program - Fall 2013



"Our mission is to enhance Minnesotans' quality of life by ensuring the integrity of our food supply, the health of our environment and the strength of our agricultural economy."

www.mda.state.mn.us

This Minnesota School Garden Guide is also available at the
Minnesota Agriculture in the Classroom website:

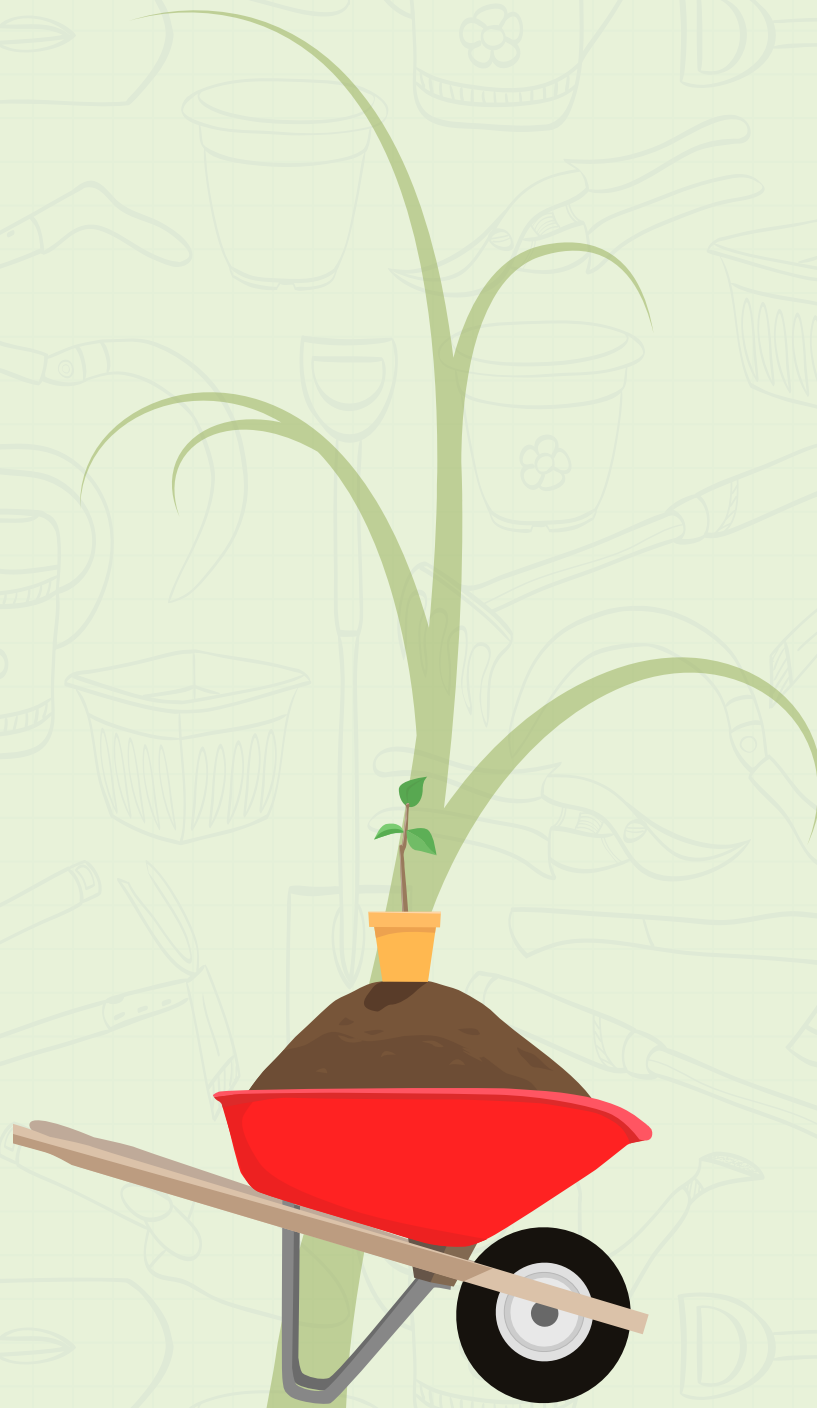
www.mda.state.mn.us/maitc

This Minnesota School Garden Guide is also available at the
Minnesota Agriculture in the Classroom website:

www.mda.state.mn.us/maitc



In accordance with the Americans with Disabilities Act, this information is available in alternative forms of communication upon request by calling 651/201-6000. TTY users can call the Minnesota Relay Service at 711 or 1-800-627-3529. The MDA is an equal opportunity employer and provider.



Minnesota Agriculture in the Classroom
www.mda.state.mn.us/maitc

Thank You

to our Partners and Sponsors

Granted Permission for Lessons and Material

Anoka County Community Health & Environmental Services Department

Curriculum for Agricultural Science Education

Florida Agriculture in the Classroom

Iowa State Extension Office

National FFA Organization

National Gardening Association

New York Agriculture in the Classroom

University of Minnesota Extension and Farm to School

Utah State Office of Education

Funding

Minnesota Department of Agriculture

Minnesota Grown Program

Reviewers

Leah Bott
Mary Crampton
Monica Foss

Editor

Jan Hoppe

Layout and Design

Clare Buche
Liz Kasper

Garden Guide Developer

Mary Robinson

Project Coordinators

Sue Knott
Al Withers

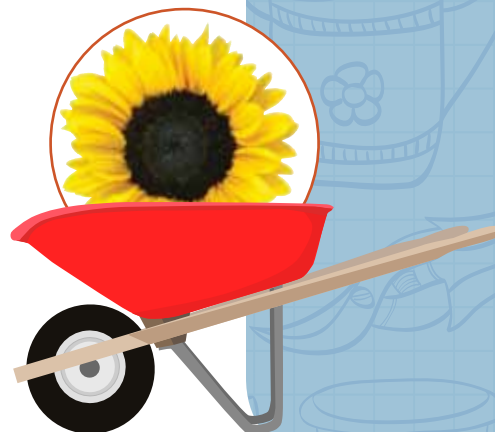


Table of contents

Introduction	4
Example Garden Case Studies	
Columbia Heights	6
Crosswinds Arts and Science	8
Dover-Eyota	9
Sibley East	10
Chapter 1. Getting Started	
Teacher Information	11
Plant It, Map It (<i>Elementary 3-5</i>)	22
Plant Parts Become Me (<i>Elementary K-3</i>)	27
Salad Investigation (<i>Middle School</i>)	31
Importance of Plants (<i>Middle School</i>)	37
Surrounded by Plants (<i>High School</i>)	41
Garden Goals (<i>High School</i>)	47
Chapter 2. Selection of Crops and Garden Themes	
Teacher Information	53
Right Plants, Right Place (<i>Elementary 3-5</i>)	62
Magic Beans and Giant Plants (<i>Elementary K-5</i>)	70
What? No Soil? (<i>Middle School</i>)	76
Plant Needs (<i>Middle School</i>)	85
Comparing Growing Locations (<i>High School</i>)	93
Photosynthesis (<i>High School</i>)	107



Chapter 3. Preparing and Planting

Teacher Information	112
It all Begins with Soil (<i>Elementary 3-5</i>)	115
Composting for Better Soil (<i>Elementary 3-5</i>)	121
Yo Seeds, Wake Up! (<i>Elementary K-5</i>)	130
Soil Testing 1, 2, 3 (<i>Middle School</i>).	134
Germination Research (<i>Middle School</i>)	140
Sorting Out Potting Soil (<i>High School</i>)	144
Gardening Economics and Efficiency (<i>High School</i>)	152

Chapter 4. Maintaining and Sustaining

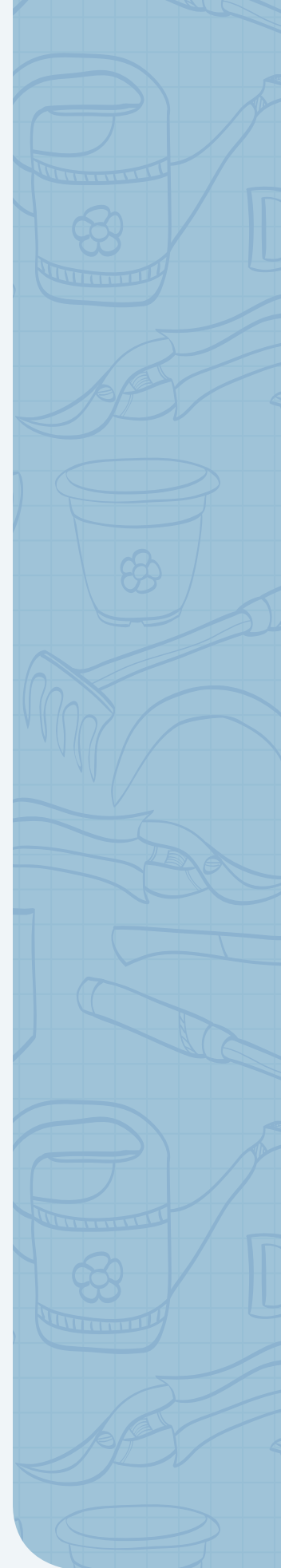
Teacher Information	157
Learning About Integrated Pest Management (<i>Elementary 4-5</i>)	160
Why Plants Need Water (<i>Elementary K-5</i>).	169
Make Room for Raddy (<i>Elementary K-5</i>)	173
Plant Doctor – Challenges with Growing Plants (<i>Middle School</i>)	180
Fertilizer Figures (<i>High School</i>)	188
A Bug’s Life (<i>High School</i>)	205

Chapter 5. Harvest, Food Safety, Nutrition, and Recipes

Teacher Information	214
What Are We Eating? (<i>Elementary K-5</i>)	222
The Healthy Hop’n Shop (<i>Elementary K-5</i>)	228
Safety First – Responsibilities for a Safe Food Supply (<i>Middle School</i>)	233
It’s All in a Label (<i>Middle School</i>).	240
Choosing Foods (<i>High School</i>).	246
Food Safety (<i>High School</i>)	254

Appendixes

Garden Related Literature	260
Alphabetical List of Lessons	261
Lesson Summary Overview	262
Garden Connection Overview	265
Standard Areas Overview.	267



Introduction

Benefits of Gardens

School gardens provide teachers with excellent hands-on learning for their students. Gardens can be incorporated into many subject areas. Lessons about gardens can meet K-12 academic standards in science, social studies, math, language arts, and health and nutrition. Working in the garden helps students learn patience as well as responsibility. They also become aware of the origins of their food and the work required to grow healthy and nutritious produce.

Background/History

The school garden movement began in Europe and later moved to the United States. The first known school garden in the United States was in 1891 at George Putnam School in Roxbury, Massachusetts. The concept took off and the United States Department of Agriculture estimates there were approximately 75,000 school gardens by 1906. World Wars I and II created even greater interest when Victory Gardens were introduced. Citizens were encouraged to plant gardens in any available space.

Victory Gardens sought to reduce demand on the food supply and lower the cost of produce purchased by the U.S. War Department. Following the wars the perceived need for gardens, including school gardens, declined until there was a renewed interest in the 1970s. Another upsurge was seen in the 1990s. Since then, the push for farm-to-school produce and use of locally grown foods has continued to create interest in school gardens.



School gardens provide teachers with excellent hands-on learning for their students.



Minnesota Movement

Many resources are available in Minnesota to support school gardens. Numerous organizations support similar goals such as eating locally grown foods and creating a greater awareness of ecology and sustainability. Current programs include the following:

Farm to School connects schools with fresh, locally grown food. It emphasizes food raised by family farmers for the mutual benefit of our youth, farmers, and communities. It builds partnerships, coordinates trainings, and provides hands-on nutrition education to children. A plethora of information and resources for school foodservice, farmers, parents, community members and educators is available on their website.

www1.extension.umn.edu/food/farm-to-school/

Gardening Matters is a nonprofit dedicated to promoting and preserving community gardening across the Twin Cities by connecting gardeners to each other and to the communities in which they reside. It provides training and resources to help community gardeners achieve gardens that are successful and sustainable.

www.gardeningmatters.org/

Master Gardeners, coordinated through the University of Minnesota Extension, is designed to benefit schools, community gardens, youth programs, environmental education programs, and farmers' markets. Master Gardeners volunteer their time and offer their expert knowledge in gardening.

<http://www1.extension.umn.edu/master-gardener/>

Minnesota Grown is a statewide partnership between the Minnesota Department of Agriculture and Minnesota producers of specialty crops and livestock. They have worked with growers since 1987 to differentiate their produce from out-of-state competitors.

www3.mda.state.mn.us/mngrown/

Minnesota Landscape Arboretum of the University of Minnesota provides garden and summer camp programming for youth of all ages.

www.arboretum.umn.edu/kidclasses.aspx

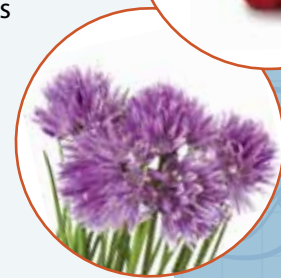
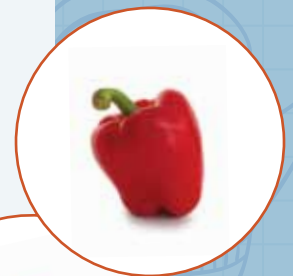
Schoolyard Ecology Explorations seeks to increase student and teacher expertise in ecological research, natural history, and sustainability. Through summer workshops, curriculum and schoolyard garden grants, teachers gain the skills and tools needed to lead their students to investigate the natural world.

www.monarchlab.org/see/

School Gardens Today

Today's school gardens take on many shapes and sizes; they all allow students to grow plants. They can be indoors or outdoors, in pots or in the ground, and can vary from growing vegetables to a small orchard of apple trees. Examples of school gardens include:

- herbs in a classroom window
- flowers attracting butterflies planted in pots along a sidewalk or path
- a traditional vegetable garden growing tomatoes, peppers, and green beans
- a sensory garden within walking distance of an elementary school
- school-colored flowers planted around a school sign
- raised beds for individual classrooms or grades



Example Gardens Case Studies

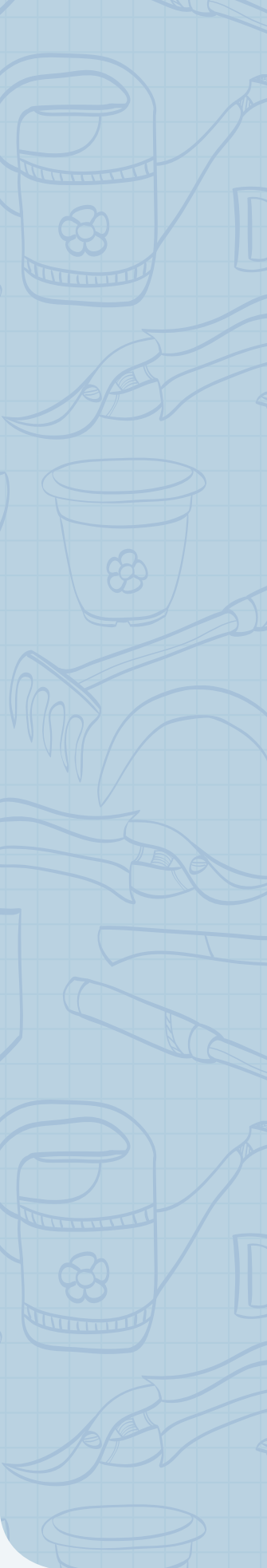
Columbia Heights

Town	Columbia Heights, Minnesota
Garden Grade Levels	Early Childhood through High School, as well as adults in Adult Enrichment Classes.
Garden Overview	Planning for Blooming Heights began in 2009 and the garden was established in 2010. The garden is centrally located in the school district and provides a beautiful space for students and staff to engage in hands-on learning within the context of multiple academic subjects. The garden includes a fruit tree orchard with apple, cherry, plum and pear trees, a variety of fruit bushes and perennial vegetables, a number of raised beds for annual vegetable production, an herb garden, and additional garden beds for native and perennial wildflowers. The garden is maintained organically and all garden debris is composted on site. In addition to the growing space, there are also a number of gathering spaces with seating throughout the garden and provide teachers with places to gather students for directions, lessons and storytelling.
Goals	<ul style="list-style-type: none"> • Space to contextualize classroom learning through hands-on activities. • Laboratory for science and exploration. • Provide a beautiful setting for students to explore, appreciate and connect to the natural world. • Promote wellness and healthy nutrition, academic achievement, community engagement and environmental awareness. • Teaching tool for nutrition education and expanding students' palates for fresh fruits and veggies; teaching students how to grow fruits and vegetables to support their health, especially with our demographics which are at high risk for nutrition-related health disparities.



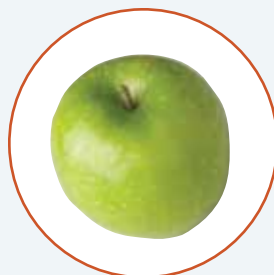


Town	Columbia Heights, Minnesota
Contributors	Maintaining the garden is truly a collaborative effort. A number of dedicated staff and teachers have maintained the garden for the first three years, and then the district hired a full-time, year round garden specialist. During the winter months multiple classes and grade levels throughout the district plant vegetable and flower starts in indoor grow labs. The starts are then planted outdoors by the students in the spring. Students and teachers also help with garden bed prep in the spring and fall, weeding, watering, harvesting, processing produce and general garden upkeep. The district's grounds crew also helps with mowing the grassy areas and general maintenance.
Budget	The garden was established with funds from a Statewide Health Improvement Program grant (\$60,000) and a Lowe's grant (\$5,000). The garden specialist salary is paid through Community Education (25%) and the General Education Fund (75%). The grants allowed for the purchase of the necessary supplies and materials to keep the garden going each year with little extra cost. The nominal cost of extra materials is absorbed by Community Education.
Summer and Long-term Maintenance Plan	The garden specialist works during the summer to engage students in summer garden maintenance. Students involved in Adventure Club, the summer program for kindergarten through sixth grade, are in the garden multiple times each week. They help with planting, weeding, watering, harvesting and processing all of the produce. Additionally, Outdoor Club (for high school students) does service projects in the garden to help with upkeep and maintenance that requires more time or skill than the younger students have (i.e. making repairs to the shed, spreading mulch, etc.)



Crosswinds Arts & Science School

Town	Woodbury, Minnesota
Garden Grade Levels	6-10
Garden Overview	Crosswinds International Peace Garden is an ongoing project that gives students and teachers the opportunity to plan, plant, and grow. The organic garden occupies 7,000 square feet and is watered by an irrigation system. There are three areas in the garden: a vegetable garden, butterfly garden and tree nursery.
Goals	Growing and harvesting our own food helps our efforts to nurture lifelong learners and environmental stewards. Students gain practical life skills to grow their own vegetables and use math & problem-solving skills.
Contributors	The garden is managed by science, health and physical education teachers. Activities are fit with standards needed to be met for particular classes. Outside of the classroom, local Boy Scouts and National Honor Society students have the opportunity to work in the garden. In the past volunteer parents worked with a family involvement coordinator to care for the garden.
Budget	<p>There was no startup cost for this garden as plants and resources from the existing land were utilized. Prior to being used for a garden the site had been an agricultural field with an irrigation system. Additionally, trees and native plants were already on the land.</p> <p>The garden has utilized money from grants including Whole Foods: Seeds-As-Donation. Annual cost depends on teachers and their departmental budgets. One year the science department spent \$500.00.</p>
Summer and Long-term Maintenance Plan	Crosswinds is a year round school. Sixth graders are very involved in caring for the garden. Other classes that assist with the garden include Earth and Life Science, Ecology for ninth and tenth graders and Physical Education.



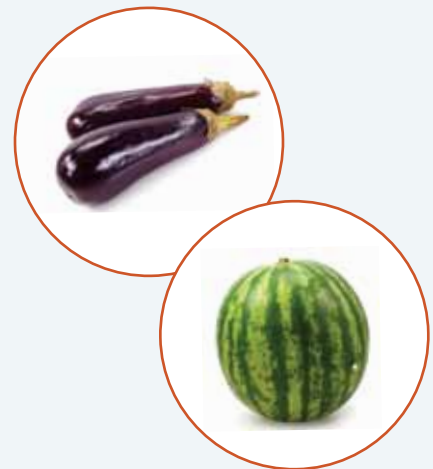
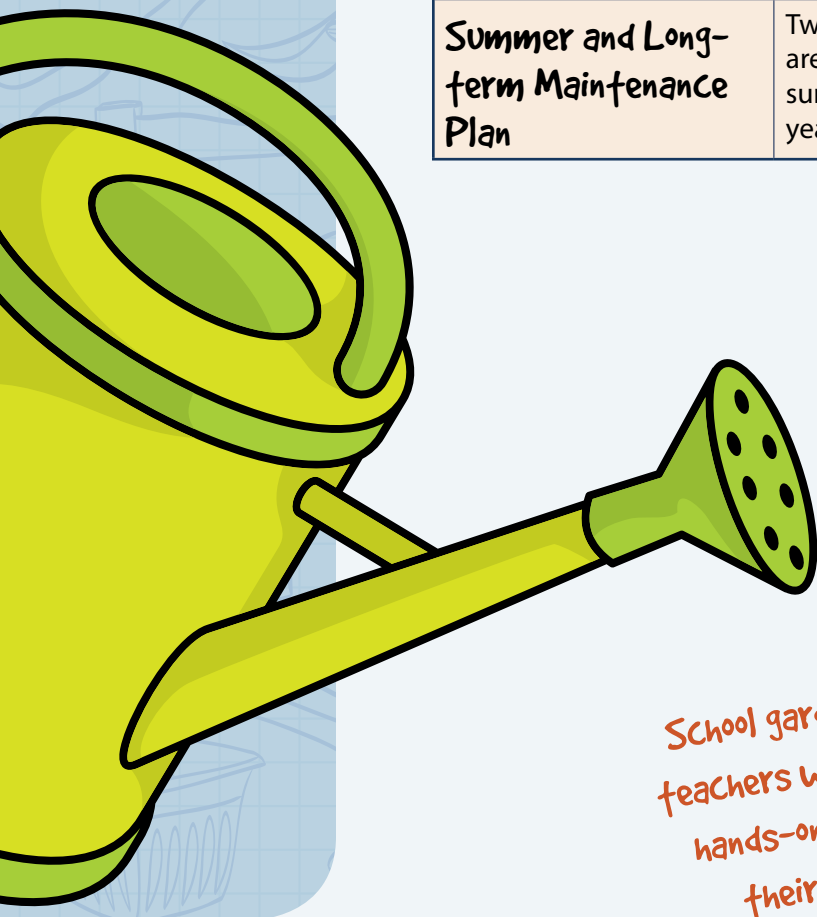
Dover-Eyota High School

Town, State	Eyota, Minnesota
Garden Grade Levels	7-12
Garden Overview	The garden contains fruit trees and bushes at the school building: 15 apple trees, 5 pear trees, and 10 blueberry shrubs. The high school horticulture class also uses a 10'X10' plot at the Eyota community gardens to plant cool season vegetables in the early spring. Produce is collected from the gardens and eaten by students in class, used in labs, or in school lunches.
Goals	<ul style="list-style-type: none"> • To educate students about agriculture and food production through hands-on learning. • To educate students about the nutritional benefits of growing their own food.
Contributors	The high school horticulture class does most of the work during the school year. A local apple grower visits and provides advice as needed. The food service director secured grant money for planting the trees and shrubs.
Budget	The startup cost was about \$15.00 per blueberry shrub and around \$50.00 per tree. Grant money helped cover the costs of the project. The annual maintenance cost is around \$50 for chemicals and garden seeds.
Summer and Long-term Maintenance Plan	The trees and shrubs need to be watered regularly during their first years after being planted (and during droughts). The trees and shrubs need to be sprayed with insecticides and foliar nutrients to improve the fruit yield and quality. The blueberry bushes need to be covered with nets when they start producing fruit to keep birds from harvesting the crop. Watering and chemical application is done by the school grounds crew.



Sibley East

Town	Arlington, Minnesota
Garden Grade Levels	8-12
Garden Overview	Students grow 2 acres of vegetables in plastic mulch. A wide variety of vegetables are produced including tomatoes, peppers, cabbage, celery, potatoes, onions and many others. A 30 foot by 48 foot high tunnel is used to grow peppers and cucumbers. Other crops include 30 apple trees and 50 grape vines. The garden is planted during school and five students are hired to maintain the garden during the summer.
Goals	<ul style="list-style-type: none"> • Grow fresh food for school cafeteria. • Teach students about growing crops. • Create and maintain a true hands-on learning lab.
Contributors	The school, FFA, Agricultural Education Program, local coops, local farmers, and local businesses.
Budget	<p>Start-up costs included \$6,000 tractor, \$2,500 tiller, \$2,000 mulch layer, and \$2,500 for small tillers and tools. Later \$1,000 was spent on trees and grapes.</p> <p>Annual costs include \$1,500 in plants and seeds, \$500 for mulch, \$500 for irrigation and approximately \$10,000 in labor costs.</p>
Summer and Long-term Maintenance Plan	Two Agricultural Education teachers and five students are paid to maintain the garden throughout the summer. The garden makes enough money each year to pay these expenses.



School gardens provide teachers with excellent hands-on learning for their students.

Teacher Information

Creating the Plan

After acknowledging the benefits of gardens and choosing to implement a garden, thorough planning is crucial to the success of your project. This garden guide assists you in creating a blueprint for success and making your vision a reality. Figures 1 and 2 found on pages 20 and 21 illustrate a model to assist in garden planning developed by Tim Kenny and Randy Gage of the Minnesota Landscape Arboretum.

Brainstorm

Before asking for approval from school administration, take time to outline and organize a plan for your garden. Include goals and objectives, benefits to students and community members, possible partners, funding needs and ideas, list of garden options and locations, and a timeline.

Approval and Support

Seek approval for your project from administration, and involve them in the planning process. Ask for support from teachers, food service staff, students, parents, community members, and local businesses. Promote the garden by presenting the project to faculty, school board members, parent-teacher organizations, and other local volunteer groups. Share how the garden promotes the current school mission statement and goals. Explain how the garden can be incorporated into curriculum to support academic standards.



*A garden can promote
your school mission
statement and goals*

Garden Advisory Committee

Invite stakeholders from several groups supporting the school garden to participate on an advisory committee. The committee will be instrumental in developing goals, establishing the garden, and creating a plan for summer care and long-term sustainability.

Assign roles to members of the Garden Advisory Committee. Adapt the responsibilities to meet your specific needs. Below is a list of suggested roles. Depending on your specific needs, you may need to edit role descriptions.



- **FACILITATOR:** The facilitator plans and convenes the meetings, enlists community support, helps with fundraising, and takes on other leadership responsibilities.
- **GARDEN COORDINATOR:** The garden coordinator works with the facilitator to create a core team; makes plans for the garden (location, planting and harvest plan), and orders seeds.
- **PLANTING DAY LEADER:** The planting day leader works ahead of time to get seeds started in the classroom, secure access to water and tools, and train staff.
- **RESOURCE LEADER:** The resource leader collects, stores, and distributes educational materials to help teachers use the garden.
- **PARENT-TEACHER LIAISON:** The P-T liaison keeps the school parent-teacher organization informed about the garden and recruits parents and community members to help along the way.
- **FUNDRAISER and OUTREACH COORDINATOR:** The fundraiser/outreach coordinator works with the facilitator and garden coordinator to make a garden budget; seeks funds from grants and community organizations, and documents the garden's progress with photographs and articles to the school newsletter and local newspapers.

Following is a suggested list of steps to assist the Garden Advisory Committee in establishing your project. Each step should have a target completion date and an identified lead person. Your step list may vary depending on your project.

Step 1. Identify Goals

As a committee, develop a clear focus for your garden by writing specific goals. Review the questions below to ensure the committee has addressed all necessary functions and roles of the garden.

Garden as an Outdoor Classroom

- How will the garden support the larger educational goals and values of the school?
- What educational activities and lessons will you incorporate into the garden?
- Do some goals take priority over others? If so, how should this influence the design?
- How will you meet the needs of students with disabilities or special learning issues?

Student Involvement

- How will the student body be involved with the garden?
- What aspects of garden installation and maintenance involve student's participation?
- What smaller scale events and activities make the garden part of the students' daily lives (recess time, story hours)?

Healthy Eating

- Who will harvest fruits and vegetables produced by the garden?
- What will happen to produce from the garden? Can it be eaten by students during a nutrition lesson? Can it be served to students during lunchtime? Will individual students produce for themselves and their families? Will students sell the food at a farmers' market?
- What are the school policies on farm fresh produce?

Community Connections

- For which extra-curricular and community activities will the garden be used?
- How will the garden team work with existing in-school networks of parents (PTO/PTA)?
- Where are opportunities to tap into the support and resources offered by parents and parent groups?

Step 2. Address Legal Issues

It is important to address legal and policy issues that impact your garden's construction and ongoing maintenance. Written policy adopted by the school board is highly advised.

Items to consider when addressing legal and policy issues for your garden include:

Liability

Liability is a civil responsibility for an injury that occurs based on your action or inaction. Liability for school gardens includes two areas:

- Physical injury from garden activity
- Injury from food consumption

Risk Management

Risk management involves planning and taking actions to prevent injuries before they happen. Risk management for school gardens includes education and training, good planning, good policy drafting, using garden safety protocols and best practices, and using waivers, contracts, and insurance.

Governmental Immunity

Governmental immunity can protect municipalities, including school districts, from liability. When deciding if immunity should apply, courts consider a school district's written policies and the school district's response to a history of accidents, complaints or comments about safety, results of safety inspections, common usage, and existing standards.

School Policies

School policies that include school gardens can provide institutional support needed to ensure the garden is successful and help to integrate the garden in the school. School gardens can be included in different school policies, including school wellness policies, student activities, and building and sites policies.

Food Safety

Food safety is an important consideration when growing produce for children to eat. Established food handling practices should be followed when growing, harvesting, and preparing school garden produce. Items that need to be considered include safe site selection, using safe materials and water, safe growing techniques, safe harvesting techniques, and safe storage.

Helpful Publications:

Legal Issues Impacting Farm to School and School Garden Programs in Minnesota

<http://publichealthlawcenter.org/sites/default/files/resources/ship-f2s-school%20garden%20legal%20issues-2011.pdf>

Sample School Wellness Policy: School Gardens

<http://publichealthlawcenter.org/sites/default/files/resources/ship-fs2-schooIwellnesssamplepolicyIanguage-2011SchoolGardens.pdf>

Further information can be found at the Public Health Law Center website:

www.publichealthlawcenter.org

Step 3. Select a Garden Location

When choosing an area of the schoolyard for a garden, many items need to be considered.

Use this checklist to help determine resources that are available to create the garden.

Land Considerations

- It is imperative to know the past and present uses of your potential garden site as well as proximity to pollution sources. This information, along with a soil test, can help determine the safety of the site and if the soil is suitable for a garden. Slope, drainage, and natural water runs should also be taken into account. Gardens planted on steep areas and places water typically runs are likely to wash away. To find out if there are underground utilities crossing your site, be sure to contact Gopher State One Call at 1-800-252-1166 or visit them online <http://www.gopherstateonecall.org/>

Sun

- Plants make food from sunlight, and some plants need a certain amount of light to grow. Indoor plants can thrive with very low light levels, but most vegetables, fruits, herbs, and flowers need six-to-eight hours of full sun to grow properly (typically between 9 a.m. and 4 p.m.). Gardening under trees, or in the shade of trees and buildings, can be done with certain types of plants. Consult local master gardeners or extension agents for direction about the types of plants that can grow in shady areas. Seed catalogs and packages also provide this information. Use the expertise of your schoolyard caretakers – they may know whether an area remains sunny year round!



Water

- Every type of garden needs easy access to water. Once you've found a sunny site, determine if there are outdoor water spigots near the site. If not, can they be installed? It will be tedious to bring water from inside the building out to water plants. If indoor water is all that's available, think of creating small container gardens in or near the classroom.
- Consider an automatic watering system. Systems can be simple or complex, from soaker hoses to automatic sprinklers to low-flow irrigation systems. Look for community partners to design, plan, and install the irrigation system.
- If an automatic system is not possible, use hoses or watering cans. Another option is the "cup of water" method. Dip a margarine tub (or other cup-sized container) in a bucket to individually water plants. If using a hose to water, purchase a water wand, adjustable nozzle, or other method to soften the flow of water from the hose. Consider using a camper or recreational vehicle hose that is labeled "drinking water safe." Potable water is important when gardeners take drinks, wash utensils, and rinse produce at harvest time.

□ Space

- What space is available to garden? Be creative. Look for existing raised planters around walkways, courtyard areas, and larger pieces of unused land. Make sure the space is not used for other classroom instruction. If it is, check with other teachers and staff to reach a compromise about site usage. Consider what is visible and accessible to your potential sites (i.e. classrooms, cafeteria, main entrance). If space is tight, container gardening may be a good solution. Consider how to give all students equal access. For example, beds raised high enough can give children in wheelchairs the same access as those not in wheelchairs.



- How many classes will be using the garden? Ideally, each child would grow his or her own plant. An entire grade growing beans will need four inches of row per child. For example, 80 students will need two 14-foot-long rows of space for their bean seedlings.

Suggested Resource

Soil Contaminants and Best Practices for Healthy Gardens

http://cwmi.css.cornell.edu/Soil_Contaminants.pdf

Step 4. Plan Garden Design and Construction

When planning the garden design, be sure it allows you to satisfy your garden goals. It's important to keep your project simple and manageable. Perhaps develop a five-year plan with components being added each year. Common school garden components include garden beds, paths, outdoor classroom areas, compost areas, storage areas, and a greenhouse or hoop house.

Next create a list of supplies needed to build, plant, maintain, and teach about the garden. Develop a realistic budget for materials. Common school garden supplies include:

- Garden beds (raised beds, container gardens, in-ground beds)
- Soil
- Seeds and plants
- Paths
- Mulch
- Fertilizer
- Hoses and sprinklers
- Tables and benches
- Storage shed
- Compost bin
- Fencing/edging
- Child-sized garden tools
- Gardening curriculum

Step 5. Secure Funding

Many grants are available to assist with funding school gardens. Before applying, be sure to review the guidelines to ensure your project is appropriate to the funding requirements. Here are some programs with funding available; key in titles on your search engine for Internet information.

Schoolyard Ecology Explorations: SEE is an outreach program with roots in the University of Minnesota. Grants are offered in two different plans. Plan A is a prescribed garden for teachers with little gardening experience and Plan B is for teachers who are designing their own gardens.

Minnesota Agriculture in the Classroom: This agricultural education program offers grants in the areas of youth gardening, unique integration and innovation in the classroom, and field trip experiences. First time applicants have priority for funding.

Fiskars' Project Orange Thumb: Funding is available for gardens and/or gardening projects geared toward community involvement as well as youth groups, schools, community centers, camps, clubs, etc., and is geared toward sustainable agriculture and education.

General Mills Champions for Healthy Kids Grant: The goal of this grant is to encourage communities in the United States to improve the eating and physical activity patterns of young people, ages 2-20. Grants are awarded to organizations that demonstrate the greatest need and likelihood of sustainable impact on young people's nutrition and activity levels through innovative programs.

Lowe's Toolbox for Education (\$200-\$500) Grant: The purpose of this grant is to fund school improvement projects initiated by parents. Projects that encourage parent involvement and build stronger community spirit will be favored.

Midwest School Garden Grant: Elementary, middle, and high schools serving low- to middle-income students located in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin are eligible. Educators should be planning to use the garden to teach life skills, reinforce academics, develop environmental stewardship, and encourage students to make positive choices.

National Gardening Association Youth Garden Grants: The National Gardening Association site lists several gardening grants for quick and easy review.

<http://assoc.garden.org>

In addition to grants, local businesses and organizations may be willing to support your school garden. Invite them to partner with you by donating supplies, garden workers, or financial resources.



Step 6. Plant Your Garden

After securing your financial resources and supplies, plan two to three workdays to build your garden. Organize Garden Advisory Committee members or a group of parents, teachers, students, and community members to construct your initial garden. Once again, keep your project simple and manageable. Adding to the garden each year generates enthusiasm and renews interest.

Decide who will plant the garden. It is best to have students plant with assistance from several adults. Be sure to go over garden basics with the group. Discuss where to find tools and plants, how to plant seeds according to the package, tips for transplanting, how to label seeds after planting, and watering instructions. Assign groups to specific tasks or areas of the garden.

Many space-saving techniques can be utilized when planting a garden:

- **Interplanting:** Plant two or more vegetables in one area, integrating a slow-growing vegetable with a fast-growing vegetable. For example, plant lettuce with tomatoes or plant pole beans at the base of corn stalks and they will climb the stalks.
- **Succession Planting:** Plant a second crop or a completely different crop of vegetables in the same location. For example, plant spinach and once harvested, plant beans or beets.
- **Wide-Row Planting:** Scatter fruit and vegetable seeds over an 8 x 12 inch band instead of in a single row to create dense foliage and prevent weed growth.
- **Vertical Space:** Use trellises or fencing to support climbing plants.
- **Square Foot Gardening:** Mark off 1-foot by 1-foot squares and plant seeds inside the complete square rather than in straight rows. (Or make triangles, circles, etc.)
- **Companion Planting:** It can be beneficial to plant two different plants next to each other as they will increase the overall production while decreasing pest problems and diseases. For example, beans and potatoes, or carrots and peas.

After your garden is planted, take a moment to enjoy the beauty of a freshly planted garden. Review your plans for maintenance and sustainability, harvest, and reflection.

Implement Your Maintenance and Sustainability Plan

To keep the garden healthy and productive, regular summer maintenance is required. It is helpful to have a garden manager who can oversee maintenance items. Plants need water during dry spells. Create a weekly watering schedule and post it in the garden. The garden needs to be weeded and monitored for pests and fungal infections. Some plants may need staking or cages to assist in their growth.

After the growing season comes to a close, it is important to make plans for future years. Sustainable gardens do not just happen; a well thought out plan is required. Adding new pieces to your project can renew support for your garden. New items can also assist in new funding opportunities. Invite stakeholders to visit the garden and learn what students are gaining from the experience.



Harvest the Garden

If the weather cooperates, some crops can be harvested in late May or early June in time for students to enjoy at school. Early-harvest crops include asparagus, green onions, leaf lettuce, radishes, rhubarb, and spinach. Other crops can be harvested late in the year and eaten in September. Late-harvest crops include broccoli, cabbage, carrots, cauliflower, and potatoes.

Follow good agricultural practices to ensure a safe food harvest. Good hygiene and proper hand washing for food handlers is critical. Use clean tools and containers. If produce is rinsed or washed, potable water must be used.

Reflect and Evaluate Your Success

After you have harvested all your produce, take time to reflect and evaluate your project. Revisit the goals developed by the Garden Advisory Committee. Did you accomplish the goals? How did the garden benefit students, your school, and the community? Were there any surprise benefits? What feedback was received? Make a list of changes to improve the garden for next year.

Additional Lesson Resources

Lesson: Plants 'R' Us and What's in a Name

Grades: 3-8

Source: National Gardening Association

Curriculum: *Grow Lab: Activities for Growing Minds*

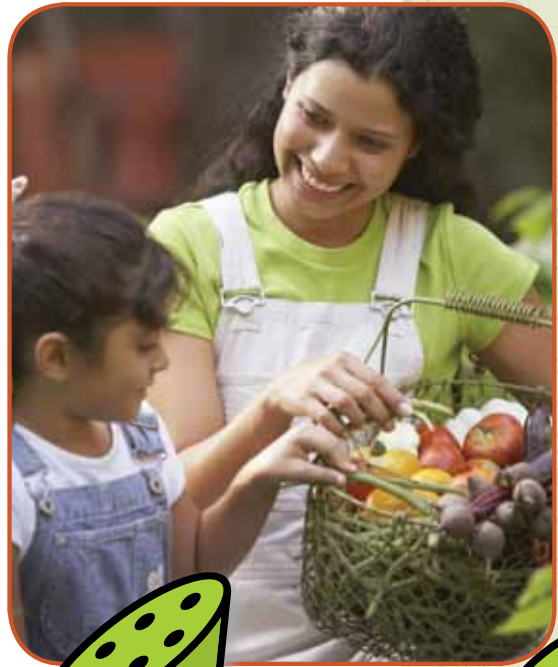
Location: Can be purchased from www.gardeningwithkids.org

Lesson: Plant Parts We Eat

Grades: Pre-kindergarten-2

Source: Oklahoma Agriculture in the Classroom

Location: <http://oklahoma4h.okstate.edu/aitc/lessons/primary/parts.pdf>



Sources/Credits

Garden Advisory Committee Roles, Identify Goals

Adapted from *Gardening 101* developed by Susan DeBlick and Marjorie Peronto.

Addressing Legal Issues

Adapted from Mary Marrow, Public Health Law Center presentation at the Schoolyard Garden Conference February 22, 2013

Select a Garden Location

Adapted from Florida Agriculture in the Classroom, Inc.'s *Gardening for Grades* school garden curriculum.

Plan Garden Design and Construction and Plant Your Garden

Adapted from *Creating and Growing Edible Schoolyards: A How-to Manual for School Professionals* created in partnership between Anoka County Community Health & Environmental Services Department's SHIP initiative and the Anoka-Hennepin School District.

Planning a Successful Garden Project

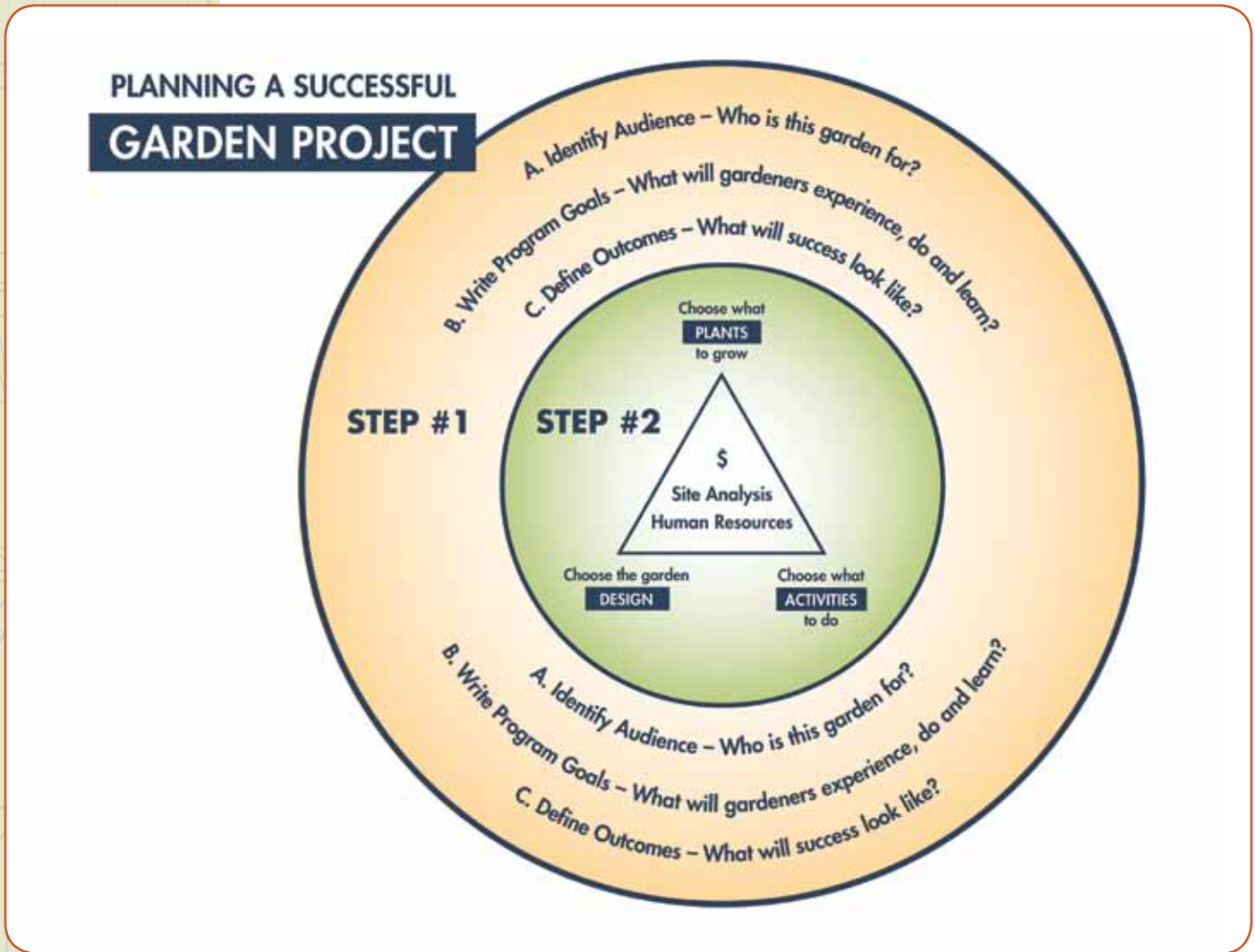


Figure 1

This diagram shows that planning a successful garden project has two main steps. The first step has two parts; defining garden program goals, and defining outcomes for success. As enticing as it might be to jump to step two, it is essential to finish step one first - because the decisions in step two should all be based on the result of step one. With clearly defined goals and outcomes, planning can move into step two: garden design, plant selection, and garden activities.

Diagram and information used with permission from Tim Kenny and Randy Gage.

KEEPING YOUR GARDEN
PROJECT ON COURSE!

MANAGING
INCOMING

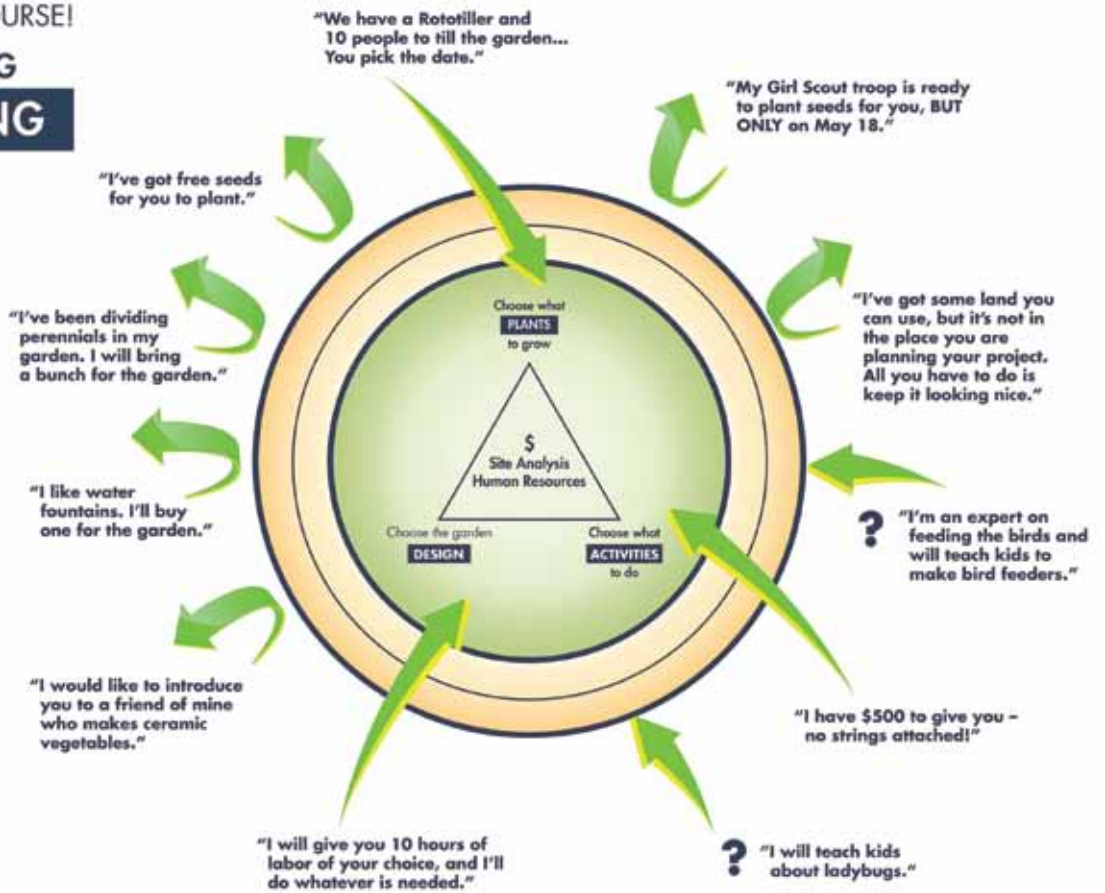


Figure 2

A clearly defined project that results from the “planning a successful garden project” process will help communicate the purpose of your garden to many stakeholders: funders, neighbors, teachers, parents, school leadership, and more. It will also define what resources are necessary to implement the plan - plants, hardscape, supplies, labor, and the like. Your plan helps you redirect (well-meaning but not aligned with garden goals and outcomes) offers of resources (seeds, plants, hardscape, labor, etc.) to things that are essential to the success of the garden.

Diagram and information used with permission from Tim Kenny and Randy Gage.

Grade

Elementary 3-5

Materials/Preparation

- Handout A – Plant Dimensions Chart – one per student
- Handout B – Plan It, Map It – one per student
- Seed catalogs or Internet access to seed catalogs
- Rulers, yardsticks, measuring tapes
- Paper, graph paper or notebook (or purchase garden planning software to use computers)
- Writing instruments

optional

- Calculators

Fun Fact

Apple trees take four to five years to produce their first fruit.



Plan It, Map It

Minnesota K-12 Academic Standards

Math	3.3.2	Understand perimeter as a measurable attribute of real world and mathematical objects. Use various tools to measure distances.
Math	4.3.2	Understand angle and area as measurable attributes of real world and mathematical objects. Use various tools to measure angles and areas.
Math	5.2.3	Understand and interpret equations and inequalities involving variables and whole numbers, and use them to represent and solve real-world and mathematical problems.
Science	3.4.1.1 5.4.1.1	Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.
Science	5.4.2.1	Natural systems have many parts that interact to maintain the living system.

Summary/Overview

Using the information provided, students use math skills to plan their garden.

Garden Connection

Students learn about plant varieties, row width, space between plants, and height.

Background Information

Living things compete with one another to survive and reproduce. Plants have differing characteristics unique to their species and variety. Even within species there are differences between varieties. Consider the number of different squashes, or the variety of tomato plants. Much of the information in this guide sets standard parameters that plants need. But this can vary. This activity gives students the opportunity to experience first-hand that math has a purpose with real-life applications, research various plant information, and make decisions about the garden they will plan and plant.

Objectives

- List plant-growing requirements to consider when planning a garden.
- Use simple multiplication to calculate garden rows and size.

Procedure

Interest Approach

Have students brainstorm their favorite vegetables. Create a list on the board.

Summary of Content and Teaching Strategies

Groundwork: Spacing Requirements

Have students select vegetable plants they could plant in the garden. Make a list of those plants. Students may refer to the list of favorite vegetables from the Interest Approach above.

Using hard copy seed catalogs or online seed suppliers, ask students to identify the number of varieties of one of these vegetables. Students can work in small groups to find the information on their chosen or assigned vegetable. Provide students with copies of Handout A. They list the names of the varieties available on Handout A. Burpee Seeds online is a good resource for finding this information.

NOTE: For plants with more than 10 varieties, have students select a specific type of that vegetable (i.e. tomatoes: select full-sized, slicing tomatoes or heirloom; squash: select winter squash or summer squash; peppers: select sweet bell peppers or hot peppers).

Ask students to identify each variety's growing requirements and note them in the chart provided. Have them select the variety they think is best to plant in the school garden and estimate the number of plants they would like to have.

Next have students calculate the number of square feet their garden will require to grow the number of vegetables they have selected. Students then create a rough-draft map of their garden drawn to approximate scale. The teacher should set the specific scale for the class and determine if the garden will be planted using rows or square foot gardening.

Groups take turns sharing the information on their specific vegetable with the rest of the class.

Exploration

Designing the School Garden

Give students the actual school garden dimensions. Share what garden space will be available for their class to use.

Have students determine what and how many of each plant they will incorporate into the garden. Decisions to be made:

1. Will each student have his or her own plant or plants (number)?
2. Will each student have the same type of plant?
3. If so, what will it be? If not, how many total types of vegetables will be grown?
4. Will more than one variety of each vegetable be grown?



As a group, plan the school garden. Consider plant height in relation to the sun to prevent tall plants from shading short plants. Also plan room for humans to weed, water, and harvest the garden.

Instruct students to make a scale drawing of the garden plot. For younger students, plant needs can be depicted graphically by making a paper pattern of the space needed by each plant. Use these patterns to map out the garden in scale size.

Review/Summary

Have students answer the following questions in small groups:

1. Name three vegetables that can be grown in a garden.
2. Explain why it is important to leave room between plants.
3. Describe why plant height needs to be considered when planning a garden.

Modifications/Extensions

- Have students create algebraic equations for planning the garden.
- Have students create gardens that incorporate circles, triangles, rectangles, octagons, and create a garden diagram drawn to scale that provides adequate plant space and human working space.
- Have students create three-dimensional gardens that use fencing, wire cages, climbing poles, etc. to make use of vertical as well as horizontal space.



"Children are born naturalists. They explore the world with all of their senses, experiment in the environment, and communicate their discoveries to those around them."

The Audubon Nature Preschool

Sources/Credits

The above lesson is provided courtesy of Florida Agriculture in the Classroom, Inc. from its *Gardening for Grades* school garden curriculum.

Name _____



Plant Dimensions Chart

Vegetable Selected			
Variety	Row Width	Space Between Plants	Height

Name _____



Plan It, Map It

1. Name three plants you would like to grow.

2. Select one of those plants and list it below.

Does this plant have any special needs?

3. How much distance should there be between this plant and the next plant in the same row?

4. If this plant were planted in several rows, how far apart should each of these rows be from the next row?

5. How tall does this plant grow?

Grade

Elementary K-3

Materials/Preparation

- Handout A – Plant Illustrations – one per student
- Crayons or markers
- Scissors
- Staples, glue sticks or tape
- Samples of fruits and vegetables that represent different plant parts. (When possible, save one example of each of the following. Wash and cut the rest into bite-sized samples for tasting: fruit or flower – apples, oranges, grapes, kiwi, strawberries, broccoli, cauliflower; seed or flower – peas in a pod, sunflower or pumpkin seed snacks, popcorn; leaf – lettuce; stem – celery; root – carrot, radishes.)
- Tray for samples
- Vegetable dip
- Tub of cream cheese mixed with equal amount of brown sugar for fruit dip
- Spoons for dips
- Small paper plates – one per student
- Napkins – one per student



Plant Parts Become Me

Minnesota K-12 Academic Standards

Science	0.4.1.1 1.4.1.1 2.4.1.1	Living things are diverse with many different observable characteristics.
Science	3.4.1.1 5.4.1.1	Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.

Summary/Overview

Students begin by reviewing the main parts of plants through a role-play activity. They design their own plants and compare the variety of their creations to those of their classmates. Students identify and taste fruits and vegetables that come from different plant parts.

Garden Connection

Roots, stems, leaves, flowers make up the foods we harvest from gardens.

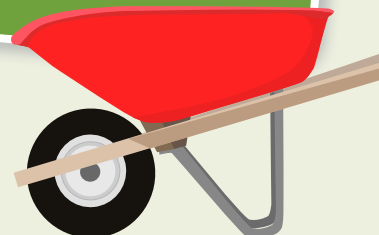
Background Information

Plants have four basic parts: roots, stems, leaves, and flowers. Roots anchor and support plants as well as absorb nutrients and water. Roots also store excess food produced by the plant. Stems support leaves and flowers. They also act as a transportation system moving water and nutrients up from the roots and taking excess food produced by the plant down to the roots. The main job of leaves is to create food and energy through the process of photosynthesis. Finally, flowers provide plants a way to reproduce. The brightly colored petals attract insects, which aid in pollination. Pollination leads to fertilized eggs that create new seeds.

While each plant part is crucial to the growth and development of the plant, humans also benefit from these parts. The fruits and vegetables we eat come from the four main parts of a plant as well as from the seeds. Edible roots include carrots and radishes. Asparagus, celery, and rhubarb are stems. Lettuce is an edible leaf. Most of the flowers we eat have turned into fruits. Fruits are the fleshy produce containing one or more seeds. Apples, oranges, grapes, kiwi, strawberries, broccoli, and cauliflower are all examples of flowers or flowers that have grown into fruit. Edible seeds include peas in a pod, sunflower or pumpkin seeds, and popcorn.

Fun Fact

Carrots are members of the parsley family, characterized by the feathery green leaves. Other members include parsnips, fennel, dill, and celery.



Objectives

- Identify the four parts of plants and their functions.
- Make connections between plants and personal food choices.

Procedure

Interest Approach

Guide students in a role-play activity where they pretend to be a plant. Start by pretending that it is spring and you are seeds that have been planted in the ground. Curl up on the floor or “ground” like a seed in our garden. You are underground. The soil or ground is all around you. Spring rains come down and soften the seed coat so that your roots start to grow into the soil.

Ask students, “What part of your body can you use to become roots?”

Feet and legs are the roots growing out of the seed and pushing down into the soil. Roots are the first plant part to grow out of seeds. Wiggle your toes as your roots start growing out of the seed.

Ask students, “What part of your body is the stem?”

Your body is the stem. Wiggle your bottom, shoulders, and elbows. Pop up your head and start growing tall. Stand up tall and straight so that your stem is growing above the ground. (Above ground is the height of desks or tables.)

Ask students, “What parts of your body could be the leaves and branches?”

Your arms could be branches and your hands and fingers could be leaves. Put your arms out away from your body and wiggle your hands and fingers as if they were leaves fluttering in the breeze. Reach toward the sky to catch the sun’s rays.

Stand up straight with your head held high and a big smile on your face because your head is a beautiful flower on top of a sturdy stem. Move it back and forth like it is enjoying the sunshine and the breeze.

Summary of Content and Teaching Strategies

Groundwork: Designing Plants

Distribute Handout A. Have students look at the pictures on the activity sheet and identify the four parts of a plant. Every picture in the first column is a root. Every picture in the second column shows a stem and leaves. Every picture in the third column is a flower. Explain that flowers develop into fruit that contains seeds.

Provide crayons or markers for students to color pictures of the plant parts on Handout A. Students can design their own plants by carefully cutting out the boxes with the pictures. Mix them up and design a favorite combination to make plants, each with a top, middle, and bottom in the correct order.

After the students have colored, cut, and lined up their plants, they attach the parts in any of the following ways.

Staple or glue them on paint stir sticks so they can carry them around like stick puppets and pretend to plant them in a flowerpot in the room.

- Glue them on colorful construction paper to hang around the room.
- Tape them together in a strip and hang them around the room.

Have students name their new flowers and tell the rest of the class about them. Discuss similarities and differences.

- How many people put the same combinations of flowers, leaves, and roots together?
- How many different combinations do we have?
- How many are exactly the same?

Exploration

Edible Parts of Plants

Review the four parts of plants. Make four columns on the board with these headings:

- flowers
- leaves
- stems
- roots

If desired, flowers can be further subdivided into fruits and seeds.

Before the following activity, wash and cut fruit and vegetable plant part samples and put them on a large tray. Prepare the dips for spooning out onto the students' plates.

Ask students what fruits and vegetables they have eaten yesterday and today. Have them list what they ate under columns on the board labeled roots, stems, leaves, and flowers. Explain that fruits and vegetables are important to our health because they contain vitamins and minerals that help keep us healthy. They also contain fiber to help clean out our bodies. Eating a variety of vegetables and fruits of different colors is a healthy eating habit.

Have the students wash their hands in preparation to try some vegetables and fruits. Show them actual samples of roots – an entire carrot; stems – a celery stalk but remind them it is really a leaf stem; leaves – a lettuce leaf; and flowers – an entire apple or orange. Have them guess what they are and what part of a plant they come from. Give each student a small paper plate and a napkin. Show the tray of fruits and vegetables and encourage the students to try at least two to three different fruits and vegetables. Offer ranch dressing and cream cheese mixed with brown sugar to use as dips. The dips may encourage them to try new vegetables and fruits. If choosing is difficult for your students, prepare sample plates for them. Optional: Challenge students to try one root, one stem, one leaf, and one flower.

Discuss and describe the differences in flavor, texture, and color between the root, stem, leaf, and flower.



Sources/Credits

Adapted from Growing in the Garden Elementary Curriculum that Grows with the Child written by the Iowa 4-H Development Program and revised in June 2012. The curriculum can be purchased from the Iowa State Extension Office <http://www.extension.iastate.edu/4h/page/curricula-info-ordering>

Review/Summary

Divide the class into four groups and assign each group one of the foods listed below. Some foods may be assigned to more than one group; add your own food ideas to the list. Students discuss the vegetables or fruits that are in each food and the plant part they come from. Have groups report back to the class. You may want to write the ingredients on the board or provide students with a labeled colored picture of their food.

- **Pizza** – onions (leaves); tomatoes, peppers, olives (fruits); crust (wheat seeds)
- **Hamburger** – onion, lettuce (leaves); tomato, catsup (fruit); mustard (seeds); bun (wheat seeds, sesame seeds)
- **Vegetable soup** – onions, celery (leaves); potato (stem); tomatoes, pepper, peas, beans, okra (fruit); carrots (roots)
- **Spaghetti and sauce** – tomatoes, peppers (fruit); onions (leaves); pasta (wheat seeds)

Modifications/Extensions

Get “Dirt Made My Lunch or Singing in Our Garden” CD by the Banana Slug String Band (bananaslugstringband.com). After playing the song, ask students to identify the six parts of the plant listed in the song. Ask them what each part is doing in the song.

Read Stone Soup by Marcia Brown. Make cards for each vegetable mentioned in the book and distribute to students. As you read, have students bring their cards to the front when each vegetable is read. They can sort the vegetables by plant parts at the front of the room.

Name _____



IOWA STATE UNIVERSITY
Extension and Outreach
Healthy People. Environments. Economies.

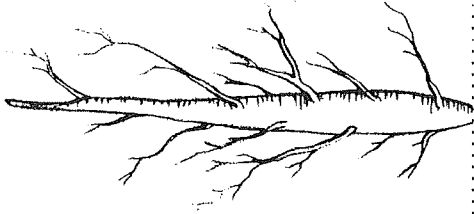
Roots, Stems, Leaves, and Flowers

ACTIVITY SHEET
PLANT PARTS BECOME ME!

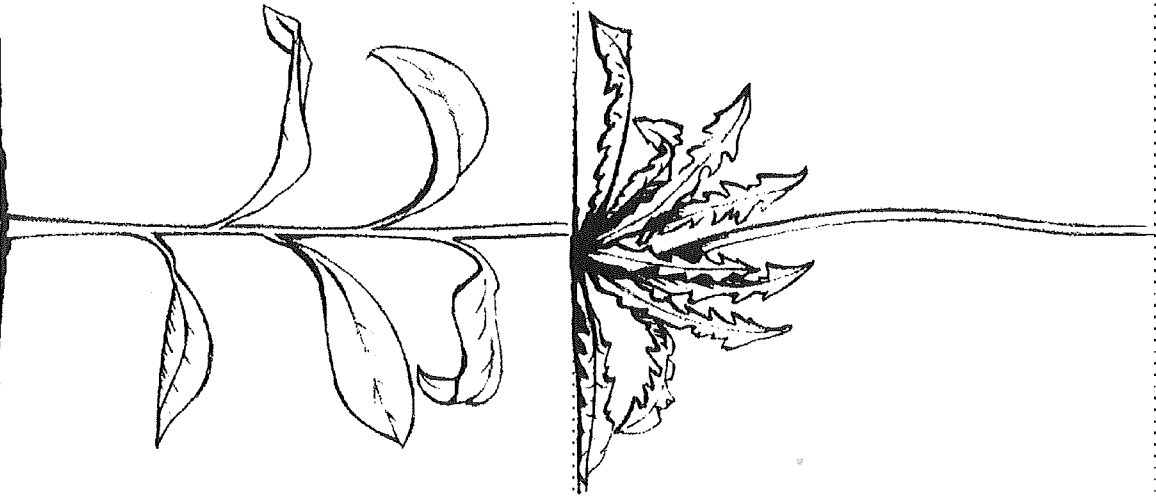
4-H Youth Development
4H-905A3 | Revised June 2012



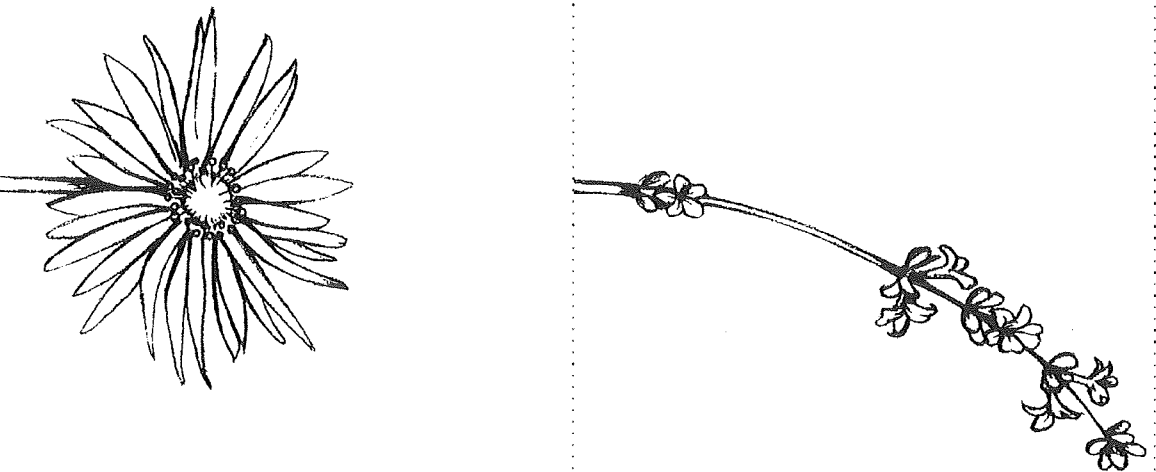
Roots



Stems and Leaves



Flowers



Grade

Middle School

Materials/Preparation

- Teacher Material A – Parts of a Plant – one per teacher
- Teacher Material B – Edible Plant Parts – one per teacher
- Handout A – Salad Investigation Report - one per student
- Assessment A – Salad Investigation – one per student
- Paring knife
- Salad ingredients: Enough to make each student one small salad each with seven of the following: carrots, lettuce, tomatoes, sunflower seeds, celery, broccoli, cucumbers, mandarin oranges
- Plates, napkins, and forks – one set per student
- Variety of salad dressings
- Writing utensils

Before class begins, prepare enough miniature salads for each student in the class to have one. Choose seven plant foods from the Materials list or add your own. Salads should include samples of at least one of each of the six basic plant parts. (Suggestion: have salads prepared and set at each student's individual seat with a fork and napkin). Display Teacher Material A on a large board or suitable wall space.

Salad Investigation

Minnesota K-12 Academic Standards

Science	7.4.1.1	Tissues, organs and organ systems are composed of cells and function to serve the needs of all cells for food, air and waste removal.
Health	6.6.1	The student will apply strategies and skills needed to attain personal health goals.

Summary/Overview

Students learn about edible plant parts and the difference between fruits and vegetables while eating a salad.

Garden Connection

Students identify the parts of plants used to make a salad.

Background Information

Plants are the most important source of food in the world (both for humans and animals). All the fruits, vegetables, and starches we enjoy each day come from the six distinct parts of plants: roots, stems, leaves, flowers, seeds, and fruits. Edible plant parts are classified as either vegetables or fruits. *Vegetables* are any edible part of the plant that is not the fruit. This includes foods that are leaves, roots, stems, flowers, and seeds. Technically, *fruits* that we consume (apples and oranges, for example) are the fruiting body of the plant. Believe it or not, ketchup is a fruit product because it is derived from the fruit of a tomato plant.

Objectives

- Cite five examples of edible plant parts.
- Explain the difference between fruits and vegetables.

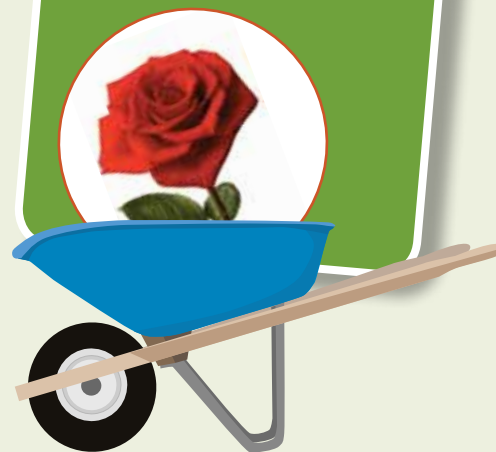
Procedure

Interest Approach

Tell students not to touch the salad, napkin, or fork on their desk. Have them wash their hands. Or you may wish to provide hand-sanitizing gel. Provide students with copies of Handout A. Invite them to be detectives investigating their salad and name the seven different food components on the Salad

Fun Fact

An apple is in the pome family – a fruit whose seeds are embedded in the core of the fruit. Another surprising member of this family is the rose.



Investigation Report. Point out the “salad component” section on the worksheet. Provide students with three minutes to complete this one column. Verbally review each component of the salad.

Summary of Content and Teaching Strategies

Review the parts of the plant. Display Teacher Material A and have students point out the plant parts. Plants are the most important source of food in the world (both for humans and animals). The fruits, vegetables, and starches we enjoy each day come from different parts of the plants. These foods are all one of the six main plant parts: roots, stems, leaves, flowers, seeds, and fruits.

Discuss the difference between fruits and vegetables. Decide whether each of the salad foods is a fruit or vegetable, and what part of the plant it is. Ask students to do this activity in pencil so they can go through each one and correct any answers that need to be rethought. Invite them to add other foods that come from this same part of the plant.

Discuss commonly misnamed fruits and vegetables. There is a simple way to remember the difference. Vegetables are any edible part of the plant that is not the fruit. This includes foods that are leaves, roots, stems, flowers, and seeds. Discuss information on **Teacher Material B**. Point out these plant parts on **Teacher Material A**. Discuss the vegetables and fruits students listed on their Salad Investigation Reports. The reports should now be completed. Provide salad dressing and invite students to eat their salad.



Review/Summary

Have students answer the following questions in small groups:

1. What part of the plant is lettuce?
2. Is a cucumber a fruit or vegetable? (Fruit; seeds are inside)
3. Name an example of a vegetable. (Lettuce, carrots, turnips, lima beans, etc.)
4. Is ketchup a fruit or vegetable product? (Fruit because it comes from tomatoes, which are the fruit of the tomato plant.)

Modifications/Extensions

Have students do a fanciful Complete Salad Plant activity. Students draw single plants that could be a complete salad; their parts are made of the foods discussed in the lesson (carrots, lettuce, tomatoes, sunflower seeds, celery, broccoli, cucumbers, mandarin oranges). Students label each plant part with the name of the food and which of the six basic plants is represented (for example: lettuce leaves, carrot roots). Have students share their drawings with classmates. Post these in the classroom as a fun reminder of the origins of their salad.

Challenge students to use the knowledge they gained from this lesson to write three healthy eating goals for themselves. The goals should relate to eating a variety of healthy foods and include foods from each plant part.



Sources/Credits

Adapted from: National FFA Organization Middle School Food and Agricultural Literacy Curriculum, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit www.ffa.org/documents/learn/MS.PS.1.3.pdf to access the full length version of this lesson.

Parts of a Plant

Leaves Functions:

1. Site of photosynthesis
2. Absorbs sunlight to produce energy
3. Site of the majority of transpiration

Flower Functions:

1. Site of reproduction
2. Contain male and/or female parts
3. Can be bright and fragrant to attract pollinators

Stems Functions:

1. Channel of water, nutrient, and sugar transportation throughout the plant
2. Supports buds and leaves

Fruit Functions:

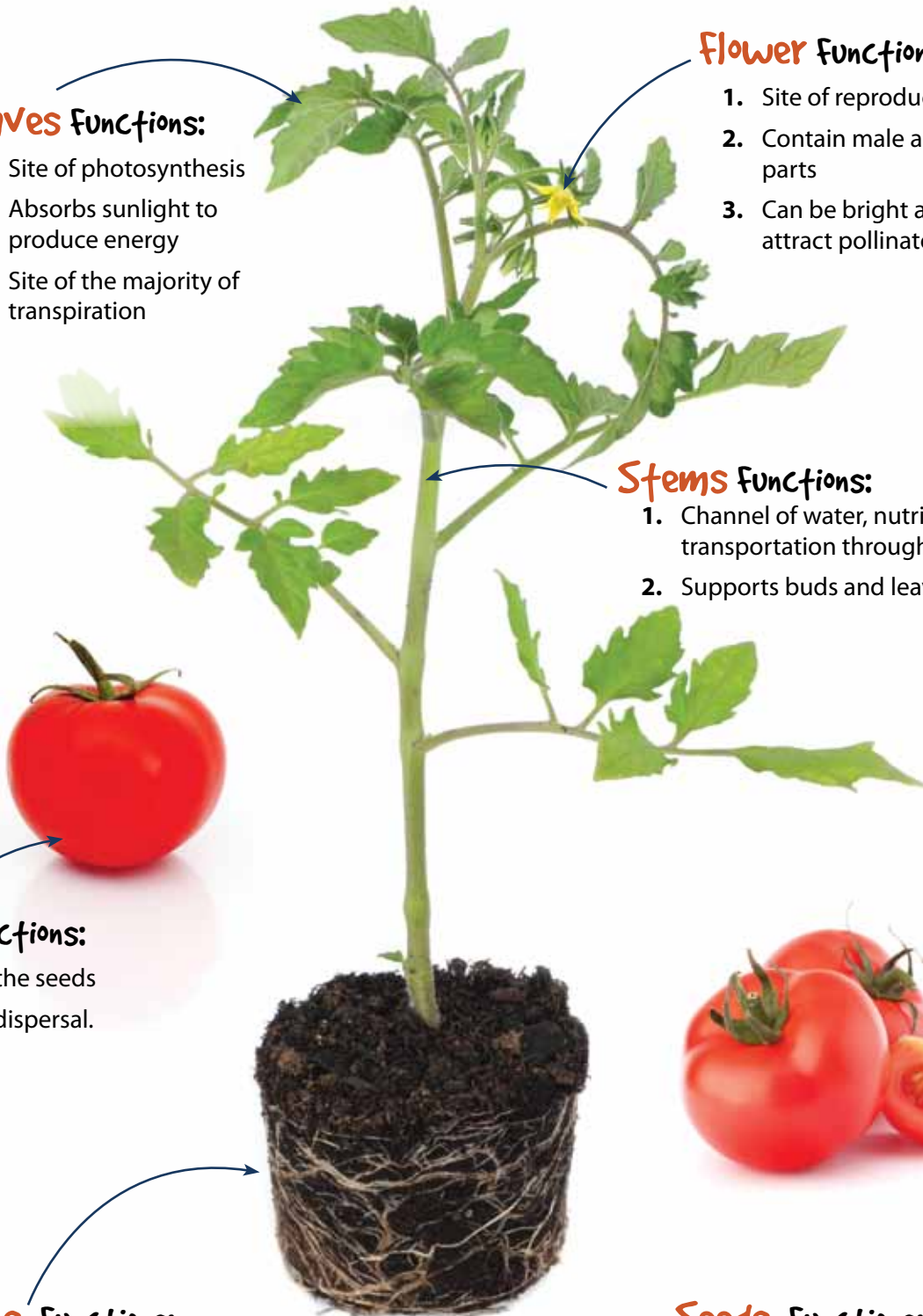
1. Protect the seeds
2. Help in dispersal. How?

Roots Functions:

1. Absorb water and minerals from the soil
2. Anchor plant to ground
3. Support stem structure

Seeds Functions:

1. Contain the embryo which will become new plants



Edible Plant Parts

A. Plants are the most important source of food in the world (both for humans and animals). The fruits, vegetables, and starches we enjoy each day come from different parts of the plants. All these foods are one of the six main plant parts: roots, stems, leaves, flowers, seeds, and fruits. Edible plant parts are classified as either vegetables or fruits.

B. Vegetables: Vegetables are any edible part of the plant that is not the fruit. This includes foods that are leaves, roots, stems, flowers, and seeds.

- 1. Roots:** Roots collect water and minerals from the soil. Roots are also used for energy and food storage for some plants. Examples of edible roots include carrots, beets, turnips, and rutabaga.
- 2. Stems:** Stems transport water and minerals from the roots to the rest of the plant and transport the energy created by photosynthesis from the roots to the rest of the plant. Commonly eaten stem parts include celery, onions, and potatoes. Potatoes are actually modified stems that plants use to store energy, which is why they are such a great source of energy.
- 3. Leaves:** Leaves are the primary site of photosynthesis in plants. They are also the site of transpiration. Leaves are a great source of many vitamins needed for healthy humans and animals. Commonly consumed leaf foods include lettuce, kale, spinach, cabbage, collards, and mustard greens.

- 4. Flowers:** Flowers are the reproductive structure in plants and can contain male (stamen) and/or female (pistil) structures. Flowers are usually the flashiest part of the plant in order to attract pollinators. Many flowers are common foods for humans including broccoli and cauliflower.
- 5. Seeds:** Seeds are the mature ovules that are originally found in the female part of the flower and are usually housed in a type of fruit or cone. Seeds contain the embryo, which will germinate and become a new plant. Common edible seeds include lima beans, peas, sunflower seeds, green beans, and pinto beans.

C. Fruits: Technically, fruits that we consume (apples and oranges, for example) are the fruiting body of the plant..

Fruits are formed from the fertilized ovule (seeds) and the ovary walls of the female part of the flower. The fruit protects the seed and assists in the dispersal of seeds (by attracting animals that may consume the fruit and disperse the seed). Edible fruits include apples, oranges, and strawberries. Although they are often called vegetables, tomatoes and cucumbers are also the fruit of the plant.

Vocabulary Words

Ovules: small eggs found in the female part of the flower

Photosynthesis: the process by which plants use energy from the sun, carbon dioxide, and water to make food

Pollinator: an agent that transfers flower pollen from the male anthers to the female stigma

Transpiration: water evaporation from leaves

Name _____



Salad Investigation Report

As we explore the components of our salads, fill in the following chart. **First**, list the seven components. **Second**, determine whether the food is a vegetable or fruit and write a V or F in the box. **Third**, name what part of the plant it is (root, stem, leaves, flowers, fruit, or seeds). Finally, list 3-4 examples of other plant foods that are from the same part of the plant as the component.

Salad component	Fruit or Vegetable?	Part of Plant	other foods from this Plant Part



Salad Investigation

Determine whether each food is a fruit or vegetable. In the third column, name the part of the plant the food is. Use the list of basic plant parts below.

Plant Parts					
Root	Stem	Leaves	Flower	Seed	Fruit

Name of Food	Fruit or Vegetable	Plant Part
Turnip Greens	1.	2.
Carrots	3.	4.
Lima Beans	5.	6.
Tomato	7.	8.
Celery	9.	10.
Broccoli	11.	12.

Grade

Middle School

Materials/Preparation

- Teacher Material A – Mind Map Example – one per teacher
- Assessment A – Importance of Plants – one per student
- Computer
- Poster paper
- Notebook paper
- Magazines
- Scissors
- Glue
- Writing Utensils
- Markers
- Food for Thought Desk Map*

*The Food for Thought Desk Map is available online at www.mda.state.mn.us/Global/MDADocs/kids/food4thought/deskmap11x17.aspx. Printed maps can be ordered from *Minnesota Agriculture in the Classroom*.

Fun Fact

Carrots have a higher natural sugar content than all other vegetables with the exception of beets.



Importance of Plants

Minnesota K-12 Academic Standards

Science	7.4.3.2	Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.
Social Studies	5.3.1.3	Places have physical characteristics (such as climate, topography and vegetation) and human characteristics (such as culture, population, political and economic systems).
Social Studies	7.3.1.1 8.3.1.1	People use geographic representations and geospatial technologies to acquire, process and report information within a spatial context.

Summary/Overview

Students learn about the importance of plants and create a mind map to display the ways in which plants influence their lives. Next they use a thematic map to help understand why crops grow in specific areas of the state.

Garden Connection

Students explore some factors that influence plant growth.

Background Information

Plants impact our daily lives. Students may not realize how many products they use contain plants. This lesson opens their eyes to the importance of plants. In order to effectively grow the plants we use so often, it is helpful to know what influences plant growth. Landforms, annual precipitation, annual frost-free days, and native vegetation all play a role in where farmers and gardeners choose to grow certain crops in Minnesota. Students review maps of these factors and compare them to maps showing growing areas of four major crops.



Objectives

- List five ways humans use plants.
- Explain factors that influence crop production.
- Identify important crops grown in Minnesota.
- Analyze why crops are grown in specific areas of Minnesota.

Procedure

Interest Approach

As students enter the room, have them write one way they have used plants during the day on the board. After everyone has shared, review the answers as a class. Ask how the answers might be categorized. As a class, develop categories. Examples: food, fiber, building materials, oxygen, medicine, beauty, and economic value. Help students think of any areas that might be missing.

Summary of Content and Teaching Strategies

Plant Uses

On notebook paper, instruct students to create the outline of a mind map for the importance of plants. See Teacher Material A for a sample outline. Use categories developed by the class or example categories.



Divide the class into groups assigning each group a plant use category. Each group makes a poster with a list of plants and plant materials that belong in their category. Next groups should add pictures or magazine clippings illustrating items found in their category. Students may need to research their topic using a computer. Have each group share their findings with the class. Students note the findings on their mind maps.

Sources/Credits

This lesson was developed for the Minnesota Garden Guide.

Factors Influencing Growth

Understanding factors that influence plant growth is critical for a successful harvest. Ask students to brainstorm a list of things they think affect plant growth. Be sure they include landforms, annual precipitation, annual frost-free days, and native vegetation on their lists. Discuss how different plants require different kinds of growing conditions to thrive.

Utilize Minnesota Agriculture in the Classroom's (MAITC) Food for Thought maps and curriculum to investigate Minnesota's plant growth factors.

Plants in Minnesota

Next ask students to name and list important agricultural crops grown in Minnesota. For each crop, ask students to develop a hypothesis as to why these crops grow in each particular area of Minnesota.

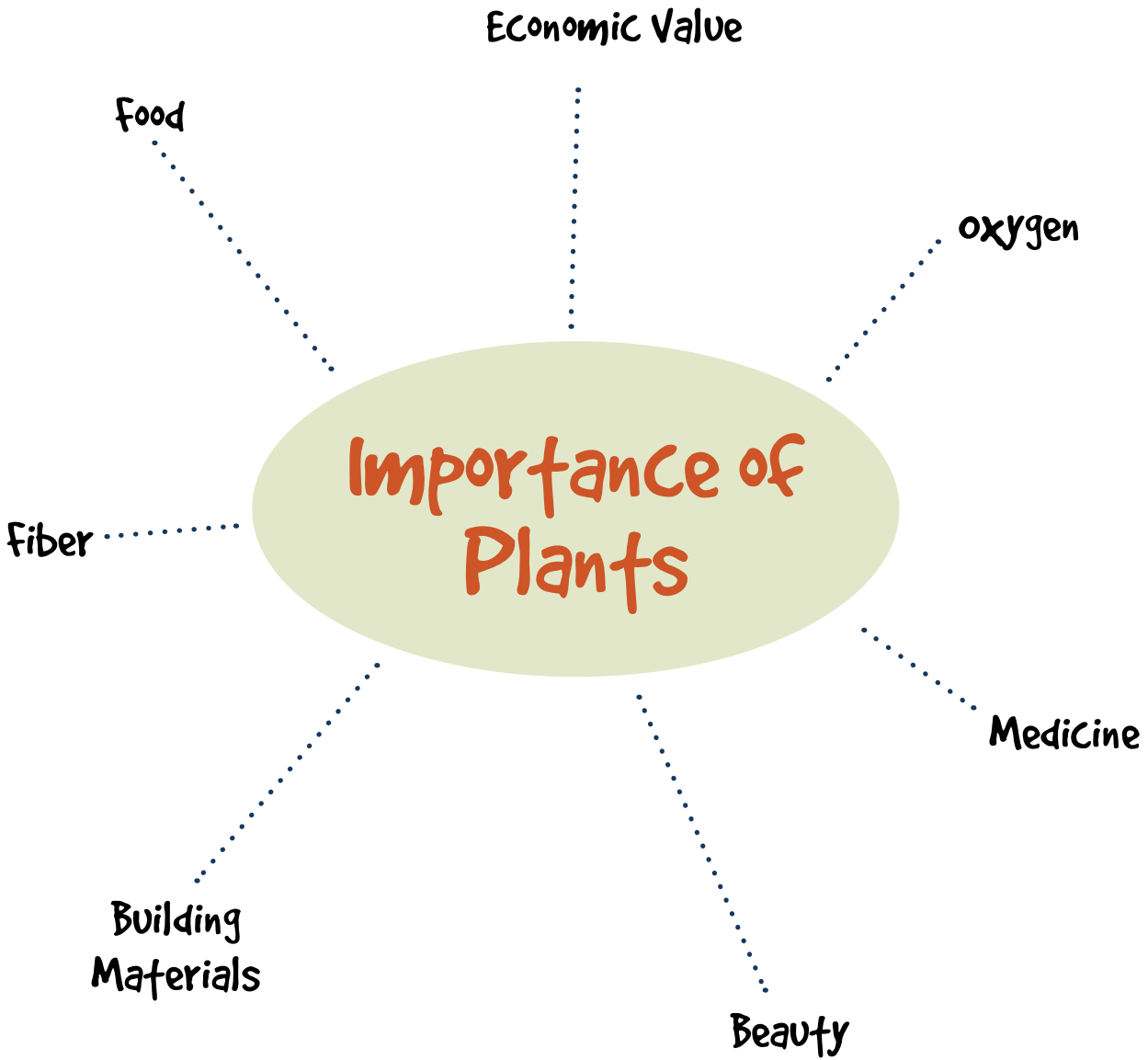
Again consult MAITC's Food for Thought maps and curriculum to discover Minnesota plant growth locations and conditions.

Review/Summary

Ask students to name three uses of plants they learned about during the lesson. Discuss the hypotheses they developed while looking at the maps of Minnesota.

Modifications/Extensions

Utilize lessons from the Food for Thought Mapping Curriculum *Connecting Minnesota Geography, Agriculture and Communities* available from Minnesota Agriculture in the Classroom. www.mda.state.mn.us/kids/food4thought.aspx



Name _____



Importance of Plants

1. List five ways humans use plants.

2. Name two factors that influence crop production.

3. Identify two important crops grown in Minnesota.

4. Explain why some crops are grown in northern Minnesota and others are grown in southern Minnesota.

Grade

High School

Materials/Preparation

- Teacher Material A – Plants in Our World – one per teacher
- Handout A – Surrounded by Plants – one per student
- Assessment A – Surrounded by Plants – one per student
- Computers with Internet access and ability to print
- Colored pencils
- Notebooks
- Map of U.S. from the 50states.com website
- USDA Agricultural Census Data from USDA website <http://www.agcensus.usda.gov>

Fun Fact

It takes about 36 apples to create one gallon of apple cider.



Surrounded By Plants

Minnesota K-12 Academic Standards

Science	9.4.2.1	The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.
Science	9.4.4.1	Human activity has consequences on living organisms and ecosystems.
Social Studies	9.3.1.1	People use geographic representations and geospatial technologies to acquire, process and report information within a spatial context.

Summary/Overview

In an effort to connect students with the key idea of plant importance for human life, Surrounded by Plants begins by asking students to survey their home and neighborhood for plant products they encounter in daily life.

Garden Connection

Plants harvest energy from the sun and provide us with many usable products.

Background Information

Plants are vital to all life on Earth. They mean survival. Plants are the base of food for all humans and animals.

They can harvest energy from the sun and exchange gas. (Plants use carbon dioxide from the air and convert it into oxygen.) Plants use the energy from sunlight to convert raw materials from the Earth into carbohydrates, fats, and oils. Humans depend on plant materials for food, feed for livestock, fiber, fuel, medicine, aesthetic value, and much more.



Plants are affected by environmental factors, including frost-free periods or growing season, mean average temperature or growing degree days, and rainfall. These factors create unique growing conditions across the United States and throughout the world.

Objectives

- Identify why plants are critical for all life on Earth.
- List plant products found in your everyday world.
- Explain why certain plants are grown in certain regions of the United States.
- Compare and contrast the growing conditions in Minnesota to other areas of the country.

Procedure

Interest Approach

Ask student to think about the many times a day they touch or eat things that come from plant materials. Our world consists of an unimaginable number of products originating with plants. Students are likely touching several as they sit in a chair and take notes in their notebooks. Plants are a major part of daily life in several forms. As a class, make a list of plant products found in the classroom.

Summary of Content and Teaching Strategies

Present and discuss Teacher Material A. Have students brainstorm examples for each of the ways humans use plant material.

Distribute a copy of Handout A to each student. Review the handout and answer any questions. Have students complete the triangle in Figure 1. Part 2 of the activity is for students to research the common growing regions for one crop from each category in Figure 1. The directions instruct students to print off a United States map from the 50states.com website at <http://www.50states.com/maps/print/usamap.htm>. Using this map, students shade growth regions using colored pencils for one crop from each use category. Use a different color for each crop and label the colors in a map legend. Students must incorporate the TODALS (title, orientation, date, author, legend and scale) map basics into the map they create.

For forestry products, the USDA Forest Service database is provided: http://www.srs.fs.usda.gov/pubs/misc/misc_reston.pdf.

Students will need to research medicinal crops separately. The following are common medicinal crops to consider providing to students who need assistance in this category:

- aloe
- Echinacea
- Saint John's Wort
- aspirin
- ginkgo
- castor bean
- hemp

Sources/Credits

Adapted from: *Curriculum for Agricultural Science Education (2012) Principles of Agricultural Science – Plant*. [Curriculum materials for secondary agricultural education instruction.] Lexington, KY.

Parker, R. (2010). *Plant and soil science: Fundamentals and applications*. Clifton Park, NY: Delmar. An *Introduction to Plant Science* is found on pages 174-184 and additional information on climate data is found on pages 247-257.

Once Part 2 is completed, students access hardiness zone and precipitation websites to determine the climate correlations to the production regions shaded on their maps. This activity provides an understanding of why certain crops are grown in certain regions due to their dependence upon climate conditions. Find information on hardiness zones in the Teacher Information for Chapter 2 on page 53.

Review/Summary

Have students share their completed maps with the class and explain two things they learned during the activity.

Modifications/Extensions

Get a large wall chart of the United States and have each student add different crops to it in order to summarize crop-growing regions of the United States. Next have students research the social, economic, and ecological risks and benefits of changing a natural ecosystem as a result of human activity. Ask them how these changes might influence crop-growing regions in the future.

Students have researched environmental factors that affect where plants grow. Take this idea a step further and investigate how carrying capacity influences the population of particular plants. After further research, ask students to describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.



Plants in our world

Plants are vital to all life on Earth for two reasons:

1. **Harvesting the Sun:** Plants use the energy from sunlight to convert raw materials from the Earth into carbohydrates, fats, and oils.
2. **Gas Exchange:** Plants use carbon dioxide from the air and convert it into oxygen. The process of food production and gas conversion is called photosynthesis.

Human Value

What are some ways humans use plant material?

1. Food
2. Feed for livestock
3. Fiber
4. Fuel
5. Medicine
6. Aesthetic value

Crop Regions

Certain crops grow in specific regions of Minnesota and the United States. Influencing environmental factors include:

1. Frost free periods (growing season)
2. Mean average temperature (growing degree days)
3. Rainfall

Name _____



Surrounded by Plants

Part 1. Survey Personal Plant Exposure

Survey your home and neighborhood to determine the plant products you are exposed to every day. Complete the lists for the categories of plant products in Figure 1.

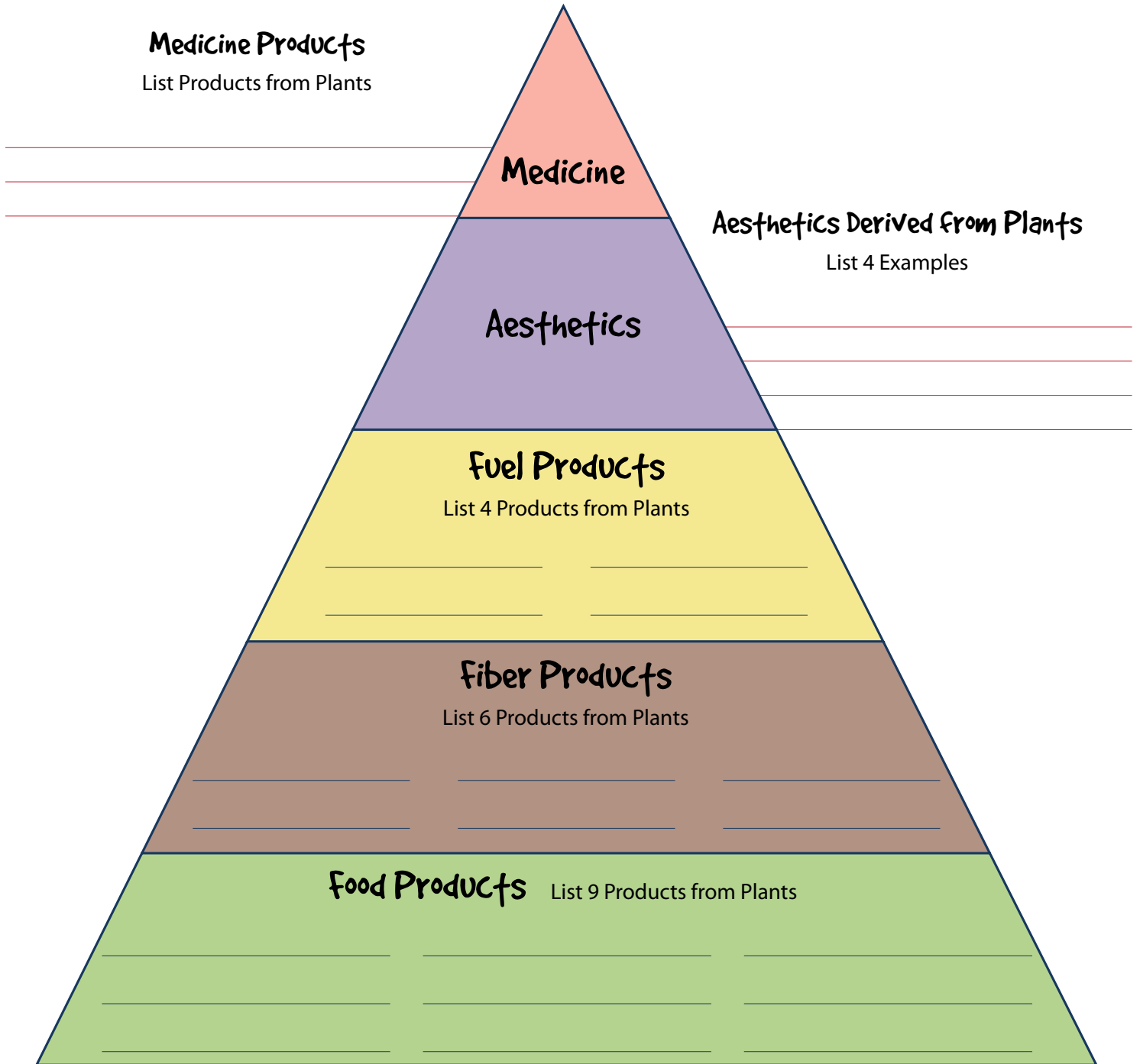


Figure 1. Crop Commodity Triangle

Part 2. Identify Crop Regions

1. Use the USDA Census website to locate the growing regions for ONE CROP from EACH CATEGORY listed in Figure 1.
2. Print off the map of the United States from the 50states.com website at <http://www.50states.com/maps/print/usamap.htm> and use it as the template.
3. Shade in the growing region of each crop using a specific color of pencil to indicate each crop. Include a key on the map to identify which color represents each crop.

For crop growing region, view the USDA 2007 Agriculture Census data:

http://www.nass.usda.gov/research/2007mapgallery/album/Crops_and_Plants/Field_Crops_Harvested/index.html

For information related to forestry products, use the following URL:

http://www.srs.fs.usda.gov/pubs/misc/misc_reston.pdf

Part 3. Identify Growing Conditions

Once your map of crop growing regions is complete, use the following websites to investigate what environmental influences, such as temperature and rainfall, affect plant production.

For plant hardiness zones, view the following website:

<http://www.usna.usda.gov/Hardzone/ushzmap.html>

For rainfall data related to crop regions, see the NRCS website:

<http://www.wcc.nrcs.usda.gov/climate/prism.html>

Conclusion

1. What environmental factors have the greatest effect on determining regions for crop production?

2. What are the predominant crops grown in Minnesota?

3. Explain how growing conditions in Minnesota compare to the southwestern part of the United States.

4. Why do you suspect a large number of cattle and hogs are raised in the Midwest United States?

5. List two plant products that you feel do not fit into any of the categories identified on the pyramid.

Name _____



Surrounded by Plants

1. Explain how plants “harvest” energy from the sun.

2. Name two ways humans use plants.

3. List two environmental factors influencing plants.

4. How do the growing conditions in Minnesota compare to those in other parts of the country?

Grade

High School

Materials/Preparation

- Handout A – Garden Goals – one per student
- Handout B – Action Plan – one per student
- Assessment A – Planning a Garden – one per student
- Writing utensils
- Computers (optional)
- Refer to Chapter One Teacher Information as needed on page 13.

Garden Goals

Minnesota K-12 Academic Standards

Language Arts	9.9.1.1b	Work with peers to set rules for collegial discussions and decision-making (e.g., informal consensus, taking votes on key issues, presentation of alternate views), clear goals and deadlines, and individual roles as needed.
Language Arts	11.9.1.1b	Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed.
Language Arts	9.9.4.4	While respecting intellectual property, present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task (e.g., persuasion, argumentation, debate).
Language Arts	11.9.4.4	While respecting intellectual property, present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks (e.g., persuasion, argumentation, debate).

Summary/Overview

Students take ownership in the school garden by creating goals and planning for success.



Garden Connection

A successful garden requires planning and goal setting.

Background Information

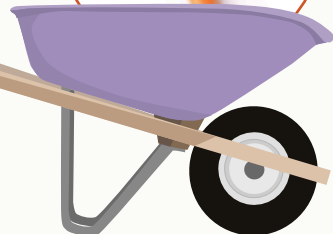
Whether it is a trip, a birthday party, or a garden, the planning stage takes time, can be a lot of fun, and is a necessary step in ensuring success. Dreaming of the many possibilities and selecting favorites can be very exciting. As you plan your school garden, be sure to include the students in as much of the process as possible. The more the students are involved in decisions, the more they feel ownership in the project.

Objectives

- List three goals your school has for the garden.
- Create a garden design.
- Explain why the class selected a specific garden design.
- Make a list of activities and projects related to the garden.

Fun Fact

The World's Longest Carrot, recorded in 2007, was 19 feet 1 7/8 inches (5.839 meters) long.



Procedure

Interest Approach

Discuss different types of school gardens. Review the examples of school gardens in Minnesota listed after the Introduction in this guide (pages 6-9). Encourage students to note the differences in size and scope. Start a discussion about what kinds of gardens might work at your school.

Summary of Content and Teaching Strategies

Provide students with a copy of Handout A. Students complete the worksheet as you discuss each area.

Goals

Discuss each of the four key areas and why they are important parts of a school garden: outdoor classroom, student involvement, healthy eating, and community connections. Ask students to write down a goal for each of the four key areas as described in the Chapter One Teacher Information on page 13. When finished, they share their goals with a partner. Next ask pairs to list their goals on the board. As a class, come to a consensus on which goals to adopt.

Design

With the adopted goals in mind, what is the best design for your school garden? Have students brainstorm a list of possible garden designs. Gardens range from growing a few plants indoors near a window to a large in-ground vegetable garden. Help students select a garden design with a size and scope appropriate to your school. If this is the first year your school has had a garden, start small. Your garden can expand over the next several years.

Activities/Projects

Create a list of activities to do in the garden and projects related to the growing of plants. Brainstorm what skills and information students will learn from growing their plants. Examples of activities to be done in the garden include planting, weeding, watering, and harvesting. A project related to growing plants is to research recipes using herbs grown in a classroom window. Or, if you will be growing vegetables in a

large quantity to sell, have students research different methods of selling produce including Community Supported Agriculture (CSA) or farmers' markets.

As a class, develop an action plan to accomplish the goals of the garden. What steps need to be completed in order to get your plants started, maintain plants over the growing period, and harvest the crop? Include timelines and assign a lead person for each task.



If your schedule allows, evaluate the garden at the end of the project. Discuss what students learned from the experience, what went well and what could be improved.

Review/Summary

Discuss the following questions as a class or ask students to journal their responses.

1. Why is it important to create a plan for the garden?
2. What part of the garden are you most excited about?

Modifications/Extensions

Provide students with graph paper to map out the school garden to scale. Be sure they take into account spacing between plants and rows and allow for walkways. Maps should include a legend as well as indicate the scale used.

Sources/Credits

This lesson was developed for the Minnesota Garden Guide.

Name _____



Garden Goals

Brainstorm

Adopted By Class

Garden goals	<p>outdoor classroom</p> <p>student involvement</p> <p>healthy eating</p> <p>community connections</p>	<p>outdoor classroom</p> <p>student involvement</p> <p>healthy eating</p> <p>community connections</p>
Garden design		

Brainstorm

Adopted By Class

Garden activities/projects		
Plants to grow in the garden		

Name _____



Action Plan

Task	Timeline	Lead Person	others Helping

Name _____



Garden Goals

Create a brochure or PowerPoint presentation highlighting the different aspects of the school garden to be shared with administration, teachers, school board members, parents, and community groups. Be sure to include all items listed in the grading rubric.

	Points Possible	Grade
Content		
Goals	10	
Design	10	
Activities/Projects	10	
Appearance		
Pictures	5	
Creative	5	
Well organized	5	
Use of class time	5	
Total	50	

Include a scanned copy of the garden design.

Selection of Crops and Garden Themes

Chapter 2

Teacher Information

Crop Selection in Minnesota

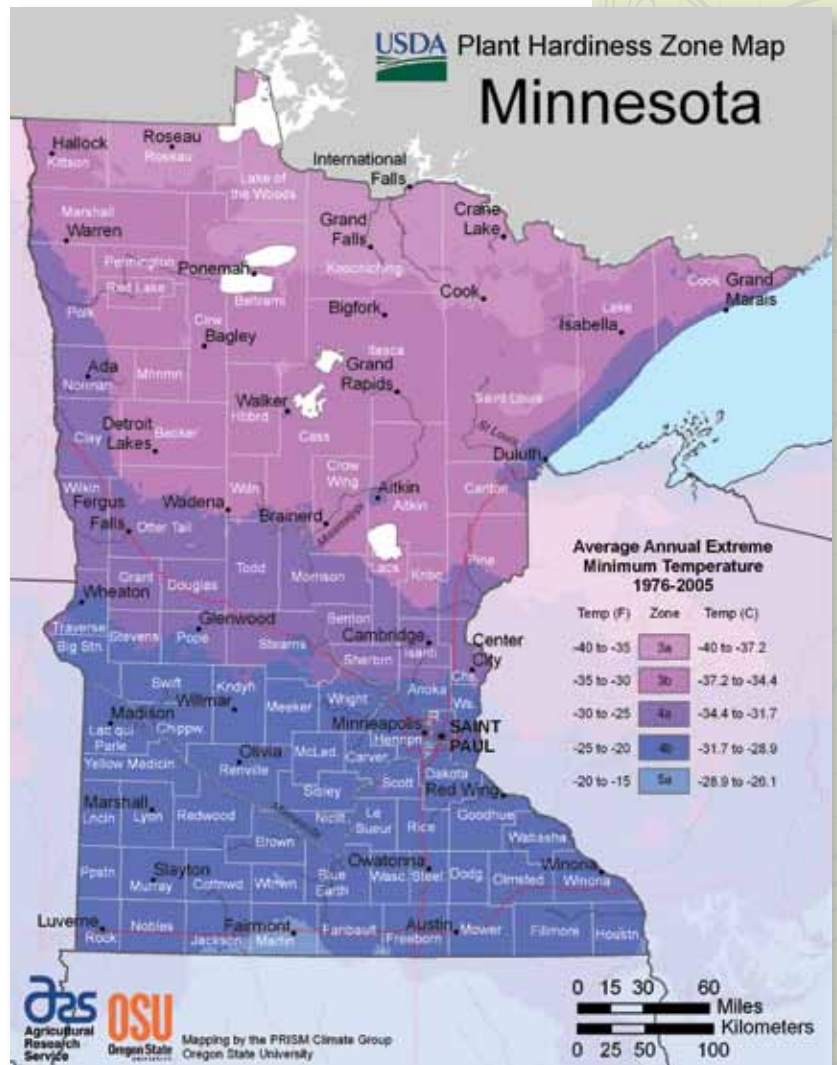
When choosing crops, there are several items to consider. Be sure to check the mature height of plants as well as the distance between plants and rows. If plants are too crowded they may not grow to maturity and produce quality fruit or vegetables. Next, determine if the plant is a warm or cool season crop. It is also important to note how and when to start plants. Some need to be started indoors and later transplanted while others can be seeded directly into the garden. Harvest dates are also vital to note, as you need to be prepared to remove produce from the garden. Finally, be sure to find out if the crop can grow in Minnesota climate. For some crops, Minnesota summers are not long enough to allow them to reach maturity.

Cool-Season and Warm-Season Crops

Cool-season crops are able to tolerate colder temperatures and can be planted earlier than warm-season crops. Examples of cool-season vegetables are lettuce, cabbage, cauliflower, broccoli, Brussels sprouts, and onions. Warm-season crops, including tomatoes, eggplant, and peppers, should not be planted outside until after frost danger in mid-to-late May. Some plants can be started indoors or in a greenhouse and later transplanted outdoors.

Starting Plants

Plants can be grown in two ways: direct seeding and transplanting. Direct seeding is when seeds are planted in their final destinations. This method works well for faster-growing flowers and vegetables. Slower-growing flowers and vegetables do better when they are started indoors and later transplanted or moved to their final destinations. Many gardens use both methods of planting. Read seed packets and refer to the chart on pages 54-56 to determine the best method for the plants you have selected.



USDA Plant Hardiness Zone Map - Minnesota

Source <http://planthardiness.ars.usda.gov/PHZMWeb/#>

The United States Department of Agriculture (USDA) has developed a map to assist gardeners when selecting plants. The map reflects the average extreme minimum temperature by zone using data from 1976-2012. Gardeners use zone information to select plants that thrive in their climate. This is especially important for perennial plants that over-winter.

Planting Dates and Distances for Garden Vegetables

Vegetable	Planting Dates		Planting Distances (in inches)		Depth of seeding (inches)	Amount to order per 20 feet of row
	Start seed indoors	Plant seed or plant outdoors	Between rows, hand cultivated	Between plants		
Asparagus		April 15 - May 1 (crowns)	36	12 - 18	6 - 8	15 crowns
Beans, snap (bush)		May 15 - July 1	18 - 24	3 - 4	1½ - 2	3 - 4 oz.
Beans, snap (pole)		May 15 - July 1	36	4 - 6	1½ - 2	2 - 3 oz.
Beans, dry shell		May 15	18 - 24	3 - 4	1½	3 - 4 oz.
Beans, lima		May 15 - June 10	18 - 24	4 - 6	1½	3 - 4 oz.
Beets		April 15 - July 1	12 - 18	2 - 4	½ - 1	1 packet
Broccoli	March 1 - 15	April 15 or June 1	24 - 30	24	¼ (indoors)	1 packet or 9 plants
Brussels sprouts	March 1 - 15	April 15 or June 1	24 - 30	24	¼ (indoors)	1 packet or 9 plants
Cabbage, early	March 1 - 15	April 1 - May 1	24 - 30	18	¼ (indoors)	1 packet or 12 plants
Cabbage, late	April 15 - May 1	June 1	24 - 30	24	¼ (seedbed)	1 packet or 9 plants
Cabbage, Chinese		July 1	24 - 30	18	½	1 packet
Carrots		April 15 - June 15	18 - 24	2 - 3	¼	1 packet
Cauliflower	March 1 - 15	April 15 or June 1	24 - 30	18 - 24	¼ (indoors)	1 packet or 12 plants
Celery	Feb. 15 - March 1	May 15	18 - 24	8	1/8 (indoors)	1 packet or 24 plants
Chard, Swiss		May 1	18 - 24	6 - 8	1	1 packet
Collards		April 15	24 - 36	6	¼	1 packet

"Packet" refers to average commercially-packaged seed packet.

Vegetable	Planting Dates		Planting Distances (in inches)		Depth of seeding (inches)	Amount to order per 20 feet of row
	Start seed indoors	Plant seed or plant outdoors	Between rows, hand cultivated	Between plants		
Cucumbers		May 1 - June 15	48 - 60	12 between single plants; 36 between hills of three	1	1 packet
Eggplant	March 15 - April 1	June 1	24 - 30	24	¼ (indoors)	1 packet or 9 plants
Endive		April 15	18 - 24	8 - 12	½	1 packet
Garlic		Oct. 1 - Nov. 1	18 - 24	4 - 6	3 - 4	1 lb. of cloves
Horseradish		April 15 - May 1	24 - 30	12 - 18	6 (roots)	18 roots
Kale		April 15 - July 15	18 - 24	12 - 18	½	1 packet
Kohlrabi		April 15 - June 1 or Aug. 1 - 15	18 - 24	6	½	1 packet
Lettuce, leaf		April 15 - June 1 or Aug. 1 - 15	12 - 18	4 - 6	¼	1 packet
Lettuce, head	March 1 - 15	April 15 - May 1	18 - 24	12	¼ (indoors)	1 packet or 18 plants
Muskmelon		May 15 - June 1	60 - 72	18	1	1 packet
Okra	March 15 - April 1	June 1	24 - 36	12 - 15	½ (indoors)	1 packet
Onion seeds		April 15	12 - 24	2	½	1 packet
Onion, transplants	Feb. 1 - 15	April 15	12 - 24	2 - 3	½ (indoors)	1 packet
Onion, sets		April 15	12 - 24	2 - 3	1 - 2	½ lb.
Parsley		April 15 - May 1	12 - 24	4 - 6	¼	1 packet
Parsnips		May 1 - 15	18 - 24	3 - 4	½	1 packet
Peas		April 10 - May 15	18 - 24	2	1½	1 packet
Pepper	March 15 - April 1	June 1	24 - 36	18 - 24	½ (indoors)	1 packet or 12 plants
Potatoes, Irish		April 15 - June 1	24 - 30	12 - 18	4 (each piece)	3 lbs. seed potatoes
Potatoes, sweet	April 15 (roots)	June 1	36 - 48	18 - 24		9 - 12 plants

"Packet" refers to average commercially-packaged seed packet.

Vegetable	Planting Dates		Planting Distances (in inches)		Depth of seeding (inches)	Amount to order per 20 feet of row
	Start seed indoors	Plant seed or plant outdoors	Between rows, hand cultivated	Between plants		
Pumpkin		May 10 - June 1	72 - 96	24 - 36 between single plants; 60 - 72 between hills of three	1 - 2	1 packet
Radish		April 10 - June 1 or Aug. 1 - 15	6 - 12	1 - 2	½	1 packet
Rhubarb		April 15 - May 1	36 - 48	36 - 48		5 or 6 plants
Rutabaga		May 15 - June 15	18 - 24	8 - 12	½	1 packet
Spinach		April 15 or Aug. 1 - 15	12 - 18	3 - 4	½	1 packet
Squash, summer		May 10 - June 1	24 - 36	24 - 36	1	1 packet
Squash, winter		May 10 - June 1	72 - 96	24 - 36 between single plants; 60 - 72 between hills of three	1	1 packet
Sweet corn		May 10 - July 1	30	12	1 - 2	1 packet
Tomato	April 1 - 15	May 15 - June 1	24 - 36	36 - 48	¼ (indoors)	1 packet or 6 - 8 plants
Turnip		April 15 or Aug. 1	15 - 18	3 - 4	½	1 packet
Watermelon		May 15 - June 1	60 - 72	24 - 36 between single plants; 60 - 72 between hills of three	½	1 packet

"Packet" refers to average commercially-packaged seed packet.

Source: <http://www.extension.umn.edu/distribution/horticulture/dg1422.html>

Information on growing flowers in Minnesota can be found on the University of Minnesota Extension website at <http://www1.extension.umn.edu/garden/yard-garden/flowers/>.

Types of Gardens

Gardens come in many shapes and sizes. The goals of your garden and resources available help you determine what type of garden is best for your school.

Container Gardens

Smaller garden projects work well in containers. Criteria for an effective container include ability to hold soil, holes in the bottom for drainage, and enough room for root growth. Suggested containers include pots, plastic totes, bushel baskets, and wooden barrels. If you are planting edible crops, be sure toxic materials have not contaminated the container. Larger containers need less frequent watering and fertilizing. Select a good potting soil to fill containers. Garden soil is often too heavy and becomes compact when used in a container.



Raised Beds

In a raised bed garden, soil is raised above its surroundings. The bed is contained within a structure between six inches and waist high. Raised beds are most often constructed of wood but can be made of rock or concrete block. Raised beds for children are typically no more than three feet wide, allowing students to reach the middle. Advantages of raised beds include clearly defined garden space, loose soil that is better for root growth, ability to warm quickly in spring, and well-drained soil. In addition, plants are less likely to be stepped on by students. Raised beds are also more handicap accessible.



In-Ground Beds

Before preparing a site for an in-ground bed, dig several samples of soil and have it tested. Testing is available from the University of Minnesota's Soil Testing Laboratory, visit their website for more information <http://soiltest.cfans.umn.edu/>. If soil tests are acceptable, the next step is tilling. Tilling introduces air into the soil, making it easier to plant and easier for plants to grow. Soil that is too wet or too dry should not be tilled. To determine if soil has the proper amount of moisture, form a handful of soil into a ball. If the moisture is correct, the ball will hold its shape but easily fall apart when touched. Compost and fertilizer may be added to soil during the tilling process. Newly started gardens need more than one tilling before planting. In-ground beds require the removal of grass.

Hydroponics

Hydroponics is a method of growing plants with nutrient-rich water instead of soil. A growing medium such as rock wool or clay pellets is used to anchor the roots. Systems can be set up in a classroom with grow lights, allowing students to have a gardening experience in the winter. Other advantages of hydroponics include a controlled pest environment, easier harvest, and ability to recycle water. Schools interested in using a hydroponic system are advised to find a hydroponic grower in the area who can provide assistance and troubleshooting.

Greenhouses

Many schools build greenhouses to grow plants indoors. Greenhouses allow for large amounts of light to reach plants, yet keep them warm on cold days. Plants can be transplanted outdoors after the threat of frost. Some Minnesota greenhouses are used to grow plants year round. Two examples of crops grown this way are tomatoes and green beans. Cold frames are a much smaller version of greenhouses that do not require a heat source. Cold frames are often used to “harden-off” plants and prepare them for the outside temperatures.



Themed Gardens

Themed gardens can be a springboard for science investigations and studies in other areas.

Organic

Growing plants organically is a science and art that emphasizes biological and ecological principles. The word “organic” is a marketing claim that is regulated by USDA standards. Organic crops must be grown on land that is managed to reduce erosion and improve soil quality. Weeds, insects, and other pests are controlled using practices like crop rotation, mulching, tillage, variety selection, and biological control. Most synthetic herbicides and pesticides are prohibited, although a very few synthetic products appear on a special National List and are allowed. There are strict manure and compost guidelines. Sewage sludge is prohibited, and organic farmers may not use genetically modified or fungicide-treated seed.

School gardens that want to sell organic produce can explore the possibility of becoming certified to do so (see *Minnesota Guide to Organic Certification*, www.extension.umn.edu/distribution/cropsystems/DC8497.html). Those who don't intend to sell produce labeled “organic” may simply want to incorporate some organic and sustainable methods and practices in their gardens. To learn more about growing organically, visit, <https://attra.ncat.org/organic.html>.

Salad Garden

Salad vegetables are popular in most school gardens. Plant salad vegetables and edible flowers at staggered intervals and culminate the unit in a salad feast. Encourage students to use “days to maturity” information on seed packets to



calculate when to plant different ingredients. As the salad garden grows, explore such areas as germination and growth needs, life cycles, and histories of plants. Plants to include: tomatoes, lettuce, beans, radishes, peppers, nasturtiums, carrots, beet greens, sprouts, and cucumbers. Plan 12 weeks to complete harvest if using long-season crops such as tomatoes or peppers. An example of a 12-week salad garden unit can be found in the National Gardening Association's Grow Lab Activities for Growing Minds. The book can be purchased from www.gardeningwithkids.org.

Color Garden

Particularly appealing to the primary grades, a colorful garden integrates well with art projects, language arts exercises, flower adaptations, and wildflowers. Crops can include marigolds, zinnias, coleus, petunias, lettuces, impatiens, and nasturtiums.

Herb Garden

A garden of annual and perennial herbs can be a delightful sensory addition to your classroom. In addition to studying basic plant needs, growth, or adaptations consider integrating activities on cultural differences in herb use, culinary and medicinal uses for herbs, sensory communications, sorting and classifying smells and flavors, and explorations of leaf adaptations. Possible plants to include: basil, dill, parsley, thyme, oregano, and chives.

Ethnic and Cultural Foods

Tie your garden into a social studies unit about a different geographic region by planting some indigenous crops. Two such gardens that have been created in classrooms are crops of the South (peanuts, cotton, collards) and Japanese gardens (including Japanese greens).

"Garbage" Garden

This project allows students to explore how otherwise discarded plant parts can be propagated to produce new plants. Include potato pieces, avocado pits, carrot and beet tops, ginger root, orange seeds, kiwi seeds, and other leftovers from students' home kitchen sinks or the school lunchroom.

Houseplant Cuttings

Learning about asexual propagation of different types of houseplants might culminate in gifts to take home or a student-organized plant sale. Since most houseplants come



from tropical habitats, this might be tied into studies of adaptations to specific habitats. In four-plus weeks, you can get good results with ivy, spider plants, wandering Jews, aloe, snake plants, impatiens, and jade plants. One class grew cuttings to sell, calculated the financial projections, designed and produced fliers, enlisted community volunteers, and used the money raised to finance a class trip.



Wildflowers and Native Plants

Growing native wildflowers from seed can lead to explorations of basic plant needs, reproduction, and adaptations. It can be a springboard for students to consider our actions' effects on the diversity of species and the implications of endangered and extinct species. An exciting and meaningful class project can be to raise regionally appropriate wildflowers from seeds or plants and replant them in appropriate habitats in the community. Black-eyed Susans (*Rudbeckia hirta*) can grow outside in most parts of the country. Contact your local Cooperative Extension office for other ideas.

MyPlate

Create a round garden divided into four sections, fruits, vegetables, grains, and protein. Plant crops that correspond with each food group in their designated section. For example grow watermelons or cantaloupe for fruits, lettuce or carrots for vegetables, oats or popcorn for grains, and sunflowers or black-eyed peas for protein. For more information about MyPlate, visit the website <http://www.choosemyplate.gov/>.

More Themed Project Ideas

- Garden of weeds
- Wild-to-cultivated comparison garden
- Pizza topping garden
- Children's literature garden
- Bulb garden
- Historical garden
- Three Sisters garden
- Alphabet garden
- Salsa garden
- Soup garden
- Heirloom garden
- Colonial garden



Themed Gardens

Adapted from the National Gardening Association's Grow Lab: Activities for Growing Minds.

Additional Lesson Resources

Lesson: Enough is Enough and Puzzled by Photosynthesis

Grades: 3-8

Source: National Gardening Association

Curriculum: *Grow Lab: Activities for Growing Minds*

Location: Can be purchased from www.gardeningwithkids.org

Lesson: Simplified Floating Hydroponics

Grades: Grades 4-5

Source: New York Agriculture in the Classroom

Curriculum: *Science of Life Explorations through Agriculture (SOLE)*

Location: www.agclassroom.org/ny/resources/pdf/activities/hydro.pdf

Lesson: We're the Producers

Grades: 3-8

Source: Florida Agriculture in the Classroom

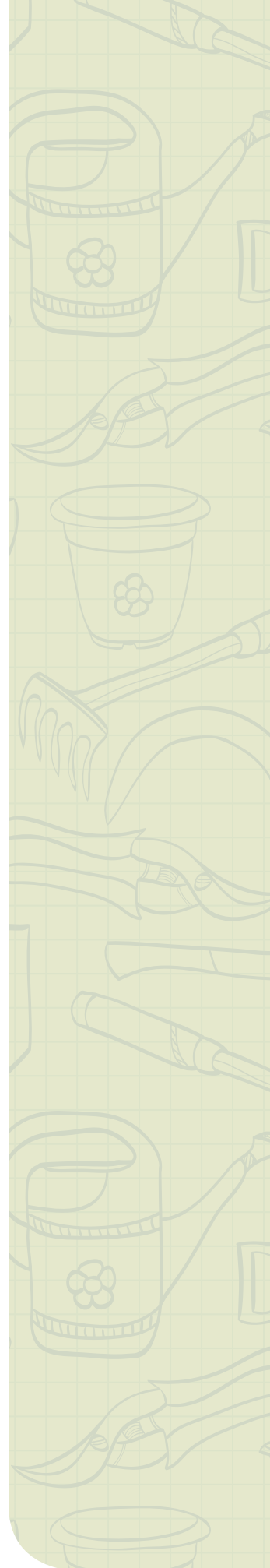
Curriculum: *Gardening for Grades*

Location: www.flagintheclassroom.com/gardening

Sources/Credits

Themed Gardens, Organic

Information obtained from Meg Moynihan, Minnesota Department of Agriculture.



Grade

Elementary 3-5

Materials/Preparation

- Teacher Material A – Plant Hardiness Zones – one per teacher
- Handout A – How Do I Know if the Plant is Right for the Spot? – one per student
- Assessment A – Right Plants, Right Place – one per student
- Writing instruments
- Colored pencils or markers (optional, for mapping)
- Map of the school grounds – one per student

Fun Fact

Lettuce varieties can be put into four main groups: romaine, butterhead, crisphead, and looseleaf. Each group has its own growth and taste characteristics.



Right Plants, Right Place

Minnesota K-12 Academic Standards

Science	3.4.1.1 5.4.1.1	Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.
Science	5.4.2.1	Natural systems have many parts that interact to maintain the living system.
Social Studies	3.3.1.1 4.3.1.1 5.3.1.1	People use geographic representations and geospatial technologies to acquire, process and report information within a spatial context.

Summary/Overview

In this lesson, students learn that plants - vegetables, flowers, shrubs, and trees - should be planted with care and thought to their needs. They are introduced to annuals and perennials and the influence of climate. Students consider how variables such as shade, sun, dry or wet soil, and plant size at maturity must be considered before a gardener or farmer plants a seed or seedling.

Garden Connection

Plants need sun and water in varying amounts. The location in which a plant is placed is critical for its healthy growth.

Background Information

Where and When

Students who have not been exposed to gardening or raising plants may not know that thought needs to go into where plants are planted and grown. Plants can be ornamental and used to enhance the landscape around us, or grown for food. Even though most vegetables are raised as seasonal crops (annuals), thought must be put into where and when they are planted. Most vegetables need abundant sun, consistent soil moisture, and enough days to reach maturity before the end of the season.

Human Needs

It is important to know what we want from the plant. In a vegetable garden, we want to know what food products or crops we will be able to harvest at the end of the season. With flowering plants, do we want color throughout the season? Do we want plants that provide shade or privacy? Or that attract birds and provide fragrance?

Plant Needs

When a plant is not right for the site, it will not thrive and may be more susceptible to disease or insect attack. To prevent problems, planning must go into the selection of the plant and its needs. Some plants can tolerate both sun and shade, and will not do as well if planted in the wrong place. This lesson reinforces three important needs of plants - sun, water, and soil - and other factors: climate, growing season, and size of plant at

maturity. The amount of sun needed varies according to the plant, as will the amount of water, the soil type, and pH. However, most plants need consistent moisture and good drainage. They also need soil that is not compacted so the roots can access oxygen and water and have room to spread. Climate affects plants because it includes water, temperature, wind, and sun, and it affects the growing season, or the amount of time available for a plant to grow, develop, and mature. In a region with a very short growing season, plants that need a long time to mature may not do as well. A plant's size at maturity can be affected by its ability to get what it needs. If it doesn't get the proper nutrients, it may not reach full size. Also, if it is a large plant, it may prevent other plants around it from meeting their own needs.

Vegetables

Vegetables may be started as small transplants or seeded right out of the packet. Enough room must be given to allow for their size at maturity. As plants grow taller they cast shadows and can reduce sunlight for neighboring plants. Many plants need the entire growing season to mature.

Flowering Plants

Flowers are classified by the time it takes to complete its life cycle starting from a seed, grow into a plant, produce a new seed, and die. Annual flowers complete their life cycle in one growing season while perennial flowers grow for two or more years. Annual flowers may not be 'annual' in more temperate parts of the world. Students will be introduced to the 'hardiness zones' map and the effects of climate on how plants succeed. This map is found online and in many seed catalogs. Perennials are most successful when planted in an area similar to that from which they originated. Many books and online sources offer this information on plants, shrubs, and trees.

Houseplants

This lesson focuses on outdoor plants, especially vegetables and flowers, but these ideas also apply to a houseplant or one that sits on the windowsill of the classroom. Many houseplants are tropical plants that would never survive outdoors in Minnesota's climate. If we are away from them for a week or two, can they tolerate not being watered? Do they thrive in partial sun situations, or do they grow long and leggy and become yellow?

Green Thumb

The notion of having a green thumb is often simply the art of choosing the right plant for the conditions and maintaining the plant according to its needs. Behind every green-thumbed gardener and farmer is an interest in plants and the willingness to learn about and provide for their needs.

Objectives

- List the factors that are important to consider when selecting a plant for a specific location.
- Explain the difference between an annual and perennial.
- Describe how the plant hardiness zone map can be helpful to growers.



Procedure

Interest Approach

Selecting the right plant is a challenge. Students will learn a great deal from their surroundings by identifying plants growing in different conditions on the school grounds. Conditions can include the amount of sunlight (full sun, partial shade, or full shade), soil characteristics, moisture and drainage levels, and types of nearby plants.

Take students on a tour of the school grounds to assess the environment. Give each student a map of the school grounds on which to note their observations. Items to evaluate and activities to complete include:

Students should determine how much moisture and sunlight the planned planting area gets.

Consider drainage. Does the area hold moisture? Soil moisture is difficult to determine. To assist in student observation, follow the directions provided by the University of California, Davis titled *How to Measure Soil Infiltration Rate* found at http://afghanag.ucdavis.edu/natural-resource-management/soil-topics/soil-fact-sheets/FS_Soil_Infiltration.pdf.

To determine soil type, check clumps of soil. Try to decide whether it is clay-like (sticky, smooth), sandy (gritty and rough), or a combination. Make a note of the soil type you find in each location.

Students may want to draw on their maps, highlighting sunny areas in yellow, wet areas in blue, etc.

Take a walk around the school, writing down the types of plants found. Write down the names of plants if they are known. Be sure to note conditions such as moist shade, dry shade, moist sun, dry sun, and wet conditions. Create a table to keep track of findings. When done, find the total number of plants in each category.

1. Where were the most plants found? Why do you think so?
2. Where were the fewest plants found? Why do you think so?
3. Were the plants different sizes in the sun vs. in the shade? If so, why do you think that is?
4. Were the plants different sizes in places with different amounts of water? If so, why do you think that is?

Summary of Content and Teaching Strategies

Choosing the right plants for your garden is very important. This can mean choosing vegetable plants that won't get too big in a small garden, or not placing a shade-loving plant in a sunny part of your yard. Ask students if they think it is important to know how big a tree will get before you plant it and why. Next discuss whether every plant will grow in any place. Different plants need different things in order to grow well. The perfect growing location for one plant is not the perfect growing location for the next.



Have students brainstorm plant needs to consider when choosing plants for a vegetable or flower garden. Develop a list as a class. Be sure to include sun, water, soil, climate, growing season, the plant's size when it is mature, and the purpose of the plant (food, shade, beauty).

Successful farmers or gardeners must be able to answer these questions:

1. What is the right plant?
2. How do I know if the plant is right for the spot?
3. Why does it matter?

What is the right plant? Think about plants in two ways:

Plants we grow for enjoyment, usually because we like the way they look or smell, are ornamental plants. They include flowers, shrubs, and trees that may or may not grow edible fruit.

Some ornamental plants have different life cycles. Plants that only live one growing season in our climate are called annuals. Plants that grow and get bigger for more than two years are called perennials. We use both annual and perennial flowers and vegetables in the yard and garden.

Some annual flowers planted in Minnesota might live for many years if they are planted in the southern United States. This has to do with climate. With a partner, have students discuss the meaning of climate. Show Teacher Material A and discuss plant hardiness zones. The map shows the average coldest temperatures for the United States. Growers use the map to determine which plants will be most successful in their area.

Plants we grow for food are vegetables and fruits. Most vegetable crops are annuals, but some are perennials. Most fruits are perennials.

Annuals are plants that only grow for one growing season in our area. Perennials are plants that can live and grow for more than one year.

Ask students to think of an example of one annual and one perennial plant. It can be a fruit, a vegetable, a flower, or a tree. Examples of annual vegetables include peas, beans, and tomatoes. Examples of perennial vegetables include asparagus, artichokes, and rhubarb.

Provide students with the two-page Handout A. Working in groups, they determine the placement of Mrs. MacGregor's plants. The activity can be extended by asking students to list the number and color of plants by the season they will bloom. How many spring flowers will Mrs. MacGregor have? How many in summer? Most of Mrs. MacGregor's plants are perennials. Remind students that plants may get wider each year, but not necessarily taller. In a few years some will go from one small plant with one flower stem to a wider plant with many flower stems. Plant #4 (Morning Glory) is an annual. It is not expected to come back next year. However, it may have dropped seeds (reseeded) and may grow again in the same area. To ensure another morning glory plant, she needs to plant new seeds.

Review/Summary

Discuss why successful farmers or gardeners must be able to answer these questions:

1. What is the right plant?
2. How do I know if the plant is right for the spot?
3. Why does it matter?

Modifications/Extensions

Have students go to the garden location on school grounds and select three to five plants that would grow well in this location. Students prepare a poster or report explaining their reasoning.

Assign students to prepare a report in poster form related to climate and plants, using information from a variety of materials. Provide students with seed catalogs and computers with Internet access.

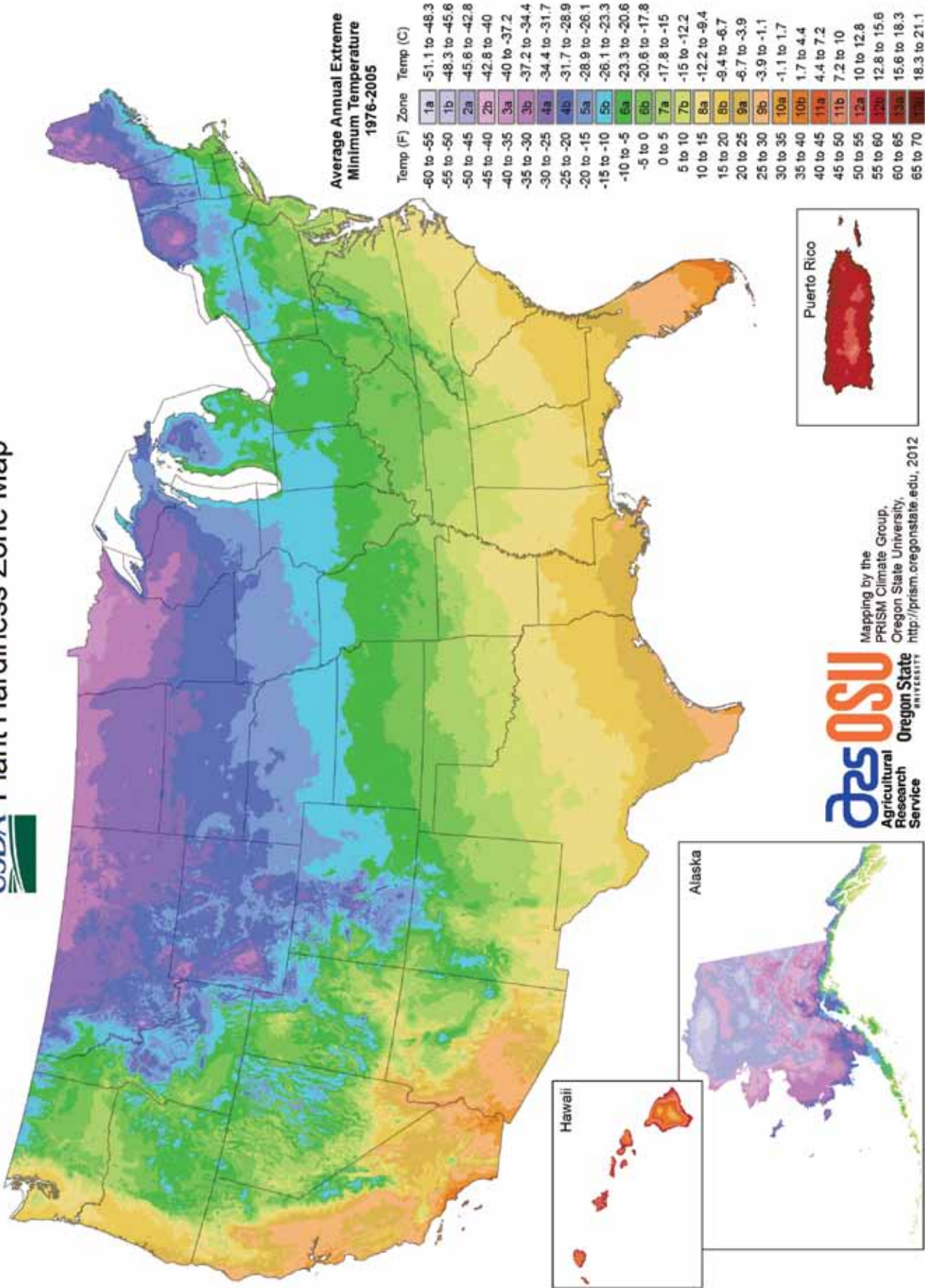
Have students label physical features on a map of Minnesota. Then have them identify the significance of geographic locations of cities in Minnesota. Consider location in relation to the climatic conditions, plant hardiness zone, topography, and other things that affect plant growth.



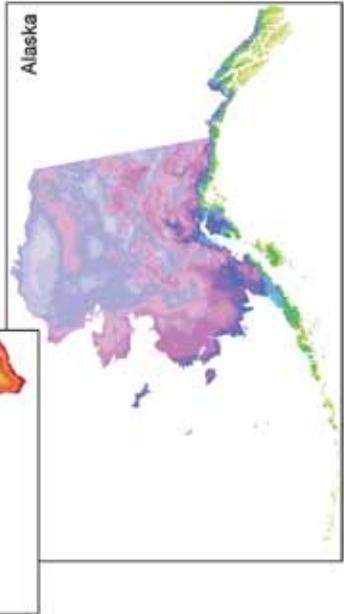
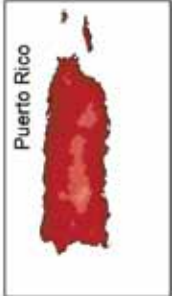
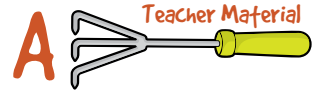
Sources/Credits

Adapted from New York Agriculture in the Classroom and Cornell University's Sciences of Life Explorations (SOLE).

USDA Plant Hardiness Zone Map



Plant Hardiness Zones



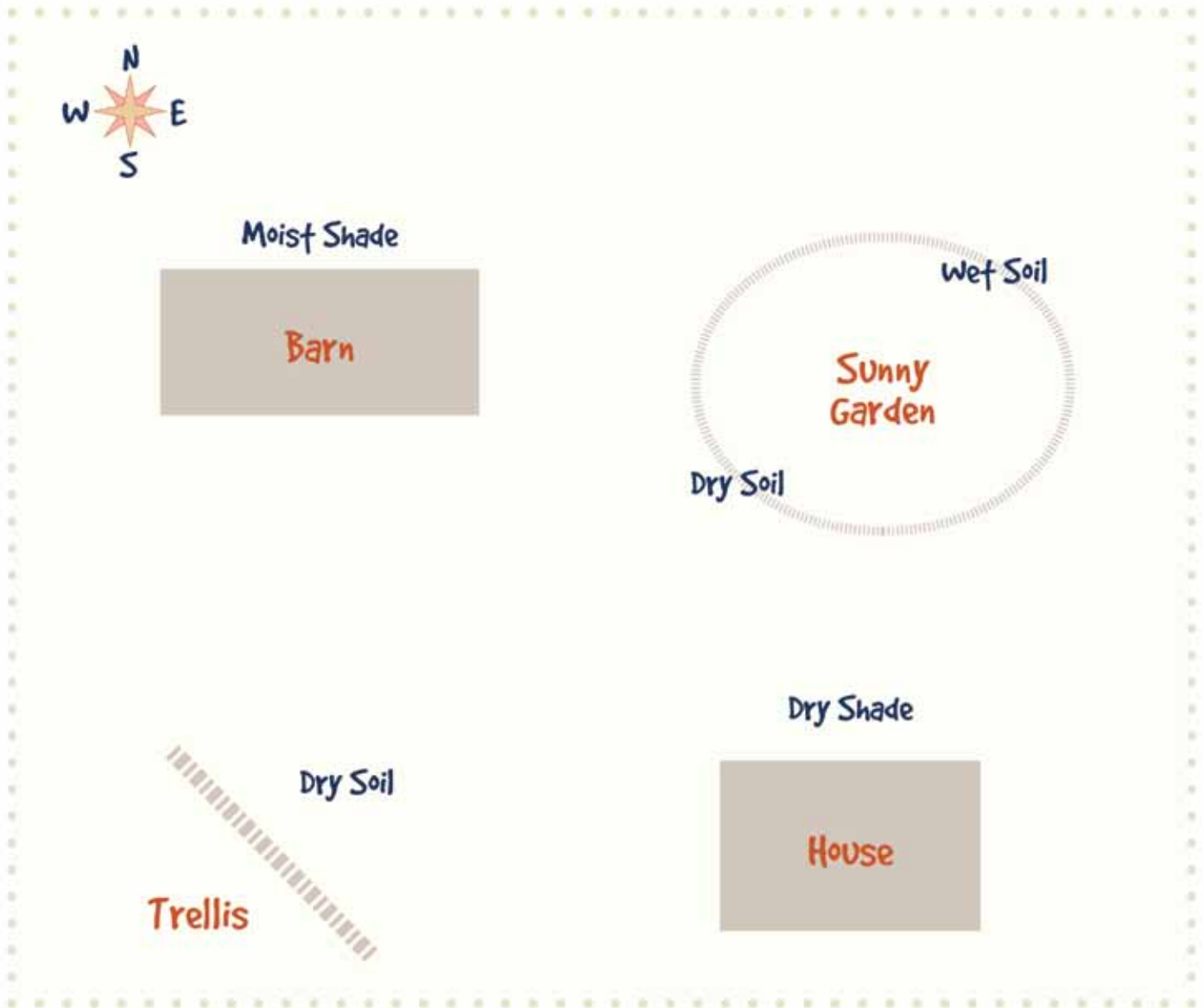

Oregon State University
 Agricultural Research Service
 Mapping by the PRISM Climate Group,
 Oregon State University,
<http://prism.oregonstate.edu>, 2012

Name _____



Do I Know if the Plant is Right for the Spot?

Here's a sketch of Mrs. MacGregor's yard. She wants her new plants to grow well. On the next page, read the descriptions for each plant, then determine where to place the flowers in Mrs. MacGregor's yard. Indicate the location of the flowers by placing the corresponding number on the map. Because perennial flowers, shrubs, and trees are around for a long time, you must think carefully about where you plant them.



The yard has some shady spots and a lot of sunny spots. Some spots are moist, or wet, or dry. Mrs. MacGregor has chosen some plants that bloom in spring, some in summer, and some in fall, so she will have color in her garden all season long.

Mrs. MacGregor chose these flowers because she likes their shapes and textures. Another important reason she is adding flowers is to encourage beneficial (helpful) insects in her yard. She also wants more visits from birds and butterflies.



Name: Bluebell
Blooms in: Spring
Likes: Dry shade
Special notes:



Name: Chrysanthemum
Blooms in: Fall
Likes: Sun and wet soil
Special notes: Attracts moths



Name: Black-Eyed Susan
Blooms in: All summer
Likes: Sun and wet or dry soil
Special notes: Very sturdy!



Name: Morning Glory
Blooms in: Summer
Likes: Sun, dry soil
Special notes: Climbing vine; place on



Name: Iris
Blooms in: Early summer
Likes: Sun and moist soil



Name: Columbine
Blooms in: Spring
Likes: Shade and moist soil
Special notes: Attracts birds and bees

Name _____



Right Plants, Right Place

1. Plants that like sun can grow in the shade, too.
Will they grow as well as if they were in the sun?

Yes No

2. Why is it necessary to think about how big a plant might get when we plant it?

3. What is the main difference between annuals and perennials?

4. List three basic needs that are important for a healthy plant.

Grade

Elementary K-5

Materials/Preparation

- Teacher Material A – Class Results – one per teacher
- Handout A – Magic Beans Problem Solving – one per student
- Optional: *Jack and the Beanstalk* by Ann Keay Beneduce, Gennady Spirin
- Beans (pole beans such as limas or scarlet runners are best)
- Optional: *Unearthing Garden Mysteries: Experiments for Kids* by Ellen Talmage
- Potting mix
- 4" or 6" pots
- Notebooks
- Writing instruments

Fun Fact

Green beans are actually the pods and seeds of immature dry beans, and their pods can be flat, oval, or rounded. Varieties called "green" beans are bred to have a juicier, more tender pod than the types used for dry beans.



Magic Beans and Giant Plants

Minnesota K-12 Academic Standards

Science	0.1.1.2 2.1.1.2 3.1.1.2 5.1.1.2	Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.
Language Arts	3.6.7.7	Conduct short research projects that build knowledge about a topic.
Language Arts	4.6.7.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
Language Arts	5.6.7.7	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Summary/Overview

After predicting what, other than magic, caused Jack's beanstalk to grow so tall, students design and conduct experiments to explore how different conditions affect plant growth. This open-ended investigation of conditions for plant growth assumes some student knowledge of basic plant needs (light, water, etc.). It can be a springboard for more in-depth investigations of these factors.

Garden Connection

Students experiment with growing plants and the factors that influence their growth.

Background Information

Like all living things, green plants have basic needs. If light, water, air, nutrients, and an adequate temperature range are not available, plants cannot thrive and grow.

Light energy is required for *photosynthesis*, in which plants make sugars in the leaves. Light also triggers changes, particularly flowering, in certain plants.

Water is necessary to carry dissolved nutrients into the plant through the roots. It is one of the key ingredients in the process of photosynthesis, and helps the plant release energy from stored food when needed. Water pressure in plant cells, which are 65 to 95 percent water, supports stems and leaves. Water transports nutrients and gasses into, around, and out of the plant. It is an important component in the cells of all living things.

Plants require two of the components of air. They use carbon dioxide to make food (photosynthesis), and they use oxygen, as do humans and

other animals, to release the energy from that food (respiration).

Plants require mineral nutrients for growth, repair, and proper functioning. Mineral nutrients are formed by the breakdown of rocks and other materials in the earth. While humans get these minerals from plants, animals, or in the form of supplements, plants take these minerals from the soil (dissolved in water) or through fertilizers applied by humans. Although these minerals are important supplements for health and maintenance, they cannot replace the sugars produced in the leaves, which can also be stored as carbohydrates, fats, and proteins.

Objectives

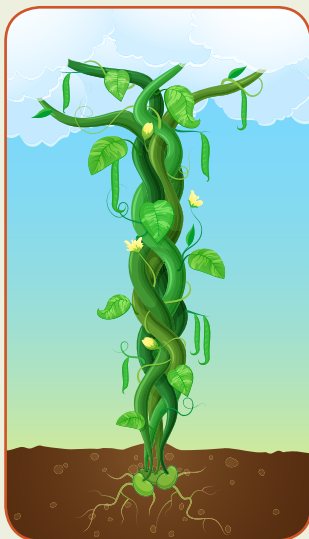
- To consider which specific conditions might affect plant growth.
- To design and conduct experiments using a problem-solving process.
- To understand that different types of conditions influence the health and growth of living things.

Procedure

Interest Approach

Tell your students a version of *Jack and the Beanstalk* or read the optional book. Hand out some “magic” beans (see materials) and ask, “What do you think is the secret to growing tall bean plants?” Explain that although magic may have influenced the growth of Jack’s plants, scientists do know that other important factors contribute to plant growth.

As a class, generate a list of general factors (light, temperature, water, growing space, etc.) that students think green plants need to stay alive. Label it “All Green Plants Need.” Next to each factor, ask students to predict what specific conditions they think might result in the tallest bean plants. For example, if sunlight is a factor perhaps students predict ten hours per day. Accept all student suggestions whether or not you think they are correct. If students need help finding



ideas, have them look through *Unearthing Garden Mysteries: Experiments for Kids* by Ellen Talmage.

Ask students how they might explore which of these conditions would help grow the tallest bean plants.

Summary of Content and Teaching Strategies

Challenge small groups of students to choose one of the predicted factors for growing the tallest bean plants generated in the interest approach (light, water, temperature, good soil, etc.). To test predictions, have each group of students design an experiment, lasting up to four weeks. Use Handout A to help



guide the learning process. Students use notebook paper to record regular observations. (Younger children will need help setting up experiments, observing, and recording data.) Example work process: Group A and B might each have two plants. The plants in Group A get 24 hours of light while the plants in Group B, the control, get 14 hours of light. A control is used to minimize the effects of variables other than the one being tested. In this example the control is 14 hours of light because plants receive roughly 14 hours of light a day during the summer months.

Before groups of students set up experiments, have each group present its design for review by the class. Have students explain why they predict their particular conditions will improve plant growth. For example, “We think 24 hours of light will make the beans grow taller in four weeks, because we know they need light to make food. So the more light, the more food, and the taller the plant.”

Have each group decide how they’ll gather their data. Suggest that at the end of each week students graph the daily growth rate of their plant and predict, based on the growth rate, how tall their plant will be by the end of the next week. On the graph, illustrate both predictions and actual growth rate results.

After four weeks of experimenting, have each older student group present a three-minute “news conference” to the class highlighting its findings. Suggest a title such as “Grade ____ Scientists Find That ____ May Have Contributed to Jack’s Mammoth Beanstalk.” Have students use creative summary charts and graphs to present data.

Encourage other class members to review the findings and ask questions about the nature of the experiment, conclusions, etc. For example, “Why did you plant X number of seeds in each pot? How did you treat each of your groups? What might you do differently if you were to repeat the experiment? How do you know it was not _____ that affected your plants?”

Combine results from different experiments on a class chart. Use Teacher Material A if desired. Refer to the chart when discussing the Review/Summary questions.



Review/Summary

Review the following questions with the class:

- Were there growing conditions the tallest plants seemed to have in common? What seemed to contribute most to the height of bean plants?
- Did any of your findings surprise you? Which ones?
- Did the tallest plants seem to be the healthiest plants? Explain your response. Do you think bigger is necessarily better? Why or why not?
- How did the data from the whole group help give us a better understanding of conditions for good bean plant growth?

Modifications/Extensions

Devise an experiment to grow the smallest bean plant that will produce flowers.

Replant beans harvested from your stalks. (Wait to replant seeds until pods have dried, about four weeks after the beans were ripe.) Notice whether the seeds from the biggest plants produce bigger offspring.

Rewrite or act out a new version of *Jack and the Beanstalk* using some of the new information gained from your exploration. Post these “techno-tales” around the room.

Sources/Credits

Adapted from the National Gardening Association’s *Grow Lab Activities for Growing Minds*, second edition, copyright 2009. For information on obtaining a copy of their curriculum, visit www.gardeningwithkids.org.

Class Results

Question/
Hypothesis

Experimental
Findings

Comments/New
Questions

	Question/ Hypothesis	Experimental Findings	Comments/New Questions
Group A			
Group B			
Group C			
Group D			
Group E			

Name _____



Magic Beans Problem Solving

Use these two pages to guide you through the stages of problem solving.

Plant a Question

Hmm, I wonder what will happen if...

Sprout a Hypothesis

I think... the more I water plants, the faster they'll grow

Describe Your Growing Exploration

What steps will I take to find the answer?

Which is the control group?

Oh, I need to remember to change only one factor and keep the others constant!

Let's see... what materials will I need?

What will I observe? How often?

Did I remember repetition? Did I remember repetition?

Record Fruitful Observations:

(attach all record sheets)

Harvest Your Findings:

What happened?
How can I explain it?

Oops, maybe I
should be more
careful about...

On Growing Review:

What else could have
affected my results?

Next time, I'm
going to...

Cultivating New Ideas

This makes me
wonder about...

I still have
questions about...

Now I would
like to try...

Grade

Middle School

Materials/Preparation

- Teacher Material A – New Terms – one per teacher
- Teacher Material B – Plant Nutrients – one per teacher
- Handout A – Static Hydroponic Activities – one per student
- Assessment A – What? No Soil? – one per student
- Several two-liter plastic soda bottles
- Large piece of one-inch thick styrofoam
- Marking pen and labels
- Distilled water
- Electronic electrical conductivity (EC) meter
- Hydroponic nutrient solution (Hydro-Sol)
- Wisconsin Fast Plant with roots or other rooted plant start
- Calcium nitrate
- Electronic pH tester
- Aquarium air pump
- Aquarium air pump line/tubing
- Razor or utility knife
- Short blade scissors
- Cotton balls
- Optional: PVC pipe, PVC cement and PVC pipe cap

Many of the supplies required for this lab can be purchased from Carolina Biological Supply Company www.carolina.com, 2700 York Road Burlington, NC 27215 800-334-5551.

What? No Soil?

Minnesota K-12 Academic Standards

Science	6.1.2.1	Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.
---------	---------	--

Summary/Overview

After learning the five basic requirements of plant growth, students discuss terms related to hydroponics. Students then build and maintain hydroponic units from soda bottles.

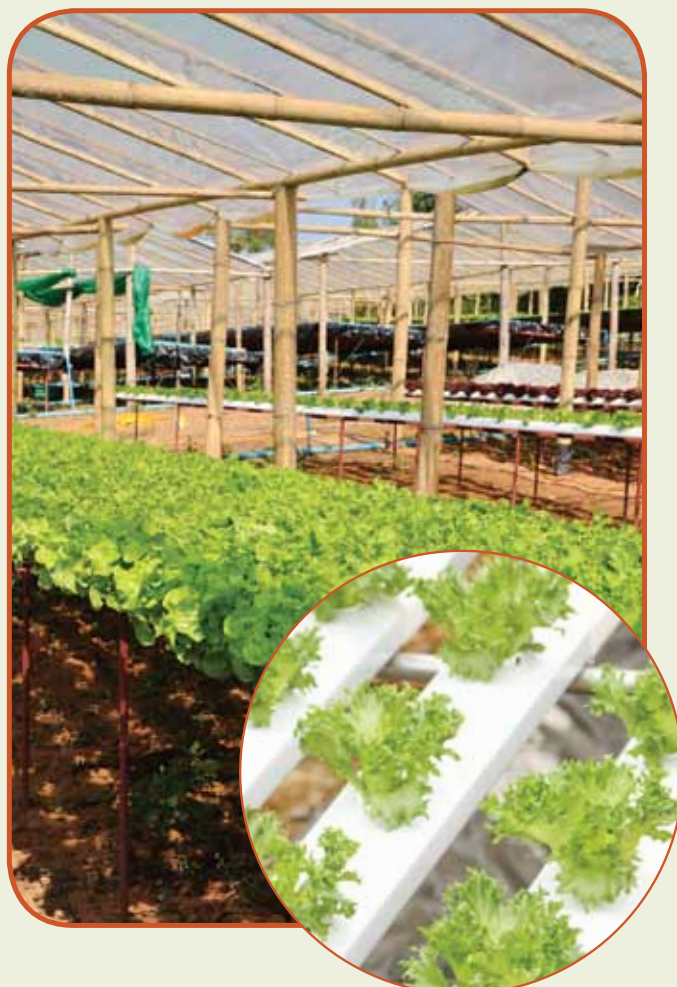
Garden Connection

Gardens can grow anywhere, even without soil!

Background Information

The floating gardens of the Aztecs of Mexico and the hieroglyphics of ancient Egypt describe growing plants in water. Some even speculate that the hanging gardens of Babylon were in fact hydroponic. (Resh) Although we have ancient accounts, John Woodward is the first person accredited for growing plants in liquid medium (1699). In the 1860's, German scientists Sachs and Knop organized the first liquid solution into a research science technique. William Gericke of University of California Berkeley was the first hydroponic user to produce crops with the method. (Bugbee/Hershey)

The word "Hydroponics" refers to two Greek words, "water" and "working." It is defined as the science of growing plants without soil.



In order for hydroponics to provide for the five basic needs of plants which are air, nutrients, water, light, and anchorage, some changes need to be made from traditional crop production. An aquarium pump provides the oxygen in a static hydroponic culture. The method of aerating the roots is not as important as the movement of the water over them. Nutrients are provided by a nutrient solution added to the jar. It must be checked every few days to maintain optimum pH levels. Water is provided along with the nutrient solution. Light is provided by the sun or artificial light. Anchorage is provided by a sponge or other material holding the plant in suspension above the nutrient solution.

Nutrients are essential to plant growth because they provide a constant source of food and energy. Without nutrients, the plant will not complete its life cycle in a normal manner. With prolonged deficiency, the plant will not survive. The primary nutrients involved in plant growth are nitrogen (N), phosphorus (P), and potassium (K).

The effects of these nutrients can be visually observed under many conditions:

Nitrogen (N)

Optimum: Plants with the optimum amount of N are dark green and high in protein content.

Deficient: Nitrogen deficiency is detected by a light green color. The lower leaves turn yellow and brown as they dry up. The plant is stunted, making the stem short and slender.

Excess: Too much N will cause the plant to become very leafy. Flowering will be delayed.

Phosphorus (P)

Optimum: P stimulates root formation and growth, provides plants with a healthy start, and stimulates flowering and seed development.

Deficient: Phosphorus is needed for growth and flowering. If P is not provided, the plant grows slower and delays flower and pod development. The leaves in a P deprived plant are dark green with purple or red appearing along the veins. The lower leaves turn yellow and brown as they dry up. The plant stem becomes short and slender.

Potassium (K)

Optimum: At optimum levels, K increases vigor and disease resistance. It also is important for the formation of starches, sugars, and translocated sugars.

Deficient: Chlorotic (yellowing) leaves result from K deficiency. Necrotic (tissue death) spots between the veins, margins, or leaf tips appear. The plant stem becomes slender.

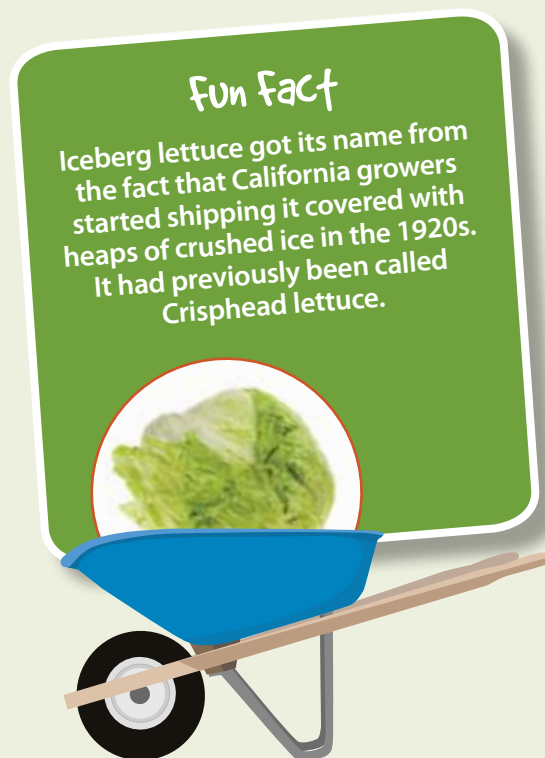
Information about the NPK effects is provided by the Wisconsin Fast Plants Program, University of Wisconsin, Department of Plant Pathology. *Investigating Plant Physiology*. Copyright 1989. Carolina Biological Supply Company.

The students will construct and monitor their own hydroponic system by following the instructor's directions and prompting. Form groups of two or three students for this project.

Objectives

- Describe the five requirements that plants need to survive.
- Explain the three primary nutrients (macro elements) required by all plants.
- Define hydroponics.
- Construct and monitor a hydroponic system.

If desired, have a parent volunteer complete steps 5 and 6 of Part 1 on Handout A.



Procedure

Interest Approach

Ask students to make a list of things plants need to grow. After they finish, discuss answers as a class. Talk about the five main growth requirements: air, nutrients, water, light, and anchorage. Next ask students if plants must be planted in soil to obtain these requirements. Explain that plants grown in a hydroponic system do not use soil and their needs are still met.

Summary of Content and Teaching Strategies

Discuss the vocabulary words found on Teacher Material A. Using Teacher Material B, discuss the nutrients required by plants to grow to maturity. Also discuss what happens when too little or too much of the nutrient is present.

Assist students in creating and maintaining a hydroponic system made from soda bottles. Provide students with a copy of Handout A and the materials needed to complete the project.

Review/Summary

As a class, discuss the following questions:

1. What is hydroponics? How is it different than geponics (growing of plants in soil- based media)?
2. Describe why plants need phosphorus to survive. What will happen if the plant has too much phosphorus?
3. Explain why plants need nitrogen. What will happen if it has too much nitrogen? Too little?
4. What are the five main needs of plants to survive? Explain what will happen if one of those needs is missing.

5. After constructing your own hydroponic system, what do you see as a potential for hydroponics in the future? Can hydroponics feed the world? Is it a good way to produce food?
6. Why does the plant need air from the aquarium pump? What will happen if the aquarium pump is taken out?
7. What are some of the benefits of having a hydroponic system? What are some downfalls?

Modifications/Extensions

Test pH using hydroponic growing systems. Three different solutions will be needed: acidic, basic, and neutral with pH numbers of 4, 6, and 8. Acidic solutions can be obtained by adding sulfuric acid or vinegar to the nutrient solution. Basic solutions with a higher pH can be obtained by adding potassium hydroxide solution or baking soda to the nutrient solution. pH can be tested with a pocket, glass-electrode pH meter, or pH paper. The plants should be grown in three separate containers. Each container will have a different pH number. All other factors should remain constant. Record data and determine which solution is most tolerable to plant growth.

Compare hydroponics and geponics (growing plants in soil) by using the same plants and containers. Soda bottles will hold both mediums. Take care to assure that each plant starts under all the same conditions with exception to the growing medium. Plant one set of plants in the soil and one set in the hydroponic system. Monitor their growth and compare. (Bugbee/ Hershey)

Sources/Credits

Adapted from *Technology, Life and Careers Agricultural Science and Technology Instructional Guide*, project of the Utah State Office of Education. Protect Director Richard M Joerger, PhD., developed and written by Brenda Mager and Kari Osterhout, 1995.

Bugbee, Bruce and Gus Koerner. *Teaching Hydroponic Science*. "Inexpensive Hydroponic Teaching Methods" by David R. Hershey. (27-33)

Hershey, David R. "Solution Culture Hydroponics: History and Inexpensive Equipment." *The American Biology Teacher*, Volume 56, No. 2, Feb 94 (111-118).

New Terms

1. **Aerating:** Adding air to the growing media.
2. **Anchorage:** Plant roots and stems becoming stabilized or “anchored” in their growing media. In hydroponics systems, devices or systems must anchor plants in the absence of soil.
3. **Geponics:** Growing plants in the soil found on the earth’s surface. Geponics can be looked as the “opposite” of hydroponics.
4. **Hydroponics:** The art and science of crop production in liquid media.
5. **Nutrient:** The mineral quantities plants need to obtain optimum growth.
6. **Nutrient solution:** The replacement of soil in a hydroponic solution that supplies the plant with nutrients, water, air, and anchorage.
7. **Primary nutrients:** The mineral nutrients plants need in the greatest quantities: Nitrogen (N), Phosphorus (P), and Potassium (K).
8. **Respiration:** The process by which the plant sugars produced in photosynthesis are used up (or burned) to produce energy for the plant’s life processes.
9. **Transpiration:** Evaporation or loss of water through plant surfaces.

Plant Nutrients

Nutrients are essential to plant growth because they provide a constant source of food and energy. Without nutrients, the plant will not complete its life cycle in a normal manner. With prolonged deficiency, the plant will not survive. The primary nutrients involved in plant growth are nitrogen (N), phosphorus (P), and potassium (K).

The effects of these nutrients can be visually observed under many conditions:

Nitrogen (N)

Optimum: Plants with the optimum amount of N are dark green and high in protein content.

Deficient: Nitrogen deficiency is detected by a light green color. The lower leaves turn yellow and brown as they dry up. The plant is stunted, making the stem short and slender.

Excess: Too much N causes the plant to become very leafy. Flowering will be delayed.

Phosphorus (P)

Optimum: P stimulates root formation and growth, provides plants with a healthy start, and stimulates flowering and seed development.

Deficient: Phosphorus is needed for growth and flowering. If P is not provided, the plant grows slower and delays flower and pod development. The leaves in a P-deprived plant are dark green with purple or red appearing along the veins. Lower leaves turn yellow and brown as they dry up. The plant stem becomes short and slender.

Potassium (K)

Optimum: At optimum levels, K increases vigor and disease resistance. It also is important for the formation of starches and sugars.

Deficient: Chlorotic (yellowing) leaves result from K deficiency. Necrotic (tissue death) spots between the veins, margins, or leaf tips appear. The plant stem becomes slender.

Information about the NPK effects is provided by the Wisconsin Fast Plants Program, University of Wisconsin, Department of Plant Pathology. Investigating Plant Physiology. Copyright 1989. Carolina Biological Supply Company.



Static Hydroponic Activities

Part 1. The Soda Bottle

Materials Needed

- One two-liter plastic soda bottle
- One- inch thick styrofoam
- Marking pen and labels
- Distilled water
- Electronic electrical conductivity (EC) meter
- Hydroponic nutrient solution (Hydro-Sol)
- Wisconsin Fast Plant with roots or other rooted plant start
- Calcium nitrate
- Electronic pH tester
- Aquarium air pump
- Aquarium air pump line/tubing
- Razor or utility knife
- Short blade scissors
- Cotton balls

optional

- PVC pipe, PVC cement, and PVC pipe cap

1. Obtain one plastic two-liter soda bottle.
2. Fill the bottle with hot water to soften the glue on the label. Swish the water around to soften all the glue. Remove label. You may also use a hair dryer/blower to remove the labels.
3. Mark the bottle at 23 cm from the base with a felt tip marker. Draw a line completely around the bottle.
4. Use a razor or utility knife to start the cut and short-blade scissors to complete it.
5. Place the cut soda bottle cut side down on the styrofoam block. Draw a line around the soda bottle on the styrofoam.
6. Cut around the circle drawn on the styrofoam with a sharp knife. To get an even finish on the edges of the styrofoam, rub an extra piece of styrofoam against the rough edges of the styrofoam.
7. Cut holes for the plants with scissors or poke a pencil through the styrofoam. If needed, surround the plant stems with cotton from cotton balls to help the plant stems stay in place in the holes.
8. Make a hole in the styrofoam for the aquarium tube coming from the aquarium pump. The line should be extended through the hole and into the nutrient solution.

9. Label your hydroponic system with your name, group number, and the date. Use a label and marking pen.
10. Insert the styrofoam round into the soda bottle. Another soda bottle may serve as a humidity dome if desired. See Figure 1.

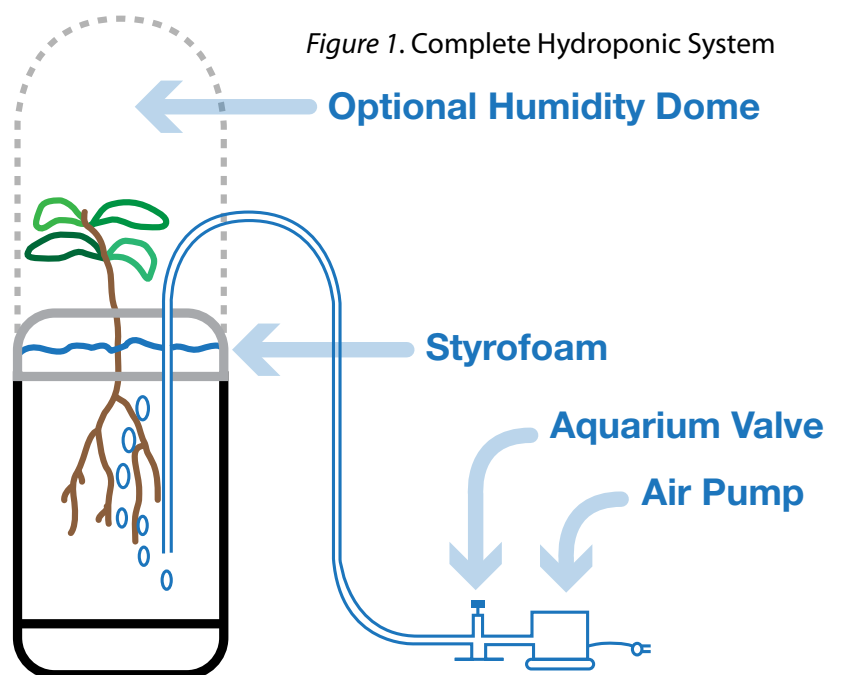


Figure 1. Complete Hydroponic System

Optional Humidity Dome

Styrofoam

Aquarium Valve

Air Pump

Part 2. The Nutrient Solution

Your instructor will provide you with the Hydro-Sol and Calcium nitrate needed to complete this exercise. Mix one teaspoon of Hydro-Sol and ½ teaspoon of Calcium nitrate per gallon of water for the nutrient solution. Hydro-sol is a name brand product of nutrient solution for hydroponic systems. It provides the plants with the primary and secondary nutrients it will need to produce successfully. Calcium nitrate aids in the EC (electrical conductivity) count to ensure a standard for the EC meter.

Obtain the Wisconsin Fast Plant with developed roots from your instructor.

Gently insert the roots through the holes made in the styrofoam in Part 1.

Fill the soda bottle with nutrient solution and record the amount of solution added to the bottle in Table 1. The nutrient solution should be high enough to cover some, but not all of the roots. This is called the “fill” level.

Part 3. Aeration - Plants Need Air

Insert the aquarium air tubing into the reservoir through one of the pre-punched holes made in the styrofoam in Part 1.

The tubing can be made rigid by slipping a plastic straw onto the tubing.

One pump can operate many individual reservoirs by using a series of 3-way aquarium valves.

Optional: To operate multiple pop bottle units from one pump, develop a manifold. Run a line from the aquarium pump into one end of a 12 inch long piece of PVC pipe. Stop the other end of the PVC pipe with a PVC cap and PVC cement to make it airtight. Bore holes into the length of the PVC pipe and run a line out the holes for each hydroponic unit. See *Figure 2*.

Adjust the aeration to a rate of 1 to 3 bubbles per second.

Manifold for Hydroponic System Using PVC Pipe

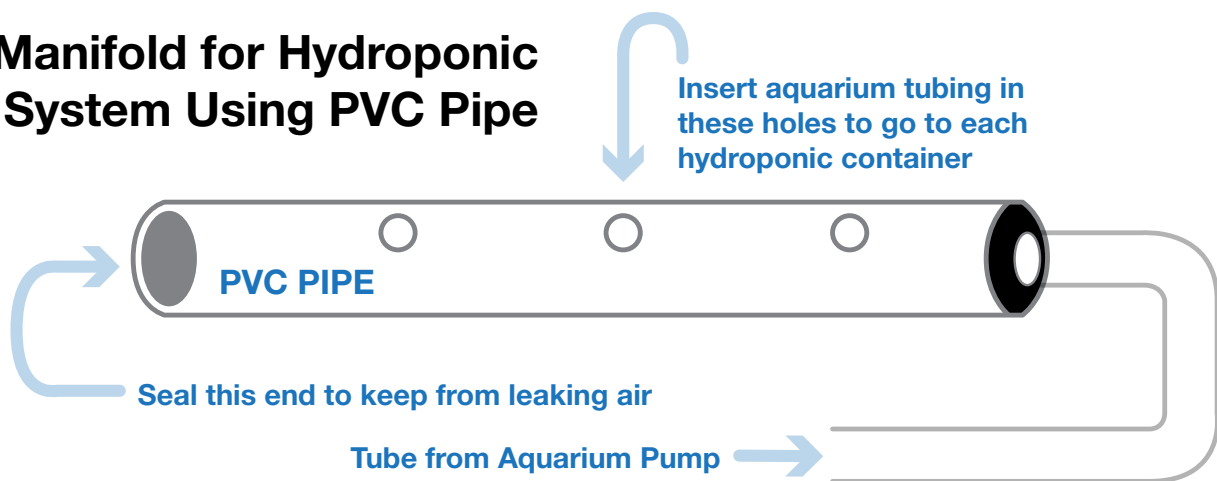


Figure 2. Manifold for hydroponic system using PVC pipe.

Part 4. Maintenance

1. Nutrient solution levels change due to transpiration and respiration. The nutrient solution level needs to be replaced every few days.
2. Develop a schedule for replacing the nutrient solution every one or two weeks. The rate of replacement depends on the rate of evaporation or water loss. Keep the nutrient solution at the “fill” level of your bottle at all times. Water daily and record how much water has been added each time the bottles are re-filled. When half of the total volume of water has been replaced, it is time to replace the entire nutrient solution with new water and nutrients. The total volume of water will vary depending on the height of the styrofoam piece and the amount of root growth. Keep a record of the total amount of water added daily by using the following watering chart. Note the day the nutrient solution was replaced and re-start the recording of total water added.
3. Use a razor or utility knife to widen the opening for plant stems as the plants grow. Be careful to not damage the plant stems when cutting.

Table 1. Water Added Daily: Hydroponic Plant Unit							
Week	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1							
2							
3							
4							
5							

The procedures and figures for the static hydroponic system were adapted from the following sources:

Bugbee, Bruce and Gus Koerner. *Teaching Hydroponic Science*. Hershey, David R. “Inexpensive Hydroponic Teaching Methods” (27-33).

Hershey, David R. “Solution Culture Hydroponics: History and Inexpensive Equipment.” *The American Biology Teacher*, Volume 56, No. 2, Feb 94 (111-118).

Greentrees Hydroponics. 2013. Frequently Asked Questions. Retrieved from: www.hydroponics.net/learn/faq.asp#How_often_should_I_change_solution



What? No Soil?

1. Place the letter of the correct vocabulary word by the corresponding definition.

A. Hydroponics

1. _____ is the growing of plants without soil.

B. Nutrient

2. _____ are the mineral quantities plants need to obtain optimum growth.

C. Nutrient solution

3. _____ is the replacement of soil in a hydroponic solution that supplies the plant with nutrients, water, air, and anchorage.

D. Primary nutrients

2. The primary nutrients needed by plants are:

A. nitrogen, phosphorus, sulfur. (N, P, S)

B. nitrogen, phosphorus, potassium. (N, P, K)

C. nickel, phosphorus, sulfur. (Ni, P, S)

D. nitrogen, oxygen, calcium. (N, O, Ca)

3. The five basic needs of plants to survive are:

A. air, nutrients, water, light, and soil.

B. air, nutrients, money, soil, and shelter.

C. air, nutrients, care, temperature, and soil.

D. air, nutrients, anchorage, light, and water.

Grade

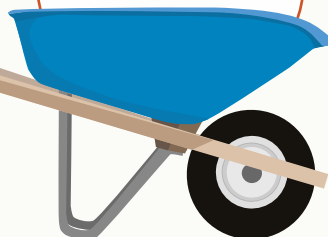
Middle School

Materials/Preparation

- Teacher Material A – Basic Plant Requirements (Venn Diagram) – one per teacher
- Teacher Material B – Basic Plant Requirements – one per teacher
- Teacher Material C – Basic Photosynthesis – one per teacher
- Handout A – Basic Plant Requirements – one per student
- Handout B – Minnesota Plant Hardiness Zone Map – one per student
- Assessment A – Plant Needs – one per student
- Venn Diagram on board or overhead transparency
- Writing instruments

Fun Fact

“Green” beans can actually be green, yellow, purple, or speckled in these colors.



Plant Needs

Minnesota K-12 Academic Standards

Science	7.4.2.2	The flow of energy and the recycling of matter are essential to a stable ecosystem.
Language Arts	6.13.7.7	Compare and 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, table, map).

Summary/Overview

Students compare their needs to the needs of plants using a Venn diagram. They also learn about the process of photosynthesis.

Garden Connection

Without light, air, water, and a growing media plants would not survive.

Background Information

Photosynthesis is the process by which plants make their energy. Photosynthesis occurs when light, carbon dioxide, and water are converted into energy for the plant.

Objectives

- Identify four basic plant requirements.
- Explain the importance of each plant requirement.
- Compare and contrast the needs of humans and plants.

Procedure

Interest Approach

Students will complete a Venn diagram (refer to Teacher Material A) that will eventually compare and contrast the students' needs to the needs of plants. First have students write down all of the things they need to survive in the first circle that is labeled MY NEEDS. Share their responses with the class as you record their answers on the transparency or on a replicated Venn diagram drawn on a board.

Summary of Content and Teaching Strategies

Move into discussing what plants need to grow. For this part of the lesson, students need a copy of Handout A and a pencil. Use Teacher Material B to help guide the lesson and provide a visual reference as students take notes. Also, ensure that you have Teacher Material C available. First, students must understand the process of photosynthesis and how this process dictates what plants need to grow.

While we rely on food sources such as fruits, vegetables, and meats to provide energy, plants are able to produce their own “food” through a process called *photosynthesis*. Show the class Teacher Material C. *Photosynthesis* is the process by which plants use carbon dioxide from the air, water from the soil, and light to create energy that plants need to live, grow, and reproduce.

Take a closer look at the four major plant requirements. As you go over each of these needs, students place them on the Venn diagram in the circle labeled “Plant Needs.” As you discuss the basic plant requirements, display Teacher Material B and Teacher Material C.

Review/Summary

Review the four basic plant needs. Allow students time to review both outside circle lists and write common needs in the center of the Venn diagram. Both plants and humans need air and water to survive. Without plants, humans would not have oxygen or food. Only plants are able to convert energy from the sun into food products usable for animals and humans.



Sources/Credits

Adapted from: National FFA Organization *Middle School Food and Agricultural Literacy Curriculum*, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit www.ffa.org/documents/learn/MS.PS.1.2.pdf to access the full-length version of this lesson.

Modifications/Extensions

The United States Department of Agriculture (USDA) has developed a map to assist gardeners when selecting plants. The map reflects the average extreme minimum temperature by zone using data from 1976-2012. Gardeners use zone information to select plants that will thrive in their climate. This is especially important for perennial plants that over-winter. Provide students with copies of Handout B. Discuss the map and answer the questions.

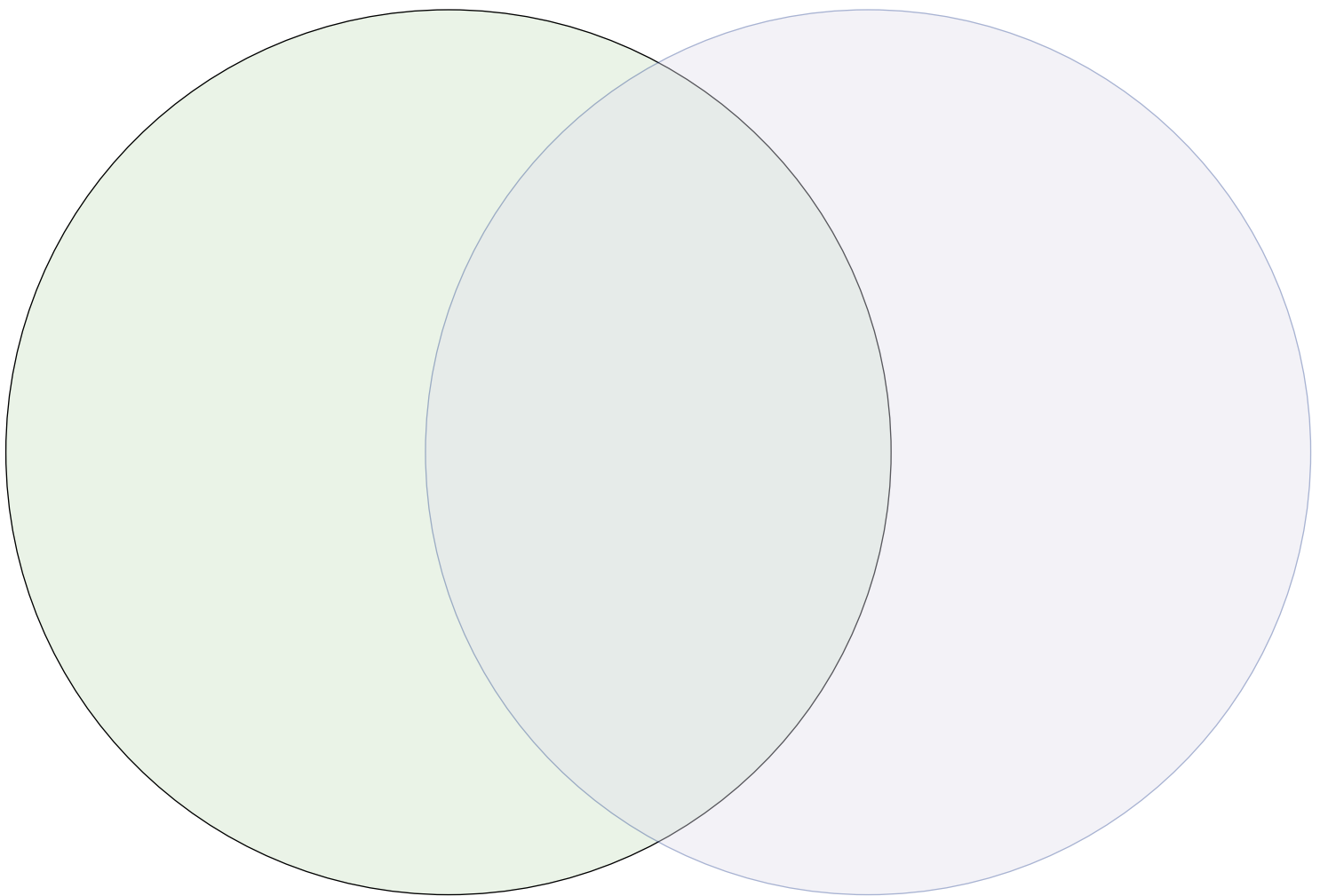


Conduct a two-week experiment with the class. You’ll need four identical plants, a clear nonporous bag, and a very dark closet or room. On day one, show the class the four identical plants. Place one plant in the nonporous bag and label it AIR. Place the second plant in a very dark room or closet and label it LIGHT. Label third plant WATER; do not water this plant for the entire length of the experiment. Put fourth plant in an area with plenty of light and air and label it CONTROL. Water the CONTROL plant every day or as needed. Have the class observe the plants about every two days and document changes in the different plants. By the end of two weeks, the three plants that were restricted from light, water, and air will be dead or close to dead. Discuss these results with the class.

Basic Plant Requirements

MY NEEDS

PLANT NEEDS



Basic Plant Requirements

A. Light

1. Light is required for photosynthesis.
2. Light is the energy that powers the photosynthetic process.
3. Light can either be natural or artificial.
 - a. Natural Light – light from the sun. The sun is the most important energy source in the world as all of our food products (even meat and eggs) ultimately rely on the sun's energy.
Ex: Steaks come from cattle that eat plant matter, which was grown using the sun's energy.
 - b. Artificial Light – Plants can also use artificial light for the process of photosynthesis. Artificial light is light from bulbs and other human-made sources. Artificial light can be used to manipulate plants to flower, fruit, or germinate at specific times.

B. Air

1. Plants must have plenty of air to perform photosynthesis and to live.
2. During photosynthesis, plants absorb carbon dioxide and release oxygen.
3. Plants are important to our survival and the health of the earth because they convert harmful carbon dioxide into the oxygen we breathe.

C. Water

1. All living organisms, including plants, require water to live.
2. Water is essential for the process of photosynthesis.
3. Also, plants use water to transport minerals and nutrients from the roots to the rest of the plants and the energy created by photosynthesis from the leaves back down to the roots.

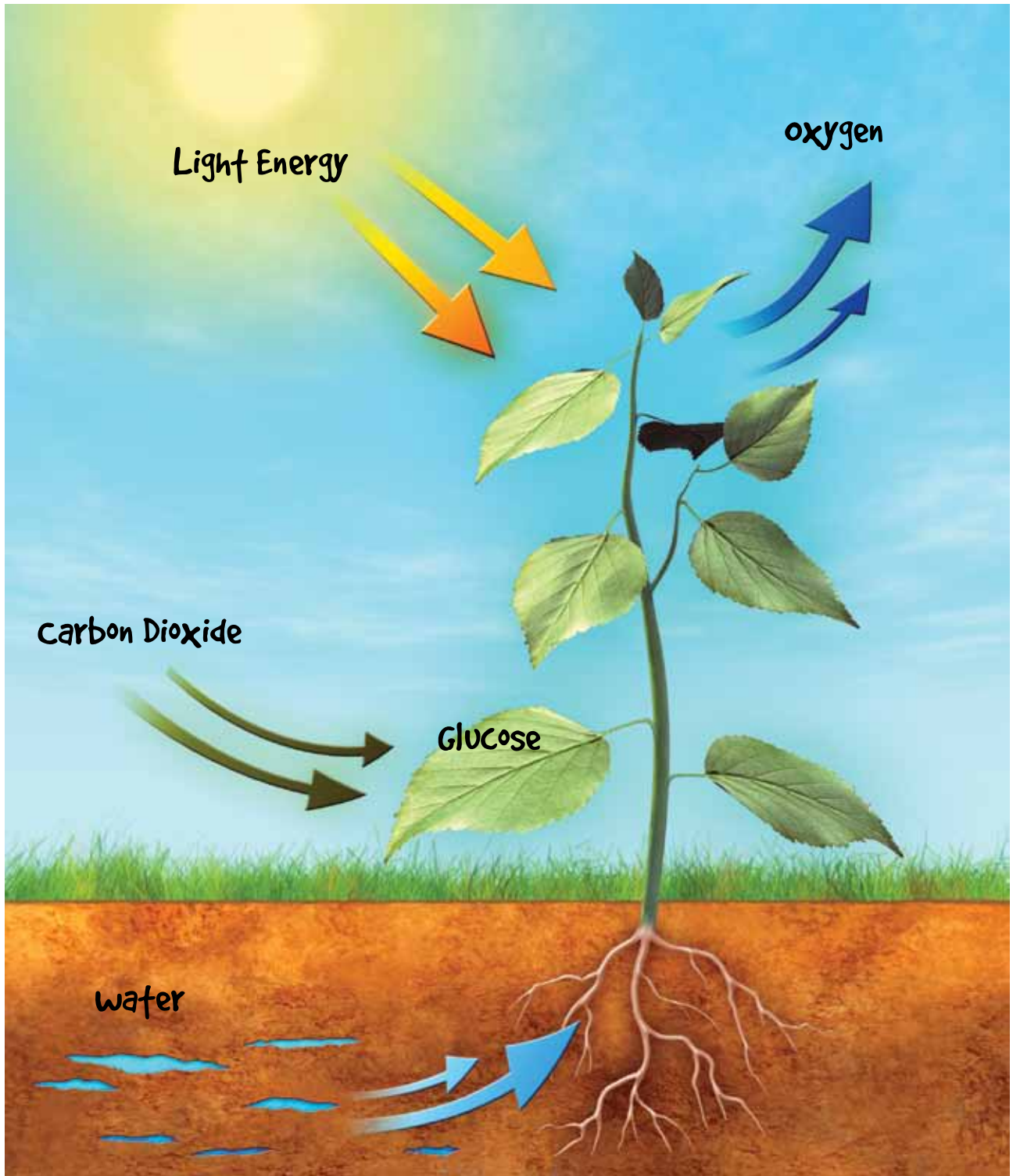
D. Growing Media

1. Plants require a medium to anchor the plant and provide minerals.
2. Soil
 - a. Plants are most commonly grown in soil.
 - b. Plants anchor themselves in the soil using their roots.
 - c. Soil provides water and nutrients for the plants.
3. Soilless Media
 - a. In greenhouses, plants are commonly grown in soilless medium.
 - b. Soilless medium may contain moss, perlite, vermiculite, sand, and bark.
 - c. Soilless media is effective because it is sterile.
4. Hydroponics
 - a. Hydroponics is the practice of growing plants in the absence of soil, using just water and nutrients.
 - b. In large greenhouse operations, hydroponics reduce the amount of water needed and wasted by ensuring that all of the water reaches the roots.

When plant needs are met, they are able to carry out the process of **Photosynthesis**:

1. The process by which plants make their energy (food in the form of glucose).
2. Most photosynthesis occurs in the leaves of the plant because they have the greatest surface area to collect the most light.
3. Photosynthesis occurs when light, carbon dioxide, and water are converted into energy for the plant.

Basic Photosynthesis



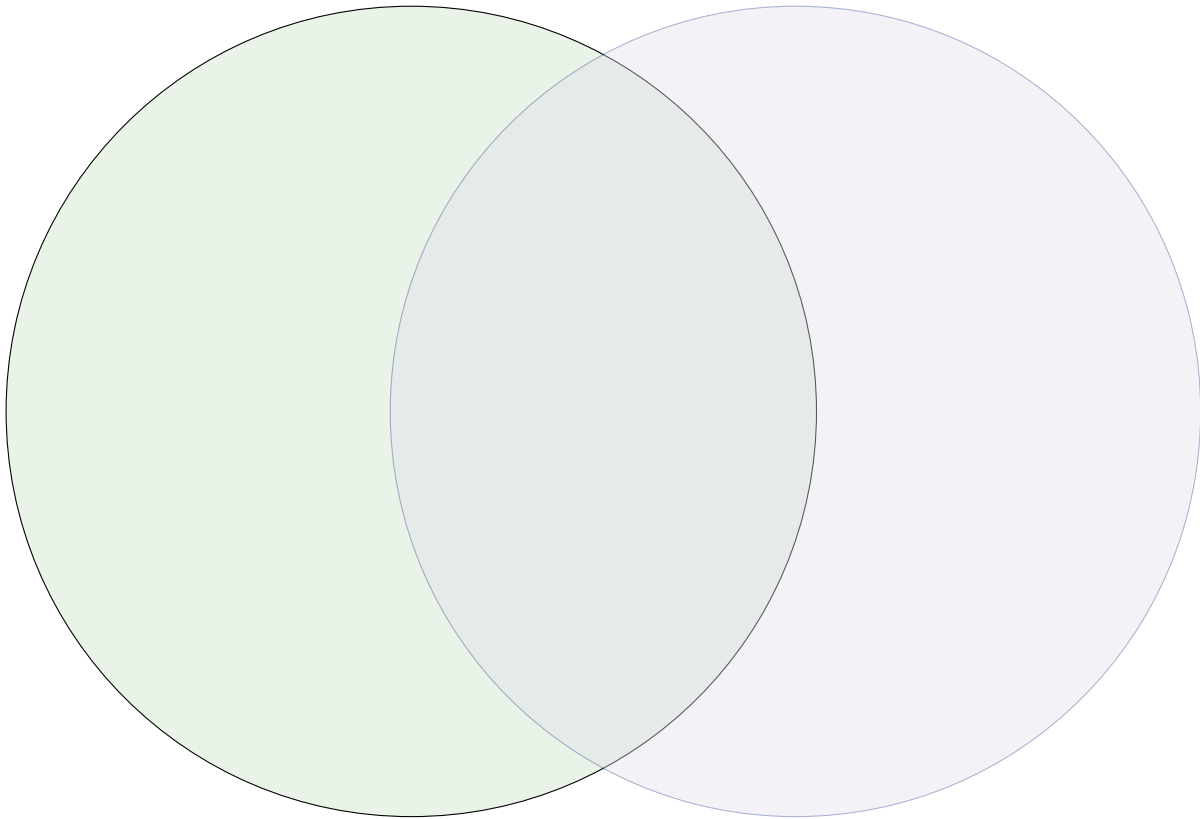
Name _____



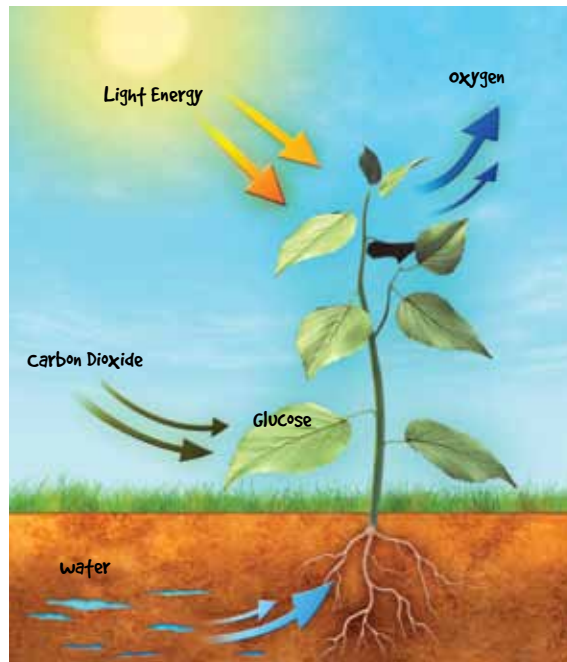
Basic Plant Requirements

MY NEEDS

PLANT NEEDS



The Process of Photosynthesis



Name _____



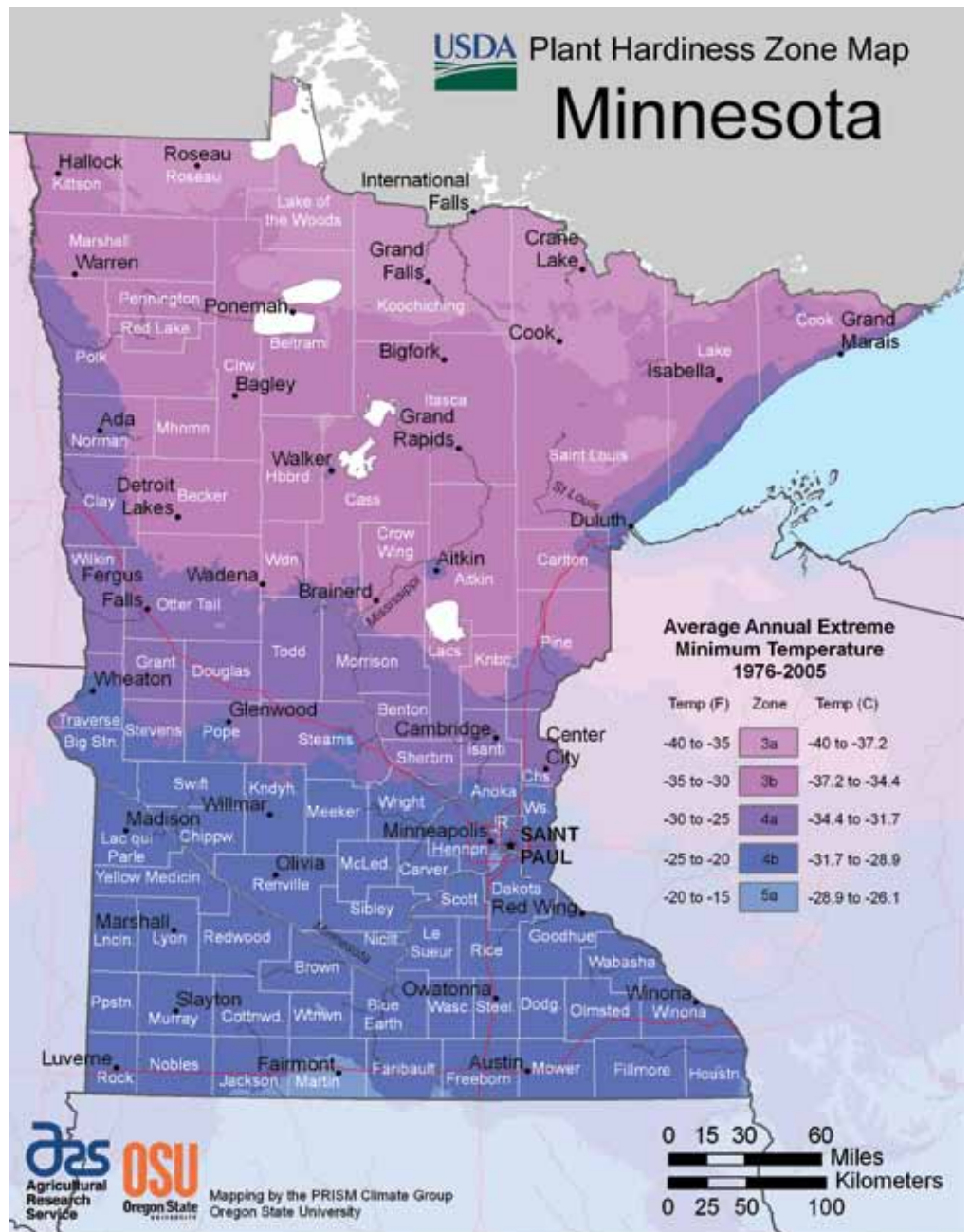
Minnesota Plant Hardiness Zone Map

Find the county where you live and place a star in the location of your town. In which plant hardiness zone do you live?

What is the average annual extreme minimum temperature in F° for your zone?

What part of the state has the coldest temperatures?

What part has the warmest temperatures?



Source: <http://planthardiness.ars.usda.gov>

Why do you think the land near Lake Superior is warmer than other places in the northeast corner of Minnesota?

Name _____



Plant Needs

Using the word bank below, answer the questions below by filling in the blanks.
Each word will only be used once.

Word Bank

Photosynthesis carbon Dioxide oxygen Hydroponics Artificial Leaves

_____ are the primary site of photosynthesis in plants.
This is where plants gather the most sunlight to be converted to energy.

_____ is the practice of growing plants in water with
the absence of soil or any other growing media.

During photosynthesis, plants take in _____ from the
air and release _____ which humans breathe.

While most plants and crops grow using the sun's light, _____
light, such as light bulbs, is often used in greenhouse operations.

Plants convert carbon dioxide, water, and energy from the sun to produce all of
the energy they need to grow and reproduce through a process called

_____.

Grade

High School

Materials/Preparation

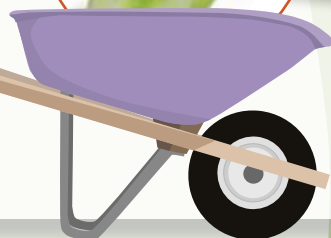
- Teacher Material A – Degrees of Growth – one per teacher
- Handout A – Comparing Growth Locations – one per student
- Assessment A – Comparing Growing Locations – one per student
- Highlighter
- Calculators

optional

- Computer with spreadsheet software
- Writing instruments

Fun Fact

Lettuce is a fairly hardy, cool-weather vegetable that thrives when the average daily temperature is between 60 and 70°F. Lettuce should be planted in early spring or late summer. At high temperatures, growth is stunted and the leaves may become bitter.



Comparing Growing Locations

Minnesota K-12 Academic Standards

Math	9.2.4	Represent real world and mathematical situations using equations and inequalities involving linear, quadratic, exponential and nth root functions. Solve equations and inequalities symbolically and graphically. Interpret solutions in the original context.
Science	9.4.1.1	Organisms use the interaction of cellular processes as well as tissues and organ systems to maintain homeostasis.

Summary/Overview

Students examine several different ways temperature influences plant health and growth. Next they examine two different geographic locations and calculate when fruit would be ready to harvest in both areas.

Garden Connection

Students use a mathematical formula to calculate the harvest of tomatoes based on average temperatures.

Background Information

Latitude, elevation, and microclimate zones, such as coastal areas, influence climate, specifically temperature, for a geographic location. A hardiness zone map (page 91) provides information related to temperature ranges of geographic regions. This information is used to determine the species and varieties of plants best suited for an area.



Plants may be classified into two general categories based on temperature requirements. Cool-season plants can survive mild frost and tolerate cool spring and fall temperatures. Warm-season plants are typically killed by frost and require warm temperatures to grow and thrive.

Plant growth and temperature have a direct relationship. As temperature increases, plant growth increases and as temperature decreases, plant growth decreases. Plants require a specific amount of time exposed to a specific threshold of temperature in order to initiate flowering. The requirement is met by accumulating Growing Degree Days (GDD).

Growing Degree Days (GDD) are units of exposure to adequate temperatures required for plant growth. To calculate GDD subtract the base temperature for a specific plant from the average daily temperature. The base temperature is the minimum temperature requirement a plant needs to grow.

For example, the base temperature for tomatoes is 50 degrees Fahrenheit. If the high is 69 and the low is 44, the average daily temperature is 56.5. So the average temperature, 56.5 minus the base temperature is 6.5 GDD.

Objectives

- Define growing degree days.
- Calculate estimated plant maturity dates using growing degree-days in two different geographical locations.
- Compare and contrast cool-season and warm-season crops.
- Explain the relationship between temperature and plant growth.

Procedure

Interest Approach

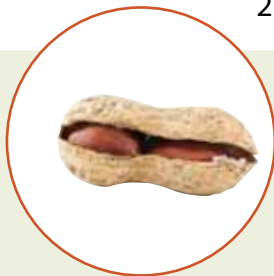
Discuss why certain crops are grown in certain parts of the country. Examples: oranges in Florida, potatoes in Idaho, peaches in Missouri, and apples in Washington. Explain that this lesson gives students a better understanding of how climate influences crop production.

Summary of Content and Teaching Strategies

Present and discuss information on Teacher Material A. Students write down the formula for Growing Degree Days (GDD) in their notes. If desired, use the first three dates for each location on Handout A as example problems.

Provide students with copies of Handout A. Students will need to refer to their notes from Teacher Material A to retrieve the correct formula for calculating Growing Degree Days (GDD). For teacher reference, the following is the correct formula.

$$\frac{\text{Daily High Temperature} + \text{Daily Low Temperature}}{2} - \text{Base Temperature Requirement} = \text{GDD Units}$$



Remember, if the average daily temperature is below the base temperature requirement, the GDD units for that day are zero. Negative numbers always equal zero in this calculation.

Students compare two location's growing seasons by calculating the GDD unit accumulation. Data is provided to the students including the minimum, maximum, and average daily temperatures for May 1 through September 30. On Handout A, students will keep a running total of GDD units until they reach the 2100 requirement for tomato fruit production.

An alternative to calculating the GDD by hand is to prepare a spreadsheet with the correct formulas to calculate for you. If desired, instruct students on proper use of spreadsheet software and provide the correct formulas to students.



Please note the values in Table 1 are provided for daily GDD units rather than a running total. This format assists you with helping students determine errors in their calculations.

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Ave	Daily GDD	Min	Max	Ave	Daily GDD
1-May	32	65	48.5	0	56	91	73.5	23.5
2-May	44	69	56.5	6.5	63	88	75.5	25.5
3-May	54	77	65.5	15.5	59	89	74	24
4-May	49	55	52	2	62	87	74.5	24.5
5-May	51	60	55.5	5.5	68	89	78.5	28.5
6-May	51	68	59.5	9.5	64	81	72.5	22.5
7-May	45	72	58.5	8.5	52	74	63	13
8-May	46	80	63	13	49	83	66	16
9-May	56	84	70	20	60	83	71.5	21.5
10-May	41	68	54.5	4.5	61	88	74.5	24.5
11-May	43	63	53	3	64	90	77	27
12-May	45	75	60	10	64	90	77	27
13-May	57	84	70.5	20.5	65	89	77	27
14-May	40	70	55	5	66	84	75	25
15-May	36	68	52	2	58	86	72	22
16-May	36	63	49.5	0	63	86	74.5	24.5
17-May	57	74	65.5	15.5	63	83	73	23
18-May	43	86	64.5	14.5	57	82	69.5	19.5
19-May	41	58	49.5	0	56	80	68	18
20-May	45	63	54	4	48	86	67	17
21-May	52	80	66	16	52	90	71	21
22-May	54	78	66	16	60	88	74	24
23-May	44	72	58	8	62	86	74	24
24-May	33	51	42	0	60	86	73	23
25-May	43	53	48	0	62	87	74.5	24.5
26-May	36	52	44	0	59	87	73	23
27-May	44	66	55	5	60	85	72.5	22.5
28-May	58	85	71.5	21.5	62	87	74.5	24.5
29-May	53	80	66.5	16.5	63	89	76	26
30-May	53	75	64	14	62	90	76	26
31-May	54	75	64.5	14.5	69	88	78.5	28.5
1-Jun	60	74	67	17	65	84	74.5	24.5
2-Jun	59	78	68.5	18.5	65	74	69.5	19.5
3-Jun	57	81	69	19	61	89	75	25
4-Jun	40	71	55.5	5.5	70	91	80.5	30.5
5-Jun	48	70	59	9	70	89	79.5	29.5
6-Jun	57	70	63.5	13.5	66	91	78.5	28.5
7-Jun	44	70	57	7	73	92	82.5	32.5
8-Jun	52	74	63	13	72	96	84	34
9-Jun	58	79	68.5	18.5	71	96	83.5	33.5
10-Jun	67	86	76.5	26.5	71	97	84	34
11-Jun	72	90	81	31	73	94	83.5	33.5
12-Jun	65	89	77	27	71	85	78	28
13-Jun	64	71	67.5	17.5	66	86	76	26
14-Jun	63	73	68	18	63	86	74.5	24.5
15-Jun	52	72	62	12	65	85	75	25
16-Jun	61	80	70.5	20.5	65	89	77	27

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Ave	Daily GDD	Min	Max	Ave	Daily GDD
17-Jun	63	84	73.5	23.5	71	95	83	33
18-Jun	52	72	62	12	71	94	82.5	32.5
19-Jun	57	74	65.5	15.5	71	83	77	27
20-Jun	54	78	66	16	70	90	80	30
21-Jun	56	83	69.5	19.5	69	89	79	29
22-Jun	64	85	74.5	24.5	64	93	78.5	28.5
23-Jun	69	91	80	30	66	97	81.5	31.5
24-Jun	70	87	78.5	28.5	68	95	81.5	31.5
25-Jun	65	89	77	27	73	93	83	33
26-Jun	54	79	66.5	16.5	71	91	81	31
27-Jun	54	63	58.5	8.5	70	93	81.5	31.5
28-Jun	47	70	58.5	8.5	72	95	83.5	33.5
29-Jun	57	75	66	16	72	95	83.5	33.5
30-Jun	65	82	73.5	23.5	72	94	83	33
1-Jul	66	81	73.5	23.5	70	96	83	33
2-Jul	58	87	72.5	22.5	70	86	78	28
3-Jul	61	85	73	23	72	81	76.5	26.5
4-Jul	57	87	72	22	67	86	76.5	26.5
5-Jul	53	82	67.5	17.5	66	88	77	27
6-Jul	65	86	75.5	25.5	69	92	80.5	30.5
7-Jul	64	95	79.5	29.5	73	88	80.5	30.5
8-Jul	57	80	68.5	18.5	72	86	79	29
9-Jul	56	79	67.5	17.5	74	91	82.5	32.5
10-Jul	50	71	60.5	10.5	72	93	82.5	32.5
11-Jul	52	73	62.5	12.5	74	92	83	33
12-Jul	49	75	62	12	73	92	82.5	32.5
13-Jul	56	82	69	19	67	93	80	30
14-Jul	52	76	64	14	71	88	79.5	29.5
15-Jul	58	71	64.5	14.5	71	86	78.5	28.5
16-Jul	59	78	68.5	18.5	68	90	79	29
17-Jul	60	84	72	22	73	91	82	32
18-Jul	55	85	70	20	73	92	82.5	32.5
19-Jul	48	77	62.5	12.5	72	93	82.5	32.5
20-Jul	59	81	70	20	71	95	83	33
21-Jul	65	85	75	25	72	90	81	31
22-Jul	66	88	77	27	68	88	78	28
23-Jul	71	95	83	33	66	87	76.5	26.5
24-Jul	73	89	81	31	66	88	77	27
25-Jul	69	94	81.5	31.5	69	89	79	29
26-Jul	56	83	69.5	19.5	69	93	81	31
27-Jul	52	81	66.5	16.5	72	93	82.5	32.5
28-Jul	52	86	69	19	74	95	84.5	34.5
29-Jul	66	91	78.5	28.5	74	93	83.5	33.5
30-Jul	69	90	79.5	29.5	72	93	82.5	32.5
31-Jul	68	92	80	30	73	91	82	32
1-Aug	58	83	70.5	20.5	72	93	82.5	32.5
2-Aug	49	82	65.5	15.5	69	93	81	31
3-Aug	58	83	70.5	20.5	72	93	82.5	32.5
4-Aug	62	81	71.5	21.5	69	97	83	33
5-Aug	51	85	68	18	75	96	85.5	35.5

Met GA (2125)

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Ave	Daily GDD	Min	Max	Ave	Daily GDD
6-Aug	58	75	66.5	16.5	76	97	86.5	36.5
7-Aug	60	82	71	21	76	100	88	38
8-Aug	57	76	66.5	16.5	75	101	88	38
9-Aug	64	88	76	26	78	99	88.5	38.5
10-Aug	64	89	76.5	26.5	78	100	89	39
11-Aug	48	86	67	17	76	103	89.5	39.5
12-Aug	54	73	63.5	13.5	74	93	83.5	33.5
13-Aug	56	74	65	15	72	95	83.5	33.5
14-Aug	53	75	64	14	76	98	87	37
15-Aug	46	80	63	13	74	99	86.5	36.5
16-Aug	41	75	58	8	73	98	85.5	35.5
17-Aug	49	72	60.5	10.5	73	98	85.5	35.5
18-Aug	53	74	63.5	13.5	71	93	82	32
19-Aug	56	71	63.5	13.5	72	94	83	33
20-Aug	58	65	61.5	11.5	72	95	83.5	33.5
21-Aug	58	77	67.5	17.5	73	99	86	36
22-Aug	49	85	67	17	78	102	90	40
23-Aug	50	72	61	11	72	92	82	32
24-Aug	47	70	58.5	8.5	73	93	83	33
25-Aug	54	75	64.5	14.5	72	91	81.5	31.5
26-Aug	58	89	73.5	23.5	73	91	82	32
27-Aug	51	66	58.5	8.5	73	89	81	31
28-Aug	47	64	55.5	5.5	74	92	83	33
29-Aug	49	73	61	11	74	92	83	33
30-Aug	57	79	68	18	73	93	83	33
31-Aug	60	84	72	22	73	86	79.5	29.5
1-Sep	59	87	73	23	73	80	76.5	26.5
2-Sep	57	75	66	16	72	82	77	27
3-Sep	54	88	71	21	70	87	78.5	28.5
4-Sep	56	83	69.5	19.5	67	93	80	30
5-Sep	56	93	74.5	24.5	68	91	79.5	29.5
6-Sep	57	71	64	14	66	88	77	27
7-Sep	45	67	56	6	71	87	79	29
8-Sep	36	53	44.5	0	65	88	76.5	26.5
9-Sep	39	64	51.5	1.5	62	89	75.5	25.5
10-Sep	41	70	55.5	5.5	62	91	76.5	26.5
11-Sep	33	55	44	0	71	93	82	32
12-Sep	45	68	56.5	6.5	72	90	81	31

Met MN (2106)

Review/Summary

Discuss the conclusion questions found on Handout A.

Modifications/Extensions

Experiment with plants that have dormancy requirements. Get an assortment of spring flowering

bulbs including tulips, daffodils, crocus, and hyacinth. Force the bulbs to bloom out of season by using a refrigerator to apply a cold treatment. For more information, read the “Forcing Bulbs for Indoor Beauty in Winter” article from the University of Minnesota Extension found at <http://www.extension.umn.edu/distribution/horticulture/dg1116.html>.

Sources/Credits

Adapted from: *Curriculum for Agricultural Science Education (2012) Principles of Agricultural Science – Plant*. [Curriculum materials for secondary agricultural education instruction]. Lexington, KY.

Degrees of Growth

Environmental Temperature Variations

The climate, specifically temperature, for a geographic location is influenced by:

- Latitude
- Elevation
- Microclimate zones, such as coastal areas

Hardiness Zones

A hardiness zone map provides information related to temperature ranges of geographic regions. This information is used to determine the species and varieties of plants best suited for an area.

Source: <http://www.usna.usda.gov/Hardzone/ushzmap.html>



Temperature Sensitive

Some plants are sensitive to freezing temperatures (Examples: eggplants, peppers, and tomatoes)

Other plants require cold temperatures for adequate growth or dormancy requirements (Examples: crocus, daffodils, and tulips)

Plants have different growth requirements to reach maturity based on the length of time exposed to warm temperatures (example: watermelon need 70-90 days to grow to maturity and do best with temperatures reaching 80 degrees during the day)

Temperature Classifications

Plants may be classified into two general categories based on temperature requirements.

Cool-season: Plants that can survive mild frost and tolerate cool spring and fall temperatures (Examples: cabbage, cauliflower, broccoli, and lettuce)

Warm-season: Plants are typically killed by frost and require warm temperatures to thrive and grow. (Examples: eggplants, peppers, and tomatoes)

Plants have specific temperature requirements for:

- Vegetative growth
- Physiological development
- Dormancy

Temperature vs. Growth

Plant growth and temperature have a direct relationship:

- As temperature increases, plant growth increases. (Up to a certain point at which it begins to slow.)
- As temperature decreases, plant growth decreases.
- The optimum temperature range for most plants is between 65-85 degrees Fahrenheit.

Why is plant growth influenced by temperature?

Temperature influences three main metabolic functions of plants:

- Transpiration: water evaporation from leaves
- Photosynthesis: the process in which plants use energy from the sun to make food using carbon dioxide and water
- Respiration: the process of converting sugar made by plants into energy used for growth and reproduction

Maturity Requirements

Plants require a specific amount of time exposed to a specific threshold of temperature in order to initiate flowering.

The requirement is met by accumulating Growing Degree Days (GDD).

Growing Degree Days

Growing Degree Days (GDD) are units of exposure to adequate temperatures required for plant growth. To calculate GDD use the following formula:

$$\frac{\text{Daily High Temperature} + \text{Daily Low Temperature}}{2} - \text{Base Temperature Requirement} = \text{GDD Units}$$

Dormancy Requirements

- Temperature is also used to initiate and break dormancy of seeds and vegetative growth for perennial and biennial plants.
- Plants sense natural seasonal changes in temperature to initiate growth responses.

Terms Related to Dormancy Associated with Temperature

Forcing is controlling temperature to promote vegetative growth and flowering outside of natural seasonal patterns in plants. (Example: forsythia stems brought indoors in March and forced to bloom early)

Stratification is the duration of exposure to cold temperatures to promote germination of some seed types. (Example: morning glory seeds)

Vernalization is the cold treatment applied to plants to initiate flowering. (Example: tulips growing in a pot indoors earlier than normal)

References

United States National Arboretum. (2003). "Web version" of the USDA plant hardiness zone map. Retrieved December 12, 2008 from <http://www.usna.usda.gov/Hardzone/ushzmap.html?>

Parker, R. (2010). *Plant and soil science: Fundamentals and applications*. Clifton Park, NY: Delmar.

Name _____



Comparing Growth Locations

Procedure

In this activity, you will examine two different geographic locations and calculate when fruit will be ready for harvest in both areas. You will assume tomato plants are planted on May 1 for each location. The total number of accumulated GDD units for tomatoes to reach maturity and set fruit is 2100 units. Use the temperature data in Table 1 to determine the approximate harvest date for each geographic location.

Tomatoes require a base temperature of 50 degrees for growth. Subtract the base temperature of 50 degrees from the average temperature provided for each day and record this value in the "Daily GDD" column. In the "Acc GDD" column for each location, keep a running total of the accumulated GDD units until you reach the 2100 threshold. The first three dates for each column have been done for you. Highlight the date when each location reaches 2100 GDD units.

$$\frac{\text{Daily High Temperature} + \text{Daily Low Temperature}}{2} - \text{Base Temperature Requirement} = \text{GDD Units}$$

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Daily GDD	Acc GDD	Min	Max	Daily GDD	Acc GDD
1-May	32	65	0	0	56	91	23.5	23.5
2-May	44	69	6.5	6.5	63	88	25.5	49
3-May	54	77	15.5	22	59	89	24	73
4-May	49	55			62	87		
5-May	51	60			68	89		
6-May	51	68			64	81		
7-May	45	72			52	74		
8-May	46	80			49	83		
9-May	56	84			60	83		
10-May	41	68			61	88		
11-May	43	63			64	90		
12-May	45	75			64	90		
13-May	57	84			65	89		
14-May	40	70			66	84		
15-May	36	68			58	86		
16-May	36	63			63	86		
17-May	57	74			63	83		

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Daily GDD	Acc GDD	Min	Max	Daily GDD	Acc GDD
18-May	43	86			57	82		
19-May	41	58			56	80		
20-May	45	63			48	86		
21-May	52	80			52	90		
22-May	54	78			60	88		
23-May	44	72			62	86		
24-May	33	51			60	86		
25-May	43	53			62	87		
26-May	36	52			59	87		
27-May	44	66			60	85		
28-May	58	85			62	87		
29-May	53	80			63	89		
30-May	53	75			62	90		
31-May	54	75			69	88		
1-Jun	60	74			65	84		
2-Jun	59	78			65	74		
3-Jun	57	81			61	89		
4-Jun	40	71			70	91		
5-Jun	48	70			70	89		
6-Jun	57	70			66	91		
7-Jun	44	70			73	92		
8-Jun	52	74			72	96		
9-Jun	58	79			71	96		
10-Jun	67	86			71	97		
11-Jun	72	90			73	94		
12-Jun	65	89			71	85		
13-Jun	64	71			66	86		
14-Jun	63	73			63	86		
15-Jun	52	72			65	85		
16-Jun	61	80			65	89		
17-Jun	63	84			71	95		
18-Jun	52	72			71	94		
19-Jun	57	74			71	83		
20-Jun	54	78			70	90		
21-Jun	56	83			69	89		
22-Jun	64	85			64	93		
23-Jun	69	91			66	97		
24-Jun	70	87			68	95		

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Daily GDD	Acc GDD	Min	Max	Daily GDD	Acc GDD
25-Jun	65	89			73	93		
26-Jun	54	79			71	91		
27-Jun	54	63			70	93		
28-Jun	47	70			72	95		
29-Jun	57	75			72	95		
30-Jun	65	82			72	94		
1-Jul	66	81			70	96		
2-Jul	58	87			70	86		
3-Jul	61	85			72	81		
4-Jul	57	87			67	86		
5-Jul	53	82			66	88		
6-Jul	65	86			69	92		
7-Jul	64	95			73	88		
8-Jul	57	80			72	86		
9-Jul	56	79			74	91		
10-Jul	50	71			72	93		
11-Jul	52	73			74	92		
12-Jul	49	75			73	92		
13-Jul	56	82			67	93		
14-Jul	52	76			71	88		
15-Jul	58	71			71	86		
16-Jul	59	78			68	90		
17-Jul	60	84			73	91		
18-Jul	55	85			73	92		
19-Jul	48	77			72	93		
20-Jul	59	81			71	95		
21-Jul	65	85			72	90		
22-Jul	66	88			68	88		
23-Jul	71	95			66	87		
24-Jul	73	89			66	88		
25-Jul	69	94			69	89		
26-Jul	56	83			69	93		
27-Jul	52	81			72	93		
28-Jul	52	86			74	95		
29-Jul	66	91			74	93		
30-Jul	69	90			72	93		
31-Jul	68	92			73	91		
1-Aug	58	83			72	93		

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Daily GDD	Acc GDD	Min	Max	Daily GDD	Acc GDD
2-Aug	49	82			69	93		
3-Aug	58	83			72	93		
4-Aug	62	81			69	97		
5-Aug	51	85			75	96		
6-Aug	58	75			76	97		
7-Aug	60	82			76	100		
8-Aug	57	76			75	101		
9-Aug	64	88			78	99		
10-Aug	64	89			78	100		
11-Aug	48	86			76	103		
12-Aug	54	73			74	93		
13-Aug	56	74			72	95		
14-Aug	53	75			76	98		
15-Aug	46	80			74	99		
16-Aug	41	75			73	98		
17-Aug	49	72			73	98		
18-Aug	53	74			71	93		
19-Aug	56	71			72	94		
20-Aug	58	65			72	95		
21-Aug	58	77			73	99		
22-Aug	49	85			78	102		
23-Aug	50	72			72	92		
24-Aug	47	70			73	93		
25-Aug	54	75			72	91		
26-Aug	58	89			73	91		
27-Aug	51	66			73	89		
28-Aug	47	64			74	92		
29-Aug	49	73			74	92		
30-Aug	57	79			73	93		
31-Aug	60	84			73	86		
1-Sep	59	87			73	80		
2-Sep	57	75			72	82		
3-Sep	54	88			70	87		
4-Sep	56	83			67	93		
5-Sep	56	93			68	91		
6-Sep	57	71			66	88		
7-Sep	45	67			71	87		
8-Sep	36	53			65	88		
9-Sep	39	64			62	89		

Table 1. Comparison Temperature Data

Crookston, MN

Plains, GA

Date	Min	Max	Daily GDD	Acc GDD	Min	Max	Daily GDD	Acc GDD
10-Sep	41	70			62	91		
11-Sep	33	55			71	93		
12-Sep	45	68			72	90		
13-Sep	32	54			70	89		
14-Sep	34	55			72	87		
15-Sep	36	68			68	87		
16-Sep	45	76			60	87		
17-Sep	53	73			63	83		
18-Sep	46	64			56	83		
19-Sep	48	65			55	82		
20-Sep	52	62			66	76		
21-Sep	42	64			70	80		
22-Sep	44	78			72	87		
23-Sep	62	91			73	88		
24-Sep	45	68			70	91		
25-Sep	43	57			66	89		
26-Sep	39	64			66	89		
27-Sep	33	65			67	86		
28-Sep	40	70			66	87		
29-Sep	55	80			60	84		
30-Sep	36	65			53	81		

Conclusion

1. How would the different harvest dates between Crookston, MN and Plains, GA be used to an advantage for marketing tomato crops?

2. Tomatoes typically produce their fruit over a period of several weeks to a month. Based on this information, what do you think will happen to the length of production time for tomato plants in Crookston, MN?

3. If someone asks why a crop such as cotton is only grown in the southern U.S., how would you explain it based on what has been learned in this activity?

4. What would happen to plant growth on a day with plenty of GDD units, but a lack of water? List the growth requirements for a plant and explain why meeting all but one of the requirements is not adequate for plant growth.

Name _____



Comparing Growing Locations

1. Define growing degree days.

2. How does climate and temperature influence where crops are grown in the United States?

3. Describe the difference between cool-season and warm-season crops.

4. Explain the relationship between temperature and plant growth.

Grade

High School

Materials/Preparation

- Teacher Material A – Photosynthesis – one per teacher
- Handout A – Photosynthesis Song – one per student
- Assessment A – Photosynthesis: We Can't Live Without It! – one per student

Photosynthesis

Minnesota K-12 Academic Standards

Science	9.4.2.2	Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.
Science	9C.2.1.3	Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.
Language Arts	9.14.2.2 11.14.2.2	Write informative/explanatory texts, as they apply to each discipline and reporting format, including the narration of historical events, of scientific procedures/experiments, or description of technical processes.

Summary/Overview

The process of *photosynthesis* is compared to baking cookies. Students learn the ingredients and end product of photosynthesis. Next they demonstrate their knowledge of the process by writing a song.

Garden Connection

Garden plants use sunlight and water to thrive through the process of photosynthesis,

Background Information

Plants are able to produce their own food through a process known as photosynthesis. They use energy from the sun to fuel a chemical reaction resulting in the production of glucose. Plants use the glucose they produce to grow and reproduce. The two other products of photosynthesis are oxygen and water. Plants do not need the oxygen and it is released as a byproduct. Humans benefit from the process of photosynthesis by utilizing the oxygen given off and eating fruits and vegetables produced by plants.

Objectives

- Describe the energy flow in the process of photosynthesis.
- List the beginning reactants or inputs and end products in photosynthesis.
- Apply the law of conservation of mass to photosynthesis.

Fun Fact

When first cultivated, green beans had a “string” that ran on the outer curve of the pod shell. This led to the nickname “string beans.” Botanists, however, found a way to remove the string through breeding and in 1894 the first successful stringless bean plant was cultivated. Today, nearly all varieties of edible pod beans are grown without strings.



Procedure

Interest Approach

Instruct students to make a list of ingredients used in baking cookies. Next have them describe the steps involved in baking cookies. Discuss student answers and list them on the board. Be sure to talk about inputs (ingredients), catalyst (warm oven temperature) and product (cookies).

Summary of Content and Teaching Strategies

Use Teacher Material A to show the photosynthesis diagram and equation. Arrows on the diagram indicate energy flow during photosynthesis. Carbon dioxide enters the plant through small openings called stomata. Water from soil is drawn up through the roots. Energy from the sun is absorbed by chlorophyll that is found in chloroplasts. Chlorophyll gives plants their green color by reflecting green light. It is within the chlorophyll that energy from the sun is able to convert carbon dioxide and water into glucose. Glucose is food manufactured by the plant. It is used to give the plant energy to grow and reproduce. Excess food is moved to the roots or stem to be stored in the form of sugar, starch or protein. Water and oxygen are byproducts of photosynthesis. Most photosynthesis occurs in leaves.

Discuss the concept of conservation of mass. Mass cannot be created or destroyed. This concept can be applied to the photosynthesis equation. Although the inputs undergo a chemical reaction, all molecules are accounted for in the product and byproducts. Add up the number of molecules for each element on both sides of the equation. They will be the same as no matter is gained or lost.

Provide students with copies of Handout A and review the details of their assignment. Students will be writing a Photosynthesis Song. Examples of songs can be found on [YouTube.com](https://www.youtube.com).

Review/Summary

Allow time for students to perform their songs for the class.

Modifications/Extensions

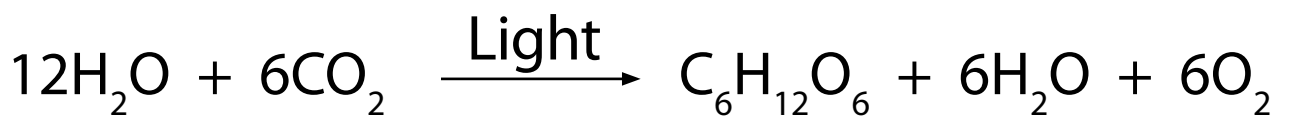
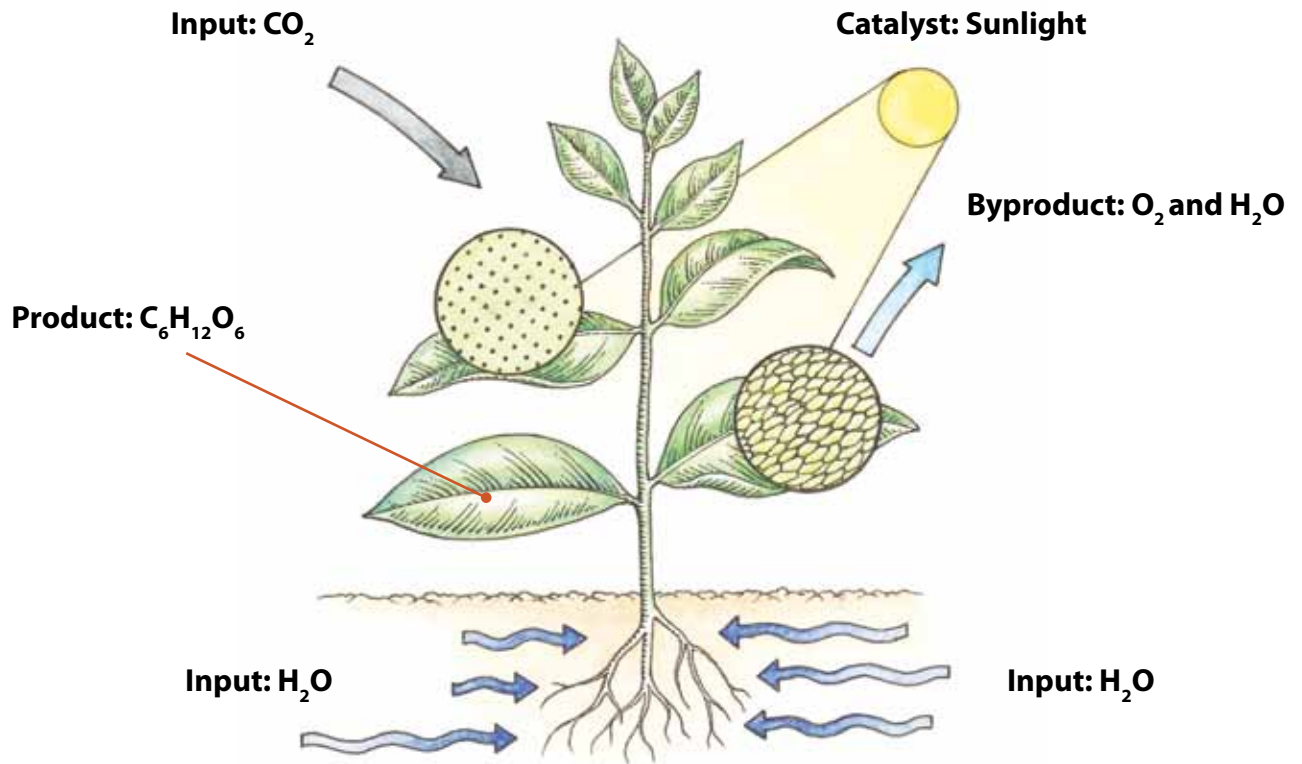
Explore the respiration process including the reactants and end products involved. Explain the function and importance of cell organelles for prokaryotic and/or eukaryotic cells as related to the basic cell processes of respiration and photosynthesis.

Have students research how seasons impact the photosynthesis process. Analyze how the rate of photosynthesis changes throughout the year. Instruct students to develop a pictogram illustrating photosynthesis during the span of one year. A pictogram is created when pictures are used instead of words.

Sources/Credits

This lesson was developed for the *Minnesota Garden Guide*.

Photosynthesis



Name _____



Photosynthesis Song

You are to rewrite the words to a song describing the process of photosynthesis. Songs can be written individually or in groups of two or three people. Choose a simple song such as a nursery rhyme or another song you know by heart like "Happy Birthday," "Take Me Out to the Ball Game," or "Whistle While You Work." Your song must include a chorus and three verses.

Make sure your song demonstrates your understanding of photosynthesis. The following words and definitions must be included:

- inputs
- products
- carbon dioxide
- sunlight
- photosynthesis

Include all items listed in the grading rubric

	Points Possible	Grade
Content		
Chorus	5	
Verse 1	5	
Verse 2	5	
Verse 3	5	
Describes photosynthesis	20	
Delivery		
Prepared Singers	5	
Creative	5	
Well organized	5	
Use of class time	5	
Total	60	

Name _____



Photosynthesis: We Can't Live Without It!

1. Describe the process of photosynthesis. You may write out the chemical equation, use words instead of symbols, or draw a picture. No matter which method you choose, be sure to include inputs, outputs, and the catalyst.

2. How does the law of conservation of mass apply to photosynthesis?

3. Explain how humans benefit from the process of photosynthesis.

4. How does human survival depend on photosynthesis?



Teacher Information

Food safety starts even before fruits and vegetables are planted in the soil. If your school intends to grow produce for human consumption, the quality and source of garden materials, soil, and water all need to be considered. Be sure all materials used to construct your garden are safe. Raised-bed gardens should be built with non-toxic, non-leaching materials. If you have chosen to have container gardens, the containers must not have been previously used to store chemicals or raw meat. The soil used in your garden should be tested for contaminants. Land use prior to the development of a garden should be examined. Purchased growing medium should be intended for growing food. Only potable water should be used to water plants and to wash or rinse vegetables. Ensure water tools including hoses, nozzles, and watering cans are also clean and safe.

Soil

Healthy soil is very important for good plant growth. Soil is different from dirt and rocks. It is the growing material found in the first few feet of the ground. Fertile soil feels crumbly and is dark in color. It provides a place for plant roots to grow and to access water and nutrients.

Plants need 14 essential nutrients from the soil. If these nutrients are not available in the amounts required, plants struggle to grow. The University of Minnesota will test your garden soil for a small fee. The test results assist you when fertilizing to ensure plants have all required nutrients. Soil testing should be done every three years. For more information, visit the University of Minnesota's Soil Testing Laboratory website, <http://soiltest.cfans.umn.edu/>.

Here are a few ideas to improve your soil and keep it healthy.

- Wait for dry soil: When wet soil is compacted, the air is pushed out. Soil without air is difficult to drain and has little room for root growth.
- Aerate garden: Introduce air into the soil by digging and turning soil with a shovel or rototiller. After the soil has been turned or tilled, avoid walking on and compacting the soil.
- Check for good drainage: Soil that dries quickly allows gardeners to begin planting in a timely manner. A well-drained soil allows oxygen to reach the root zone and fosters root health. Drainage can be improved by adding sand or compost.

Compost

Compost is made when microorganisms break down yard and food waste creating a nutrient rich organic substance. Benefits of compost include more nutrients, improved soil drainage, better water retention, and attraction of earthworms and other beneficial living things.

Many schools have created compost bins on site. Compost bins can range in size and material, but should not be too small, as the contents need to reach high temperatures to decompose. Carefully consider the location of the compost bin. Avoid areas near buildings, as beneficial bugs are not desired indoors. Bins should be protected from winds that could dry out the contents. There should be at least partial sun to assist with the heating process.



Numerous organic materials can be composted including grass, leaves, weeds, straw, plant-based food scraps, eggshells, and shredded newspaper.

The smaller the particle size, the faster items decompose. Items that should NOT be added to the compost pile include pet feces and animal products (meat, bones, grease, whole eggs, and dairy products). Plants that are diseased or infected by insects are best left out. It is important to note that some sources recommend only commercially purchased compost for your vegetable garden to ensure food safety. This is due to concern that homemade compost, if done improperly, does not get hot enough to render diseases harmless.

For more specific information on starting and maintaining a compost pile, read *Composting and Mulching: A Guide to Managing Organic Yard Wastes*. It is available online from the University of Minnesota Extension website <http://www.extension.umn.edu/distribution/horticulture/DG3296.html>

Planting the Garden

Careful planning will yield huge payoffs when planting the garden. Students enjoy digging in and getting their hands dirty, but need careful direction. First determine where plants will go. Next mark off each area with rope or flags. Be sure to allow room for walkways so students can access plants without damaging others. Gather all seeds, plants, and tools needed.

Divide the class into small groups of approximately six-to-eight students. If parents or volunteers are available to help, you can have all groups planting at the same time. If you will be the only adult, have other tasks for students when it is not their turn to plant.

Begin work in the garden by demonstrating how to plant. If you are direct seeding, read the instructions on the seed packet to find out planting depth and spacing. Be sure to label seed rows with an identifying marking. Students can create decorative labels if you have time. If you will be transplanting, show students how to carefully remove the plant from the pot. Gently squeeze or tap the bottom of the pot to loosen the soil and roots, being careful not to pull on the stem. Use a trowel or a spade to dig a hole the same depth and twice the width of the root ball. The plant should be the same depth in the ground as in the pot.

Newly planted seeds and transplanted plants should be watered shortly after planting. It is important to use a gentle flow of water so seeds and new transplants will not be disturbed. You can create “rain makers” using plastic food containers that have small holes punched in the bottom. Have large pails of water close to the garden for students to dip their rainmakers.

For more detailed information about specific vegetables visit the University of Minnesota Extension website <http://www.extension.umn.edu/topics.html?topic=5&subtopic=157>.

Additional Lesson Resources

Lesson: What's Living in My Soil

Grades: 4-5

Source: New York Agriculture in the Classroom

Curriculum: *Science of Life Explorations through Agriculture (SOLE)*

Location: www.agclassroom.org/ny/resources/pdf/activities/soil.pdf

Lesson: A Soil-a-bration and Soil Sort

Grades: K-2 and 3-8

Source: National Gardening Association

Curriculum: *Grow Lab: Activities for Growing Minds*

Location: Can be purchased from www.gardeningwithkids.org

Lesson: The Germinator

Grades: 2-7

Source: Activity Idea by the Exploratorium's Teacher Institute

Curriculum: Written by RAFT Education Department

Location: www.agclassroom.org/teen/agro/05_09/Germinator.pdf



Careful planning will
yield huge payoffs when
planting the garden.

Grade

Elementary 3-5

Materials/Preparation

- Teacher Material A – Soil Composition and Particle Size – one per teacher
- Handout A – Soil Type Triangle – one per student
- Assessment A – It all Begins with Soil – one per student
- Soil from different locations, several cups per site
- Scales
- Artificial potting mix
- Potting soil
- Hand lenses and/or microscopes
- Paper
- Tweezers or other utensils to separate components
- Quart jars with lids
- Water
- Rulers
- Writing instruments
- Notebooks (can be individual or class lab notebooks)
- Soil samples (one per group of two or three students)

You may provide students with soil samples from different areas, or you can ask them to bring in samples from their homes. When taking a soil sample, it is best to select a site where soil has not been disturbed by building or other projects. Collect samples from home gardens or fields instead of a location right next to a home. After collecting a sample, label the location from which it was taken.

It All Begins with Soil

Minnesota K-12 Academic Standards

Science	3.1.1.2	Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.
Science	5.1.1.2	Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.
Science	3.1.3.4 5.1.3.4	Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.
Science	5.4.2.1	Natural systems have many parts that interact to maintain the living system.
Science	4.2.1.1	Objects have observable properties that can be measured.
Science	4.3.1.3	Rocks are Earth materials that may vary in composition.
Math	K.3.2	Compare and order objects according to location and measurable attributes.
Math	3.4.1	Collect, organize, display, and interpret data. Use labels and a variety of scales and units in displays.
Math	4.4.1	Collect, organize, display and interpret data, including data collected over a period of time and data represented by fractions and decimals.

Summary/Overview

Students examine soil samples to identify its components and differences between samples.

Garden Connection

Most of the produce we eat is grown in soil.

Background Information

Most of the foods we eat are grown in soil across the planet. These soils differ a great deal due to the rocks that eroded to create it, the temperature and temperature changes that occurred as it developed, rainfall and humidity present as it developed, and other factors. Soil types are determined by the composition of sand, silt, clay, and organic matter. Soil types affect the soil structure, ability to hold nutrients, water, air, structural support for plant roots, habitat suitability for animal and microbial life, and more. This activity is an introductory exploration for students. Soil science is very complicated. It is actually a science and there are careers in this field.

Objectives

- To recognize there are many components found in soil that determines soil type.
- To recognize there are different soil types and determine soil type found in the school garden site.

Procedure

Interest Approach

Ask the students what soil is. Answers will vary. Most commonly they will say that soil is dirt. Explain that dirt is an unwanted item where soil is not. Soil is very important. Soil becomes dirt when it is where you do not want it but dirt and soil are not interchangeable words, although they are often used as such. Ask students if they would like to eat plants grown in the dirt that is cleaned up from sweeping the floor or vacuuming. No, but much of that dirt can be recycled back into soil that can grow plants. Show students Teacher Material A. Discuss the components of soil as well as the size of particles found in the soil.

Summary of Content and Teaching Strategies

Soil Components Activity

Distribute soil samples to groups of two or three. Use a sample that is approximately a ½ cup. Students weigh the ½ cup and record the amount in a lab notebook. Save the balance of the sample collected. Ask them to identify the components they can find in the soil sample. Make a list. (Minerals, insects, worms, leaves, etc.) Ask them to separate out into separate piles the different components that are large enough to see with the naked eye.

Next have the students examine the remaining soil under the hand lens or microscope and separate additional components if possible. Add these to the appropriate piles. Once they are all separated, students weigh each component and record the weight in their lab notebooks.

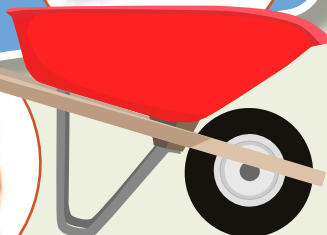
Discuss and calculate the percentage of each component. Provide a place on the board for students to share their results. Discuss the class findings and explain that different soils will contain different components. Have them speculate what this may influence. As a class, choose one sample to create a pie graph of the components. Optional: If your students are older, you may wish to have each group graph their own sample.

Soil Type Activity

Have the students return the components to their soil sample less any rocks, pebbles or live insects and worms. Return any living animals to the garden. Place two cups of soil in a quart jar and fill the jar with water. (If soil samples are obviously different, put several samples in separate jars and repeat the activity.) As the water is added, students will see bubbles rising showing the air being forced out of the sample. Place the lid on tightly, and shake up the sample. Then place the jar(s) in a location where it will not be jostled to allow the soil to settle. This may happen quickly or take several days to settle completely. The water will be clear when the total sample has settled.

Fun Fact

Squash is technically a fruit because it contains the plant's seeds, but it is treated like a vegetable. In addition to the squash fruit, its seeds can be eaten directly, ground into paste, or (particularly for pumpkins) pressed for vegetable oil. The shoots, leaves, and tendrils can be eaten as greens. The blossoms are an important part of Native American cooking and are also used as food in many other parts of the world.



The particles have settled according to size with the largest and heaviest on the bottom and smallest and lightest on the top. Explain the layer closest to the bottom is the sand, the next layer is silt, and the top layer is clay. Above that will be any organic matter including dead insects and leaves that may be floating on the water surface.

Using a ruler, have the students measure the total of the three lowest layers and record the total number of inches. Then have students measure and record each of the layers in their lab notebook.

Have students calculate the percentage of each soil sample that is sand, silt, and clay. Using Handout A, students determine soil types. You may wish to select one sample and determine the soil type as a class. Younger students will need help drawing their lines on the triangle diagram.

Review/Summary

Have the students collect soil samples from around the schoolyard and repeat the process to determine soil type.

Modifications/Extensions

Have students access <http://soils.usda.gov/use/thematic/> and <http://soils.usda.gov/use/worldsoils/gsr/> to examine soil issues in the United States and globally. Have them use this information to develop an opinion piece about the importance of soil to future world food production.

Download some soil type maps from sites such as these to examine a variety of soil maps and conditions (<http://soils.usda.gov/use/worldsoils/mapindex/index.html>) and a comparison of soil types in Russia (http://www.agroatlas.ru/en/content/soil_maps/Soil_types/).

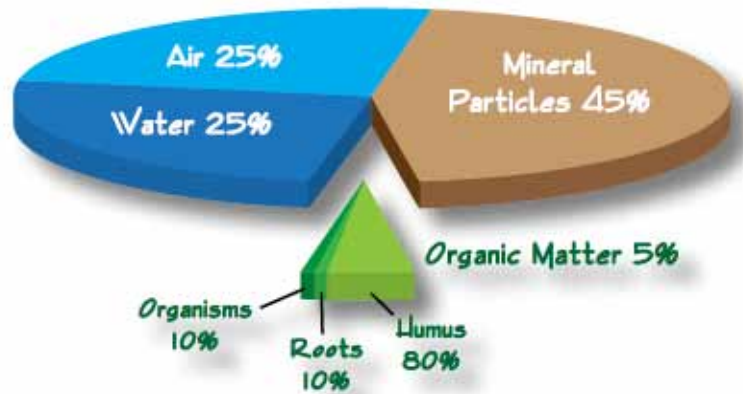
Have students access the Detailed Soil Survey Atlas and examine soil productivity for Minnesota at http://www.ngdc.wvu.edu/soil_survey_atlas/subpage_3 and write a short essay on Minnesota soils, their strengths, and weaknesses.



Sources/Credits

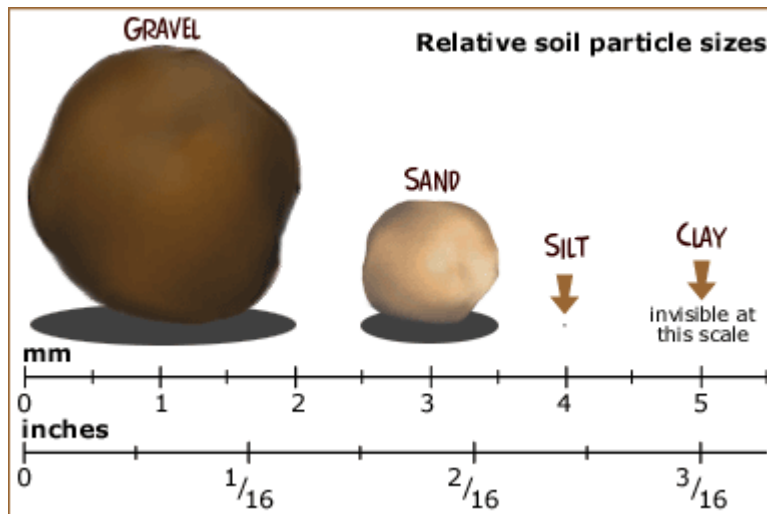
This lesson is provided courtesy of Florida Agriculture in the Classroom, Inc. from its Gardening for Grades school garden curriculum.

Soil composition and Particle Size



Pie Graph of Soil Composition

Source: www.physicalgeography.net/fundamentals/10t.html, accessed July 25, 2010



Source: http://school.discoveryeducation.com/schooladventures/soil/name_soil.html

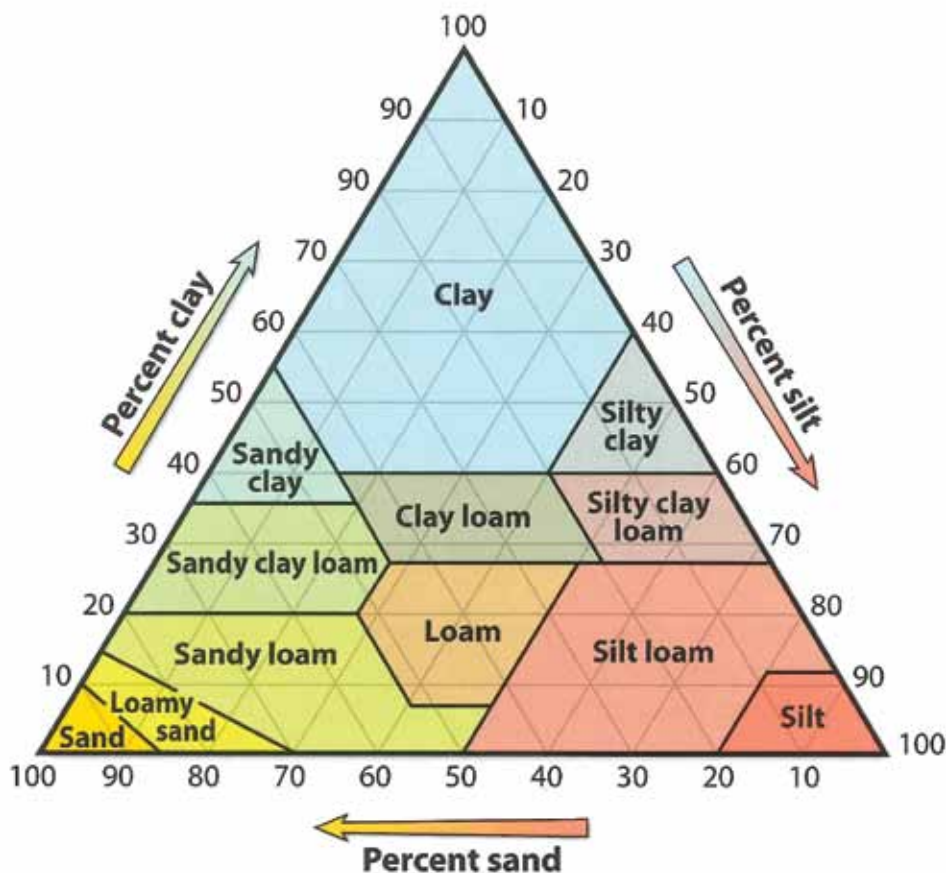


Soil Type Triangle

1. First find the percentage of clay in the soil sample along the clay side of the graph triangle. Using a ruler, draw a line across the graph parallel to the other percentage lines for clay.
2. Next find the percent of sand along the sand side of the triangle and draw a line across the graph parallel to the other percentage lines for sand.
3. Third, find the percentage of silt along the silt side of the triangle and draw a third line parallel to the percentage lines of silt.

The intersection of these three lines on the graph will fall within a soil type.

Write down your type of soil.



Name _____

If All Begins with Soil



1. Soil is made of:

2. The process for creating soil begins with _____.

- a. the weathering of rocks
- b. the ocean
- c. sandy beaches
- d. microorganisms

3. Soils differ around the world because:

4. List the mineral components of soil in order of largest to smallest:

5. Soil is alive.

- True False

Composting for Better Soil

Grade

Elementary 3-5

Materials/Preparation

- Teacher Material A – Mineral Comparison – one per teacher
- Teacher Material B – Soil Organisms – one per teacher
- Handout A – Composting Concepts: Moisture – one per student
- Assessment A – Composting – one per student
- Writing instruments
- Clear glass or plastic jar with lid
- Student access to the Internet, reference books, or other sources.
- Materials for lab: leaves (2 per student), magnifying glass, zippered sandwich bags (2 per student), and spray bottle of water
- Where the Sidewalk Ends* by Shel Silverstein
- A video reading of the poem “Sara Sylvia Cynthia Stout” can be found at http://www.teachertube.com/viewVideo.php?video_id=92707
- Garbage Helps Our Garden Grow: A Compost Story* by Linda Glaser

Fun Fact

Corn always has an even number of rows on each ear.

Minnesota K-12 Academic Standards

Science	3.4.1.1 5.4.1.1	Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.
Science	5.4.2.1	Natural systems have many components that interact to maintain the system.
Language Arts	3.6.3.3 4.6.3.3 5.6.3.3	Write narratives and other creative texts to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

Summary/Overview

In this lesson, students learn about composting: its definition, its effect on soil, how to make it, and what lives in it.

Garden Connection

Gardens provide us with the nutrients we need. Compost provides garden soil the nutrients it needs to support plants.

Background Information

Composting is a method of recycling as old as time. The Earth composts as a matter of course.

Compost releases its nutrients slowly, over several months or years. As students complete the activities, they begin to understand more about the relationship of healthy soil to healthy plants. For instance, the nutrients humans get from vegetables are because plants need many of the same minerals, and get them from the soil.

Composting is also a way to reduce the amount of trash going to the landfill. It is amazing to think of the amount of food waste that goes into trash bags; it is free fertilizer when used properly. Soil retains fertilizers better when enriched with compost. Less fertilizer runs off to pollute waterways.

Students are taught how to compost food scraps and garden waste, producing a product they can use to enhance garden and potting soil. Compost balances both acid and alkaline soils, bringing pH levels into a good range of nutrients. Compost is also natural topdressing for lawns.

Tiny organisms, especially microorganisms, do much of the work of composting. Time and weather are factors, but good microorganism activity speeds up the process. Students will learn about these organisms.

Compost helps bind clusters of soil particles (aggregates). Soil rich in aggregates is full of tiny channels and pores that hold air, moisture, and nutrients like a sponge. Compost helps sandy soil hold water and nutrients that would normally wash right out. Compost particles attract and hold nutrients strongly enough to prevent them from washing out,

but loosely enough so that plant roots can take them up as needed. Compost also breaks up tightly bound particles in clay or silt soil, allowing roots to spread, water to drain, and air to penetrate. It changes the texture and structure of all soils, increasing their resistance to erosion and making them easier to work with and cultivate (“A Green Guide to Yard Care,” Texas Natural Resource Conservation Commission).

The key to composting is adding a balance of materials. An easy way to do that is to include “greens,” or food and yard wastes such as fruit skins, rotting vegetables, and grass clippings. This adds active nitrogen. To avoid animal pests and odors, do not add meats, bones, dairy products, or fats. For best results, add an equal portion of “browns” to provide carbon. Browns are similar kitchen and yard wastes that have dried out such as dead flower stalks, dried leaves, and shredded paper. Adding paper from your shredder is an excellent way to balance the amount of kitchen scraps you use.



Keep the compost moist and always add some garden soil when you begin. Soil contains the organisms you need to help the composting process.

Some classrooms may be able to start a composting project at their schools, especially if they are including an outdoor garden in the year’s activities. Some people have concerns that composting will attract pests and produce odors. Too many decomposing fruits and vegetables can cause odor. But when the compost has a good balance of wet to dry, and is turned so that it is not compacted (greens to browns), odors do not occur or are minimal. For that reason, it is best to locate a compost pile close enough to your building or home to be usable, but far enough away to not cause concerns about odors and pests.

Many classrooms that cannot use an outdoor compost pile will try indoor composting, called vermiposting. Many Cooperative Extension programs and nurseries offer composting classes or directions.

Objectives

- Define composting.
- Describe what happens in a compost pile.
- List the components of a compost pile.
- Name an organism that lives in compost.

Procedure

Interest Approach

Read the poem, “Sara Sylvia Cynthia Stout” from Shel Silverstein’s *Where the Sidewalk Ends*. This humorous poem is about a little girl who lived with her father and would do anything except throw the garbage out. As a result, it piled as high as the sky. Your class will love it, and it can be a springboard for discussion on what else she might have done with the garbage. In the poem, there is a long litany of items Sara piled high. Have students make a list of the garbage mentioned in the poem.

Summary of Content and Teaching Strategies

Begin a class discussion on compost. Questions to use as discussion starters might include:

- What do you know about composting?
- What is going on in the compost pile or bin?
- What are microorganisms?
- What does healthy soil have to do with you?
- Why is compost good for plants?
- How can you make compost?
- What lives in a compost pile?

Read the book *Garbage Helps Our Garden Grow: A Compost Story*.

A quick, optional decomposition lesson can be found on Handout A.

Compost is a rich, soil-like mixture that is produced when organic matter breaks down. When compost is added to soil, it adds nutrients that plants need and improves soil texture.

Ask students if they see anything similar about the two words compost and decompose. Discuss fruit that has been in the kitchen too long and how it starts to get soft and black. It is decomposing. This means it is changing and breaking down.

Composting is a way to recycle and make usable product from things we might throw out, like apple cores, eggshells, dried leaves, and wilted lettuce. We can create a compost bin or pile in our yards. Add “greens” like kitchen scraps, “browns” like yard wastes, some water and some garden soil. This is the recipe for a compost pile! Do not add meat scraps or fats like butter or cheese. Ask students to look at their list of garbage from the Shel Silverstein poem. Discuss which items would be appropriate for composting and which should be thrown away.

Show Teacher Material B. Microorganisms are tiny creatures that live in the soil and feed on organic matter. Organic matter is made up of things that were once alive, or part of something alive. It will decompose (break down) over time. Microorganisms help the process of decomposition. They eat what we wouldn't! They help change a banana peel into a rich, brown product called humus. Sometimes they are so active they create heat. A warm or “hot” compost pile is breaking down rapidly.

Compost is good for plants because it improves soil. Plants need nutrients just like we do. If foods grow in healthy soil, they are more likely to give us the nutrients we need. Ask students how they would probably feel if the foods they ate had very few nutrients in them because they grew in poor soil. Show Teacher Material A and review minerals needed by people and plants.

Compost is made by layering greens and browns. Moisture and microorganisms are needed to assist in decomposing the greens and browns.

- **greens** - kitchen and yard waste (like grass clippings)
- **browns** - dried leaves, garden wastes, and shredded paper
- **moisture** - do not let the compost dry out, but don't over-water it, either
- **microorganisms** - add some garden soil; the living microorganisms in the soil feed on the compost materials, multiply, and break down your wastes.

Compost piles should be turned or stirred. Active compost heats up as microorganisms go to work. The more it heats, the sooner it will be ready to use.

Many organisms live in compost to help the ingredients decompose.

Sources/Credits

Adapted from New York Agriculture in the Classroom and Cornell University's *Sciences of Life Explorations (SOLE)*. The full lesson plan can be viewed at <http://www.agclassroom.org/ny/resources/pdf/activities/composting.pdf>

Examples of organisms found in compost include earthworms, snow bugs, millipedes, pill bugs, springtails, soil mites, beetles, ants, centipedes, land snails, soil bacteria, nematodes, and soil funguses. Assign students or groups of students an organism to research. They create a poster that answers the following questions:

1. What is the name of your organism?
2. What does it eat?
3. Can you see it without magnification?
4. Is it an insect? If not, what is it? (Remember, insects have six jointed legs.)

Share the posters with the class.

Review/Summary

As a class, review the questions below:

- What do you know about composting?
- What is going on in the compost pile or bin?
- What are microorganisms?
- What does healthy soil have to do with us?
- Why is compost good for plants?
- How can we make compost?
- What lives in a compost pile?

Modifications/Extensions

Build a compost bin on the school grounds. Have students and parents assist with the construction. Once the bin is ready to be filled, students collect greens and browns from around the school and help with the layering process. More information on composting is available from the University of Minnesota Extension website at <http://www.extension.umn.edu/distribution/horticulture/DG3296.html>.

Mineral comparison

Look at the list of minerals that people need to be healthy.

Look at the list of minerals that plants need to be healthy.

Circle the mineral nutrients that are needed by both people and plants.

People need:

Boron
Calcium
Chromium
Copper
Fluoride
Iodine
Iron
Magnesium
Manganese
Molybdenum
Nickel
Phosphorus
Potassium
Selenium
Vanadium
Zinc

Plants need:

Boron
Calcium
Chloride
Copper
Iron
Magnesium
Manganese
Molybdenum
Nitrogen
Phosphorus
Potassium
Sulfur
Zinc

Soil organisms

These organisms can typically be found in one cup of undisturbed native soil.

Bacteria	200 billion
Protozoa	20 million
Fungi	100,000 meters
Nematodes	100,000
Arthropods	50,000

Source: Colorado State University Extension

Insert pictures of above named organisms

Name _____



Composting Concepts: Moisture

Moisture content is one of the key ingredients for composting. This activity helps you discover its importance.

Leaf experiment

Materials

- leaves
 - magnifying glass
 - zippered sandwich bags
 - spray bottle of water
1. Bring two green leaves to school.
 2. Observe leaves with a magnifying glass. Draw a picture of each leaf in the chart below.
 3. Put each leaf into a plastic bag and label with your name.
 4. Seal one bag (label it CLOSED) and leave the other one open (label it OPEN).
 5. Twice a week, spray water lightly on the leaf in the CLOSED bag. Leave the OPEN bag dry.
 6. Predict what changes you expect to see and record them in the space below.
 7. Observe your leaves, making note of changes so you can compare them with your initial prediction.

Prediction

observations

Day	closed Bag	open Bag

conclusion

Write a summary of the experiment and your findings.

Name _____



Composting

1. Composting is *(check one)*

- a way to recycle.
- a way to make soil healthier.
- a process using microorganisms to help break down organic matter.
- all of the above.

2. Kayley is creating an outdoor compost bin and she is ready to fill it. She has vegetable scraps, grass clippings, weeds from the flower garden, and some soil. She has a full water bucket ready to pour. What is she missing? *(circle one)*

meat scraps

leaves, pine needles, and shredded paper

moldy cheese

diseased plants

3. Name two organisms that live in compost piles.

4. Plants and people need many of the same mineral nutrients.

- True False

5. Name two things you should not put into a compost pile or bin.

6. Organic is something that is living or once living. Name something that is inorganic.

7. Is paper an organic material?

Yes

No

Why?

Grade

Elementary K-5

Materials/Preparation

- Handout A – Yo Seeds, Wake Up! – one per student
- Seeds (suggested: beans, mung beans, sunflowers)
- Writing instruments
- Plastic bags
- Paper towels
- Refrigerator

optional

- Frog and Toad Together* by Arnold Lobel

Fun Fact

Zucchini is sometimes called Italian squash, green squash, or summer squash. Zucchini seeds are soft and edible.



Yo Seeds, Wake Up!

Minnesota K-12 Academic Standards

Science	0.1.1.2 2.1.1.2 3.1.1.2 5.1.1.2	Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.
Language Arts	3.6.7.7	Conduct short research projects that build knowledge about a topic.
Language Arts	4.6.7.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
Language Arts	5.6.7.7	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Summary/Overview

Students examine ideas about what seeds need to sprout.

Garden Connection

Oxygen, water, and proper temperature are required for seeds to begin growing.

Background Information

You can hold 100 radishes in one hand, 1,000 carrots in the other, and a wildflower garden in your front pocket — for in every seed lives a tiny plant, or embryo, complete with a leaf, stem, and root parts.



The seed coat protects the embryo. A temporary food source nourishes (“feeds”) the embryo, either as an endosperm packed around the young plant or stored in special leaves called cotyledons. Most seeds are either monocots, having one cotyledon, or dicots, with two. Seeds remain inactive until conditions are right for them to begin to grow, or germinate.

All seeds need oxygen, water, and the proper temperature range in order to germinate. Some seeds require light; others require darkness. Oxygen and moisture, initially taken through the seed coat and later by the root, help the seed get energy from its food supply. Different types of seeds have specific temperature needs and preferences for germination. Some require warmer temperatures — 70-to-75 degrees Fahrenheit is ideal for tomatoes — and others germinate better in cool temperatures — 40-to-65 degrees Fahrenheit is ideal for lettuce. Many seeds also require the proper light conditions to germinate. Some require light to germinate and others are inhibited from germinating by light.

When a seed is exposed to proper conditions for germination, water is taken in through the seed coat. The embryo’s cells begin to enlarge and

the seed coat breaks open. The root emerges first, followed by the shoot, which contains the stem and leaves.

Our treatment of seeds during germination affects their chances of survival. If seeds (particularly small ones) are planted too deeply, the young plants can use up their food reserves before they ever reach light and begin to make their own food. If planted in soil that's too dry, seeds may not get the necessary moisture to germinate. Soaking wet soil, on the other hand, may prevent seeds from getting oxygen, or may cause them to rot.

Objectives

- To predict what factors will affect seeds' sprouting.
- To understand that certain factors affect seeds' sprouting.

Procedure

Interest Approach

Pass some seeds around the classroom. Ask: Do you think these seeds are alive? Why or why not? How could we find out if they're alive? If they are alive, what do you think will make them start to grow? Explain that when seeds begin to grow, we call it 'sprouting' or 'germinating.' As a class, brainstorm a list of factors students think seeds need to sprout. List them on a class chart.

Optional: Read the story called "The Garden" in *Frog and Toad Together*. After reading the story, add Toad's ideas about how to "wake up" seeds on the class chart. Discuss some of Toad's ideas. Ask: "Do you think yelling might wake seeds up?" Were Toad's ideas the same as or different from those of the student?

Summary of Content and Teaching Strategies

Have the class test some of the ideas from the chart to find out what helps seeds sprout. Use large seeds such as beans or, if you want to have edible sprouts, try mung beans or sunflowers. (Alfalfa and radish seeds also make nice edible sprouts, but may be too small for young students to handle.)

Week 1 – Moisture

If water was one of the factors mentioned by students, ask: "Do you think seeds need to be moist or dry to sprout?" What have students seen that makes them believe this? List the headings "Moist" and "Dry" on the

board, and have students suggest how they could try and sprout seeds in different conditions (e.g., by using sponges, paper towels, or soil).

If none of the students' ideas resembles the experimental setup below, suggest it as another option. As a class, choose several setups to test both moist and dry conditions.

Ask: "How will we decide when seeds have sprouted?" Tell students they must decide together what constitutes 'sprouting' in their experiments. Is it when they see the root or when it's two centimeters long?

Using Handout A, have students draw setups for both moist and dry conditions. Each day, students should fill in the total number of seeds that have sprouted to date.

At the end, have students chart on a bar graph the number of seeds sprouted in the setup. Guide their thinking with questions such as, How did seeds seem to sprout best? How did you decide when they'd sprouted? Why do you think we tried sprouting seeds in different conditions? What factors, other than the amount of water, might have affected whether seeds sprouted? (e.g. some may have been in a warmer spot.)

What to expect: Within five days, most of the moist seeds should have sprouted, but not the dry seeds. If the students' setups included submerging seeds in water, they may find that seeds fail to germinate when too wet.

Week 2 – Temperature

If students mentioned temperature as a factor to help seeds sprout, discuss: Do you think seeds might sprout better in warmer or cooler temperatures? What have you ever observed that makes you believe that? How do you think we should set up a test to see whether warm or cool conditions help seeds sprout? List student suggestions for the setup under the headings "Warm Temperatures" and "Cool Temperatures."

Suggest the setup below (or on the next page) as another option. As a class, use several of the suggested setups to test how temperature affects seed germination.

Ask: "From what we've already learned, do you think we should keep the seeds moist or dry from this experiment? If the cool-temperature seeds are in a dark refrigerator, where should we place the warm-temperature seeds?" Remind students that they must give both sets of seeds the same conditions except for temperature, to have a fair test. If we kept one set

of seeds in cool, dark conditions and one in warm, light conditions, how would we know whether it was temperature or light that affected sprouting? The warm-temperature seeds, therefore, should also be in a dark place.

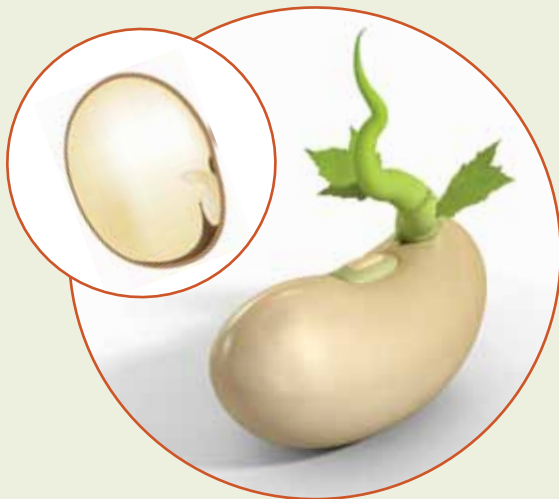
Students keep track of their investigations, as in Week 1, using the worksheet. Have them chart the number of seeds that sprouted after five days under both warm and cool conditions. Ask: "How did seeds seem to sprout best? What do you think would happen if we tried sprouting seeds in warm, dry conditions? In cool, moist conditions?"

What to expect: Within five days, you should find seed sprouting is generally improved with moderate warmth and inhibited with cool temperatures. Temperatures at either extreme can inhibit sprouting.

Week 3 – Students' and Toad's Ideas!

Review the suggestions made by the class and by Toad. Have the class vote on one condition, or have small groups each choose one condition to test. Set up investigations similar to Weeks 1 and 2 to determine what other conditions (e.g. light, yelling, fertilizing, singing) help seeds to sprout. Help students think about whether they're conducting fair tests (with one variable).

When all experiments are complete, combine results on a class graph. Ask: "What conditions seemed to be the best for sprouting seeds?"



Sources/Credits

Adapted from the National Gardening Association's *Grow Lab Activities for Growing Minds*, second edition, copyright 2009. For information on obtaining a copy of their curriculum, visit www.gardeningwithkids.org.

Review/Summary

Review the following questions with your students:

- How did you decide when seeds had sprouted?
- Were you surprised by any of your findings? Which ones?
- If we knew some seeds preferred warmth, could we assume that they preferred very hot temperatures? Why or why not? How could we find out?
- Would you plant bean seeds outside in December? Why or why not?
- What other questions do you have about seed sprouting?

Modifications/Extensions

After reviewing findings, write a class recipe for making sprouts to eat. Grow and taste different edible sprouts. Prepare different sprouted foods (e.g., salads, soups, "hairy" peanut butter sandwiches.)

Play Seedling Tic-Tac-Toe. Divide flat containers into nine squares. Plant one type of seed in each square. The first student to have three germinated seeds in a row wins.

Move the plants from the experiments in this lesson outdoors into your school garden. Observe how large the plant becomes compared to the tiny seed it all started from.

Name _____



Yo Seeds, Wake Up!

Draw your setups:

Condition:

Condition:

Number of seeds used: _____

How many seeds have sprouted by...

Day 2	
Day 3	
Day 4	
Day 5	

Number of seeds used: _____

How many seeds have sprouted by...

Day 2	
Day 3	
Day 4	
Day 5	

Other Observations:

Grade

Middle School

Materials/Preparation

- Teacher Material A – Vocabulary Organizer – one per teacher
- Teacher Material B – Soil Test Results – one per teacher
- Handout A – New Terms – one per student
- Assessment A – Soil Testing 1, 2, 3 – one per student
- Pictures or samples of plants with nutrient deficiencies
- Soil testing kit available from a garden center or the LaMotte Top Soil Tour Kit from Carolina Biological Supply Company
- Soil sample from school garden plot or container
- Soil samples from other locations; students may bring samples from home

Get a soil testing kit before the lessons. If you have the LaMotte Top Soil Tour Kit, read through the suggested units provided. Duplicate any handouts, procedures, or background information students may need to complete the experiences. Prior to the lesson, instruct students to collect soil samples from a lawn near their home.

Soil Testing 1, 2, 3

Minnesota K-12 Academic Standards

Science	7.4.2.2	The flow of energy and the recycling of matter are essential to a stable ecosystem.
Language Arts	9.5.4.4	Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language of a court opinion differs from that of a newspaper).

Summary/Overview

Students learn terms associated with soil science. Using soil samples from several locations, students test for nutrient levels. A soil testing kit is required for this lesson.

Garden Connection

Students collect soil samples and analyze them to determine the soil composition.

Background Information

We live on soil. Fibers for our clothes are collected from crops grown in various types of soils. The basis of the USDA MyPlate nutritional guide is supported by soil. Soil also provides a home for microorganisms and animals that replenish the soil with nutrients that are required for everything mentioned above.

Plants in soil need various amounts of each element to be healthy. The concentration of an element in the soil can be directly related to how well the plant produces. The element must be present in an optimum dose, not too much or too little. In the agricultural industry, managing proper soil fertility is critical for a good harvest. Rotating crops is important, as nutrients need to be replenished in the soil. Planting the same crop year after year in the same soil depletes the soil of certain nutrients. Producers

Fun Fact

Sweet corn comes from the maize family. Its scientific name is *Zea mays*. Other types of maize, or corn, are used as flour to make some types of bread and breakfast cereals. Popcorn is also a type of maize.



test their soil to determine levels of nutrients. This information helps them determine the best way to manage their soil.

Objectives

- Organize soil testing vocabulary terms according to theme.
- Conduct a soil test.
- Compare nutrient levels in different soil samples.

Procedure

Interest Approach

Display pictures or samples of plants with nutrient deficiencies. (Find images of nutrient deficient plants on Google Images.) Ask students if they know what is wrong with the plants. Explain that just like us, plants need certain nutrients for healthy growth. Some nutrients are needed in larger amounts than others. Even though some nutrients are needed in small quantities, all essential nutrients are important for healthy plants.

Next ask students where plants obtain the nutrients they need. Discuss how plants absorb nutrients from the soil. If the soil is lacking in required nutrients, plant health suffers. Soil tests reveal nutrient levels and assist gardeners in applying correct amounts and types of nutrients.

Summary of Content and Teaching Strategies

Discuss the terms on Handout A. Show Teacher Material A and lead students through the vocabulary organizer as described. When students are finished they compare with other groups or the whole class.

Conduct activities and labs selected from the LaMotte Top Soil Tour Kit. Students record their test results. They also write a recommendation for the soil. For example: add nitrogen and decrease potassium.

Review/Summary

When students have completed their soil tests, have them write their results on Teacher Material B. Discuss the difference between samples.

Modifications/Extensions

Have students select a career related to soil science. They research the career and write a report including basic information such as general work activities, skills and abilities, working conditions, preparation, wages, and employment outlook. Include a paragraph on how the career relates to soil science.



Sources/Credits

Adapted from *Technology, Life and Careers Agricultural Science and Technology Instructional Guide*, project of the Utah State Office of Education. Protect Director Richard M Joerger, PhD., developed and written by Brenda Mager and Kari Osterhout, 1995.

Vocabulary organizer

1. Break into groups of two or three students.
2. Cut the new terms found on Handout A into strips.
3. Look for common themes in the terms and organize them in groups.
4. Create descriptive titles for the themes and list across the top of a piece of paper. (It may be helpful to turn the paper to the landscape orientation.)
5. Terms may be used in more than one theme, while others may not fit into a theme.

Example Answers

Theme: It's Alive

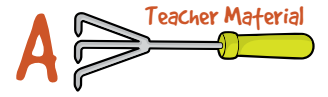
Terms: decomposers, legumes, and microorganisms

Theme: pH

Terms: pH, acidic soil, alkaline soil

Theme: Elements

Terms: micronutrient, macronutrient



Soil Test Results

Student(s) Name(s)	Soil Sample (location of sample)	pH Level (#, basic, acidic)	Nitrogen Level (low, medium, high)	Potassium Level (low, medium, high)	Phosphorus Level (low, medium, high)



New Terms

pH: a measure of how acidic or basic things are.

Acidic soil: soil with a pH value of less than 7.0.

Alkaline soil: soil having a pH greater than 7.0.

Compost: a mixture of dead and decaying organic matter-leaves, garbage, animals with soil. Bacteria in the soil break down the organic matter into soil and nutrients.

Decomposers: animals and microorganisms that help break down organic matter in the soil: worms, bacteria, fungus, etc.

Extraction: separation of plant nutrients from soil samples by dissolving them and filtering out soil particles.

Filtrate: the liquid solution that passes through a filter.

Humus: very decomposed organic matter; contains mainly carbon, nitrogen, phosphorus, and sulfur.

Legumes: a group of plants that have a unique capability of converting nitrogen in the atmosphere into a form that can be used by the plant. Alfalfa, clover, peanuts, and soybeans are examples of legumes.

Macronutrients: an essential chemical element needed in large amounts for the healthy growth of plants – Nitrogen (N), Phosphorus (P), and Potassium (K) are considered the primary macronutrients

Micronutrients: an essential chemical element needed only in extremely small amounts for the healthy growth of plants.

Microorganisms: living organisms that are so small individually they can only be seen through a microscope.

Organic matter: remains of decomposed plants and animals.

Soil: the top layer of the Earth's surface; a mixture of mineral, organic matter, and living things in which plants grow.

Topsoil: the upper layer of soil that contains the greatest amount of decomposed organic matter and plant nutrients.

Name _____



Soil Testing 1, 2, 3

Matching

Place the letter of the correct vocabulary word the corresponding definition.

- | | |
|--------------------------|---|
| A. pH | 1. _____ an essential chemical element needed in large amounts for the healthy growth of plants – Nitrogen (N), Phosphorus (P), and Potassium (K) are considered the primary macro elements. |
| B. Acidic soil | 2. _____ a measure of how acidic or basic things are. |
| C. Alkaline soil | 3. _____ an essential chemical element needed only in extremely small amounts for the healthy growth of plants. |
| D. Macronutrient | 4. _____ the upper layer of soil; contains the greatest amount of decomposed organic matter and plant nutrients. |
| E. Micronutrient | 5. _____ soil with a pH value of less than 7.0. |
| F. Organic matter | 6. _____ the top layer of the earth's surface; a mixture of mineral, organic matter, and living things in which plants grow. |
| G. Soil | 7. _____ any soil having a pH greater than 7.0. |
| H. Topsoil | 8. _____ remains of decomposed plants and animals. |

Grade

Middle School

Materials/Preparation

- Teacher Material A – Germination Research Activity – one per teacher
- Assessment A – Multiple Choice Quiz – one per student
- Clear plastic cups
- Cotton balls
- Pea seeds
- Bean seeds
- Radish seeds
- Corn seeds
- Water droppers
- Thermometers
- Various fluids
- Various lights (grow light, incandescent, fluorescent, halogen, LED)
- Paper

Fun Fact

Both summer and winter squash belong to the plant family that contains melons and cucumbers, and come in many different shapes and colors. Even though some varieties grow on vines and others grow on bushes, squash are commonly divided into two groups, summer and winter.



Germination Research

Minnesota K-12 Academic Standards

Science	5.1.1.2.	Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.
Science	7.1.1.2	Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.
Language Arts	6.14.2.2	Write informative/explanatory texts, as they apply to each discipline and reporting format, including the narration of historical events, of scientific procedures/experiments, or description of technical processes.

Summary/Overview

Students discuss factors that affect the amount of time it takes a seed to germinate. Then they perform a mini experiment involving the steps of the scientific theory.

Garden Connection

Germination occurs when a seed sprouts a tiny plant. Students learn factors that influence germination.

Background Information

Germination is when a sprout is seen coming out of a seed. When a seed is planted, the goal is for it to sprout and grow into a plant. However, many things can either stop or enhance the sprouting of a seed. Factors that may influence germination include amount of light, temperature, type of moisture applied, type of seed, time of day planting occurred, orientation of seed, and type of gas exposed to the seed (i.e. carbon dioxide, oxygen).

Objectives

- Define germination.
- List factors that influence seed germination.
- Apply research methods to investigate an agricultural problem.

Procedure

Interest Approach

Show students a dying houseplant. As they observe this yellowish/brown and wilted plant they might start to ask questions: How did it become wilted? What caused it to turn brown? As students observe this gloomy-looking plant, their questions become a hypothesis for why the plant is dying. Ask students to name the process they are beginning (scientific process).

Summary of Content and Teaching Strategies

Inform students they will conduct the first few steps of the scientific method while carrying out a seed germination lab. Start by discussing the definition of germination: when a sprout is seen coming out of a seed. Have students write the definition in their notes.

Explain that seeds are planted with the goal of growing a plant. However, many things can either stop or enhance the sprouting of a seed. Lay out five to ten different seeds on a display table or pass them around for students to observe. Pictures of seeds could be used in place of real seeds.

Observation

Have students write down three to five observations about the seeds; this may include seed size, shape, color, or texture. They may be individual observations or comparable. Students share their observations with the class.

Question

If the goal of the seed is to sprout, what factors affect the amount of time it takes for a seed to germinate? Start a classroom discussion that evaluates what affects the seed germination rate. Ask questions such as: What factors make a seed germinate? What would stop a seed from germinating? What is the ideal condition for a seed to germinate the quickest? Take notes on the board. Answers could include:

- Amount of light
- Temperature
- Amount and type of moisture applied
- Type of seed
- Time of day planting occurred
- Orientation of seed
- Type of gas exposed to the seed (i.e. carbon dioxide, oxygen)

Students should select one of the factors mentioned during the discussion to test. They should develop a question about the factor.

Hypothesis

Next students will create a hypothesis. They should make an educated guess answering the question they developed. The hypothesis must be a prediction about what will happen when the selected question is tested.

Test

After students create a hypothesis, have them follow the steps on Teacher Material A to start their lab. Use a variety of different seeds. It is best if students are able to plant their seeds on a Monday so they have 24-hour intervals to watch their seeds germinate.

Although everyone's hypothesis may be slightly different, all students complete the first three basic steps of the procedure. Have students retrieve their lab materials from the display table and return to their seats. Next they follow steps one through five, or modify these steps based on their hypothesis.

Review/Summary

Have students think back to when they were small children. Ask them to name their favorite Mother Goose rhyme. Students now create their own nursery rhymes. Divide the group into pairs or trios. Challenge them to re-write the words with their newly learned knowledge about the scientific method to the rhyme of "Mary Had a Little Lamb." Rhymes should have a title and includes all five steps of the scientific method. Give students five minutes to write rhymes. If student groups are reluctant to share, have an example ready to show your own involvement. Grade students on completed content and creative elements.

Modifications/Extensions

If your school has a greenhouse, take students out to the greenhouse and have them work on planting seeds of bedding plants for a plant sale.

Have students create a card (business card size) with the scientific method printed on it. Attach the card to a magnet and display as a reminder in a locker or another handy place.

Sources/Credits

Adapted from: National FFA Organization *Middle School Food and Agricultural Literacy Curriculum*, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit www.ffa.org/documents/learn/MS.AST.2.6.pdf to access the full-length version of this lesson.

Germination Research Activity

Germination: when a sprout is seen coming out of a seed.

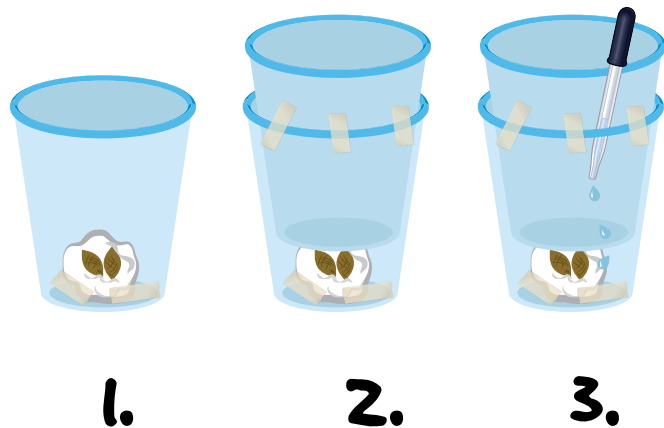
Question

What factors affect the amount of time it takes for a seed to germinate?

Laboratory Steps and Set-Up

Procedure:

1. Tape a cotton ball containing two seeds to the inside of a plastic cup.
2. Place another cup inside the first to further secure the seeds.
Tape the inside cup in place.
3. Use a dropper to add liquid so the cotton ball does not dry out.
4. Make observations each day.



Writing Activity

Incorporate the five steps of the Scientific Method when writing your nursery rhyme.

Five Steps of the Scientific Method:

1. Observation
2. Question
3. Hypothesis
4. Test
5. Conclusion

Name _____

Multiple Choice Quiz



1. When observing seed germination, which attributes of a seed will you observe?
 - a. Shape
 - b. Size
 - c. Color
 - d. All of the above

2. The definition of germination is what?
 - a. When a sprout is seen coming out of a seed
 - b. When a seed grows
 - c. When a plant produces flowers
 - d. When a seed is planted in soil

3. Observations and hypothesizing are the first steps in what process?
 - a. Scientific process
 - b. Scientific method
 - c. Scientific theory
 - d. Scientific steps

4. An educated guess is what?
 - a. Observation
 - b. Test
 - c. Hypothesis
 - d. Conclusion

5. After creating a hypothesis, you must examine what _____ may influence it.
 - a. steps
 - b. factors
 - c. observations
 - d. people

Grade

High School

Materials/Preparation

- Materials/Preparation
- Teacher Material A –Potting Media Components – one per teacher
- Handout A – Sorting Out Potting Soil – one per student
- Assessment A – Sorting Out Potting Soil – one per student
- 100 ml graduated cylinders
- 30 ml cup
- Electronic balances
- Calculators
- Ziploc® bags – quart size
- Permanent marker
- Paper towels
- Premixed potting media
- Media components: vermiculite, perlite, peat moss, bark, pumice, sand, Osmocote®
- Notebooks
- Writing instruments

You will need to prepare the samples for Part 1 of this activity by placing a small amount (approximately 1 cup) of each of the media components into a quart size Ziploc® bag. Media components include vermiculite, perlite, peat moss, bark, pumice, sand, Osmocote®, and dry potting media. Label each bag with a permanent marker. Students work in pairs for this activity; you will need enough sets to accommodate half of the class enrollment. Media samples can be purchased from Ward's Science or a garden supply center.

Sorting out Potting Soil

Minnesota K-12 Academic Standards

Math	9.2.4	Represent real world and mathematical situations using equations and inequalities involving linear, quadratic, exponential and nth root functions. Solve equations and inequalities symbolically and graphically. Interpret solutions in the original context.
------	-------	--

Summary/Overview

After learning about the uses and components of potting media, students observe and calculate percentages of potting soil components.

Garden Connection

Potting medias are used to grow container plants. These medias are carefully composed to assist plants in growth.

Background Information

Mineral soils are made up of three main components: sand, silt, and clay in varying quantities depending on where in nature they are located. Mineral soils taken from fields, gardens, or lawns are not suited for container-grown crops because of weight and drainage issues. Excess weight adds management problems and costs for shipping live plant materials. Mineral soils can also be so dense that water holds to the particles too tightly to drain adequately. A good potting media, made up a variety of materials such as perlite, vermiculite, and peat moss, provides a balance of the proper drainage, porosity, and water retention plants require.

Not all potting media mixes are the same. The use of specific mixes varies depending upon the type and the growth stage of plants. Another factor is whether the plant is grown outdoors for a long period of time, such as perennial nursery plants, or indoors, such as houseplants. No matter what the intended use of the media mix is, the goals are still the same: to provide porosity for good aeration and drainage and at the same time hold adequate moisture to prevent the constant need for irrigation.

Objectives

- Understand the purpose of using potting media.
- List the three types of ingredients found in commercial potting media.
- Identify components commonly used in potting media.
- Determine the percentage of ingredients found in potting media.

Procedure

Interest Approach

Display several samples of components of potting soil as prepared for the activity on Handout A. Ask students if they know the names of the samples and the role they play in a potting medium. Explain that this lesson helps them understand the ingredients found in potting media and their purpose.



Summary of Content and Teaching Strategies

Present and discuss Teacher Material A with students. Students take notes in their notebooks.

Divide students into groups of two. Give students copies of Handout A. Provide students with paper towels to place media components on for examination.

Explain how to measure density by calculating mass and volume. Density is equal to mass divided by volume. Explain that when the density of an object is less than the density of water, it will float. The density of water is 1 gram/milliliter.

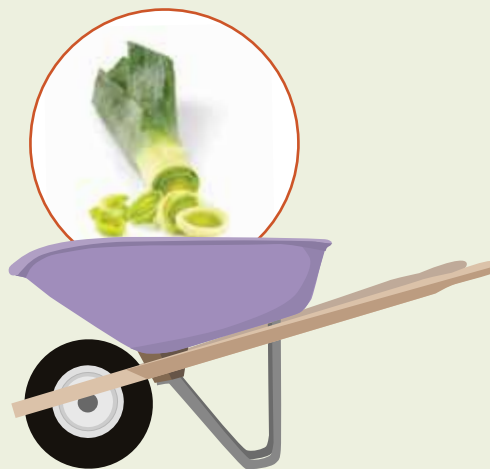
For Part 2, students determine the percentage of components for a premixed potting media. Students need to separate components, identify them, and determine the proportion of each in the mix. You need to provide students a sample of pre-mixed potting media. Answers will vary depending on the media mix you purchase. Garden store mixes that have packaging for the average consumer will provide you a list of ingredients and possibly proportions on the label. Commercial mixes will not provide this information unless you ask the manufacturer.

Review/Summary

Discuss the conclusion questions found on Handout A.

Modifications/Extensions

Conduct an experiment comparing plant growth in a container using potting soil and garden soil. Before the experiment, have students create a hypothesis specifying which plant will do the best. Students should observe plants for several weeks noting plant height, width, and overall health. At the end of their experiment students share results with the class and determine which medium is the best for plants when grown in a container.



Sources/Credits

Adapted from: *Curriculum for Agricultural Science Education (2012) Principles of Agricultural Science – Plant*. [Curriculum materials for secondary agricultural education instruction]. Lexington, KY.

Potting Media Components

Potting media is better suited for growing crops in containers.

Purpose of Using Potting Media

- Light-weight potting media for shipping and handling
- Good porosity for drainage and aeration
- Good water retention to prevent containers from drying out too quickly

Media Ingredients

Three types of ingredients are used in potting media:

- **Inorganic materials** – minerals and substances derived from non-living matter
- **Organic materials** – substances derived from plant or animal tissues
- **Soil enhancers** – includes fertilizers, wetting agents, and soil chemistry buffers

Inorganic Materials

For potting media, inorganic materials are typically volcanic materials, such as:

- Perlite
- Pumice
- Vermiculite

These are lightweight and very porous materials.

Other Inorganic Materials

Besides volcanic materials, human-made materials are used, such as:

- Plastic polymer beads
- Clay beads
- Rockwool

Anything inexpensive, light, and that will not disintegrate in wet conditions.

Organics

Organic materials absorb water and will break down to provide improved porosity.

Common materials used in potting media:

- Peat moss (sphagnum peat)
- Bark chips
- Sawdust
- Coconut fibers
- Seed hulls and husks

Soil Enhancers

Because potting media provides plant roots access to everything they require, media can have enhancers mixed in for efficient plant growth.

Some enhancement amendments:

- Fertilizers
- Wetting agents
- Lime or gypsum

Slow-Release Fertilizers

Potting media can be mixed with time- release fertilizer pellets whose layers melt away over time, providing plants steady nutrients over the length of the growing season.

Common product name is Osmocote®. These look like little round clay pellets.

Purchasing Media

Potting media is typically sold two ways

- Bulk – loose, sold by the cubic yard
- Packaged – compressed in plastic wrapped bales, sold by the cubic foot

References

Boodley, J. W. (1998). *The commercial greenhouse* (2nd ed.). Albany, NY: Delmar.

Parker, R. (2010). *Plant and soil science: Fundamentals and applications*. Clifton Park, NY: Delmar.



Sorting out Potting Soil

You will be investigating the role potting media components have in a container mix. Follow the instructions to determine how to test and collect evidence to support conclusions you determine.

Part 1. Introduction to Ingredients

1. Get a plastic bag of each media ingredient: bark, peat moss, perlite, pumice, sand, slow release fertilizer (Osmocote®), and vermiculite.
2. Examine each sample and record observations in Table 1. Observations should include color and other features (for example size and shape) that will help you to identify the material within a potting media mix. Density will be calculated in step thirteen.
3. Determine the mass of the 30ml cup and record in the second column of Table 2.
4. Place a small amount of one of the media ingredients in a cup. Determine the mass of the cup and media and record in Table 2.
5. Record the mass of the media by subtracting the mass of the cup from the mass of the media and cup. Record this amount in Table 2.
6. Pour 50ml of water into a 100ml graduated cylinder.
7. Place the media from the 30ml cup into the graduated cylinder.
8. Record the volume of the water and the media in Table 2.
9. Calculate the volume of the media by using the following formula:
10. (Volume of water and media found in step 7) – 50ml = volume of media
11. Record the volume of the media in Table 2.
12. Repeat Steps 2–9 for each media ingredient.
13. Calculate the density of each ingredient by taking the mass of the media divided by the volume of the media. Record the value in Table 1.

$$\text{Formula for density} = \frac{\text{Mass of media}}{\text{Volume of media}}$$

Materials

Per pair of students:

- Media samples
- 30ml cup
- 100ml graduated cylinder
- Electronic scales

Per student:

- Calculator
- Pencil
- Notebook

Part 2. Determining Percentage of Components

1. Get a sample of a potting media mix from your teacher.
2. You and your partner need to come up with a way to separate the components of the media to calculate the percentage of each component.
3. Start with a known volume or mass (you choose which variable) of potting media mix and determine the volume or mass for each component.
4. Divide the volume or mass of each component by the whole sample volume or mass to get the percentage for each. Use the formula below to determine percentages of components.

$$\text{volume or mass of component} \div \text{volume or mass of whole sample} = \% \text{ of component}$$

5. Record the data in Table 3.

Table 1. Physical characteristics of components			
Ingredient	color	other	Density
Bark			
Osmocote®			
Peat Moss			
Perlite			
Pumice			
Sand			
Vermiculite			

Table 2. Mass and Volume of Media					
Ingredient	Mass of Media & Cup	Mass of Cup	Mass of Media	Volume of Media & Water	Volume of Media
Bark					
Osmocote®					
Peat Moss					
Perlite					
Pumice					
Sand					
Vermiculite					

Table 3. Percentage of components in a Mix

Substance	Volume or Weight	Percentage of Mix
Potting Soil Mix		100%

Conclusion

Large diameter sand provides a great natural soil amendment to improve porosity. Discuss the limitations sand has in potting mixes.

List some organic materials found in your local area that may be substituted for some of the materials you studied in Part 1 of this activity. Your substituted materials must stay consistent with the same desired functions.

If you were trying to grow a plant that was very sensitive to excessive soil moisture, which ingredients would you increase the percentage of in the potting mix?

Why should peat moss be used for a mix growing young seedlings?

What are the similarities in terms of function for the different organic materials?

Name _____

Sorting out Potting Soil



1. List two of the three purposes of using potting media.

2. List the three types of ingredients found in potting media.

3. Name two organic components commonly used in potting media.

4. Explain how slow-release fertilizer works.

Grade

High School

Materials/Preparation

- Handout A – Economics of Planting – one per student
- Assessment A – Planting Efficiently – one per student
- Empty or full seed packets – one per student
- Area to plant annual flowers
- Annual flowers or other started seedlings
- Two small baskets
- Paper clips
- Garden hand shovels
- Stopwatch

Gardening Economics and Efficiency

Minnesota K-12 Academic Standards

Social
Studies

9.2.4.7

Resource markets and financial markets; determine wages, interest rates and commodity prices.

Summary/Overview

Students learn technical details about planting seeds or seedlings. They also apply the principle of marginal productivity to planting in the garden.

Garden Connection

Students inspect seeds in the classroom. These seed varieties are plants that might be planted in the garden during the growing season.

Background Information

Many of your students probably have not had the opportunity to plant a garden. By utilizing the information on the back of a seed packet, your school garden has a better chance of success. Seed packets explain details such as when to plant, days to harvest, planting depth, and spacing. If seeds are planted too early they may not survive a cold spring night. Knowing the number of days from planting to harvest allows you to plan when you will be able to harvest your crop. This information can also be used to ensure there is enough time for the plant to produce its crop before the first fall frost. Planting depth is also important. Seeds that are planted too deep will most likely germinate, but may not have enough stored nutrients inside the seed to help the developing seedling reach the surface and sunlight. Plant spacing is important to consider so the plants have access to the resources they require.

Objectives

- Explain the importance of planting depth and spacing.
- Find the marginal productivity of labor in planting a garden.
- Observe the effects of increasing the minimum wage on profit margins.

Fun Fact

Columbus brought squash to Europe from the Americas.



Procedure

Interest Approach

Have two baskets on opposite sides of the classroom. One should have a lot of paper clips in it; the other is empty. Ask for a volunteer. Have him/her move one paper clip at a time from one basket to the other and do as many as he/she can in one minute. Count the paper clips. Then ask for a second volunteer. Have the two students work together to move as many paper clips as they can, one at a time from one basket to the other. Count the paper clips. Do this with three and four volunteers, counting the paper clips after each round. Discuss the results, give the definition of marginal productivity of labor and have students give examples of where they have seen this or may see this occur in school, work, or home.

Marginal productivity of labor is the difference in output due to the addition of one unit of labor.

Summary of Content and Teaching Strategies

Pass out seed packets to students. Have them find the area on the back that lists planting depth and spacing. Ask students to share how deep their seeds need to be planted. Compare difference between types of seed. Ask students how far apart their seeds should be spaced.

Discuss the importance of spacing and allowing plants growing room. If plants are overcrowded they will be short on resources including sunlight, water, and nutrients. Crowded plants are less likely to grow to maturity and produce the desired fruit or vegetable. On the other hand, if plants are spaced too far apart, there is less room in the garden for other plants. Often seeds are planted thicker than the actual desired spacing. This allows for seeds that do not germinate or for weak plants. After the seedlings are established, weak plants can be thinned out. When thinning, hand-pull smaller, weaker-looking plants while leaving sturdy, larger plants.

Seeded areas should be clearly marked. Garden markers can be purchased or made by the students. Either way, they need to be waterproof and clearly visible. The most common way to plant seeds is in rows. Some plants are planted in mounds and the mounds are also put in rows. Plants in rows are easier to distinguish from weeds and allow for gardeners to move between plants when weeding and harvesting. If your school has raised-bed gardens, you may choose to use square foot gardening. The garden is divided into squares one foot by one foot and one type of seed is planted in each section.

Plants can also be transplanted into a garden. Seeds are started early in a greenhouse or under grow lights and are later moved outside. Transplanted seedlings also need to be properly spaced. Plants should be planted the same depth in the garden as in the pot they were growing. If the roots have become bound, gently break apart the root ball allowing the roots to spread when planted in the ground.

Economics of Planting

Guide students through a planting activity that allows them to visualize the concept of marginal productivity of labor. Marginal productivity of labor is the difference in output due to the addition of one unit of labor. Provide students with copies of Handout A. Designate a space in your garden to plant seedlings that have been started in a greenhouse. Start by having one student plant for three minutes. When the time is up, record the number that has been planted in Table One. Next have two students plant for three minutes and record the number that has been planted. Continue this process until five students have planted for three minutes. As more students are added, labor can become specialized with one student digging holes, another gently removing plants from pots, etc. Students then calculate how much money would be needed to pay the employees at two different hourly rates. Two wage levels allow students to explore how wage level impacts the marginal productivity of labor. Encourage further discussion on how wage level impacts unemployment on a macroeconomic level. Assist students in completing the worksheet.

If you are not able to plant, use the data below as an example:

Table 1. Timed Planting Data

# Workers	Time	Flowers Planted/hr.	Wage 1	Wage 2	Tot. Wages 1	Tot. Wages 2
1	3 min.	60 (3 in 3 min.)	\$6.15/hr.	\$8.00/hr.	\$6.15/hr.	\$8.00/hr.
2	3 min.	100 (5 in 3 min.)	\$6.15/hr.	\$8.00/hr.	\$12.30/hr.	\$16.00/hr.
3	3 min.	160 (8 in 3 min.)	\$6.15/hr.	\$8.00/hr.	\$18.45/hr.	\$24.00/hr.
4	3 min.	200 (10 in 3 min.)	\$6.15/hr.	\$8.00/hr.	\$24.60/hr.	\$32.00/hr.
5	3 min.	220 (11 in 3 min.)	\$6.15/hr.	\$8.00/hr.	\$30.75/hr.	\$40.00/hr.

Table 2. Marginal Productivity of Workers (flowers/hour)

# of Workers	1	2	3	4	5
Difference in output due to the addition of one worker	60	40	60	40	20

Table 3. Cost and Profit Per one Hour of Production

Workers	Labor Cost 1	Labor Cost 2	Cost of Plants	Total Cost 1	Total Cost 2	Gross Profits	Net Profit 1	Net Profit 2
1	\$6.15/hr.	\$8.00/hr.	\$45	\$51.15	\$53	\$60	\$8.85	\$7
2	\$12.30/hr.	\$16.00/hr.	\$75	\$87.30	\$91	\$100	\$12.70	\$9
3	\$18.45/hr.	\$24.00/hr.	\$120	\$138.45	\$144	\$160	\$21.55	\$16
4	\$24.60/hr.	\$32.00/hr.	\$150	\$174.60	\$182	\$200	\$25.40	\$18
5	\$30.75/hr.	\$40.00/hr.	\$165	\$195.75	\$205	\$220	\$24.25	\$15

Ask students what they believe is the best number of workers to plant at a time given the data on their worksheet. Have students explain their answers. Discuss why marginal productivity of each additional worker begins to decrease. At a certain point additional workers are not significant benefit and may get in the way. Talk about the impact of marginal productivity on profit.

Review/Summary

Review the following questions with the class:

- Why is planting depth and spacing important?
- What happens when plants are overcrowded?
- What is marginal productivity? How does it apply to planting a garden?
- Why does marginal productivity of workers decrease at a certain point?
- What happens to your profit when wage is increased?

Modifications/Extensions

Plant seeds in your school garden. Before going outside, discuss rules and expectations at the garden. Make sure students read seed packets for planting information. Have students plant the garden in rows and label them with markers.

Sources/Credits

This lesson was developed for the *Minnesota Garden Guide*.

Name _____



Economics of Planting

Fill in the charts below as we conduct the flower-planting tasks as a class. This activity provides a real-world example of marginal productivity of labor.

Table 1. Timed Planting Data

# Workers	Time	Flowers Planted/hr.	Wage 1	Wage 2	Tot. Wages 1	Tot. Wages 2
1	3 min.		\$6.15/hr.	\$8.00/hr.		
2	3 min.		\$6.15/hr.	\$8.00/hr.		
3	3 min.		\$6.15/hr.	\$8.00/hr.		
4	3 min.		\$6.15/hr.	\$8.00/hr.		
5	3 min.		\$6.15/hr.	\$8.00/hr.		

Calculate the hourly marginal productivity of each worker. Marginal productivity of each worker is determined by calculating how many additional flowers the worker in question planted. The marginal productivity of the first worker is the number of flowers they can plant in one hour. The marginal productivity of the second worker is the number of additional flowers that were planted per hour due to having two workers instead of one worker.

Table 2. Marginal Productivity of workers (flowers/hour)

# of Workers	1	2	3	4	5
Difference in output due to the addition of one worker					

Use the following cost and profit numbers to calculate gross and net profits.

Plant cost: \$.75 per plant Profits: \$1.00 per plant planted

Table 3. Cost and Profit Per one Hour of Production

Workers	Labor Cost 1	Labor Cost 2	Cost of Plants	Total Cost 1	Total Cost 2	Gross Profits	Net Profit 1	Net Profit 2
1								
2								
3								
4								
5								

Name _____

Planting Efficiently



1. Explain the importance of planting depth and spacing.

2. Explain marginal productivity of labor as it relates to planting a garden.

3. Observe the effects of increasing the minimum wage on profit margins.

Maintaining and Sustaining a Garden

Chapter

4

Teacher Information

Maintaining the Garden

After your school garden is planted it will need regular care, including during the summer. Continue to involve students in the garden process during summer months. Students will enjoy nurturing the plants and it's a great opportunity to learn responsibility. Several items need regular attention.

Water: Plants need approximately one inch of water every week. This can come from rain or from manual watering. The amount of water required varies depending on weather conditions, including temperature and wind. Check the amount of moisture in the soil by pushing your finger down about one inch. Plants need water if the soil feels dry.

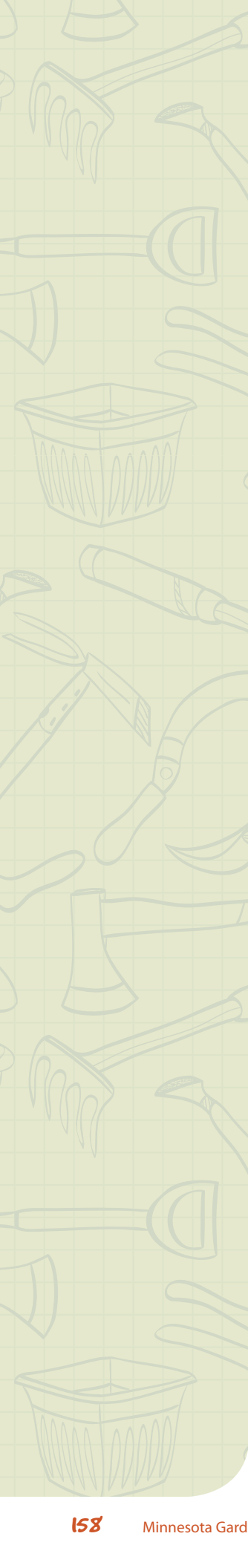
The best time of day to water plants is early morning. This decreases the amount of water lost by evaporation. Problems with fungus can occur if plants are watered in the evening and do not have enough time for their leaves to dry. The best way to water is to apply water slowly, allowing it time to soak into the soil. A common mistake is to water until the topsoil looks moist. To be effective, water must sink deeply into the soil. Push your finger inch-deep into the soil again after watering to ensure it is moist down to the tip of your finger.

The most common way to water gardens is with watering cans and hoses. Depending on the size of the garden, it may be worth it to invest in a simple irrigation system. Soaker hoses, drip irrigation, and sprinkler systems make watering an easier chore.

Thinning: Seeds planted directly into the garden are often intentionally planted thick. This provides an allowance for seeds that may not germinate. Crops may need to be thinned, giving the remaining plants enough space and resources to grow to maturity. When thinning, select the healthiest plants to remain in the garden and remove the others. Carefully pull out the plants or cut the tops off. Keep a close eye on students as they thin. It can be challenging to remove unwanted plants while not disturbing desired plants.

Weeding: Weeds are plants out of place. They need to be removed so they do not compete for the resources required by your crops. Before removing weeds, be sure you and your students can identify the crops you planted. Remove the weeds either by hand or using a hoe. Be careful around the plants you intend to keep. It is important to completely remove the roots of weeds, as in some instances the tops may regenerate. Weeding can quickly become an overwhelming task. To make it easier, remove weeds often and when they are small. A two-to-three inch layer of mulch can be added on top of the soil to decrease the number of weeds.





Fertilizer: Plants require nutrients to grow. Nitrogen (N), phosphorous (P), and potassium (K) are required in the largest amounts. Others are important too, but needed in smaller amounts. As plants grow, they use up the nutrients in the soil. Fertilizer added throughout the summer ensures plants have the nutrients they need. Some fertilizers make nutrients available immediately (liquid), while others release slow amounts over time (granular). Another fertilizer option is commercially purchased well-rotted manure. Fertilizers should only be applied by adults. Check to see if the school has rules about what kinds of fertilizer can be applied. For best results, use small amounts of fertilizer frequently. Excess fertilizer can be harmful to plants and the surrounding environment. Be sure to read and follow label directions. Model good safety practices for the students including gloves and good hand washing. To avoid contaminating your produce, properly space the date of topical fertilizer application in relationship to harvesting.

Pests and Diseases: Many insects found in your garden are beneficial. Careful monitoring of your garden helps you discover when insects or fungus become a problem. If signs of pests are present, identify the problem. Students enjoy investigating and can help research your pests. Hand picking or high-pressure water spray can often remove insects. If plants have a fungal growth, remove them from the garden so the issue does not spread. Plants that remain infested or get worse should be quickly removed from the premises. If further action is required, visit with school administration and maintenance personnel about options for pesticides. There are several other ways to promote garden health: rotate crops, plant pest-resistant varieties, allow adequate room for air circulation between plants, and more.

Dividing up the responsibilities and having a maintenance plan in place are keys to a successful garden. Ideally, students are active participants even when school is not in session. Create a schedule and post it in an outdoor bulletin board near the garden. Many groups can help with summer maintenance, including:

- Summer school classes
- School-aged childcare
- Community education
- Girl or Boy Scout troops
- Faith-based groups
- Volunteer master gardeners
- Parent volunteers

Sustaining

Building and planting a school garden is a lot of work. Creating a summer maintenance plan will ensure your garden's success for one year, but a sustainability plan is needed to ensure your garden's success for many years to come. Start by showing appreciation to donors, partners, and volunteers. Signs at the garden, regular communication, thank you notes, and sharing garden produce express gratitude.

Use the momentum from your first year's accomplishments to create a sustainability plan with your Garden Advisory Committee. Like your initial project, establish goals, create steps, and construct a timeline. Brainstorm ways of funding regular garden maintenance and the purchase of annual seeds and plants. Adding new items to the garden each year creates interest and may help obtain funding. Continue to integrate the garden into curriculum and use lessons to meet academic standards.

Communicate the progress of the garden with school administration, teachers, parents, the Garden Advisory Committee, and other stakeholders. Use established forms of communication with the community such as a school or local newspaper. Or, create a blog, website, or garden newsletter. Include pictures and description of activities showing the valuable life lessons students are learning from the garden. Promotion to the community recognizes efforts and accomplishments of the current group and creates desire and awareness for future groups.

Additional Lesson Resources

Lesson: Aphid Pets, Grass Blast and What's Bugging You?

Grades: 3-8, K-5 and 4-6

Source: National Gardening Association

Curriculum: *Grow Lab: Activities for Growing Minds*

Location: Can be purchased from www.gardeningwithkids.org

Lesson: Insect Anatomy

Grades: 4-5

Source: New York Agriculture in the Classroom

Curriculum: *Science of Life Explorations through Agriculture (SOLE)*

Location: <http://www.agclassroom.org/ny/resources/pdf/activities/insect.pdf>

Sources/Credits

Adapted from Florida Agriculture in the Classroom, Inc.'s *Gardening for Grades* school garden curriculum.

Adapted from *Creating and Growing Edible Schoolyards: A How to Manual for School Professionals* created in partnership between Anoka County Community Health & Environmental Services Department's SHIP initiative and the Anoka-Hennepin School District.

Grade

Elementary 1-5

Materials/Preparation

- Teacher Material A – Twig Detective – one per teacher
- Handout A – Pyramid of IPM Tactics: Red, Yellow, Green – one per student
- Handout B – Integrated Pest Management Steps – one per student
- Assessment A – Integrated Pest Management – one per student
- Twigs (approx. 12"-15" long whenever possible) – one per group of two students
- Magnifying lenses
- Computers with Internet access
- Notebooks or journals
- Writing instruments

Learning About Integrated Pest Management

Minnesota K-12 Academic Standards

Science	4.1.2.1	Engineers design, create and develop structures, processes and systems that are intended to improve society and may make humans more productive.
Science	4.1.3.3	The needs of any society influence the technologies that are developed and how they are used.
Science	4.3.4.1 5.3.4.1	In order to improve their existence, humans interact with and influence Earth systems.
Science	5.1.1.1	Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.
Science	5.4.1.1	Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.
Science	1.4.3.1 2.4.3.1	Plants and animals undergo a series of orderly changes during their life cycles.
Language Arts	3.6.2.2 4.6.2.2	Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Summary/Overview

In this lesson, students learn about Integrated Pest Management (IPM): the decision-making process involved in reducing pests. They will recognize that pests can be animals or insects in homes and other structures, as well as weeds, insects, and diseases in yards, gardens, and croplands.

Garden Connection

Gardens are full of insects, some beneficial and some harmful. Integrated Pest Management is a method of controlling harmful insects.

Background Information

Integrated Pest Management (IPM) is a way to reduce pests by using the safest and best methods to eliminate pests. IPM means being knowledgeable about the pest you are dealing with and thinking carefully about the best way to treat it. IPM is real-world science. It teaches about birds and bees, health and disease, and about the ever-shifting interface between science, nature, and culture.

Children are especially vulnerable to pesticides. They play close to the ground, put things in their mouths, grow rapidly, eat a lot relative to their body size, and are less able to detoxify chemicals in their bodies. Children in cities are at special risk because chemicals that may alter neurological



and reproductive development are most heavily applied there.

Teaching people about the link between pesticide use, IPM, and water quality is crucially important. Public concern about health and environmental risks, especially for children, is increasing. IPM is endorsed by the EPA and national parent-teacher groups. The National Institute of Occupational Safety and Health recommends IPM for schools. We can teach our citizens to prevent or reduce pest infestations using a combination of good science and good sense; to choose the least toxic agents when pesticides are necessary as a last resort; to base pest control decisions on identifying pests correctly and understanding their biology; and to think IPM.

Objectives

- Define integrated pest management.
- Explain the IPM pyramid.
- Describe the difference between a harmful and beneficial pest.

Procedure

Interest Approach

Observing plants is critical to determine whether they are infested with insects or plagued by a disease. This activity allows students to practice their observation skills as they look at tree twigs.

Distribute a twig (approx. 12"-15" long whenever possible) for each pair of students to examine in the classroom. As an alternative, you may choose to have students go outside to investigate twigs as they grow on the tree. Review information about parts of a twig and determining twig growth on Teacher Material A.



Procedure:

- Students use a magnifying glass to find pith, leaf scar, bud, and terminal bud ring.
- Trace back the years by measuring the distance from one terminal bud ring to the next.
- What conclusions can be made about growth? About the health of the tree?
- Discuss possible reasons for these growth patterns.
- Have any of the twigs been affected by pests? What evidence did the students find? How did it affect growth?

Summary of Content and Teaching Strategies

IPM is the short way to say Integrated Pest Management, which means being careful about how we try to reduce pests. The word "integrated" means using a combination of ways to do something.

Pesky Pests

Ask students what a pest is. What are some examples? Explain a pest is what we call things, usually living things, that are causing problems. Sometimes this means bugs are eating our plants. Sometimes it means a disease is affecting our fruit trees. Weeds can be pests in gardens because they compete for nutrients and water in the soil.

Something that is a pest in our house, like ants, may not be pests outside. Sometimes, a pest is something that is simply in the wrong place. A wasp can be a pest when it is next to your front door. But in the garden, it is a beneficial insect because it eats caterpillars that eat your vegetables.

Provide students with Handout A. Read through the pyramid of IPM tactics as a class and have students fill in the blanks. An example of applying the pyramid of IPM tactics in a home would be to reduce the number of houseflies. The green area includes sanitation techniques (ex: keep garbage sealed) and physical techniques (ex: exclude flies by replacing broken screens). The yellow area is use caution (ex: flypaper). Finally, the red area is last resort (ex: pyrethrins insecticide).

Next give students copies of Handout B and review the steps of IPM in groups. The IPM steps are quite involved requiring identification, research into life cycle, sampling, determining a threshold, choosing tactics, and evaluating. Each step is a critical component to keep pests at bay.

If weather permits, take students outside to observe plants on the school grounds and complete step one of IPM. Look at garden plants, trees, or shrubs. While observing a plant, have students look for signs of pests. The signs might be holes in leaves, scars down the stems of plants, spots on the leaves of wilting plants, etc. The pest might not be obvious or present. Have students document signs of problems and pests in a notebook or journal. Log the date, time, and location of the plant as well as a description and drawing or photo of the problem and/or pest.

Back in the classroom, instruct students to research the pests they found using the Internet. During their research, students should determine if the pest is harmful, the pest's lifecycle, and non-chemical ways of eliminating the pest. Share findings shared with the class. Examples of insects found in a garden include blister beetle, cabbage looper, earwig, lacewing larva, paper wasps, and sowbugs. An excellent resource is the University of Minnesota Extension's resource called "What insect is this?" www.extension.umn.edu/gardeninfo/insectgallery/garden/index.html.

If weather does not allow students to observe plants outside, have them research to determine common garden pests. Each student selects a pest to learn more about. They find out how the pest is harmful, pest lifecycle, and non-chemical ways of eliminating the pest. Share findings with the class.

Review/Summary

Have students create posters advertising the benefits of IPM and explaining the six steps. Or, have them develop a solution to a specific pest problem that does not use pesticides and would fit in the green area of the IPM model.

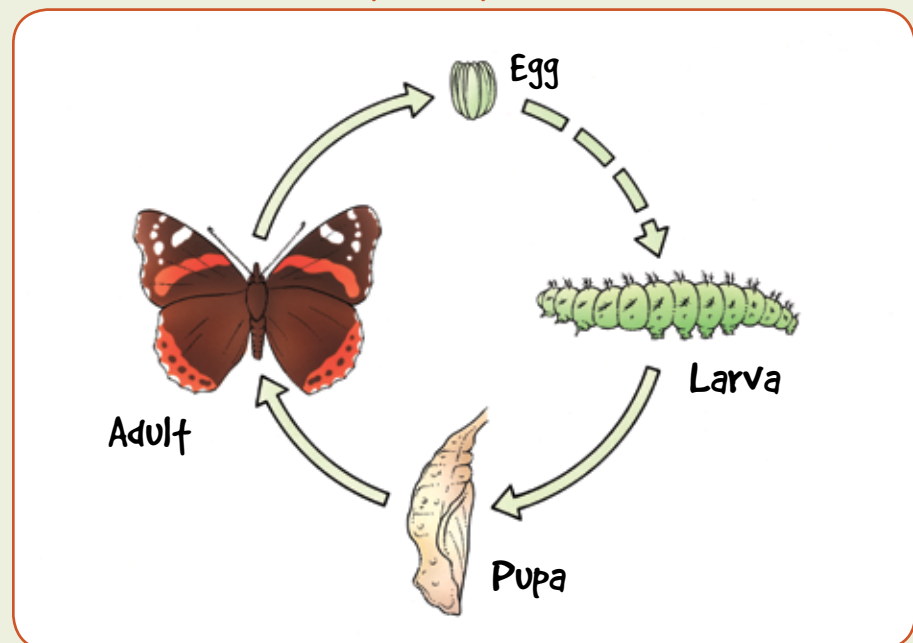
Modifications/Extensions

Explore and analyze science problems of pest-related damage to trees in the school neighborhood. Take notes and make charts of students' observations in order to gain insight into the problem. Research solutions for the pest problem and select a remedy.

Visit a local nursery, orchard, or other agricultural production facility that utilizes integrated pest management.



Complete Metamorphosis



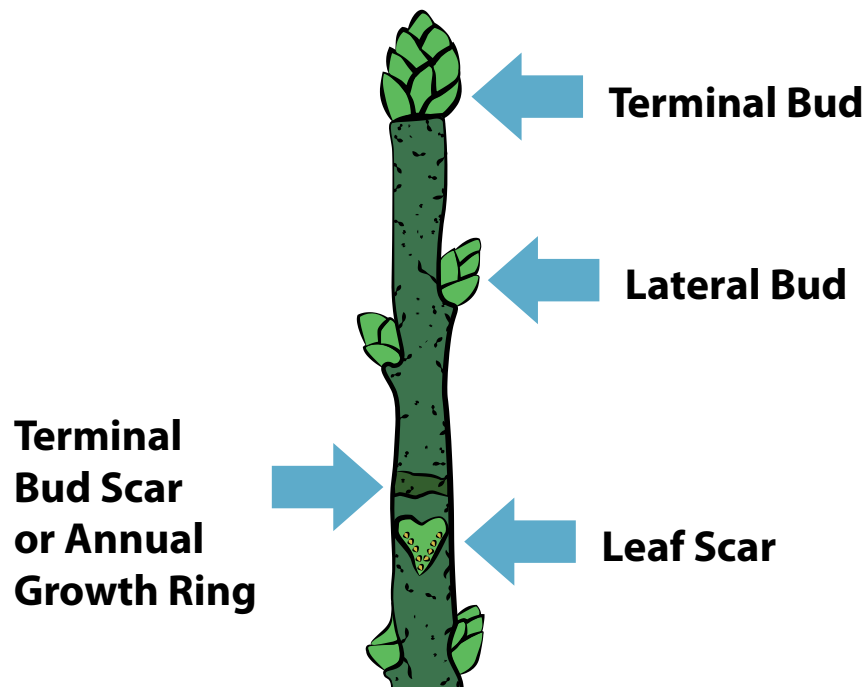
Sources/Credits

Adapted from New York Agriculture in the Classroom and Cornell University's *Sciences of Life Explorations (SOLE)*. See the full lesson plan at <http://www.agclassroom.org/ny/resources/pdf/activities/ipm.pdf>

Twig Defective

Parts of a Twig

- **pith** - center of a twig
- **leaf scar** - area where leaf was attached to the branch
- **bud** - oval-shaped structures usually found above leaf scars
- **terminal bud ring** - a scar that may form a ring around the twig, located where the prior year's terminal bud was



Determining Twig Growth

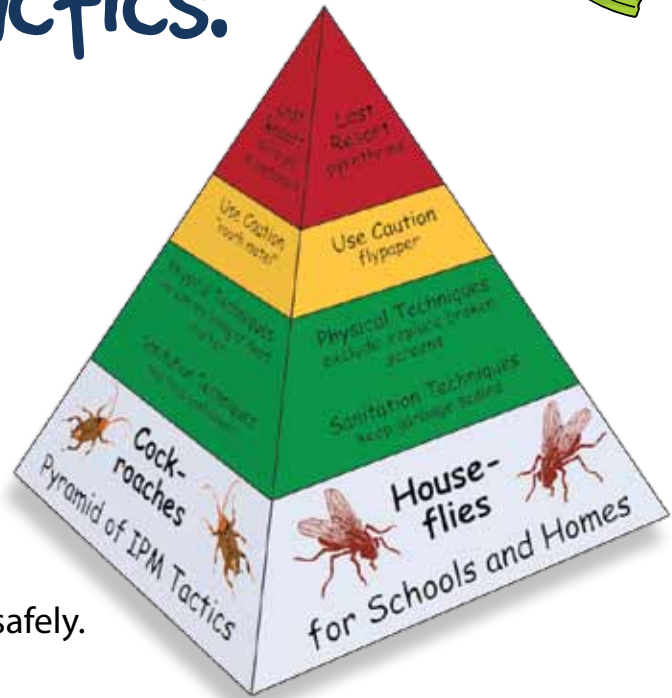
Measure the distance from one terminal bud ring to the next, or from last year's terminal bud ring to this year's terminal bud.

Name _____



Pyramid of IPM Tactics: Red, Yellow, Green

-  Red: "Stop; don't go!"
-  Yellow: "Be cautious"
-  Green: "Go safely!"



Just like traffic signals use red, yellow and green for our safety, the IPM Pyramid reminds us when and how to use pesticides safely.

Use the terms above to fill in the blanks.

Green: Sanitation and Physical Techniques

When we look at the pyramid, the largest area is the bottom – this is the green area. When we are trying to rid our home of a pest, we can use the actions in the green zone safely. They are the methods we should try first and use often. For example, to reduce ants in the house, clean up crumbs from food. This is a very safe method of pest management and can be used by both children and adults. So, it is in the green area.

Green means " _____ "

Examples of techniques in the green zone:

Yellow: Use Caution

The next area is yellow. These methods can be used, but only by an adult and only with care.

Yellow means “_____”

Examples of techniques in the yellow zone:

Red: Last Resort

Red is the smallest area of the pyramid and should be used the least often. These methods usually use a chemical to reduce the pest and may be harmful to others, especially if not used properly. These methods can only be used by an adult, and only when absolutely necessary.

Red means “_____”

Examples of techniques in the red zone:



Integrated Pest Management Steps

If you think you have found a pest, what should you do? Be careful! Ask an adult to help you. Remind them to follow the IPM steps.

Step 1. Learn to identify the pest properly.

Before you decide you need to get rid of a bug you saw on your plant, make sure you know if it's a pest or not. Some of the most ferocious "good" bugs are the larvae of ladybugs and lacewings. They eat many insect pests, so we call them beneficial insects. If you don't know what they look like, you might think they were "bad" bugs. When you spray, you destroy beneficial insects too. Think before you act!

Step 2. Learn the life cycle and biology.

Because of the life cycle of pests, there is usually a time when your treatment will work best. If you treat at the wrong time, it may not work – it may be a waste of time and money. IPM means finding out the best way to treat a pest before you take action. Look for more information about your pest online, or contact a Cooperative Extension office in your area.

Step 3. Sample and monitor the environment.

Sampling the environment means don't treat the pest until you are sure there are enough of them to be a problem. (It is important to know the pest's life cycle and biology.)

Step 4. Determine an action threshold.

There are always going to be pests (like insects, diseases, and weeds) in and around your home and yard. If you have learned about the pest, you know when you can ignore it or when you should act to treat it. Remember, you should not use pesticides yourself. Only adults should use pesticides. They should only use them when they have read the label carefully and have decided it is necessary.

Step 5. Choose actions.

The first actions (called tactics) you consider should be the safest ones. Always think of the IPM pyramid. Use tactics from the green zone first (Go Safely). For example, use a fly swatter instead of spraying, or pull young weeds by hand before they mature and drop seeds.

Step 6. Evaluate results.

Keep track of what worked and what didn't work. If you always have problems with pests in the same place, at the same time every year, it is time to make changes. For example, your Mom's favorite shrub used to get a leaf spot disease every summer. Last year, you cleaned up and removed the dry leaves in the late fall (where the fungus spores were hiding). This year, the plant did not get spots. What does that mean? Will you clean up and remove the dry leaves every year to prevent infection?

Name _____



Integrated Pest Management

1. Some insects can be both a pest and beneficial.

- Yes No

2. What color is the largest part of the IPM Pyramid?

3. What color is the smallest part of the IPM Pyramid? Why?

4. Many chemicals can be found in your home. They may be under your kitchen sink or in the garage. Does that mean you can use them?

- Yes No

Grade

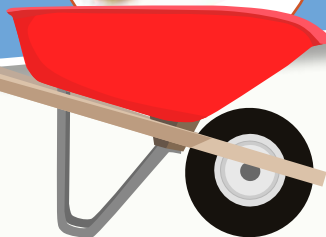
Elementary K-5

Materials/Preparation

- Handout A – Water Experiment – one per student
- Four potted plants or garden plants of the same type
- Water variable as needed for experiment
- Notebook paper
- Writing instruments

Fun Fact

The world's largest French fry feed is held every year in Grand Forks, North Dakota during Potato Bowl USA. In 2006, a new world record was set with 4,620 pounds of French fries served at the French Fry Frenzy. About 10,000 people were served. About 113 gallons of ketchup were used, too!



Why Plants Need Water

Minnesota K-12 Academic Standards

Science	0.1.1.2 2.1.1.2 3.1.1.2 5.1.1.2	Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.
Science	0.4.2.1 1.4.2.1 2.4.2.1 5.4.2.1	Natural systems have many components that interact to maintain the system.

Summary/Overview

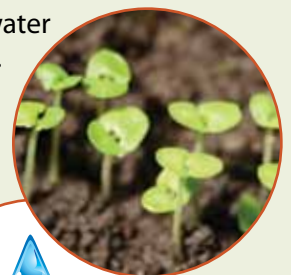
Students compare their need for water to that of plants. They learn why plants need water and how to properly water garden plants. Finally, they assist in an experiment and observe the effects of water on four potted plants in the classroom.

Garden Connection

Garden plants lose water through evaporation and transpiration. These events require gardeners to closely monitor the amount of water available to their plants.

Background Information

Without water plants would not survive. Plants use water to create food through the process of *photosynthesis*. They also use water during transpiration to help cool off on hot days. Water helps plants maintain their strength and shape. Nutrients are transported from the roots to the stem and leaves of the plant with help from water. Plants that do not get enough water are at higher risk for getting sick and are less likely to be healthy and productive.



Because water is so vital to plants, it is important that plants are watered correctly. Plants need water on a regular basis.

Sometimes it comes from rain and sometimes it needs to be provided by humans. Plants that lack water will look limp and do not stand upright. Plants absorb water through their roots. When watering, be sure to aim the water at the base of the plant rather than at the leaves. Water a plant and then give it some time for the water to soak into the soil. Come back approximately 15 to 20 minutes later and water again. This allows the water to soak deep into the soil. After watering, push your finger into the soil to ensure it is moist down to the tip of your finger. Use high-quality water that is not contaminated with chemicals and other items that would be harmful to the plant. Let the soil dry out between waterings to avoid mold and fungus growth.

Objectives

- Explain the importance of water to plants.
- Describe how to properly water plants.
- Make a prediction about the plants in the class experiment.

Procedure

Interest Approach

Ask students what happens to them when they come in from recess or finish playing in the gym. During their physical exercise, their body has been working, getting hot, and sweating. This makes us thirsty. The hotter the day or the more active the exercise, the more water is needed. The same is true for plants. When they are outside on a hot day they need water. On extra hot or very windy days, water is required more often.

Summary of Content and Teaching Strategies

Discuss why water is important to plants: photosynthesis, transpiration, nutrient transport, strength, turgor pressure, and overall health. (Turgor pressure keeps the plasma membrane pushed against the cell wall and is critical for rigidity.) Discuss and demonstrate how to properly water garden plants. It needs to be done regularly, at the base of the plant, giving time for the water to soak in. Let the soil dry out between waterings and use quality water.

Develop an experiment with your students that helps them see water's effect on plants. Follow the steps outlined below.

1. Get four of the same type of potted plant, or identify four of the same plants in the garden.
2. Select a variable
 - a. types of water (hard water, soft water, rain water ...)
 - b. frequency of watering (every day, every two days, every three days ...)
 - c. amount of water (1/2 cup, 1 cup, 2 cups ...)

3. In this experiment, the control will be the plants' environment including sun, soil, and temperature. Make sure all plants in the experiment are in the same location receiving the same amount of sunlight and temperature and have the same soil.
4. Assist the students in developing a hypothesis. What do they think will happen?
5. Conduct the experiment watering as needed for your selected variable. Have students observe plant growth over the next two to four weeks.
6. At the end of the experiment, revisit the hypothesis and compare it to the actual results. If desired, have students fill out the lab report found on Handout A during the experiment.

Review/Summary

Ask the students the following questions:

- Why do plants need water?
- What happens to plants if they do not get enough water?
- How should plants be watered?
- What do you think will happen to the plants in the class experiment?

Modifications/Extensions

Make watering cans to use in the garden. Ask students to bring an empty milk jug or laundry detergent bottle with cap to school. An adult should carefully poke holes in the cover with the end of a scissors or a hot nail. Students can decorate their containers with permanent markers. Fill the jug or container with water, secure the cap and sprinkle away.

Explore turgor pressure in carrots. Before the activity, allow a bunch of carrots to dry out on the counter for a few days. Have students examine the dried-out carrots. Ask if they look tasty. Place half of the carrots in a container of water. After the carrots soak for an hour or so, examine them again. Compare the dried-out carrots to the ones soaking in water. Do students see a difference? The dried-out carrots have a low turgor pressure while the ones soaking have a higher pressure.

Sources/Credits

This lesson was developed for the *Minnesota Garden Guide*.

Name _____



Water Experiment

During this experiment you will observe the importance of water to plants.

1. Name the variable you are testing _____

2. List the treatments each plant will receive.

Plant one	Plant Two	Plant Three	Plant Four

3. Explain how often and how much the plants will be watered.

4. What do you think is going to happen? List your hypothesis.

5. Observe your plants over the next couple of weeks. Use the back of this paper to write down what you observe each week.

6. What do the plants look like at the end of the experiment? Compare the actual results with your hypothesis. Were you correct?

7. Why do you think the plants reacted the way they did?

Weekly Observations



Grade

Elementary K-5

Materials/Preparation

- Handout A – Make Room for Raddy Problem Solving – one per student
- Newsprint/drawing paper
- Notebook paper
- Crayons
- Masking tape
- Raisins (optional)
- Radish seeds
- Pots for planting seeds
- Potting mix
- Grow lights (optional)
- Writing instruments

Fun Fact

Members of the nightshade family, tomatoes are close cousins with chili peppers, potatoes, and eggplants.



Make Room for Raddy

Minnesota K-12 Academic Standards

Science	1.1.1.1 3.1.1.1 5.1.1.1	Scientists work as individuals and groups to investigate the natural world, emphasizing evidence and communicating with others.
Science	2.1.1.2 3.1.1.2 5.1.1.2	Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.
Science	2.4.2.1	Recognize that plants need space, water, nutrients and air, and that they fulfill these needs in different ways.
Language Arts	3.6.7.7	Conduct short research projects that build knowledge about a topic.
Language Arts	4.6.7.7	Conduct short research projects that build knowledge through investigation of different aspects of a topic.
Language Arts	5.6.7.7	Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

Summary/Overview

Students observe how plants and people respond when crowded and forced to share limited resources. This activity helps students understand that even their precious garden plants must sometimes be thinned.

Garden Connection

Students learn that seedlings often need to be thinned in order to receive enough nutrients and sunlight.

Background Information

Like all living things, green plants have basic needs. If light, water, air, nutrients, and an adequate temperature range are not available, plants cannot thrive and grow. Overcrowding causes competition for limited resources and limits the ability of individual plants to meet basic needs. Too much of a good thing can be as harmful as too little. An excess of fertilizer, for instance, can cause plant cells to grow too quickly, resulting in weak or dead plants. Too much water can prevent necessary oxygen from reaching roots.

In this lesson, students grow radishes to observe what happens when plants are overcrowded. For good root development of radishes grown indoors, keep lights within two to three inches of the plants and have students pile more soil mix around the base of the plants as radishes grow.

The crowded radishes may look stunted and pale from competing for necessary nutrients and water. Sometimes crowded plants actually look taller ("leggier") as they compete for light. Radishes in a crowded situation, however, are less likely to develop the large food storage roots that we eat.

Objectives

- To experience and reflect on the limitations of a crowded situation.
- To conduct an experiment to examine how radishes respond to crowding.
- To infer that overcrowding affects the ability of living things to meet basic needs.

Procedure

Interest Approach

Divide your class into an even number of small groups, with a maximum of eight students per group. Ask each group to draw a mural showing plants growing in a garden. Give half of the groups the following resources:

- A long sheet of drawing paper
- Enough crayons for each student
- A snack of raisins with plenty to go around (optional)
- A large area in which to draw
- Five minutes time to complete the drawing

Here is the twist: ask the remaining group(s) each to work in a 4 by-4- foot square taped on the floor, and give them a shortage of resources:

- One very small sheet of drawing paper
- A couple of small crayons
- A couple of raisins for snacking (optional)
- Limited space
- Three minutes to complete the drawing

After the allotted time, ask members from each group to show and describe their drawings to the rest of the class. Ask each group how they felt about the drawing experience. Ask if they had any problems and if so, what were they? Ask the class what was different about the two groups' experiences.

Help the groups focus on the contrast between having limited resources and plenty of resources. Besides a lack of space, what else did students notice was in short supply? Ask students what might happen if they never got enough of what they needed? Ask how a lack of space might affect plants and why.

Summary of Content and Teaching Strategies

As a class or in small groups, discuss how you might set up an investigation to test the effects of crowding on radish plants. Use Handout A to guide the investigation. Have students record predictions comparing the growth and appearance of radishes in the pots. As the experiment progresses, students continue to record their observations in words or drawings on notebook paper. After four or five weeks, dig up radishes to compare and record root development.

If different groups set up experiments, make a class chart to compare observations. Review observations as a class. Ask students what they notice about the plants in each pot. Which pot seemed to have the healthiest plants? How did you decide if they were healthier? Which pot had the tallest plants? Did they look healthier? How did these compare to your predictions? What was the biggest difference between the radishes in the three pots?

Use student findings to ask specific questions about the investigation. For instance, ask why students think

- ... the radishes were rounder in the less crowded pot?
- ...the leaves in the more-crowded pot turned yellow?
- ...there was not much difference in the radishes in Pots A and B?

Review/Summary

Review the following questions with the class:

1. How was what happened in your “mural” challenge similar to what happened to the radishes in the crowded pot?
2. Do you think you would have felt crowded if you had had enough paper and crayons?
3. What are some other situations in which crowding can be a problem for people, animals, or plants?
4. Would we have learned as much if we had planted only one pot of crowded radishes? Why?
5. What are some other ways we could set up an investigation to test the effects of crowding on plants?

Modifications/Extensions

Plant seeds in several pots. Place dividers between the seeds and give each section its own nutrients and water. Examine whether this can compensate for overcrowding.

Develop a progressive story about an overcrowded situation involving people or plants. One student begins the story and passes it on for continuation to the next student, and so on.



Sources/Credits

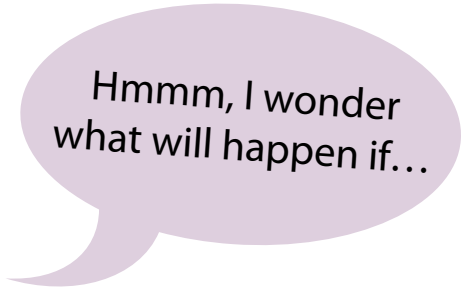
Adapted from the National Gardening Association's *Grow Lab Activities for Growing Minds*, second edition, copyright 2009. For information on obtaining a copy of their curriculum, visit www.gardeningwithkids.org.

Name _____

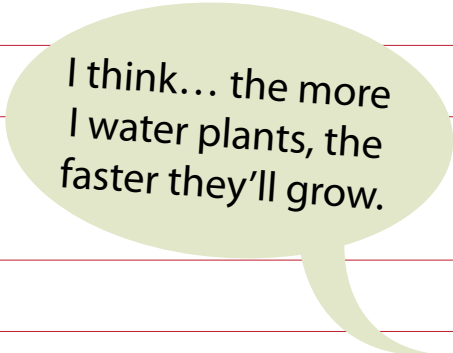


Make Room for Raddy Problem Solving

Use these two pages to guide you through the stages of problem solving.



Plant a Question



Sprout a Hypothesis

Describe Your Growing Exploration:

What steps will I take to find the answer?

Let's see... what materials will I need?

Oh, I need to remember to change only one factor and keep the others constant!

What will I observe? How often?

Which is the control group?

Did I remember repetition? Did I remember repetition?

Record Fruitful observations

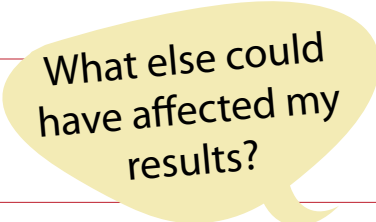
(attach all record sheets)

Harvest Your Findings




What happened?
How can I explain
it?

Ongoing Review



What else could
have affected my
results?



Oops, maybe I
should be more
careful about...

Cultivating New Ideas

Next time, I'm going to...

This makes me wonder about...

I still have questions about...

Now I would like to try...

Grade

Middle School

Materials/Preparation

- Teacher Material A – Challenges with Growing Plants – one per teacher and one overhead transparency
- Teacher Material B – Plant Doctor – Challenges with Growing Plants – one per teacher
- Handout A – Plant Doctor Field Guide – one per student
- Assessment A – Plant Doctor – Challenges with Growing Plants – one per student
- Writing surface
- Writing instruments
- Various healthy and unhealthy plants

Plant Doctor - Challenges with Growing Plants

Minnesota K-12 Academic Standards

Science	5.1.1.2	Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.
Science	7.1.1.2	Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.
Math	5.2.1	Recognize and represent patterns of change; use patterns, tables, graphs and rules to solve real world and mathematical problems.

Summary/Overview

Students take a look at the challenges of raising plants. They learn the five major challenges of growing plants and do their best to solve plant problem puzzles.

Garden Connection

Students learn how to investigate challenges faced by plants.

Background Information

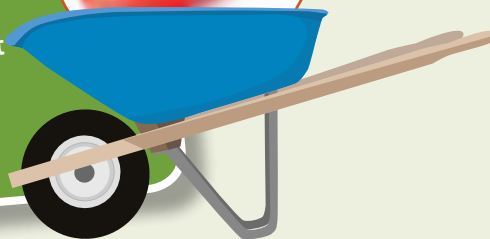
Growing plants is a huge part of our planet! Plants across the globe feed, clothe, medicate, and shade us. Growing plants can be very challenging. Five major challenges face anyone who grows plants. Those challenges are insects, nutrients, weeds, disease, and weather.

Objectives

- Identify challenges related to growing plants.
- Evaluate five plant scenarios and explain which major challenge(s) caused the damage.

Fun Fact

The tomato is by definition a fruit because it contains the plant's seeds, although its lack of sweetness puts it in the vegetable category for most eaters.



Procedure

Interest Approach

Display a number of different plants. One plant would be sufficient, but it's ideal if you have access to a variety of plants, including a food-producing plant, an ornamental plant, a healthy plant, and a plant that is struggling. Point out that some of the plants are doing really well, and others are not. (Adapt according to your examples.) Ask students for some hypotheses about how well or poorly these plants are doing. Ask students if they feel like they have a green thumb. Whether students have a green thumb or not, raising plants can be a tough task. There are challenges associated with growing plants whether planting a garden for home or school, or planting crops to feed the world. During this lesson, students learn the five major challenges of growing plants and work to solve a few puzzling plant problems.

Summary of Content and Teaching Strategies

Help students break into groups. A random grouping could be accomplished by handing out different plant seeds (one type for each group formed). Students find students with the same seed to form the groups. Show and review the Teacher Material A.

Give groups up to 10 minutes to review and discuss the Plant Doctor Field Guide on Handout A. Keep students on task and answer any questions. Give students time benchmarks at five minutes, two minutes and one minute remaining.

Now that students are "experts," put their skills to work in thinking critically and being problem solvers. Read or show a scenario (Teacher Material B). Groups work to figure out exactly what happened that led to the plant problem. Allow groups to take turns asking yes or no questions that lead to the root of the problem. All groups hear each question and answer as they try to figure out the problem in the given scenario. Students cannot ask if it is a weed, insect, weather, disease, or nutrient issue. Take student questions and provide answers. To solve the mystery, a whole group must stand and explain their answer. If they are not correct, they are out of the round and cannot answer again.

Teacher Material B Plant Doctor Scenario Answers

Scenario 1:

A section of the cornfield is infected by insects, the European Corn Borer. The insects just recently started infecting the field, and they began in this small spot. A storm came through the night before, but it was only strong winds. The combination of the wind and the insect damage caused the corn to lay over.

Scenario 2:

During the time when the potatoes were to bloom and form, a hailstorm knocked the blossoms off the potato plants. The farmer knew the plants had been hit, but when they bounced back and continued to grow, he thought they were fine. Unfortunately, without the blooms, the potatoes didn't develop.

Scenario 3:

The teacher used soil from her home garden for all the plants. This soil was low in potassium, which caused the plants to develop a purple tint. The potassium deficiency led to diseases when the plants did not receive sufficient water. White and yellow stripes formed on the leaves. The plants didn't do well with the changing temperature in the room.

Scenario 4:

The problem is a fungus or disease that kills and thins out the grass. The fungus is most active when it is warm and very humid. Conditions are perfect this year. The fungus grows really fast when grass is highly fertilized with nitrogen.

Challenge Scenario:

This family lived in the country. When they dug up a piece of ground, seeds from a weed called Johnson Grass were able to grow. The weeds look a lot like corn and the family never cut them down. During pollination, the Johnson Grass cross-pollinated with the corn, which caused the corn to not produce ears of sweet corn. Their friends in the city didn't have to deal with Johnson Grass.

NOTE TO INSTRUCTORS: This activity is really designed to cause dissonance as students strive to figure out the issues. Feel free to give hints or alter the information given to help students find the answers. Your job is to only answer yes or no. The point is for students to continue to look for clues to find the root of the cause. The scenarios match what they read in their *Plant Doctor Field Guide*. After they solve the scenario, explain any details the students may have missed or expand on the scenario information if you desire.

Review/Summary

Have students take a second look at the plants on display. What do they now see or think after learning about the challenges of growing plants? Do they have ideas of why these plants look the way they do? Discuss all the options of the challenges the plants face as a review of the content.

Modifications/Extensions

Schedule a trip with students to a nearby nursery, agricultural field, or golf course and have someone discuss and show the challenges they face working with plants. You could also work with your school's groundskeepers to take the students on a tour of the campus. The purpose is to discuss what precautions the school takes to maintain healthy plants on school grounds.

Set up a mathematical problem for the students related to insect or pest damage to crops. For example, a farmer owns a 100-acre sweet corn field that will yield a net profit of \$300 an acre. Unfortunately, the field has insect damage and only 75 to 90 percent of the field will be profitable. Have students create a table that records the total net profit of the field for any harvest between 75 and 90 percent.



Sources/Credits

Adapted from: National FFA Organization *Middle School Food and Agricultural Literacy Curriculum*, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit www.ffa.org/documents/learn/MS.PS.5.3.pdf to access the full-length version of this lesson.

Plant Doctor - Challenges with Growing Plants

Five major challenges face anyone who grows plants:

Insects: Some insects can damage or even destroy crops.

Nutrients: Plants need certain nutrients to stay healthy and productive.

Weeds: These are plants that compete against the plants you want to grow.

Diseases: Pesky bacteria, viruses, fungi, and other things that kill your crop.

Weather: Abnormal weather is a big factor in growing crops.

Plant Doctor - Challenges with Growing Plants

Scenario 1

A farmer drives out to his or her field of corn and finds a small section of six-foot-tall corn lying on the ground. What happened, plant doctors?

Scenario 2

A local organic farmer plants a large section of potatoes this year. The potato plants seem to grow as expected but when he begins to dig up the potatoes to harvest them, he doesn't find any potatoes. What could have happened?

Scenario 3

A teacher at your school decides she is tired of her room looking so boring. She decides to grow her own plants so the class can watch them grow and also to make her room more appealing. She plants a few flowers, an ivy vine that grows up the window, and a small spider plant that hangs from the ceiling near the window. The plants do well at first, but later they wilt and have some funny colored spots on them. Why is her green thumb not so green?

Scenario 4

The Garden Club has a golf tournament every year. This year is especially hot, it has rained a lot, and it is very humid outside. As the teams line up to get started, you are in the cart going to the first hole. You hit a beautiful shot up onto the green, and as you walk to putt it in, you notice large discolored round areas on the green. This could really mess up your winning putt! What in the world is going on?

Challenge Scenario

A family gets really excited to grow corn in their back yard this year. They work a piece of soil, plant the corn, and work very hard every day to make sure it has all it needs to grow. There are some weeds on the outskirts of the garden, but they aren't taking water or sun from the corn. Their friends, who live in the city, are already harvesting beautiful ears of corn, but their corn plants aren't producing beautiful ears of sweet corn. What happened?



Plant Doctor Field Guide

Tips for Identifying Insect Damage

- Plants will often show obvious damage from insects eating the leaves or fruit.
- Insects sometimes damage parts of plants that you can't see, like the stems or the roots.
- Damage to the stems and roots slow down the growth but also affect the plant's structure.
- When insects move from plant to plant, they can spread diseases.

Tips for Identifying Disease Damage

- Plants may appear wilted or have colored spots on the leaves, stems, or fruit.
- You will often find a white powdery substance on the leaves.
- Certain viral and bacterial diseases discolor the entire plant.
- Plants with diseases are usually smaller and don't grow as well.
- Moisture in the soil and the temperature sometimes cause diseases to form under the ground on roots or underground fruit.
- Insects can transfer diseases.

Tips for Identifying Nutrient Damage

- Plants' main nutrient needs are nitrogen, phosphorous, and potassium.
- Nitrogen is key for plant growth and development. It helps the plant make chlorophyll, which produces a pretty green plant. A lack of nitrogen makes the plant yellow and stunted.
- Phosphorous is important for producing seeds. It also helps develop strong roots. A lack of phosphorous causes the plant to have a purple color.
- Potassium is important in helping a plant resist diseases and changing weather conditions. Without enough potassium, plants appear to have burned tips and may have yellow or white streaks on the leaves.

TIPS for Identifying Weed Damage

- Weeds compete for the resources that are important for plants to grow. They use water, shade the plants from sun, use valuable nutrients, and spread disease.
- Some weeds can cross-pollinate with a crop, causing plants to not produce fruit.
- Weeds multiply quickly by spreading their seeds.

TIPS for Identifying Weather Damage:

- Too much water can cause plants to have too little air in the soil. Not enough water causes plants to wilt.
- Storms with high winds, hail, floods, or cold temperatures can affect the plant's ability to produce fruit or grow properly.
- Storms can affect the pollination of plants by damaging the flower.
- Cold weather and freezing during the growing season kills many plants.
- Some weather conditions can promote disease.
- Storms can make it difficult for people to tend to their crops.

Name _____



Plant Doctor - Challenges with Growing Plants

1. List the five major challenges of growing plants.

2. If a plant is small and looks yellowish, it probably has _____.

- a. been attacked by insects.
- b. been over-watered.
- c. a nitrogen deficiency.
- d. a phosphorous deficiency.

3. If you see a white powdery substance on a plant, it most likely _____.

- a. has been infected by the European Corn Borer.
- b. has some type of disease.
- c. has been covered in pollen from a weed.
- d. none of the above.

4. How can weather affect the growing of plants?

- a. Too much rain can cause plants to not get enough air in the roots.
- b. Hail can disrupt plant pollination.
- c. Cold temperatures during the growing season can damage plants.
- d. All of the above.

5. Insects can damage plants by eating plant tissue, but they also can _____.

- a. spread plant diseases to other plants.
- b. use water that the plant needs.
- c. cause a nutrient deficiency by eating the nutrients.
- d. attract birds that eat the plants.

Grade

High School

Materials/Preparation

- Teacher Material A – A Plant's Grocery Store – one per teacher
- Teacher Material B – Part 1 – Determine Pounds of Nutrient per Pounds of Fertilizer – one per teacher
- Handout A – Fertilizer Figures – one per student
- Assessment A – Fertilizer Figures – one per student
- Fertilizer labels
- Food labels
- Calculators
- Notebooks
- Writing instruments

Fertilizer Figures

Minnesota K-12 Academic Standards

Math	9.2.4	Represent real world and mathematical situations using equations and inequalities involving linear, quadratic, exponential and nth root functions. Solve equations and inequalities symbolically and graphically. Interpret solutions in the original context.
-------------	--------------	--

Summary/Overview

Students learn how to calculate the amount of fertilizer in a bag and fertilizer application rates.

Garden Connection

Students learn how to calculate the amount of fertilizer required by plants.

Background Information

Successful plant producers understand how to calculate fertilizer rates. Fertilizer nutrient content is always expressed by numbers with primary nutrients listed first in a specific order of nitrogen, (N) phosphorus, (P) and potassium (K). The values are expressed as percentages of nutrient content for the formulation in that bag or container. Other numbers beyond the first three represent other macronutrients, such as sulfur. If micronutrients are included, these nutrients and their percentages are clearly identified in the guaranteed analysis section on the package.

Dry commercial fertilizers are sold in bags or other smaller containers by the pound to nursery managers and gardeners. For field crops, dry fertilizer is sold in larger bags or in bulk. Pricing for commercial fertilizer is typically done on a tonnage basis. This means producers must know how to calculate how much fertilizer they need and compare sources of fertilizer on a tonnage basis to determine the lowest price.

Liquid or water-soluble fertilizers are common for greenhouse operations because of automated systems that apply fertilizer and water at the same time. Liquid fertilizers are normally calculated by parts per million (ppm). This activity has students work through some of the situations gardeners, homeowners, and farmers face as they determine plant nutrient needs and how to meet those needs.

Fun Fact

The potato was the first vegetable to be grown in space!





Objectives

- List three sources of plant nutrients.
- Compare and contrast organic and chemical fertilizers.
- Explain the meaning of the numbers on a fertilizer bag.
- Use mathematical formulas to solve problems regarding fertilizer analyses, rates, and cost comparisons.

Procedure

Interest Approach

Show students labels from packages of fertilizer and food. Discuss how the ingredients on a food label are listed from largest to smallest amount. Ask students if they know what the numbers on a fertilizer package mean. (They indicate the percent of nutrients in the bag.) More information on the fertilizer label is provided later in the lesson.

Summary of Content and Teaching Strategies

Present and discuss information on Teacher Material A with students. Students take notes in their notebooks.

Provide students with copies of Handout A. This activity challenges students with various mathematical problems related to fertilizer calculations for product analysis, rates of application, and cost comparisons. Students will need to review their notes from Teacher Material A. You will need to review the correct formulas and example problems to help students solve the problems provided. Use Teacher Material B for grading purposes.

Review/Summary

Discuss the conclusion questions found on Handout A.

Answer to question four on Assessment A:

$$\frac{1 \text{ lb. of N}}{1000 \text{ ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{18 \text{ lbs. of N}} = \frac{100 \text{ lbs. of fertilizer}}{18,000 \text{ ft}^2} \text{ or } \frac{0.0056 \text{ lbs. of fertilizer}}{1 \text{ ft}^2}$$

$$\frac{.0056 \text{ lbs. of fertilizer}}{1 \text{ ft}^2} \times 1000 \text{ ft}^2 = 5.56 \text{ lbs. of fertilizer}$$

Modifications/Extensions

Invite a crop farmer to visit with the class about fertilizer use. Topics to discuss could include soil analysis, calculating fertilizer required, cost, and application. The use of GPS units and computers in crop farming is another fascinating topic.

Sources/Credits

Adapted from *Curriculum for Agricultural Science Education (2012) Principles of Agricultural Science – Plant*. [Curriculum materials for secondary agricultural education instruction]. Lexington, KY.

A Plant's Grocery Store

Sources of Plant Nutrients

Organic Fertilizers

Manure and compost are examples of organic amendments.

- Animal manure contains nitrogen (N), phosphorus (P), and potassium (K)
- Compost can raise organic matter in the soil and reduce pathogens

Legumes

- Legumes fix nitrogen, which means they convert nitrogen in the atmosphere into nitrogen that is usable to the plant
- Legumes such as peas, beans, soybeans, alfalfa and peanuts improve the soil they are grown in rather than depleting macronutrients like most crops
- Often legumes are double cropped, which means they are planted after a nitrogen-depleting crop has been harvested

Synthetic Fertilizers

Synthetic fertilizers use inorganic compounds to concentrate desired nutrients.

Benefits of synthetic fertilizers are:

- Easy to apply
- Can be concentrated
- Readily available
- Can be specifically formulated to meet plant needs

Disadvantages include

- Cost is expensive
- Many are petroleum based

Synthetic fertilizers come in different forms. Examples are:

- Dry (granular or pelleted)
- Liquid
- Water Soluble powder

What the Numbers Mean

- The first three numbers of a fertilizer analysis are always in order of N-P-K and they stand for the percentage of each nutrient found in the analysis. Example:
- A bag of 10-20-15 means the bag contains 10% nitrogen, 20% phosphorus, 15% potassium

Let's do some math...

How much nitrogen is in a 100 lb.-bag of 15-16-17 fertilizer?

Answer: 15 lbs.

$$15\% \times 100 = .15 \times 100 = 15 \text{ lbs.}$$

A little harder one...

How much phosphorus is in a 50 lb. bag of 15-16-17 fertilizer?

Answer: 8 lbs.

.16 x 50 = 8 or set up the formula:

$$\frac{\text{Value of Nutrient from Fertilizer}}{100 \text{ lbs.}} = \frac{\text{X lbs. of Nutrient}}{\text{lbs. of Fertilizer}}$$
$$\frac{16 \text{ lbs. of P}}{100 \text{ lbs. of Fertilizer}} = \frac{\text{X lbs. of P}}{50 \text{ lbs. of Fertilizer}}$$

Cross multiply to solve for X lbs. of phosphorus(P):

$$16 \times 50 = 100X \text{ this equals } 800 = 100X$$

$$\frac{800}{100} = X$$

8 = X Therefore, 8 lbs. of P

Try one more...

How much potassium is in a 5 lb. bag of 20-10-20 fertilizer?

$$\frac{20 \text{ lbs. of K}}{100 \text{ lbs.}} = \frac{\text{X lbs. of K}}{5 \text{ lbs. of Fertilizer}}$$

Cross multiply to solve for X lbs. of potassium:

$$20 \times 5 = 100x \text{ this equals } 100 = 100x$$

$$\frac{100}{100} = X$$

1 = x Therefore, 1 lb. of K

Calculating Fertilizer Application Rates

You need to know how many pounds of fertilizer to apply in order to get enough nutrients to a plant.

Pounds of fertilizer = Application rate x N, P, or K in fertilizer

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{\text{lbs. of nutrient}}{\text{ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{\text{N, P, or K number on fertilizer}}$$

References

- Parker, R. (2010). *Plant and soil science: Fundamentals and applications*. Clifton Park, NY: Delmar. d
Plaster, Edward J., (1992). *Soil science and management (2nd Ed.)*. Albany, NY: Delmar.

Let's try a rate calculation...

You want to add fertilizer to a family member's yard.

- They have 1000 square feet of lawn
- Recommended amount of nitrogen application is 1 lb. /1000 sq. ft.
- The fertilizer you have is 16-8-12

How much **nitrogen** fertilizer should you apply?

Set up the formula:

Pounds of fertilizer = Application rate x N, P, or K in fertilizer

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{1 \text{ lb. of N}}{1000 \text{ ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{16 \text{ lbs. of N}} = \frac{100 \text{ lbs. of fertilizer}}{16,000 \text{ ft}^2}$$
$$\frac{100 \text{ lbs. of fertilizer}}{16,000 \text{ ft}^2} = .00625 \text{ lbs. of fertilizer/ ft}^2$$

$$\frac{.00625 \text{ lbs. of fertilizer}}{\text{ft}^2} \times \begin{matrix} 1000 \text{ ft}^2 \\ \text{(lawn area)} \end{matrix} = \begin{matrix} 6.25 \text{ lbs. of fertilizer} \\ \text{for the lawn} \end{matrix}$$

Calculations Depends on Form

- Dry fertilizers are expressed in weight measurements
- Liquid or water soluble fertilizers are expressed in parts per million (ppm)

Fertilizer Cost

Cost can be confusing...

- Why does a 100-lb. bag of 20-20-20 cost twice as much as a 100-lb. bag of 10-10-10?

Nutrient content is based on percentage; 20-20-20 has twice as much nutrient value as 10-10-10.

Fertilizer Figures Activity on Handout A

The Fertilizer Figures activity lets you to practice these calculations. You will determine:

- Pounds of nutrient per pound of fertilizer
- Fertilizer application rates
- Liquid fertilizer application rates in ppm
- Fertilizer costs

Part I. Determine Pounds of Nutrient per Pounds of Fertilizer

For the fertilizer sources listed in Table 1, determine the pounds of each nutrient in the container:

Table 1. Fertilizer Nutrient Content				
Analysis of Fertilizer	Weight	Lbs. of N	Lbs. of P	Lbs. of K
Container mix of 15-16-17	100 lbs.	15	16	17
Urea 46-0-0	50 lbs.	23	0	0
Complete fertilizer 20-20-20	25 lbs.	5	5	5
Miracle Gro® All Purpose 24-8-16	5 lbs.	1.2	0.4	0.8
Flowering mix 5-21-18	1 lb.	.05	.21	.18

Show how you set up the formula to calculate the values of each nutrient in Table 1:

$$\frac{\text{Value of N-P-K from Fertilizer}}{100 \text{ lbs.}} = \frac{X \text{ lbs. of Nutrient}}{\text{Lbs. of Fertilizer}}$$

$$\frac{15 \text{ lbs. of N}}{100 \text{ lbs.}} = \frac{X}{100}$$

$$15 \times 100 = 100x$$

$$1500 = 100x$$

$$1500/100 = 100x/100$$

$$15 = X$$

$$15 \text{ lbs. of N}$$

Part 2. Determine Fertilizer Rates

Fertilizer in a granular form can be applied to field crops, lawns, and gardens. The following problems are provided to determine practical situations involving fertilizer rate calculations. Some helpful formulas:

$$\text{Area} = \text{Width} \times \text{Length}$$

$$\text{Pounds of fertilizer} = \text{Application rate} \times \text{N, P, or K in fertilizer}$$

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{\text{lbs. of nutrient}}{\text{ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{\text{N, P, or K number on fertilizer}}$$

$$1 \text{ ton} = 2000 \text{ lbs.}$$

Table 2. Fertilizer Rate calculations per Square Feet			
Size of Area	Nutrient Rate Needed	Fertilizer Analysis	Amount of Fertilizer
10' x 100' garden	1 lb. of N per 1000 sq. ft.	16-8-4	6.25 lbs.
50' x 80' lawn	2 lbs. of N per 1000 sq. ft.	16-16-16	50 lbs.
75' x 125' playground	1 lb. of N per 1000 sq. ft.	20-10-20	46.88 lbs.
150' x 360' football field	3 lbs. of N per 1000 sq. ft.	46-0-0	352.17 lbs.

Show the formula and the steps you used to solve the problems in Table 2:

Example "50' X 80' lawn" in Table 2.

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{2 \text{ lb. of N}}{1000 \text{ ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{16 \text{ lbs. of N}} = \frac{200 \text{ lbs. of fertilizer}}{16,000 \text{ ft}^2}$$

$$\frac{200 \text{ lbs. of fertilizer}}{16,000 \text{ ft}^2} = .0125 \text{ lbs. of fertilizer/ft}^2$$

$$\frac{.0125 \text{ lbs. of fertilizer}}{\text{ft}^2} \times \text{lawn area} = \text{fertilizer for the lawn}$$

$$\text{Lawn area} = \text{length} \times \text{width} = 50 \text{ ft} \times 80 \text{ ft} = 4000 \text{ ft}^2$$

$$\frac{.0125 \text{ lbs. of fertilizer}}{\text{ft}^2} \times 4000 \text{ ft}^2 = 50 \text{ lbs. of fertilizer}$$

Table 3. Fertilizer Rate calculations per Acre

Size of Area	Nutrient Rate Needed	Fertilizer Analysis	Amount of Fertilizer (lbs.)	Amount of Fertilizer (tons)
6-acre nursery plot	45 lbs./acre of P	16-16-18	1688 lbs.	.84 tons
20-acre field of oats	72 lbs./acre of N	20-10-20	7200 lbs.	3.6 tons
15-acre pasture	60 lbs./acre of N	46-0-0	1957 lbs.	.98 tons
180-acre field of corn	35 lbs./acre of K	15-16-17	37,059 lbs.	18.5 tons

Show the formula and the steps you used to solve the problems in Table 3:

Determine total pounds needed for field size:

$$6 \text{ acres} \times 45 \text{ lbs./acre} = 270 \text{ lbs.}$$

$$\frac{16}{100 \text{ lbs.}} = \frac{270}{X \text{ lbs. of Fertilizer}}$$

$$16x = 27,000$$

$$16x/16 = 27,000/16$$

$$X = 1688 \text{ lbs.}$$

Convert to tonnage:

$$1688/2000 = .84 \text{ tons}$$

Part 3. Calculating ppm Fertilizer Rates

Liquid or water-soluble fertilizers are mixed to create a desired concentration expressed in parts per million (ppm). Nutrient requirements for greenhouse plants are typically listed in ppm rates. The following are a few scenarios involving ppm problems. Some helpful formulas:

For a dilution ratio of 1:100 = 1 oz. per 100 gal.

You use:

% of nutrition in fertilizer x 75 = ppm in 1 oz./100 gal.

$$\frac{\text{ppm Desired}}{\text{ppm in 1 oz./100 gal.}} = \text{Ounces of fertilizer needed per 100 gallons of water}$$

Table 4. Fertilizer Rates in ppm			
Crop	Rate Needed	Fertilizer Analysis	ounces of fertilizer needed per 100 gal of water
Bedding plants	100 ppm of N	15-16-17	8.89 oz.
Hanging basket	150 ppm of N	20-9-20	10 oz.
Poinsettias	250 ppm of K	20-10-20	16.67 oz.
Chrysanthemums	100 ppm of P	15-10-30	13.33 oz.

Show the formula and the steps you used to solve the problems in Table 4:
Example for "Bedding plants" in Table 4.

Convert fertilizer percentage to a decimal:

$$15\% = .15$$

$$.15 \times 75 = 11.25 \text{ ppm in 1 oz./100 gal.}$$

$$100/11.25 = 8.89 \text{ oz.}$$

Part 4. Determine Cost Comparison for Fertilizer

Profit margins on greenhouse plants and crops can be slim depending upon the market. Producers try to limit the cost of inputs in an effort to increase profits. To have a sustainable garden, we need to be smart about purchasing fertilizer and other necessities for ensuring healthy plants.

Fertilizers are formulated at different nutrient ratios depending upon specific growing conditions for the plants. It takes a little knowledge of fertilizers and some calculating to sort out which fertilizers are the best buy.

Some helpful formulas:

$$\frac{\text{Percent of N from Fertilizer}}{100 \text{ lbs.}} = \frac{X \text{ lbs. of N}}{\text{Lbs. of Fertilizer}}$$

$$\frac{\text{Price per unit of fertilizer}}{\text{Lbs. of N/Unit of Fertilizer}} = \text{Cost of N/lb.}$$

Base your decision on **nitrogen (N)** content.

Table 5. Price comparisons of fertilizers

Your choice	Product A	Price for Product A	N cost/lb. Product A	Product B	Price for Product B	N cost/lb. Product B
A	46-0-0	\$278/ton	\$.30	46-0-0	\$7.50/50 lb. bag	\$.33
B	32-8-8	\$6.75/50 lb. bag	\$.42	45-8-12	\$6.99/ 50 lb. bag	\$.31
A	Sewage sludge	\$45/ton	\$.40	Cattle manure	\$20/ton	\$1.67
Either	16-16-16	\$3.85/50 lb. bag	\$.48	Poultry manure	\$30/ton	\$.48

Show the formula and the steps you used to solve the problems in Table 5:
Example for Row 1 in Table 5.

Product A

$$\frac{46}{100 \text{ lbs.}} = \frac{X \text{ lbs. of Nutrient}}{2000 \text{ lbs. or 1 ton}}$$

$$46 \times 2000 = 100x$$

$$92,000 = 100x$$

$$92,000/100 = 100x/100$$

$$x = 920 \text{ lbs. of N}$$

$$\frac{\$278}{920} = \$.30 \text{ of N/lb.}$$

Product B

$$\frac{46}{100 \text{ lbs.}} = \frac{X \text{ lbs. of Nutrient}}{50 \text{ lbs.}}$$

$$46 \times 50 = 100x$$

$$2300 = 100x$$

$$2300/100 = 100x/100$$

$$x = 23 \text{ lbs. of N}$$

$$\frac{\$7.50}{23} = \$.33 \text{ of N/lb.}$$

Product A is the better value.

Conclusion

1. A gardener is confused about fertilizer information. The gardener purchased a 25-pound bag of 20-10-20 fertilizer, but does not understand how there could possibly be 20 pounds of nitrogen, 10 pounds of phosphorus, and 20 pounds of potassium in this 25-pound bag. How many actual pounds of N-P-K are in the bag and why was the gardener incorrect in his or her calculations?

There are 5 pounds of nitrogen and potassium and 2.5 pounds of phosphorus in the 25-pound bag of fertilizer. The gardener did not understand the values for N-P-K are percentages and not actual pounds.

2. How do organic fertilizers such as manures compare to chemical fertilizers?

The majority of organic fertilizers do not have a very high concentration of N-P-K.

3. Why is it important to understand the percentage of nutrients in fertilizer?

Percentages allow you to determine the rate of application and cost comparisons.

Name _____



Fertilizer Figures

Work through the following scenarios to determine nutrient content of a fertilizer, amount of fertilizer needed, and product comparisons. Refer to specific calculation formulas that you recorded in your notes from Teacher Material A Plant's Grocery Store.

Part I. Determine Pounds of Nutrient Per Pounds of Fertilizer

For the fertilizer sources listed in Table 1, determine the pounds of each nutrient in the container.

Table 1. Fertilizer Nutrient Content					
	Analysis of Fertilizer	Weight	Lbs. of N	Lbs. of P	Lbs. of K
1	Container mix of 15-16-17	100 lbs.			
2	Urea 46-0-0	50 lbs.			
3	Complete fertilizer 20-20-20	25 lbs.			
4	Miracle Gro® All Purpose 24-8-16	5 lbs.			
5	Flowering mix 5-21-18	1 lb.			

Show how you set up the formula to calculate the values of each nutrient in Table 1.

Part 2. Determine Fertilizer Rates

Fertilizer in a granular form can be applied to field crops, lawns, and gardens. The following problems are provided to determine practical situations involving fertilizer rate calculations. You need to calculate area in order to compute fertilizer needs. Remember the “N” represents nitrogen. Some helpful formulas:

$$\text{Area} = \text{Width} \times \text{Length}$$

$$\text{Pounds of fertilizer} = \text{Application rate} \times \text{N, P, or K in fertilizer}$$

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{\text{lbs. of nutrient}}{\text{ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{\text{N, P, or K number on fertilizer}}$$

$$1 \text{ ton} = 2000 \text{ lbs.}$$

Table 2. Fertilizer Rate Calculations (in square footage)

	Size of Area	Nutrient Rate Needed	Fertilizer Analysis	Amount of Fertilizer
1	10' x 100' parking strip	1 lb. of N per 1000 sq. ft.	16-8-4	
2	50' x 80' lawn	2 lbs. of N per 1000 sq. ft.	16-16-16	
3	75' x 125' playground	1 lb. of N per 1000 sq. ft.	20-10-20	
4	150' x 360' football field	3 lbs. of N per 1000 sq. ft.	46-0-0	

Show the formula and the steps you used to solve the problems in Table 2.

Table 3. Fertilizer Rate Calculations (for acreage)

Size of Area		Nutrient Rate Needed	Fertilizer Analysis	Total Amount of Fertilizer (lbs.)	Total Amount of Fertilizer (tons)
1	6-acre nursery plot	45 lbs./acre of P	16-16-18		
2	20-acre field of oats	72 lbs./acre of N	20-10-20		
3	15-acre pasture	60 lbs./acre of N	46-0-0		
4	180-acre field of corn	35 lbs./acre of K	15-16-17		

Show the formula and the steps you used to solve the problems in Table 3.

Part 3. Calculating ppm Fertilizer Rates

Liquid or water-soluble fertilizers are mixed to create a desired concentration expressed in parts per million (ppm). The nutrient requirements for greenhouse plants are typically listed in ppm rates. The following are a few scenarios involving ppm problems. Some helpful formulas:

For a dilution ratio of 1:100 = 1 oz. per 100 gal.

You use:

% of nutrition in fertilizer x 75 = **ppm in 1 oz./100 gal.**

$$\frac{\text{ppm Desired}}{\text{ppm in 1 oz./100 gal.}} = \text{Ounces of fertilizer needed per 100 gallons of water}$$

Table 4. Fertilizer Rates in ppm

Crop		Rate Needed	Fertilizer Analysis	Ounces of fertilizer needed per 100 gal of water
1	Bedding plants	100 ppm of N	15-16-17	
2	Hanging basket	150 ppm of N	20-9-20	
3	Poinsettias	250 ppm of K	20-10-20	
4	Chrysanthemums	100 ppm of P	15-10-30	

Show the formula and the steps you used to solve the problems in Table 4.

Part 4. Determine Cost Comparison for Fertilizer

Profit margins on greenhouse plants and crops can be slim depending upon the market. Producers try to limit the cost of inputs in an effort to increase profits. One way to do this is buying smart when searching for inputs, such as fertilizer. If we want to have a sustainable garden we also need to be smart about purchasing fertilizer and other necessities for ensuring healthy plants.

Fertilizers are formulated at different nutrient ratios depending upon specific growing conditions for the plants. It only takes a little knowledge of fertilizers and some calculating to sort out which fertilizers are the best buy.

Some helpful formulas:

$$\frac{\text{Percent of N from Fertilizer}}{100 \text{ lbs.}} = \frac{\text{X lbs. of N}}{\text{Lbs. of Fertilizer}}$$

$$\frac{\text{Price per unit of fertilizer}}{\text{Lbs. of N/Unit of Fertilizer}} = \text{Cost of N/lb.}$$

Circle the letter (A or B) of the product that is the best buy.
Base your decision on **nitrogen (N)** content.

Table 5. Price Comparisons of Fertilizers						
Your Choice	Product A	Price for Product A	N Cost/lb. Product A	Product B	Price for Product B	N Cost/lb. Product B
1	A or B	46-0-0	\$278/ton		46-0-0	\$7.50/50 lb. bag
2	A or B	32-8-8	\$6.75/50 lb. bag		45-8-12	\$6.99/ 50 lb. bag
3	A or B	Sewage sludge	\$45/ton		Cattle manure	\$20/ton
4	A or B	16-16-16	\$3.85/50 lb. bag		Poultry manure	\$30/ton

Show the formula and the steps you used to solve the problems in Table 5.

Conclusion

1. The gardener is confused about fertilizer information. The gardener purchased a 25-pound bag of 20-10-20 fertilizer, but does not understand how there could possibly be 20 pounds of nitrogen, 10 pounds of phosphorus, and 20 pounds of potassium in this 25-pound bag. How many actual pounds of N-P-K are in the bag and why was the gardener incorrect in his/her calculations?

2. How do organic fertilizers such as manures compare to chemical fertilizers?

3. Why is it important to understand the percentage of nutrients in fertilizer?

Name _____



Fertilizer Figures

1. What are two of the three sources of plant nutrients?

2. Explain the difference between organic and chemical fertilizers.

3. If a fertilizer bag says 10-10-10, what do these numbers mean?

4. You want to add fertilizer to your yard.

- You have 1000 square feet of lawn
- Recommended amount of nitrogen application is 1 lb. /1000 sq. ft.
- The fertilizer you have is 18-12-10

How much nitrogen fertilizer should you apply?

Pounds of fertilizer = Application rate x N, P, or K in fertilizer

$$\frac{\text{X lbs. of fertilizer}}{\text{ft}^2} = \frac{\text{lbs. of nutrient}}{\text{ft}^2} \times \frac{100 \text{ lbs. of fertilizer}}{\text{N, P, or K number on fertilizer}}$$

A Bug's Life

Grade

High School

Materials/Preparation

- Teacher Material A – Plant Pests – one per teacher
- Teacher Material B – A Bug's Life – one per teacher
- Handout A – A Bug's Life – one per student
- Assessment A – A Bug's Life – one per student
- Computer with Internet access
- Notebook paper
- Writing instruments

Minnesota K-12 Academic Standards

Science	9.4.4.1	Human activity has consequences on living organisms and ecosystems.
Language Arts	9.7.7.7	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.
Language Arts	11.7.7.7	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.

Summary/Overview

For this activity, students research common garden pests. Students identify a pest to research, examine its life cycle, and prescribe the best timing to disrupt the reproduction of this pest.

Garden Connection

Insects cause the majority of plant damage. Integrated Pest Management can be used to disrupt the insect's life cycle.

Background Information

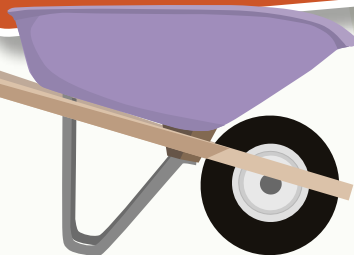
Insects are responsible for the majority of plant damage. Pesky bugs chew, suck, and bore into plant material causing stress on plants, which affects the beauty, production, and overall health of the plant.

An Integrated Pest Management (IPM) plan helps you to choose methods best suited to prevent or control pests. IPM plans also prescribe how to monitor pest situations and to determine when pest control methods should be used. The timing for using pest control methods is often based on the life cycle of an insect. Insects are more vulnerable to pesticides and biological treatments at different stages during metamorphosis.



Fun Fact

As a result of U.S. Supreme Court case *Nix vs. Hedden*, the Court ruled in 1893 that the tomato was a vegetable so it could be subject to taxes. (The tomato is technically (botanically) a fruit.)



Objectives

- Identify how pests affect crop quality.
- Name several types of plant pests.
- Explain options for pest control.
- Describe the difference between incomplete and complete metamorphosis.

Procedure

Interest Approach

Ask students, “How can pests cause negative effects on plant growth, production, and overall health?” Have them jot answers on a piece of paper. After a couple minutes, discuss their responses. Add any items students may have missed such as take away resources, eat plant tissue, eat seeds and fruit, bore holes, remove fluids, retard growth, degrade plant tissue quality, and disrupt metabolic processes.

Even though there is a long list of potential pest hazards, there is some good news. Plant damage is often easy to observe, diagnose, and prevent with a little knowledge of pest types, how pests cause damage, how to eradicate or deter pests, and pest life cycles.

Summary of Content and Teaching Strategies

- Present and discuss information on Teacher Material A and Teacher Material B.
- Give students copies of Handout A. They will research the common pests that affect garden plants.
- Students need to research control methods for the various stages of metamorphosis the pest completes. A good research website is the National Pesticide Information Center <http://npic.orst.edu/index.html>. A table in Part 3 is provided to help organize the information related to this portion of the activity.

Review/Summary

Discuss the conclusion questions found on Handout A.

Modifications/Extensions

Have students select a plant pest they have observed in the garden to research in further detail. They should find the following information about their pest: type, methods for breaking the cycle, methods of pest control, most commonly affected plants, and a picture. Display all information on a poster and share with the class.

Sources/Credits

Adapted from: *Curriculum for Agricultural Science Education (2012) Principles of Agricultural Science – Plant*. [Curriculum materials for secondary agricultural education instruction]. Lexington, KY.

Plant Pests

Insects	Mollusks	Nematodes
Vertebrates	Weeds	Plant Disease Agents

Insects

Different kinds of insects based on their eating habits:

- Chewing
- Sucking
- Boring

Mollusks and Nematodes

- Mollusks include snails and slugs
- Nematodes are soil-borne insects

Vertebrates

- Birds
- Rodents

Weeds *(undesirable plants)*

- Weeds can hinder plants by competing for resources such as water, space, light, and nutrients.
- Any plant can be a weed if it is growing in the wrong place at the wrong time.

Plant Disease Agents

- Bacteria, viruses, and fungi

Methods of Pest Control

- **Biological:** Using a living organism, such as a beneficial insect, to control a pest. (Example: lady bugs and parasitic wasps)
- **Chemical:** Herbicides, pesticides, and repellents
- **Cultural practices:** Crop rotation, clean equipment, no-till planting, and quarantine
- **Physical/Mechanical:** Cultivators, hoes, and mowing

A Bug's Life

Insects' Plight

Insects cause billions of dollars of damage to plant crops each year. They are the single greatest cause of financial loss for crop production.

Breaking the cycle

- When controlling plant pests, knowledge of its life cycles is vital.
- Pests become a threat at certain stages of their life cycles. For example, aphids are most destructive in the adult stage because they suck plant nutrients from leaves.
- Pests are often best controlled at certain stages of their life cycles. Adult aphids can be sprayed off sturdy plants with a strong stream of water. In the process, their sucking mouthparts break and they are unable to feed.
- Eliminating a pest before reproduction is vital to population control.
- Rotating the location in which fruits and vegetables are planted is one way to break life cycles.

How Insects Eat at Various Stages

- Adult insects eat vegetation or suck plant-tissue fluids.
- Larvae insects cause damage through boring into stalks and feeding on young plants or roots. For example, rootworm larvae eat on corn roots while rootworm adult eats on corn silk.

Insect Metamorphosis

As insects go through stages of development from eggs to an adult, their transformation is called metamorphosis. Two types of metamorphosis to know are:

- Incomplete
- Complete

Incomplete Metamorphosis

Also known as gradual metamorphosis.

Example: Grasshopper Transformation

Egg → Early Nymph → Late Nymph → Adult

The insect has the same eating habits at all stages.

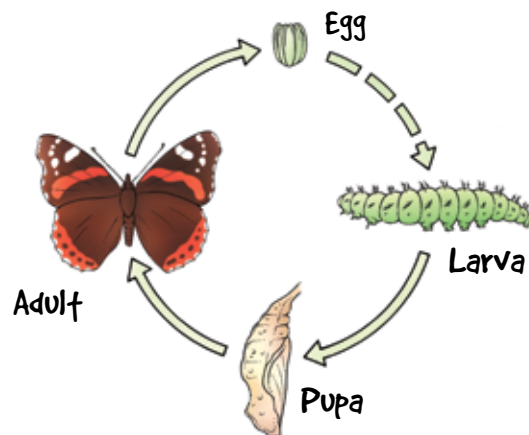
Complete Metamorphosis

Complete metamorphosis has an extreme variation of anatomical features:

Example: Butterfly Transformation

Egg → Larva → Pupa → Adult

Larva and adult stages have very different eating habits.



References

Herren, R. V. (2004). *The science of agriculture: A biological approach* (2nd ed.). Albany, NY: Delmar.

Reiley, H. E., & Shry, C. L. (2007). *Introduction to horticulture* (7th ed.). Clifton Park, NY: Delmar.

Name _____



A Bug's Life

Part I. Research Pests

Find information pertaining to the different kinds of pests that commonly are a problem for garden plants. First, list common pests by category. Second, briefly describe how each pest negatively affects plants.

Table I. Pest Inventory		
Pest	Category	How pest negatively affects plants
Insect		
Weed		
Mollusk		
Vertebrate Animal		
Other		

Name _____



Part 2. Research an Insect Pest

From the list in Part 1, choose an insect pest that has the potential to damage plants in your garden and research its lifecycle. In the space below, draw a circle diagram representing the cycle of metamorphosis of this insect.

Name of Insect

Part 3. Research Methods of Control

List the stages of metamorphosis identified in Part 2 in the appropriate column below. Using the Internet, research appropriate types of treatment for each stage. Place an "X" in the cell of the table if the treatment is appropriate to control your pest. Indicate the name of the treatment in the space below the "X". In situations where the insect has no control measure or stage of metamorphosis, place a "NA" in the cell.

Name of Insect _____

Stage of Metamorphosis	Biological Treatment	Chemical Treatment	Cultural Practices	Physical/Mechanical Treatment
1.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

List sources for the information you gathered from your research.

Conclusion

Why is knowledge of the pest's life cycle valuable to producers?

List the four stages of incomplete and the four stages of complete metamorphosis for insects.

Incomplete Metamorphosis:	Complete Metamorphosis:

Why are most adult insects difficult to control compared to eggs or larva?

How do incomplete and complete metamorphosis differ?

Name _____



A Bug's Life

1. List two examples of how pests affect crop quality.

2. Name two types of plant pests.

3. Explain two options for pest control.

4. Describe the difference between incomplete and complete metamorphosis.

Harvest, Food Safety, Nutrition and Recipes

Teacher Information

After months of planning and patiently caring for the garden, the long-awaited harvest arrives. It's an exciting time as students, teachers, and other invested partners have been looking forward to eating the fruits of their labor. Harvest vegetables when they are at a usable size. Produce is generally firm and gets mushy when overripe. The best time of day to pick fruits and vegetables is the morning when they are at cooler temperatures. However, harvesting can occur later in the day if you keep harvested produce in the shade. When placing in the shade of a tree, cover the produce with a tarp to keep bird poop from landing on food. Regular picking of vegetables keeps the plant producing for a longer period of time. If you miss a harvest day, remove the excess fruits or vegetables before they become too big. Produce left on the plant depletes nutrients. Depending on where the food is going, harvested produce may need to be sorted into boxes of mixed vegetables. Only potable water must be used to wash or rinse vegetables.

It is recommended that schools develop a written food safety plan for the harvesting of garden produce. Included in the plan should be harvesters' training, tools, production processes, and packaging. All students, staff, and volunteers who harvest from the garden should be trained in proper hand washing. Proper hand washing as outlined by the Centers for Disease Prevention and Control is seen in *Figure 1*. Hand washing should be done before harvesting, after using the bathroom,

Figure 1

What is the right way to wash your hands?

- Wet your hands with clean running water (warm or cold) and apply soap.
- Rub your hands together to make a lather and scrub them well; be sure to scrub the backs of your hands, wrists, between your fingers, and under your nails.
- Continue rubbing your hands for at least 20 seconds. Need a timer? Hum the "Happy Birthday" song from beginning to end twice.
- Rinse your hands well under running water.
- Dry your hands using a clean towel or air dry.
- Do not touch facets, bathroom door handles, etc. with clean hands. Use a towel or even your clothing instead of clean hands.

Washing hands with soap and water is the best way to reduce the number of germs on them. If soap and water are not available, use an alcohol-based hand sanitizer that contains at least 60% alcohol. Alcohol-based hand sanitizers can quickly reduce the number of germs on hands in some situations, but sanitizers do **not** eliminate all types of germs.

Source: Centers for Disease Control and Prevention
<http://www.cdc.gov/features/handwashing/>

touching the face, sneezing or coughing, handling pets, and any time they are dirty. Hand sanitizer is not as effective as proper hand washing. A hand washing station can be built for \$20. See instructions on “How to Build a Field Handwashing Station in 10 Easy Steps for Under \$20” on page 218.

Garden harvesters should apply sunscreen and wear hats. Those who are ill, have a fever, diarrhea, or are vomiting should not assist with the harvest. Develop a procedure to keep harvested produce cool and covered before and during delivery. All pets and livestock should be kept out of the garden. Tools and containers used in the harvest need to be designated for food use only and washed regularly. Everything touching produce should be sanitized before the start of the harvest season, then cleaned when dirty (tools daily), and sanitized as needed. Designate a clean and sanitized space to package produce. Boxes and containers for produce must be clean and must not have been used for meat or poultry.

If your school is adding new processes, foods, or menu items, the school may be required to purchase new equipment. For example, if you are growing lettuce and salad toppings for a salad bar, the school may need to purchase appropriate salad bar equipment. An application for a food plan review may also be required. A produce-washing sink, hand sinks, and additional space may be needed as well. Before purchasing new equipment, have a school representative contact your local food inspector to discuss your plans.

For more information on food safety, visit the Minnesota Farm to School website at <http://www1.extension.umn.edu/food/farm-to-school/toolkit/food-safety/>



Garden Produce for Cafeteria Use

Produce grown in the school garden is an approved food source. Cafeteria staff should follow the same system they use for other incoming food. It is a good idea to contact your local food inspector to help in the process and to answer questions. Local food inspectors are listed in the State and Local Environmental Health Contact Directory <http://www.health.state.mn.us/divs/eh/food/license/locals.pdf>.

You may also call the Minnesota Department of Health at 651-201-4500 or the Minnesota Department of Agriculture Food and Dairy Division at 651-201-6027 for more information.

Nutrition and Recipes

The USDA's MyPlate food guide recommends half our plate be filled with fruits and vegetables. School gardens are an excellent way for students to connect to the food on their plate. Students are more likely to try new foods if they have been caring for them in the garden. Produce from the garden can be picked at its peak and only travels a short distance before being served.



Raw fruits and vegetables offer the most nutrients. Mixing up a simple fruit or vegetable dip is an excellent way to encourage students to try the produce they have grown. Before serving any food in your classroom, find out if there are students with food allergies.

Creamy Fruit Dip

Soften one 8-ounce container of fruit-flavored cream cheese spread. Mix cream cheese with one 7-ounce container of marshmallow cream. Serve with fresh cut-up fruit including assorted melons, berries, and apples. Refrigerate remaining dip.

Vegetable Dip

Mix one 16-ounce container of sour cream with one packet of dry Italian or ranch dressing mix. Serve with fresh cut-up vegetables. Along with the usual veggie dippers, try cucumbers, broccoli, kohlrabi, green beans, peppers, and zucchini. Refrigerate remaining dip.

Cucumber Salad*

Number of portions: 10

Portion size: 1/2 cup

- 1 lb. peeled, sliced raw cucumbers
 - 1/4 cup chopped raw onion
 - 1/2 cup sour cream
 - 1/2 cup mayonnaise or similar salad dressing
 - 1/4 tsp. salt
 - 2 tsp. sugar
 - 2 Tbsps. vinegar
1. Place sliced cucumbers and chopped onions in a large bowl.
 2. Blend rest of ingredients to form a thin cream dressing.
 3. Pour dressing over cucumbers and onions. Mix lightly. Serve cold.

Green Beans in Cheese Sauce*

Number of portions: 10

Portion size: 1/4 cup

- 1/4 cup skim or low-fat milk
 - 6 ozs. American skim milk cheese blend
 - 1 Tbsp. margarine
 - 1/8 tsp. onion powder
 - 1/2 tsp. minced garlic
 - 1/8 tsp. dry mustard powder
 - 1/8 tsp. dried thyme leaves
 - 1/8 tsp. black pepper
 - 1 lb. + 6 ozs. raw green beans
1. Combine milk, cheese, margarine or butter, onion powder, minced garlic, dry mustard, thyme, and pepper. Stir over medium heat until cheese is melted and mixture is smooth (approximately 15 minutes).
 2. Boil or steam green beans for three minutes. Check for doneness and boil only until tender. Drain the beans.
 3. Add green beans to cheese sauce and stir gently. Cook over low heat until beans and cheese sauce are heated through. Serve hot.

Find more recipes on the Minnesota Farm to School website in the Toolkit for Foodservice section. Recipes for home and cafeteria use can be found by clicking on a food in the "Featured Minnesota Farm to School Foods" table.

<http://www1.extension.umn.edu/food/farm-to-school/toolkit/>

Additional Resources

Lesson: Fruit for Thought

Grades: K-2

Source: National Gardening Association

Curriculum: *Grow Lab: Activities for Growing Minds*

Location: Can be purchased from www.gardeningwithkids.org

Lesson: Harvesting the Garden

Grades: 4-5

Source: New York Agriculture in the Classroom

Curriculum: *Science of Life Explorations through Agriculture (SOLE)*

Location: www.agclassroom.org/ny/resources/pdf/activities/harvest.pdf

Curriculum: *Serving Up MyPlate: A Yummy Curriculum*

Grades: 1-6

Source: USDA Food and Nutrition Service, Team Nutrition

Location: teamnutrition.usda.gov/Resources/servingupmyplate.htm



Sources/Credits

Information was adapted from Tim Jenkins, Minnesota Department of Health; Michele Schermann, University of Minnesota; and Monica Pastor, University of Arizona.

*The Cucumber Salad and Green Bean Cheese Sauce recipes have been reprinted with permission from the University of Minnesota Extension's *Cucumber Salad and Green Bean Cheese Sauce Recipes* (May 15, 2013); available at www1.extension.umn.edu/food/farm-to-school/toolkit/using-food/docs/recipes/cucumber-salad-home.pdf and www1.extension.umn.edu/food/farm-to-school/toolkit/using-food/docs/recipes/greenbeans-cheesesauce-home.pdf

How to Build a Field Handwashing Station in 10 Easy Steps for Under \$20

Michele Schermann and Annalisa Hultberg
University of Minnesota, Bioproducts and Biosystems
Engineering, Agricultural Health and Safety Program
Jill Randerson
Kidzibits, Inc., Minneapolis, MN

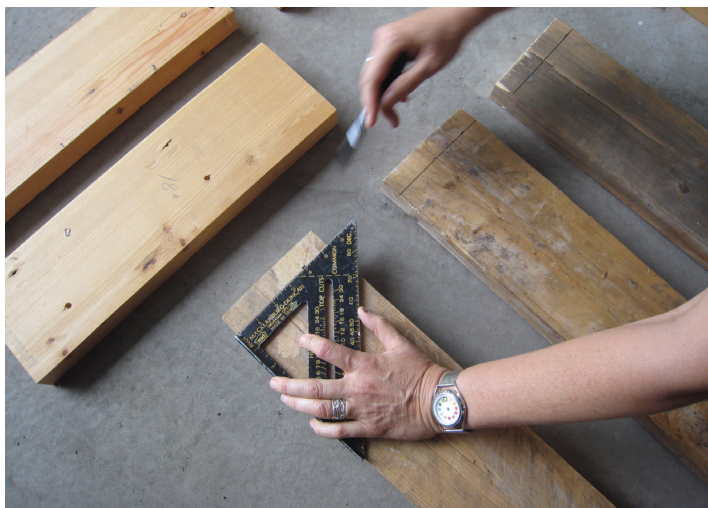
Field handwashing stations can be rented from sanitation companies or you can purchase field handwashing stations from various sources. They are easy to build with a few purchased, found, and salvaged materials. See the materials list at the right and instructions below.

Get some wood. Make the sides.



For this stand, we used
4 - 36" 2X6
4 - 18" 2x6" for
the sides of the
stand. We decided
a stand 36" high
would be good for
handwashing. You
can choose any
height you wish.

2. Square off the ends and cut them to the right sizes (for the height and size you want).



Materials List

1. Water container - The blue container hold 5 gallons of water and has an open/close valve. Available at a big-box home hardware store in the camping section. \$9.99

2. Soap

3. Trash can with a lid so paper towels don't blow around in the wind. We used an old rag container found in the barn.

4. Water catching bucket - (5 gallon bucket)

5. Dishpan - Another found item, is the "drawer" under the water container and hold single use paper towels. You can use whatever you want for this. Doesn't have to be a dishpan.

6. Wood (salvaged). 2x6's, 2x4's, and plywood for the top, sized to fit.

7. Screws - 60 2.5"

8. Bungee cord



This is how the sides will look. They aren't screwed together yet. At this point we decided to use the dishpan as the drawer because we had one and wouldn't need to purchase anything else.

The top cross piece was placed slightly below the very top to create a lip for the dishpan "drawer" to slide on.



3. Screw the crosspieces in place. We used 2.5" screws, 4 on each end (16 total per side, 32 for both sides). We drilled holes before we drilled the screws so that the wood wouldn't crack.



Here you can better see how we placed the top cross piece down from the top to be the dishpan drawer slide.

Now we have our sides built.



4. Figure out how wide to cut the width-wise crosspieces. Placing our dishpan on the “drawer slides” we measured and determined that crosspieces of 14.5” would work. We cut 4- 14” pieces of wood. This time we used 2x4s.



5. Screw the bottom widthwise crosspieces onto the other crosspieces. You could also turn them the other direction and screw them into the side pieces. With the crosspieces turned flat, they make a bigger flat area in case you want to put something on those pieces.



6. Screw the top widthwise crosspieces in place. Notice that these are turned up and down (vs flat like the bottom pieces) and screwed through the side supports. They are low enough so that the dishpan drawer fits in the remaining space.



7. Next, cut a scrap of plywood, old countertop, pieces of wood, or other flat material to fit the top of the stand.



8. Screw the top in place.



9. Install your dishpan drawer. That is where you will have the single use hand towels.

10. Get the rest of the parts together.

Use a bungee cord to hold a 5-gallon water container on the top. Supply soap. (See photo on the first page if you forgot what this looks like)

Put a bucket underneath the spigot of the water container to catch the water. You might want to put a rock in the bottom of the bucket if you are in a windy area. Do not empty the bucket of water in the produce field.

Have a lidded trash can handy for the used towels to keep the used towels from blowing away.

Final notes

This is just an idea plan. You can make this any size you want and with any materials. You could change the boards and install a paper towel dispenser under the top, or you could mount a paper towel holder on the side. If you do that, you will need to remember to remove it when it rains so your paper towels don't get wet. If you really want to be fancy, you could cover the top of the stand with a vinyl fabric covering so that it will stay dry and the plywood won't warp. Cut vinyl fabric slightly bigger and staple to the bottom side of the top.

Of course this stand won't last forever, but for a seasonal handwashing station in the field it works very well. Remember to use clean, potable water for handwashing, not rain water or surface water.

See the video, "How to build a handwashing station" at <http://z.umn.edu/gct>. More information about on farm food safety can be found at: <http://safety.cfans.umn.edu>

2011. Developed by the University of Minnesota Agricultural Health and Safety Program team. Funding through a partnership between the MN Fruit and Veg Growers Association and the USDA-Risk Management Agency.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all of its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs). USDA is an equal opportunity provider and employer.

Grade

Elementary K-5

Materials/Preparation

- Teacher Material A – What Are We Eating? – one per teacher
- Handout A – What Do We Eat? – one per student
- Assessment A – What Are We Eating? – one per student
- A variety of plants from the garden or plant part models
- Materials to make a Venn Diagram (markers and large sheets of paper or bulky yarn to make on the classroom floor)
- Material to make fruit and vegetable labels and a plant parts chart
- Writing instruments

Fun Fact

The flavor of a strawberry is influenced by weather, the variety, and stage of ripeness when harvested.



What Are We Eating?

Minnesota K-12 Academic Standards

Science	0.4.1.1 2.4.1.1 3.4.1.1 5.4.1.1	Living things are diverse with many different observable characteristics.
Health	3.7.2	The student will demonstrate strategies to improve or maintain personal health.
Health	5.7.2	The student will describe responsible health behaviors.

Summary/Overview

A significant reason to engage in gardening in schools is to teach students, and allow them to discover for themselves, how plants grow and what parts of plants we eat. That is the purpose of this activity.

Garden Connection

Students examine garden plants and produce and identify roots, stems, leaves, and flowers.

Background Information

Surprisingly, some students actually believe that food comes from the grocery store ... as if machinery in the back of the store is manufacturing the foods they eat every day. Of course, many of the foods consumed today are processed into forms unrecognizable from their plant or animal origins. While most adults recognize that foods are grown on farms from plants or raised as domesticated animals, even they would be at a loss to answer the questions posed in this lesson.

Is it a root? Is it a stem? Is it a leaf? Is it a fruit? Is it actually a vegetable? We often informally classify plant products by how they are consumed. If it is served with the main entrée in a meal, we may consider it a vegetable. If it is sweet or served as dessert, we may consider it a fruit. Actually, there is a scientific botanical definition of fruits. In laymen's terms, if it has a seed or is a seed, it is botanically the fruit of the plant. So, grains are plant fruits. Tomatoes are plant fruits. Cucumbers, squash, and pumpkins are all plant fruits.

So, what are vegetables? Vegetables are the vegetative part of the plant and the reproductive part of the plant before they bloom, set fruit, and form seeds.

Vegetables are:

Leaves	Lettuce, Cabbage, Spinach, Bay Leaves, Oregano, Sage, Parsley Flakes, Basil, Rosemary, Thyme, Tea, Dill Weed, Cilantro, Mints
Modified Leaves	Onions, Celery, Brussels Sprouts, Garlic
Flowers	Broccoli, Cauliflower, Artichoke, Cloves, Saffron
Stems	Cinnamon, Asparagus
Modified Stems	Potatoes, Turnips, Ginger
Roots	Carrots, Beets, Parsnips, Sweet Potatoes, Radishes, Turmeric

Botanically, all of these are fruits:

Often Called Vegetables	Tomatoes, Cucumbers, Peppers, Squash, Pumpkins, Green Beans, Sweet Corn, Peas, Snow Peas
Fruits	Apples, Cherries, Peaches, Plums, Watermelons, Cantaloupes, Bananas, Oranges, Lemons, Limes, Mangoes, Strawberries, Blueberries, Raspberries, Gooseberries, Grapes, Currents, Dates, Figs
Nuts	Almonds, Black Walnuts, Brazil Nuts, Cashews, Coconuts, Hazel Nuts, Hickory Nuts, Peanuts, Pecans, Walnuts
Grains	Corn, Wheat, Oats, Sorghum, Barley
Spices	Allspice, Chili Powder, Caraway, Cardamom, Coriander, Dill Seed, Mace, Mustard, Nutmeg, Paprika, Pepper, Vanilla

Of course, it isn't always so simple. In some plants both the fruit and vegetative portions are used as food. This is true with dill. The leaves are used as dill weed, and the immature flower heads are used as a flavoring in dill pickles; these are vegetative. The dill seed (fruit) are also used in making dill pickles and as a spice. The leaves of the cilantro plant are used in Mexican cooking as an herb (vegetative), but when the plant develops seed (fruit), it is used as a spice and known as coriander. And politics or the law sometimes intervenes.

In 1883, the Supreme Court ruled that tomatoes should be considered a vegetable for tax purposes. The U.S. Congress passed the Tariff Act of 1883 that imposed a 10-percent tariff on all imported vegetables. The tax collector in New York Harbor was collecting tax on tomatoes as a vegetable. Fruit importers, the Nix brothers, sued to retrieve back taxes, claiming that tomatoes were actually fruit and therefore should not be taxed. The court denied the claim and tomatoes were legally determined to be vegetables regardless of science. Tax is still paid today on imported tomatoes. This lesson is straightforward in most applications and only explores the more confusing aspects of fruits vs. vegetables as an enhancement.

Objectives

- Explain plant anatomy and foods associated with different plant parts.
- Identify if food is actually a fruit or vegetable and which parts of plants are consumed as food.

Procedure

Interest Approach

Find out what your students already know about where their foods come from by asking questions such as: "Which foods that you eat come from plants? Which foods come from animals?" Have students list favorite foods they believe come from plants and explore the ingredients. Older students can do this by reading ingredient labels, researching online or in the library. Review the parts of the plant, the process of plant growth, and reproduction using the plant diagram included. After the food sources are identified, determine the parts of the plant that are used to make up that food. Generalities are fine.

Summary of Content and Teaching Strategies

Fruit or Vegetable? Activity

As a class, make a list of as many fruits and vegetables as students can think of. Post the list where students can see it. Make labels for each fruit and vegetable with letters large enough to be seen from a distance. (Alternative: Have students find pictures of each fruit or vegetable from seed catalogs, magazines, grocery store fliers, or online.) Explain the difference between a fruit and vegetable, as described above.

On a bulletin board with paper and marker, or on the floor using heavy yarn, make two circles. Label the circles *Fruit* and *Vegetable*.

Select the first item listed and ask: "Do you think this is a fruit or a vegetable?" Place either the picture or word in the portion of the circle labeled appropriately. Continue placing all fruits and vegetables in one category or the other.

What part of the plant?

Create a chart in a visible location with the headings: Leaf/Leaves, Flowers, Stems, Roots (for younger students) or Leaf/Leaves, Modified Leaves, Flowers, Stems, Modified Stems, Roots (for older students). Provide copies of Handout A for student use either to take notes or with a group activity. Also display Teacher Material A.

Using only the plant foods identified in the previous activity as true vegetables, have the students categorize each vegetable on the list into one of these categories. This may be done in small groups or as a class.

Review/Summary

Have older students either dissect modified leaves and stems or research information about them on the Internet. Identifying onions as modified leaves is easily seen with scallions or green onions. Celery, when stripped off the bunch, reveals the stem at the center of the plant. The celery stalk connects the leaf to the stem.

Modifications/Extensions

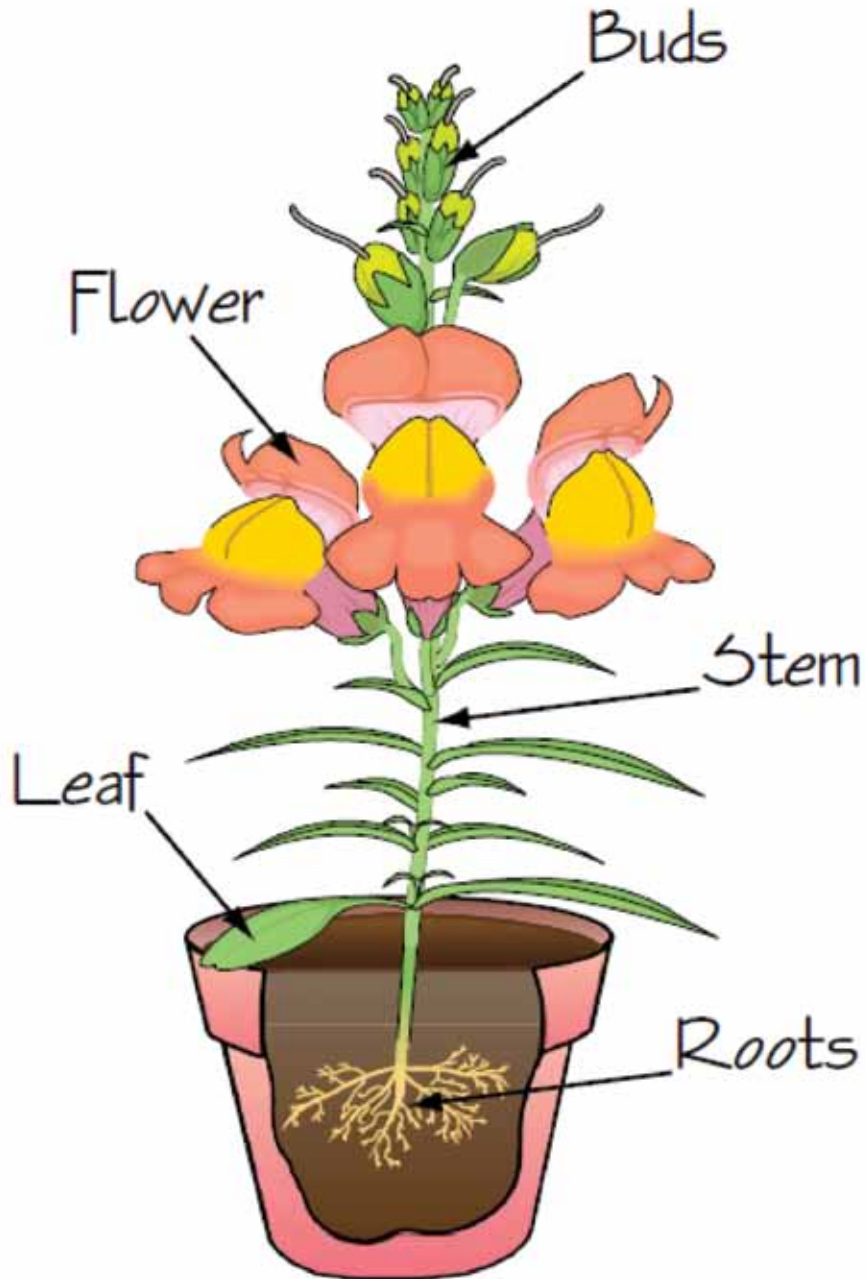
See the lesson specifically developed for teaching biology to middle school and high school students "What Parts of a Plant Do We Eat?" at: http://serendip.brynmawr.edu/sci_edu/waldron/#planteaters

Have the students select an herb or spice and research its history, origin, and uses. Use the information to write a report, create a PowerPoint presentation, or poster project.

Sources/Credits

The above lesson is provided courtesy of Florida Agriculture in the Classroom, Inc. from its *Gardening for Grades* school garden curriculum.

What Are We Eating?



Source: The above image is provided courtesy of Florida Agriculture in the Classroom, Inc from its Gardening for Grades school garden curriculum.

Name _____



What Do We Eat?

Leaf/Leaves	Flowers	Stems	Roots

Name _____



What Are We Eating?

1. What is the difference between a fruit and a vegetable?

2. Which of these are leaves?

Lettuce, cabbage, spinach

Brussels sprouts, broccoli, asparagus

Lettuce, rhubarb, potatoes

3. List two vegetables that are roots.

4. List three fruits that are commonly known as fruits and scientifically also fruits.

Grade

Elementary K-5

Materials

- Teacher Material A – Go, Glow, Grow – one per teacher
- MyPlate icon found at <http://www.choosemyplate.gov/print-materials-ordering/graphic-resources.html>
- Empty, clean food containers such as boxes, bags, or cans without sharp edges (students can bring these from home) or fruit and vegetable samples from the garden
- Plastic or paper grocery bag - one per student (students can bring their food containers in them)
- 5 paper grocery sacks and markers (label one bag for each food group: Grain, Vegetables, Fruits, Milk, Meat/Beans, on one side; on the other side write GO on the Grain sack, GLOW on the Vegetables and Fruits sacks; and GROW on the Milk and Meat/Beans sacks)
- Masking tape, ball of yarn, or colored chalk to mark the floor
- Writing instruments

Fun Fact

Rhubarb's nickname is the "pie plant" because that is the primary use for this vegetable.



The Healthy Hop 'n Shop

Minnesota K-12 Academic Standards

Science	0.4.1.1 1.4.1.1 2.4.1.1 3.4.1.1 5.4.1.1	Living things are diverse with many different observable characteristics.
Health	2.8.1	The student will express information and opinions about health information and ideas.
Health	3.7.2	The student will demonstrate strategies to improve or maintain personal health.
Health	5.7.2	The student will describe responsible health behaviors.

Summary/Overview

Students learn about the USDA MyPlate through a pretend grocery store. They also learn the importance of each food group.

Garden Connection

Garden produce fulfills two of the food groups in the USDA's MyPlate nutritional guide.



Background Information

The United States Department of Agriculture's MyPlate is a nutritional guide to help us choose what to eat. The plate is a visual representation of the suggested amounts of food to eat from each food group. Further suggestions include drinking skim or 1% milk, getting half of a person's grain intake from whole grains, eating a variety of protein, and reducing the amount of sodium and sugar consumed. Find more information on MyPlate at <http://www.choosemyplate.gov/>.

Objectives

- Categorize foods into food groups.
- Explain why it's important to eat foods from each food group and exercise every day.
- Describe the USDA MyPlate icon.

Procedure

Preparation

Select a place with enough open space for students to make a large MyPlate circle on the floor. Divide the circle into four sections: one each for fruit, vegetable, grain, and protein. Also add a smaller circle for dairy; refer to the MyPlate diagram for placement and size of sections. The MyPlate circle will become the Healthy Hop 'n Shop grocery store and each food group will be a section of the store. Have the paper grocery sacks labeled and ready to place in each food group section. Go through the food containers and garden produce to make sure there is one package or item for each student and each of the food groups are represented. Display the MyPlate icon in a place where everyone can see it.

Interest Approach

Point out the MyPlate icon to students. Ask if they have seen the icon before and if they know what it represents. Count the number of food groups with students. Mention that in addition to eating healthy foods it is important to get daily exercise. Brainstorm a list of physical activities the students enjoy.

Summary of Content and Teaching Strategies

Instruct students to move to the wide-open space. Have them stand in a large circle holding hands with arms outstretched. Give the end of the masking tape or ball of yarn to a student. Unroll the tape or yarn placing it in front of the students' feet until the circle is complete. Next add lines to divide the plate into four sections with vegetables and grains slightly bigger than fruits and protein. Finally, create a smaller circle for dairy.

Your students have just created the Healthy Hop 'n Shop grocery store. The food groups are the sections of the grocery store. Students are the grocery store customers and employees.

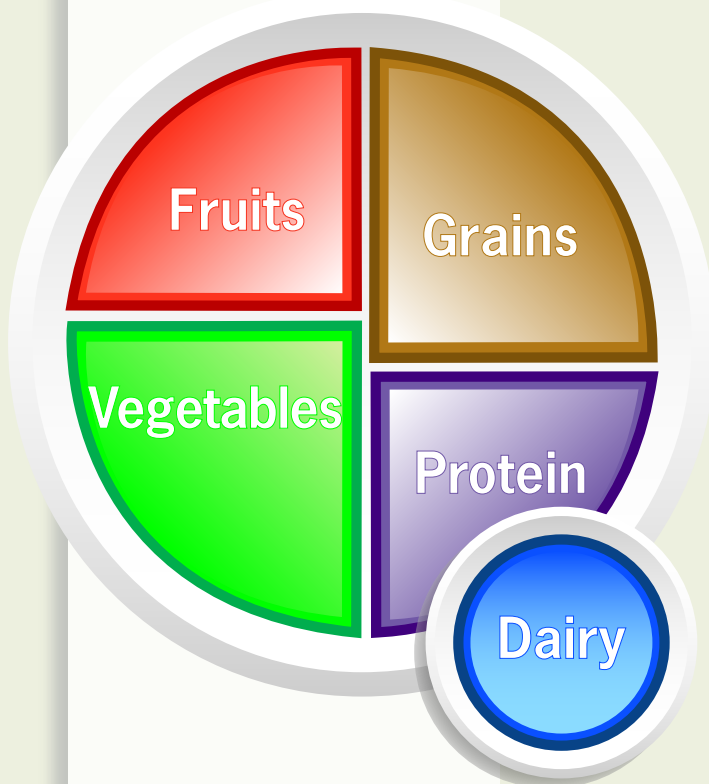
Grocery Store Employees

Have the students sit on the floor around the yarn/tape circle. Distribute the empty food containers (or food samples). Go around the circle and have the students identify the food they have and tell to which food group it belongs. Offer support if a student is not able to identify his/her food and its group. Students place their items in the correct section of the Healthy Hop 'n Shop grocery store.

Demonstrate how the students are going to become grocery store employees, stocking food at the Healthy Hop 'n Shop. Use a grain product container, go to the grain section, and say, "I'm stocking cereal (or whatever your grain product is)," hop to the grain sack, and put your food container in the grocery sack. Then walk back to where you were sitting.

Have everyone that has a grain product line up at grain section and say, "I'm stocking (whatever food item they have)." Have them hop, one at a time, to the sack, put their container inside, and walk back to their seat.

Repeat this until everyone has put their grain, vegetable, fruit, milk, and meat/beans items into the sacks at the Healthy Hop 'n Shop grocery store. Discuss how produce grown in the garden can be sold at grocery stores and farmers' markets.



Go, Glow, Grow

Refer to the chart below when teaching students about Go, Glow, and Grow. The foods we eat provide us with one of three powers. Review the food groups and their special power with students. Then ask students to name examples of food from each group. Next have them name examples of food we eat that contain food from each group. Finally, have students do the activity listed in the last column of the chart below. Use Teacher Material A as a visual if desired.

Food Group	Power	Examples	Foods	Activity
Grain	"Go"	corn, soybeans (grown as a grain, but really a legume), wheat, oats, and rice	cereal, bread, rice, pancakes, popcorn, pasta	Students stand up and pretend they have run out of power or energy – like a car that's running out of gas. Next, pretend they have lots of power or energy to "Go."
Vegetables	"Glow"	lettuce, onions, carrots, potatoes	Salad, salsa, vegetable soup	Students stand up and show others what they look like when they have a stomachache. Next, they smile really big to show off their healthy gums, skin, eyes, hair, and bodies.
Fruits	"Glow"	apples, strawberries, blueberries, raspberries, grapes, pears, peaches, plums	apple sauce, prunes, raisins, fruit smoothies	Students stand up and show others what they look like when they have a stomachache. Next, they smile really big to show off their healthy gums, skin, eyes, hair, and bodies.
Milk	"Grow"	mostly animals, except for soy milk from soybean plants	yogurt, cheese, ice cream, sour cream	Milk helps bones and teeth to grow strong and healthy. Everyone smiles, shows off their teeth, and does a "strong bones" stance.
Meat/ Beans (Protein)	"Grow"	mostly animals, except for beans from bean plants	hamburgers, hot dogs, meat balls, black beans	Meat and beans help bodies to heal, and they help to build strong muscles. Students stand and show off their muscles.

Grocery Store Customers

Have students get the individual grocery bags they brought in. It's time to go grocery shopping! In the meantime, have a small group of store employees set the foods in each store section out of the bags. Now students act as consumers or people who buy food from the store. Each student selects one item from the store, puts it in his/her individual bag, and hops back to their desk.

Go around the room and have each consumer tell what food item he/she selected, which food group/store section it came from, and whether it will help him/her to Go, Glow, or Grow.

Review/Summary

Review the following questions as a class.

- How many food groups are in the Healthy Hop 'n Shop grocery store?

One – grain; two – vegetables; three – fruits; four – dairy; five – meat and beans.

- Why should we eat food from all five food groups every day?

Eating a variety of foods from each of the food groups gives us the nutrients we need to keep us going, glowing, and growing.

- How many food items do we have in each store section or food group?

Count the number of packages in each food group and record them on the board.

- Which two food groups are the largest on MyPlate? Why is this so?

Grain and vegetables. We should eat more foods from the grain group to give us power and energy to “go” all day long. We need to eat more vegetables filled with vitamins, minerals, and fiber to keep us glowing or feeling good.

- What other food groups are important to eat?

Fruits, protein, and dairy. Fruits contain vitamins, minerals, and fiber. Meat and beans give us protein to help our muscles grow and repair themselves. Eggs are a part of this group too. We need calcium from milk products to keep our teeth and bones strong, especially as we grow.

Another food category, oils, is also important, but is not listed as a separate food group.

Modifications/Extensions

Use food from each group to do fun relay races. Try things like rolling eggs, carrying grapes on a spoon, holding a big carrot under your chin while you walk, and so on.

Older students can be asked to research food guides. They can look for previous models used in the United States and models used in other countries. Report the findings back to the class. As an extra credit assignment, students can develop their own healthy food guide.

Sources/Credits

Adapted from *Growing in the Garden Elementary Curriculum that Grows with the Child* written by the Iowa 4-H Development Program and revised in June 2012. The curriculum can be purchased from the Iowa State Extension Office: <http://www.extension.iastate.edu/4h/page/curricula-info-ordering>

Go, Glow, Grow

Food Group	Power	Examples	Foods
Grain	"Go"	corn, soybeans (grown as a grain, but really a legume), wheat, oats, and rice	cereal, bread, rice, pancakes, popcorn, pasta
Vegetables	"Glow"	lettuce, onions, carrots, potatoes	Salad, salsa, vegetable soup
Fruits	"Glow"	apples, strawberries, blueberries, raspberries, grapes, pears, peaches, plums	apple sauce, prunes, raisins, fruit smoothies
Milk	"Grow"	mostly animals, except for soymilk from soybean plants	yogurt, cheese, ice cream, sour cream
Meat/ Beans (Protein)	"Grow"	mostly animals, except for beans from bean plants	hamburgers, hot dogs, meat balls, black beans

Grade

Middle School

Materials/Preparation

- Teacher Material A – Safety First – Responsibilities for a Safe Food Supply – one per teacher
- Teacher Material B – Responsibility Cards – one copy cut into pieces – one piece as assigned per team
- Assessment A – Safety First – one per student
- Assessment B – Team Book Page Rubric – one per student
- “You Better Wash Your Hands” – music video found at <http://foodsafety.ucdavis.edu/html/video.html>
- Computer with Internet access and sound
- Speakers
- Blank paper – two sheets per team, six teams
- Timer
- Crayons/markers/colored pencils – enough for the class
- Writing instruments

Fun Fact

The strawberry is not classified by botanists (people who study plants) as a true berry. True berries, such as blueberries and cranberries, have seeds inside. The strawberry, however has its dry, yellow “seeds” on the outside (each of which is actually considered a separate fruit).

Safety First – Responsibilities for a Safe Food Supply

Minnesota K-12 Academic Standards

Health	6.3.2	The student will demonstrate the ability to utilize resources from home, school, and community that provide valid health information.
Language Arts	6.14.2.2	Write informative/explanatory texts, as they apply to each discipline and reporting format, including the narration of historical events, of scientific procedures/experiments, or description of technical processes.

Summary/Overview

Students learn about food safety responsibilities by creating a children’s book.

Garden Connection

Food safety practices in the garden help reduce the risk of food-borne illnesses.

Background Information

To meet food safety standards and minimize consumer health risks, safety responsibilities exist for everyone involved in the food supply continuum. Several laws and protocols are in place to ensure a safe food supply. Good Agricultural Practices (GAPs) are environmental and operational conditions necessary for producing safe, wholesome fruits, vegetables, and livestock. Similar to GAPs are Good Manufacturing Practices (GMPs). GMPs establish quality systems for manufacturers to make sure their products meet specific requirements to create safe products. Hazard Analysis and Critical Control Points (HACCP) identifies points in food handling where contamination is likely to occur.

Objectives

- Identify food safety responsibilities in the food supply continuum.
- Compare and contrast Good Agricultural Practices and Good Manufacturing Practices.
- Explain the importance of Hazard Analysis and Critical Control Points.

Procedure

Interest Approach

Use the music video, “You Better Wash Your Hands,” found at <http://foodsafety.ucdavis.edu/html/video.html> to begin this lesson. The song is about sanitation and washing hands, which connects to some of the content later in the lesson. The food safety music videos can also be ordered in CD form from the website. If you don’t have the resources to show the video, there are audio options without the video on the website. Another option is to simply have a discussion about washing hands and the relationship between keeping our hands and food clean. Following the video, discuss the importance of good hand washing, sanitation, and the responsibility of producers to keep our food supply safe.

Summary of Content and Teaching Strategies

To keep up with new laws, rules, and information about food safety regulations and responsibilities, farmers, ranchers, and other producers involved in the agriculture industry constantly seek new information. They subscribe to magazines, search the web, work with their local extension agents, and are constantly learning new ways to keep food safe.

Brainstorm safety-related topics that are important for growing a garden. Ask students how they can learn more about those topics (Internet research, talk to farmers, food manufacturers, master gardeners, etc.).

Divide students into six groups to create the pages of a food safety book. Have students gather their supplies: blank paper, crayons, markers, and colored pencils. Each group will be responsible for creating a page for the book, including the cover, content, and illustrations. If groups are larger than three students, you may choose to have them create multiple pages.

When students move into their groups, give each team their assigned responsibility card (Teacher Material B). Tell each team they are responsible for including the content from their Responsibility Card, as well as illustrations, on their page. Set the timer for 20 minutes work time. Be sure to give them a five-minute warning before time is up.

Depending on your class size, you may adjust work time. As students work, circulate around the room to answer questions and guide students who need assistance.

When students are finished with their pages, they share the information with the class, thus teaching the class about their assigned safety responsibilities. Call each group to present in order beginning with Team 1, Team 2, and so on. This lets you review the content in order.



Review/Summary

Students lead the discussion by explaining what they have created on their pages. Guide the discussion by asking questions and facilitating the discussion. After each team presents, instruct the students to:

- Take a moment and think about what they just learned and what they may already know.
- Write their reflections on a sheet of paper.
- Share their thoughts with their group.

As a final recap, ask the class:

- What are the three main programs that help agriculturalists maintain their safety responsibilities in the food supply? (Good Agricultural Practices - GAP; Good Manufacturing Practices - GMP; Hazard Analysis and Critical Control Point - HACCP.)
- How do these programs help to ensure a safe food supply for all of us?
- Will programs, laws and regulations keep everything safe? Why are all the *people* in the food chain the biggest part of food safety?
- How can we use the information we learned today to make sure the produce grown in our garden is safe?

Modifications/Extensions

Safety Regulation Contamination: Set up an obstacle course using objects or landmarks like desks or hula-hoops, or if outside, trees and shrubs. Along the course, be sure there are some obviously contaminated elements ... dirt, dirty tools, doorknobs, balled-up facial tissue, etc. Give each student a handful of clothespins or stickers. While walking through the obstacle course, if the students see or touch something unsafe or unclean - they put a clothespin or sticker on their shirt to signify contamination. At the end of the game, the person with the most clothespins or stickers is the most contaminated. Use the results of the game to lead to a discussion about food safety and the quick spread of contamination within foods. If someone does not have any stickers or clothespins, ask them what they did to avoid becoming contaminated. Also ask the class what they could have done differently in order to prevent contamination.

Students have learned about national resources and programs that assist in their health. Now have students make a list of health-related resources in their home, school, and community. After students are done, have them compare their list with a partner. Finally discuss resources as a class.



Sources/Credits

Adapted from: National FFA Organization *Middle School Food and Agricultural Literacy Curriculum*, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit <https://www.ffa.org/documents/learn/MS.FS.1.5.pdf> to access the full-length version of this lesson.

Safety First - Responsibilities for a Safe Food Supply

To meet food safety standards and to minimize consumer health risks, safety responsibilities exist for agriculturalists involved in the food supply.

- A. Food Sanitation:** the process of keeping food processing and preparation areas clean.
- B. Good Agricultural Practices (GAP):** environmental and operational conditions necessary for producing safe, wholesome fruits, vegetables, and livestock.
- Specific guidelines for fruit, vegetable, and livestock producers to follow to ensure safe products.
 - Guidelines for minimizing risks caused by potentially threatening sources that are part of the production process: soil, manure, cooling units, ice, transport vehicles, poor employee hygiene, etc.
 - Practices like good hygiene of employees, clean storage facilities, water quality monitoring, record keeping for the farm operations, harvest and storage sanitation, safe handling of manure, following all on-farm safety practices and procedures, etc.
 - Good Manufacturing Practices (GMP): Similar to GAP: establishes quality systems for manufacturers to ensure their products meet specific requirement for safe products.
 - GMP is a government-regulated program.
 - Record keeping, documentation, training, evaluation, and inspections help ensure that GAP and GMP are being implemented by businesses/operations.
 - Hazard Analysis and Critical Control Points (HACCP): identifies points in food handling where contamination is likely to occur.
 - HACCP provides steps to take to manage and reduce contamination of food, and applies to facilities and processes, like the process of packaging meat or a facility where ice cream is made.
 - Larger processors are more likely to have a HACCP plan than small processors.
 - HACCP is a government-regulated program.
 - HACCP aims to prevent potential microbiological, chemical, and physical hazards in foods.

Responsibility Cards

<p>Team 1. Book cover</p> <p>You are also responsible for a title for the book – be creative!</p> <p>Introduction Page</p> <ol style="list-style-type: none"> 1. To meet food safety standards and minimize customer health risks, safety responsibilities exist for agriculturalists involved in the food supply continuum. 2. Food sanitation: the process of keeping the areas where food is processed and prepared clean. 	<p>Team 2. GAP Part A</p> <ol style="list-style-type: none"> 1. Good Agricultural Practices (GAP): environmental and operational conditions necessary for producing safe, wholesome fruits, vegetables, and livestock. 2. Specific guidelines for fruit, vegetable, and livestock producers to follow to ensure safe products. 	<p>Team 3. GAP Part B</p> <ol style="list-style-type: none"> 1. To ensure a safe food supply, producers are responsible for minimizing risks caused by potentially threatening sources that are a part of the production process: soil, manure, cooling units, ice, transport vehicles, poor employee hygiene 2. GAP include practices like good hygiene of employees, clean storage facilitates, water quality monitoring, record keeping for the farm operations, harvest and storage sanitation, safe handling of manure, following all on-farm safety practices and procedures, etc.
<p>Team 4. GMP</p> <ol style="list-style-type: none"> 1. Similar to GAP: Good Manufacturing Practices (GMP): establishes quality systems for manufacturers to make sure their products meet specific requirements for safe products. 2. GMP is a government-regulated program. 3. Record-keeping, documentation, training, evaluation and inspections help ensure that GAP and GMP are being implemented by businesses/operations. 	<p>Team 5. HACCP Part A</p> <ol style="list-style-type: none"> 1. Hazard Analysis and Critical Control Points (HACCP): identifies points in food handling where contamination is likely to occur. 2. HACCP provides steps to manage and reduce the contamination of food, and applies to facilities and processes like meat or ice cream. 	<p>Team 6. HACCP Part B</p> <ol style="list-style-type: none"> 1. Larger processors are more likely to have a HACCP plan than small processors. 2. HACCP is a government-regulated program. 3. HACCP aims to prevent potential microbiological, chemical, and physical hazards in foods.

Name _____



Safety First

Read each statement and circle the letter next to the correct answer.

1. Food sanitation is the process of keeping food processing and preparation areas clean.
 True False
2. Two potential risks to supplying safe food identified by Good Agricultural Practices are...
 - a. soil and employee hygiene.
 - b. temperature and air pressure.
 - c. population and salary rates.
3. Good Agricultural Practices and Good Manufacturing Practices are not government-regulated programs.
 True False
4. Hazard Analysis and Critical Control Points (HACCP) aims to prevent potential _____ hazards to our foods.
 - a. chemical
 - b. biological
 - c. Microbial
 - d. all of the above
5. _____ identifies points in food handling where contamination is likely to occur.
 - a. GMP b. GAP c. HACCP d. all of the above

Name _____

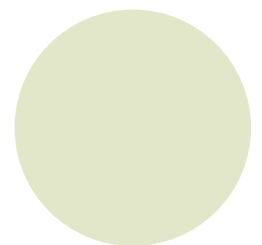
Team Book Page Rubric



	0	5	10	Total
Content	The content on the page does not reflect the content provided in class.	Most of the content is included, but some has been left out.	All of the content has been included in the book page.	
Neat/Creative	Book page is messy, hard to read, not colorful, not presentable.	Book page is somewhat neat, colorful, presentable.	Book page is very neat, creative, colorful, and presentable.	
Complete	Book page is incomplete, did not finish the assignment in the time provided in class.	Book page is somewhat complete, mostly finished the page except for minor details to the illustration or text.	Book page is complete, finished assignment in the time frame provided in class.	

Comments:

Total Score



Grade

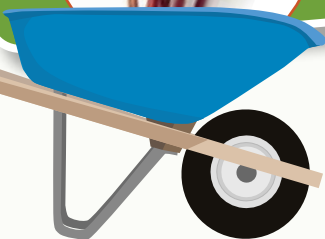
Middle School

Materials/Preparation

- Teacher Material A – It's All in a Label – Copy and cut up as many sheets needed to speed the activity
- Handout A – Nutrition Facts Label Components Note Sheet – one per student
- Handout B – It's All in a Label – Nutritional Label Interpretation – one per student
- Assessment A – It's All in a Label – one per student
- Scissors –one set for teacher
- Tape
- Notebook paper
- Writing utensils

Fun Fact

Different colors of stalks determine the taste of rhubarb. Green stalks with green flesh have the highest acid content and are particularly sour. Green stalk varieties are mainly suitable for jams and jellies. Red stalks with green flesh are less sour and have a slight tangy, sweeter flavor. Red stalk varieties are good as filling for cake, pie, tart, or cookies or cut in fruit salads.



It's All in a Label

Minnesota K-12 Academic Standards

Health	6.8.1	The student will demonstrate the ability to influence and support others in making positive health choices.
Science	6.1.3.4	Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.

Summary/Overview

Students learn about the components of nutrition labels found on food.

Garden Connection

Students use nutritional labels to compare the nutrition of fresh garden peas to canned and frozen peas.

Background Information

Nutrition labels contain lots of information. By understanding the meaning of the information, students are able to make healthier food choices. Nutrition labels have three main sections including serving size, calories, and nutrients.

Objectives

- Interpret a food label.
- Explain the meaning of serving size.
- Define calories.
- Name three examples of nutrients.



Procedure

Interest Approach

Instruct students to take out a piece of paper and a writing utensil. Give them two minutes to create a detailed list of all the food they have eaten in the last 24 hours. Have them count the number of items they ate as well.

Ask students to take a good look at the food on their list. Can they estimate how many calories are represented on their list? A food label for each item would be needed before an accurate estimate of the number of calories could be made.

The nutritional requirements of our bodies and the nutrients contained in the foods we eat don't always align! For a healthy lifestyle it is important to understand the nutrient levels in the foods we eat. During this lesson students learn to read food labels.

Summary of Content and Teaching Strategies

Cut up and paste copies of Teacher Material A around the room; feel free to have multiples of each sheet for larger classes. Distribute a copy of Handout A to each student. Give students ten minutes to travel to each nutrient/label component and fill in the meaning for each portion of the label. They need not record every word. The first bullet is the main definition for each section; they can add a key note or two from the remaining bullets. Monitor student progress as they work on their activity sheet. Give time warnings at five

minutes and two minutes remaining to help students allocate their time to complete the activity.

Provide students with copies of Handout B. Tell students to read it carefully before beginning. The sheet contains three food labels and poses questions that challenge students to evaluate the labels. Students may refer back to the information recorded from Handout A. Students turn sheets face down upon completion. This individual activity should take no more than five minutes to complete.

Review/Summary

In small groups students compare answers to questions on Handout B. If they have different answers, they consult the teacher or a different group for clarification.

Modifications/Extensions

Take an extra day to look at ingredients and allergy warnings on food labels and discuss allergens in food. Note the special care that individuals with such food allergies must take to read food labels on all the products they eat.

Discuss how students can assist others in learning how to make educated food choices. Have students make posters showing how to interpret a nutrition fact label, USDA MyPlate diagram, or other nutrition-related messages. Hang posters around the school including the cafeteria.

Sources/Credits

Adapted from: National FFA Organization *Middle School Food and Agricultural Literacy Curriculum*, sponsored by the National Pork Board as a special project of the National FFA Foundation. Visit <https://www.ffa.org/documents/learn/MS.FS.4.1.pdf> to access the full-length version of this lesson.

It's All in a Label

Make as many copies of this sheet as needed. Cut along each section line and place the sections around the classroom.

Serving Size *Details the number of servings in the package.*

- Serving size standardizes food portions and allows consumers to compare foods through similar units of measure.
- The size of servings in the packaging influences the number of calories in the food. Pay close attention to serving size because you may accidentally consume too many calories by eating multiple servings.

Calories (and Calories from Fat) *Tells a measure of energy in each serving of the packaged food.*

- Calories from fat are added to detail how many of the total calories are derived from fat.
- Many Americans consume too many calories and this portion of the label helps consumers manage their caloric intake.
- General Calorie Guide: 40 calories is low, 100 calories is moderate, 400+ calories is high.

Nutrients *Details the quantity of specific nutrients offered by each serving of food.*

- Nutrients include: Total Fat (Saturated and Trans Fat), Cholesterol, Sodium, Total Carbohydrate, Dietary Fiber, Sugar, Protein, Vitamins A and C, Calcium, and Iron.
- The FDA breaks the nutrients into two groups to assist consumers in healthy choices.
 - Nutrients to be limited: Fat (Saturated and Trans Fat), Cholesterol, and Sodium. Americans consume enough or too much of these.
 - Nutrients to get enough of: Dietary Fiber, Vitamin A, Vitamin C, Calcium, and Iron. Most Americans don't get enough of these.

Name _____



Nutrition Facts Label Components Note Sheet

Nutrition Facts	
Serving Size	Serving Size Servings Per Container
	Amount Per Serving
Calories	Calories Calories from Fat
	% Daily value*
Nutrients	Total Fat 1g %
	Saturated Fat %
	Trans Fat %
	Cholesterol %
	Sodium %
	Total Carbohydrate %
	Dietary Fiber %
	Sugars %
	Protein %
	Vitamin A %
	Vitamin C %
	Calcium %
Iron %	
*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.	
	Calories 2,000 2,500
Total Fat	Less than 85g 80g
Saturated Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g

Record Information Below

Name _____



It's All in a Label - Nutrition Label Interpretation

Study the pea labels below. Use the information in each label to answer the questions at the bottom of the page.

1. Frozen

Nutrition Facts		Amount/Serving	% Daily Value*	Amount/Serving	% Daily Value*
Serving Size 2/3 cup (84g) frozen 1/2 cup prepared		Total Fat 0g	0%	Potassium 150mg	4%
Servings Per Container 4		Saturated Fat 0g	0%	Total Carbohydrate 12g	4%
Calories 60 Calories from Fat 0		Trans Fat 0g		Dietary Fiber 4g	16%
		Cholesterol 0mg	0%	Sugars 4g	
		Sodium 135mg	6%	Protein 4g	
		Vitamin A 8% • Vitamin C 10% • Calcium 0% • Iron 6%			

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Potassium		3,500mg	3,500mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

2. Raw

Nutrition Facts	
Serving Size 1 1/2 cup (85g) Servings Per Container about 2.5	
Amount Per Serving	
Calories 35	Calories from Fat 0
% Daily Value*	
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Potassium 170mg	4%
Total Carbohydrate 6g	2%
Dietary Fiber 2g	8%
Sugars 3g	
Protein 2g	
Vitamin A 20% • Vitamin C 90%	
Vitamin K 25% • Iron 10%	
Vitamin B6 6% • Folate 8%	
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.	
Calories: 2,000 2,500	
Total Fat	Less than 65g 80g
Sat Fat	Less than 20g 25g
Cholesterol	Less than 300mg 300mg
Sodium	Less than 2,400mg 2,400mg
Potassium	3,500mg 3,500mg
Total Carbohydrate	300g 375g
Dietary Fiber	25g 30g
Calories per gram: Fat 9 • Carbohydrate 4 • Protein 4	

3. Canned

Nutrition Facts/Datos de Nutrición	
Serving Size 1/2 cup (122g) Cantidad por porción 1/2 taza (122g)	
Servings Per Container about 3 1/2 Raciones por envase 3 1/2 aproximadamente	
Amount/Serving Cantidad/Ración	
Calories/Calorías	50
Calories from Fat/Calorías de Grasa	0
% Daily Value* / % Valor Diario*	
Total Fat/Grasa Total 0g	0%
Saturated Fat/Grasa Saturada 0g	0%
Trans Fat/Grasa Trans 0g	
Cholesterol/Colesterol 0mg	0%
Sodium/Sodio 290mg	12%
Total Carbohydrate/Total de Carbohidrato 11g	4%
Dietary Fiber/Fibra Dietética 3g	14%
Sugars/Azúcares 4g	
Protein/Proteína 3g	
Vitamin A/Vitamina A 6% • Vitamin C/Vitamina C 10%	
Calcium/Calcio 0% • Iron/Hierro 4%	
* Percent Daily Values are based on a 2,000 calorie diet. * Los porcentajes de Valores Diarios están basados en una dieta de 2,000 calorías.	

- Which of the peas above is highest in protein? _____
- Which of the peas above has the most calories per serving? _____
- Which of the peas above has the most calories from fat? _____
- Which of the peas above has the most carbohydrates? _____
- Which of the peas above has the least sodium? _____
- Which of the peas above has the most Vitamin A and C? _____

Name _____

It's All in a Label



Circle the letter next to the correct answer.

1. Most Americans get plenty of dietary fiber.

True False

2. Trans Fats are a component of Total Fat.

True False

3. Sugar is an example of a _____.

- a. calorie
- b. fat
- c. carbohydrate

4. Calories are a source of _____.

- a. energy
- b. fat
- c. strength

5. If you consume a 4-oz. candy bar with 50 calories per 1-oz. serving, how many calories are you eating?

Grade

High School

Materials/Preparation

- Teacher Material A – Environmental Factors that Affect Food Availability and Choices – one per teacher
- Handout A – Experience Chart – one per student
- Handout B – Personal Food Goal – one per student
- Assessment A – Choosing Foods – one per student
- Four to six sets of unripe, ripe, or overripe raw fruits and vegetables*
- Napkins - one per student
- Tongs (to put samples on napkins)
- Blindfolds
- Writing utensils

**A typical example would be green, yellow, and brown bananas. An unripe cantaloupe or muskmelon is green and hard, a ripe one is tan or yellow, and an overripe one is soft and darker yellow and brown. Peas would be ripe when the pods are filled up with medium-sized peas. They would be unripe if the peas were not developed and overripe when they are large and tough.*

Choosing Foods

Minnesota K-12 Academic Standards

Health	9.2.1	The student will analyze how cultural diversity enriches and challenges health behaviors.
Health	10.6.1	The student will design, evaluate, and implement a plan for attaining a personal health goal.

Summary/Overview

Students learn to distinguish between unripe, ripe, and overripe produce. Next they examine influences on a person's food choices and conclude with a personal plan for trying new foods.

Garden Connection

Picking garden produce at its peak ensures the best-tasting product. Students learn how to distinguish between unripe, ripe, and overripe produce.

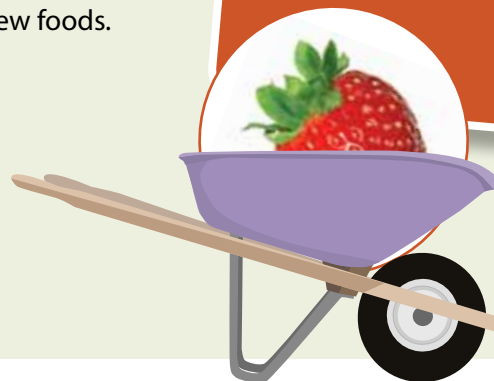
Background Information

Every day we make choices about the foods we eat. Knowing how to select fruits and vegetables at the peak of ripeness allows us to enjoy the tastiest foods. Unripe produce tends to be harder and less sweet. Ripe produce is typically firm with a slight give and is sweet. Overripe produce can be mushy and lack familiar texture. Produce grown far away from its final destination is picked during the unripe stage to allow time for travel. If unripe produce is purchased from the store, often it can be placed in a brown paper bag for a few days. The bag helps the fruit ripen by creating a chamber to hold in natural ripening gas given off by the produce. If produce becomes overripe on our counter at home it can be used in cooked foods. For example, overripe bananas are especially tasty in muffins and breads.

Many things influence the choices we make when selecting our food. We each have personal food preferences and dislikes. Sometimes our food choices are determined by the options provided to us such as in a school cafeteria line. Other times our food choices are influenced by where we live, the time of year, and climate. Whatever influences our food choices, it is important to continue to try new foods.

Fun Fact

Seventy percent of a strawberry's roots are located in the top three inches of soil.



objectives

- Identify fruits and vegetables that are unripe, ripe, and overripe.
- Describe the advantages of knowing how to identify produce that is unripe, ripe and overripe.
- Explain how environmental factors such as location, season, and climate affect food choice.
- Create a plan to incorporate new foods into your diet.



Procedure

Interest Approach

Ask students if they have ever smelled cookies baking in the oven and wished they could eat one at that moment. It sounds good, but if they did eat one, the cookie wouldn't be completely baked. It would be too soft and very hot. That is why we wait to take cookies out of the oven until the timer rings telling us they are done. Many things we eat have to be at the right stage for them to taste their best. Fruits and vegetables are that way. A fruit or vegetable is called ripe when it's ready to eat. We use our senses to tell when fruits and vegetables are ripe.



Summary of Content and Teaching Strategies

Have the class number off one through three and form groups according to their number. The three groups will determine ripeness by look, touch and smell. Have all groups wash their hands thoroughly.

Group 1 looks at each set of fruits or vegetables. They determine which one is unripe, ripe, and overripe in each set, and put the fruits or vegetables on a desk or table in order of ripeness. Put unripe produce on the left, ripe in the middle and overripe on the right.

Group 2: Blindfold this team. Place an assortment of unripe, ripe and overripe fruit or vegetables within arm's reach on the table. Place Group 2's hands on the produce and instruct them to feel the fruits or vegetables and identify them. Then have them feel the fruits or vegetables to determine which are unripe, ripe, and overripe. Have them put the unripe fruit or vegetable on the left, ripe in the middle and overripe on the right. Ask them to explain their choices.

Group 3: Blindfold this team. Use the same technique as with the twos, but instruct the students to smell the fruits and vegetables to see if they can tell the difference. Have them place the produce in order of ripeness from left to right starting with unripe. Once again, ask them to explain their choices.

Thoroughly wash the fruits and vegetables and set up a taste test. Label produce unripe, ripe or overripe. Instruct students to wash their hands again and then taste test the produce. Before eating the produce, students use their senses to observe differences between samples and complete Handout A. Discuss the difference in taste between the unripe, ripe, and overripe produce.

Ask students why is it helpful to know when fruits and vegetables are ripe. Produce is the sweetest and tastes the best when ripe. We need to eat adequate amounts of fruits and vegetables every day to keep our bodies healthy. If we know when fruits and vegetables taste the best, we might eat more of them.

Sweetness and texture can influence the food we choose to eat, but many other things do too. Ask students to brainstorm a list of factors that influence the choices we make with our foods. Be sure students think about how environmental factors such as location, season, and climate affect food choice. Display Teacher Material A and fill in the columns as a class. Ask students to name foods that are dependent

upon location or certain growing conditions. For example, watermelon plants need a sunny location with well-drained soil. Brainstorm a list of foods that grow seasonally in Minnesota such as strawberries in the spring and apples in the fall. Finally, list foods that are grown in other climates and available year round in Minnesota such as bananas. At one time, foods that were out of season or grown in another climate were not available year round. Why? Today, greenhouse growing and quick methods of transportation worldwide make it possible for Minnesota residents to enjoy out-of-season produce all year long.

Ask students to name unique foods they have tried. Have them describe their favorites, noting the ingredients. Challenge students to develop a plan to introduce new foods into their diets. If possible, provide produce from the garden for this purpose. Students have the opportunity to expand their favorite foods. Provide students with copies of Handout B. Read through the directions and complete steps one and two. After a week or so, revisit Handout B and have students complete the final steps.

Review/Summary

Have students create posters explaining the difference between unripe, ripe, and overripe produce. Posters can be hung in the school cafeteria.

Modifications/Extensions

Take a walking field trip to a grocery store produce section to identify fruits, vegetables, and seeds and the characteristics that make them ripe or the best choice. Alternatively, invite a grocery store produce manager or a fruit or vegetable grower to come and talk to your class about their jobs and the fruits and vegetables they sell.

Sources/Credits

Parts of this lesson were adapted from *Growing in the Garden Elementary Curriculum that Grows with the Child* written by the Iowa 4-H Development Program and revised in June 2012. The curriculum can be purchased from the Iowa State Extension Office <http://www.extension.iastate.edu/4h/page/curricula-info-ordering>

Environmental Factors that Affect Food Availability and Choices

<p>Location/Growing Conditions</p> <p><i>List foods that are dependent on certain locations or growing conditions</i></p>	<p>Seasonal</p> <p><i>List foods that grow seasonally in Minnesota</i></p>	<p>Climate</p> <p><i>List foods grown in other climates but available year-round in Minnesota</i></p>

Name _____



Experience Chart

An unripe _____ looks _____.

An unripe _____ feels _____.

An unripe _____ smells _____.

An unripe _____ tastes _____.

A ripe _____ looks _____.

A ripe _____ feels _____.

A ripe _____ smells _____.

A ripe _____ tastes _____.

A _____ that's too ripe looks _____.

A _____ that's too ripe feels _____.

A _____ that's too ripe smells _____.

A _____ that's too ripe tastes _____.

Name _____



Personal Food Goal

After learning about different things that affect food choices, create a plan for introducing new foods into your diet.

Step 1. Set a reasonable goal that encourages you to try new foods.

Step 2. Write a paragraph discussing the motivating and reinforcing factors that may help you accomplish your goal. Who might help you try new foods? Where will you get the foods? Discuss the challenges you may face in accomplishing your goal.

Name _____



Choosing Foods

1. Describe how to determine if a fruit or vegetable is unripe, ripe, or overripe.

2. List two advantages of knowing how to identify produce that is unripe, ripe and overripe.

3. Explain how environmental factors such as location/growing conditions, season, and climate affect food choices.

Grade

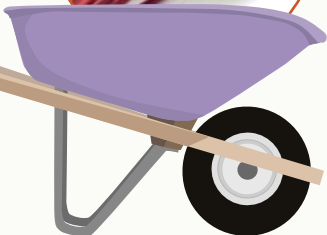
High School

Materials/Preparation

- Teacher Material A – Where Does Food Safety Happen? – one per teacher
- Handout A – Food Safety Handbook – one per student
- Handout B – Check Your Steps – one per student
- Assessment A – Food Safety – one per student
- Paper and materials for creating safety handbooks
- Computers with Internet access
- Writing utensils

Fun Fact

For good growth rhubarb requires moist, cool summers and winters severe enough to freeze the ground to a depth of several inches.



Food Safety

Minnesota K-12 Academic Standards

Health	9.2.3	The student will analyze how information from the community influences health.
--------	-------	--

Summary/Overview

Students learn how food safety is regulated. They do research to find information needed to create a food safety handbook for the school garden and to learn the four simple steps to ensure food safety.

Garden Connection

Proper hand washing, produce handling procedures, and clean food containers all contribute to a safe harvest of garden produce.

Background Information

According to www.foodsafety.gov, each year one out of six people get sick from food poisoning. Food poisoning is any sickness resulting from food contamination. The risk for contaminated food is greatly reduced when safety procedures are followed. The government has implemented numerous safety procedures and protocols making the United States food supply one of the safest in the world.

The Food and Drug Administration (FDA) is responsible for protecting the public health by assuring that foods (except for meat from livestock, poultry, and some egg products, which are regulated by the U.S. Department of Agriculture) are safe, wholesome, sanitary, and properly labeled. (As listed on www.fda.gov.)

The United States Department of Agriculture (USDA) has an agency called Food Safety and Inspection Service (FSIS). FSIS enhances public health and well being by protecting the public from foodborne illness and ensuring that the nation's meat, poultry, and egg products are safe, wholesome, and correctly packaged. (As listed on www.usda.gov.)



Objectives

- Explain where food safety occurs and who is responsible.
- Describe the importance of a food safety plan for school gardens.
- Name the four simple steps to food safety once food enters the home.

Procedure

Interest Approach

Ask students to explain food safety and name those who help ensure our food supply is safe. Food safety refers to the proper production, handling, preparation, and storage of food to prevent foodborne illness. Two government agencies that assist in ensuring a safe food supply are the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA). Food safety is the joint responsibility of producers, transporters, processors, sellers, consumers, and anyone associated with handling food.

Summary of Content and Teaching Strategies

Safe food does not just show up on our tables at home and in the school cafeteria. Many people play a role in providing us with safe food. Discuss the information on Teacher Material A.

Ask students why it is important for them as producers of a garden to consider food safety. Producers, transporters, and sellers of food develop procedures and protocol to ensure that food is kept safe. When new employees are hired, they are trained using a handbook. Students will research information related to safely harvesting garden produce. They then develop a food safety handbook for the school garden. Provide students with copies of Handout A and access to computers with Internet. You may wish to print off copies of the Chapter 5 Teacher Information for students to reference while creating their handbooks.

If possible, complete the next activity after the first fruits and vegetables have been harvested from the garden. Tell students they cannot eat any items until they can prove they understand the four simple steps to food safety once food enters the home (clean, separate, cook, and chill). Provide students with copies of Handout B and instruct them to use www.foodsafety.gov to fill in the chart.

Review/Summary

Ask students to share the two most important food safety items related to the school garden they learned with the class.

Modifications/Extensions

Instruct students to research the role of the FDA and/or USDA in the regulation of food quality. Each student selects a specific topic. For example: regulations governing processing plants, grocery stores, restaurants, and consumers. Next students determine how these agencies influence their health. Have them create posters or write reports to share their findings.

Take a closer look at food safety concerns related to using manure in the garden. Start by reading the article *If you use manure in your garden, take precautions* by Carol Savonen online at <http://extension.oregonstate.edu/gardening/if-you-use-manure-your-garden-take-precautions>. Discuss the following with students: disease-causing microorganisms found in manure, treatment of manure prior to application, animal manure to avoid, and four steps that may be taken to prevent contamination and disease by manure.



Sources/Credits

This lesson was developed for the *Minnesota Garden Guide*.

Where Does Food Safety Happen?

The Farm/Garden

Crops: Fruit, grain, and vegetable crops are treated with fertilizers and pesticides that do not harm the food's safety for human consumption. Farmers must check for quality of crops throughout the growing season and before selling, and apply chemicals to crops at times when the integrity of the food is not damaged.

All garden produce must be washed before it's eaten. The microbes found in compost, manure, and soil can cause severe illnesses in humans. Manure, irrigation water, chemicals, human handling, and unsanitary harvesting equipment can all contaminate produce.

Livestock: Farmers must inspect livestock for disease and sickness. Responsible farmers work to create living conditions that keep their livestock healthy. Only healthy, disease-free animals should be shipped to markets.

Processing

Inspectors check to make sure that foods (both meat and plant products) are stored at safe temperatures and processed in sanitary ways throughout processing. Proper food handling techniques and preparation instructions are often included on food packages.

Shipping

Both crops and meat products must be shipped at proper temperatures and in a timely manner so the freshest, safest products arrive to end consumers.

Retailers and Wholesalers

Retailers and wholesalers must make sure that food is stored at the proper conditions/temperature while in their possession and is sold or discarded before it expires (is unsafe).

Name _____



Food Safety Handbook

Creating a plan for food safety is critical for every school garden. By following proper handling procedures, the safety of food harvested from the garden can be ensured. You are to create a food safety handbook for your school garden that outlines safe handling procedures for the harvest of garden produce. The handbook will be used to train garden workers. Copies of the completed handbook will be kept in the school office in case any illness issue arises, and at the garden site as a reference for all workers. Review the chart below and be sure to include all necessary components.

	Points Possible	Grade
Handbook Sections		
Students participating in harvest Address permission slips, identification of allergies, proper footwear, sunscreen, and hats	6	
Health of those harvesting Address symptoms of sicknesses that would prevent workers from harvesting, length of time following sickness before returning, what to do with open cuts	6	
Hand-washing procedures Address length of washing, soap vs. hand sanitizer, when to wash	6	
Produce handling Address washing produce, protecting harvested produce from sun and birds, removing rotten produce	6	
Equipment and containers Address cleaning and sanitizing of tools, cleanliness of containers used to hold produce, designation of containers for food use only	6	
List of sources	3	
Appearance		
Cover page	3	
Well organized	3	
Creative	3	
Use of class time	3	
Total	45	

Suggested Websites and Sources:

Centers for Disease Control and Prevention – Wash Your Hands
<http://www.cdc.gov/features/handwashing/>

National Food Service Management Institute – Food Safety Tips for School Gardens
<http://nfsmi.org/documentlibraryfiles/PDF/20110822025700.pdf>

University of California, Davis – Food Safety Tips for Your Edible Home Garden
<http://ucfoodsafety.ucdavis.edu/files/26392.pdf>

Name _____



Check Your Steps

FoodSafety.gov hosts information from a number of government agencies. Visit their website to find three tips for each of the four simple steps to food safety once food enters the home.

Clean	
Separate	
Cook	
Chill	

www.foodsafety.gov/keep/basics

Name _____



Food Safety

1. List three different places food safety occurs.

2. Describe two key components of the food safety plan you developed for your school garden.

3. List the four simple steps to food safety once food enters the home and describe why they are important.

Step	Importance

Appendix

Garden Related Literature

The garden book list is endless.
Here are a few to get you started.

Elementary School Books

Aston, D. *A Seed is Sleepy*
Bunting, E. *Sunflower House*
Carle, E. *The Tiny Seed*
Child, L. *I Will Never Not Ever Eat a Tomato*
Dr. Seuss, *The Lorax*
Ehlert, L. *Growing Vegetable Soup*
Ehlert, L. *Planting a Rainbow*
George, L. *In the Garden: Who's Been Here?*
Glaser, L. *Garbage Helps Our Garden Grow: A Compost Story*
Hoberman, M. *Whose Garden Is It?*
Kochenderfer, L. *Victory Garden*
Lemer, C. *Butterflies in the Garden*
Lin, G. *The Ugly Vegetable*
Lobel, A. *Frog and Toad Together*
Lovejoy, S. *Roots, Shoots, Buckets & Boots: Gardening Together with Children*
Rylant, C. *This Year's Garden*
Silverstein, S. *The Giving Tree*
Stewart, S. *The Gardener*
Steele, M. *Anna's Garden Song*
Talmage, E. *Container Gardening for Kids*
Talmage, E. *Unearthing Garden Mysteries: Experiments for Kids*



Middle School Books

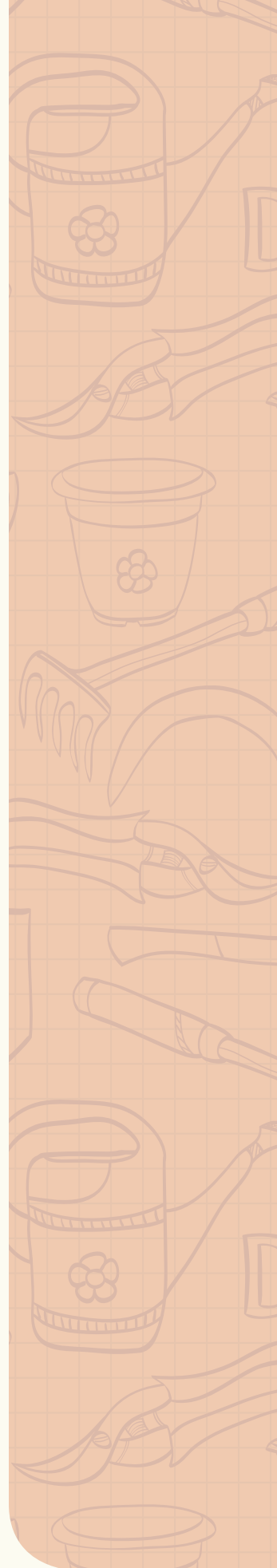
Fleischman, P. *Seedfolks*
Raab, E. *Clueless in the Kitchen: A Cookbook for Teens and Other Beginners*
Sanders, G. *You Grow Girl: The Groundbreaking Guide to Gardening*
Waters, A. *Fanny at Chez Panisse: A Child's Restaurant Adventures with 46 Recipes*

High School Books

Chasek, R. *Essential Gardening for Teens*
Hirsch, D. *Moosewood Restaurant Kitchen Garden: Creative Gardening for the Adventurous Cook*
Kingsolver, B. *Animal, Vegetable, Miracle*
Nabhan, G. *Coming Home to Eat: The Pleasures and Politics of Local Foods*

Alphabetical List of Lessons

Lesson Name	Page Number
A Bug's Life <i>(High School)</i>	205
Choosing Foods <i>(High School)</i>	246
Comparing Growing Locations <i>(High School)</i>	93
Composting for Better Soil <i>(Elementary 3-5)</i>	121
Fertilizer Figures <i>(High School)</i>	188
Food Safety <i>(High School)</i>	254
Garden Goals <i>(High School)</i>	47
Gardening Economics and Efficiency <i>(High School)</i>	152
Germination Research <i>(Middle School)</i>	140
Importance of Plants <i>(Middle School)</i>	37
It all Begins with Soil <i>(Elementary 3-5)</i>	115
It's All in a Label <i>(Middle School)</i>	240
Learning About Integrated Pest Management <i>(Elementary 4-5)</i>	160
Magic Beans and Giant Plants <i>(Elementary K-5)</i>	70
Make Room for Raddy <i>(Elementary K-5)</i>	173
Photosynthesis <i>(High School)</i>	107
Plant Doctor – Challenges with Growing Plants <i>(Middle School)</i>	180
Plant It, Map It <i>(Elementary 3-5)</i>	22
Plant Needs <i>(Middle School)</i>	85
Plant Parts Become Me <i>(Elementary K-3)</i>	27
Right Plants, Right Place <i>(Elementary 3-5)</i>	62
Safety First <i>(Middle School)</i>	233
Salad Investigation <i>(Middle School)</i>	31
Soil Testing 1, 2, 3 <i>(Middle School)</i>	134
Sorting Out Potting Soil <i>(High School)</i>	144
Surrounded by Plants <i>(High School)</i>	41
The Healthy Hop 'n Shop <i>(Elementary K-5)</i>	228
What Are We Eating? <i>(Elementary K-5)</i>	222
What? No Soil? <i>(Middle School)</i>	76
Why Plants Need Water <i>(Elementary K-5)</i>	169
Yo Seeds, Wake Up! <i>(Elementary K-5)</i>	130

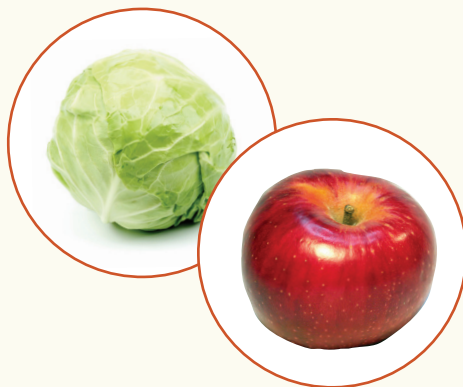


Lesson Summary/Overview

Lesson Name	Page	Summary/Overview
Plant It, Map It <i>(Elementary 3-5)</i>	22	Using the information provided, students use math skills to plan their garden.
Plant Parts Become Me <i>(Elementary K-3)</i>	27	Students begin by reviewing the main parts of plants through a role-play activity. They design their own plants and compare the variety of their creations to those of their classmates. Students identify and taste fruits and vegetables that come from different plant parts.
Salad Investigation <i>(Middle School)</i>	31	Students learn about edible plant parts and the difference between fruits and vegetables while eating a salad.
Importance of Plants <i>(Middle School)</i>	37	Students learn about the importance of plants and create a mind map to display the ways in which plants influence their lives. Next they use a thematic map to help understand why crops grow in specific areas of the state.
Surrounded by Plants <i>(High School)</i>	41	In an effort to connect students with the key idea of plant importance for human life, Surrounded by Plants asks students to survey their home and neighborhood for plant products they encounter in daily life.
Garden Goals <i>(High School)</i>	47	Students take ownership in the school garden by creating goals and planning for success.
Right Plants, Right Place <i>(Elementary 3-5)</i>	62	In this lesson, students learn that plants - vegetables, flowers, shrubs, and trees - should be planted with care and thought to their needs. They are introduced to annuals and perennials and the influence of climate. Students consider how variables such as shade, sun, dry or wet soil, and plant size at maturity must be considered before a gardener or farmer plants a seed or seedling.
Magic Beans and Giant Plants <i>(Elementary K-5)</i>	70	After predicting what, other than magic, caused Jack's beanstalk to grow so tall, students design and conduct experiments to explore how different conditions affect plant growth. This open-ended investigation of conditions for plant growth assumes some student knowledge of basic plant needs (light, water, etc.). It can be a springboard for more in-depth investigations of these factors.
What? No Soil? <i>(Middle School)</i>	76	After learning the four basic requirements of plant growth, students discuss terms related to hydroponics. Students then build and maintain hydroponic units from soda bottles.
Plant Needs <i>(Middle School)</i>	85	Students compare their needs to the needs of plants using a Venn diagram. They also learn about the process of photosynthesis.
Comparing Growing Locations <i>(High School)</i>	93	Students examine several different ways temperature influences plant health and growth. Next they examine two different geographic locations and calculate when fruit would be ready to harvest in both areas.
Photosynthesis <i>(High School)</i>	107	The process of photosynthesis is compared to baking cookies. Students learn the ingredients and end product of photosynthesis. Next they demonstrate their knowledge of the process by writing a song.
It all Begins with Soil <i>(Elementary 3-5)</i>	115	Students examine soil samples to identify its components and differences between samples.

Lesson Name	Page	Summary/Overview
Composting for Better Soil <i>(Elementary 3-5)</i>	121	In this lesson, students learn about composting: its definition, its effect on soil, how to make it, and what lives in it.
Yo Seeds, Wake Up! <i>(Elementary K-5)</i>	130	Students examine ideas about what seeds need to sprout.
Soil Testing 1, 2, 3 <i>(Middle School)</i>	134	Students learn terms associated with soil science. Using soil samples from several locations, students test for nutrient levels. A soil testing kit is required for this lesson.
Germination Research <i>(Middle School)</i>	140	Students discuss factors that affect the amount of time it takes a seed to germinate. Then they perform a mini experiment involving the steps of the scientific theory.
Sorting Out Potting Soil <i>(High School)</i>	144	After learning about the uses and components of potting media, students observe and calculate percentages of potting soil components.
Gardening Economics and Efficiency <i>(High School)</i>	152	Students learn technical details about planting seeds or seedlings. They also apply the principle of marginal productivity to planting in the garden.
Learning About Integrated Pest Management <i>(Elementary 4-5)</i>	160	In this lesson, students learn about Integrated Pest Management (IPM): the decision-making process involved in reducing pests. They will recognize that pests can be animals or insects in homes and other structures, as well as weeds, insects, and diseases in yards, gardens, and croplands.
Why Plants Need Water <i>(Elementary K-5)</i>	169	Students compare their need for water to that of plants. They learn why plants need water and how to properly water garden plants. Finally, they assist in an experiment and observe the effects of water on four potted plants in the classroom.
Make Room for Raddy <i>(Elementary K-5)</i>	173	Students observe how plants and people respond when crowded and forced to share limited resources. This activity helps students understand that even their precious garden plants must sometimes be thinned.
Plant Doctor – Challenges with Growing Plants <i>(Middle School)</i>	180	Growing plants is a huge part of our planet! Plants across the globe feed, clothe, medicate, and shade us. Growing plants can be very challenging. Five major challenges face anyone who grows plants. Those challenges are insects, nutrients, weeds, disease, and weather.
Fertilizer Figures <i>(High School)</i>	188	Students learn how to calculate the amount of fertilizer in a bag and fertilizer application rates.
A Bug's Life <i>(High School)</i>	205	For this activity, students research common garden pests. Students identify a pest to research, examine its life cycle, and prescribe the best timing to disrupt the reproduction of this pest.

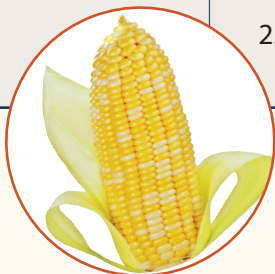
Lesson Name	Page	Summary/Overview
What Are We Eating? <i>(Elementary K-5)</i>	222	A significant reason to engage in gardening in schools is to teach students, and allow them to discover for themselves, how plants grow and what parts of plants we eat. That is the purpose of this activity.
The Healthy Hop 'n Shop <i>(Elementary K-5)</i>	228	Students learn about the USDA MyPlate through a pretend grocery store. They also learn the importance of each food group.
Safety First <i>(Middle School)</i>	233	Students learn about food safety responsibilities by creating a children's book.
It's All in a Label <i>(Middle School)</i>	240	Students learn about the components of nutrition labels found on food.
Choosing Foods <i>(High School)</i>	246	Students learn to distinguish between unripe, ripe, and overripe produce. Next they examine influences on a person's food choices and conclude with a personal plan for trying new foods.
Food Safety <i>(High School)</i>	254	Students learn how food safety is regulated. They do research to find information needed to create a food safety handbook for the school garden and to learn the four simple steps to ensure food safety.



Garden Connection Overview

Lesson Name	Page Number	Garden Connection
Plant It, Map It <i>(Elementary 3-5)</i>	22	Students learn about plant varieties, row width, space between plants, and height.
Plant Parts Become Me <i>(Elementary K-3)</i>	27	Roots, stems, leaves, flowers make up the foods we harvest from gardens.
Salad Investigation <i>(Middle School)</i>	31	Students identify the parts of plants used to make a salad.
Importance of Plants <i>(Middle School)</i>	37	Students explore some factors that influence plant growth.
Surrounded by Plants <i>(High School)</i>	41	Plants harvest energy from the sun and provide us with many usable products.
Garden Goals <i>(High School)</i>	47	A successful garden requires planning and goal setting.
Right Plants, Right Place <i>(Elementary 3-5)</i>	62	Plants need sun and water in varying amounts. The location in which a plant is placed is critical for its healthy growth.
Magic Beans and Giant Plants <i>(Elementary K-5)</i>	70	Students experiment with growing plants and the factors that influence their growth.
What? No Soil? <i>(Middle School)</i>	76	Gardens can grow anywhere, even without soil!
Plant Needs <i>(Middle School)</i>	85	Without light, air, water, and a growing media plants would not survive.
Comparing Growing Locations <i>(High School)</i>	93	Students use a mathematical formula to calculate the harvest of tomatoes based on average temperatures.
Photosynthesis <i>(High School)</i>	107	Garden plants use sunlight and water to thrive through the process of photosynthesis,
It all Begins with Soil <i>(Elementary 3-5)</i>	115	Most of the produce we eat is grown in soil.
Composting for Better Soil <i>(Elementary 3-5)</i>	121	Gardens provide us with the nutrients we need. Compost provides garden soil the nutrients it needs to support plants.
Yo Seeds, Wake Up! <i>(Elementary K-5)</i>	130	Oxygen, water, and proper temperature are required for seeds to begin growing.
Soil Testing 1, 2, 3 <i>(Middle School)</i>	134	Students collect soil samples and analyze them to determine the soil composition.

Lesson Name	Page Number	Garden Connection
Germination Research <i>(Middle School)</i>	140	Germination occurs when a seed sprouts a tiny plant. Students learn factors that influence germination.
Sorting Out Potting Soil <i>(High School)</i>	144	Potting medias are used to grow container plants. These medias are carefully composed to assist plants in growth.
Gardening Economics and Efficiency <i>(High School)</i>	152	Students inspect seeds in the classroom. These seed varieties are plants that might be planted in the garden during the growing season.
Learning About Integrated Pest Management <i>(Elementary 4-5)</i>	160	Gardens are full of insects, some beneficial and some harmful. Integrated Pest Management is a method of controlling harmful insects.
Why Plants Need Water <i>(Elementary K-5)</i>	169	Garden plants lose water through evaporation and transpiration. These events require gardeners to closely monitor the amount of water available to their plants.
Make Room for Raddy <i>(Elementary K-5)</i>	173	Students learn that seedlings often need to be thinned in order to receive enough nutrients and sunlight.
Plant Doctor – Challenges with Growing Plants <i>(Middle School)</i>	180	Students learn how to investigate challenges faced by plants.
Fertilizer Figures <i>(High School)</i>	188	Students learn how to calculate the amount of fertilizer required by plants.
A Bug’s Life <i>(High School)</i>	205	Insects cause the majority of plant damage. Integrated Pest Management can be used to disrupt the insect’s life cycle.
What Are We Eating? <i>(Elementary K-5)</i>	222	Students examine garden plants and produce and identify roots, stems, leaves, and flowers.
The Healthy Hop ‘n Shop <i>(Elementary K-5)</i>	228	Garden produce fulfills two of the food groups in the USDA’s MyPlate nutritional guide.
Safety First <i>(Middle School)</i>	233	Food safety practices in the garden help reduce the risk of food-borne illnesses.
It’s All in a Label <i>(Middle School)</i>	240	Students use nutritional labels to compare the nutrition of fresh garden peas to canned and frozen peas.
Choosing Foods <i>(High School)</i>	246	Picking garden produce at its peak ensures the best-tasting product. Students learn how to distinguish between unripe, ripe, and overripe produce.
Food Safety <i>(High School)</i>	254	Proper hand washing, produce handling procedures, and clean food containers all contribute to a safe harvest of garden produce.



Standard Areas Overview

Lesson Name	Page Number	Health	Language Arts	Math	Science	Social Studies
Plant It, Map It <i>(Elementary 3-5)</i>	22					
Plant Parts Become Me <i>(Elementary K-3)</i>	27					
Salad Investigation <i>(Middle School)</i>	31	x			x	
Importance of Plants <i>(Middle School)</i>	37				x	x
Surrounded by Plants <i>(High School)</i>	41				x	x
Garden Goals <i>(High School)</i>	47		x			
Right Plants, Right Place <i>(Elementary 3-5)</i>	62				x	x
Magic Beans and Giant Plants <i>(Elementary K-5)</i>	70		x		x	
What? No Soil? <i>(Middle School)</i>	76				x	
Plant Needs <i>(Middle School)</i>	85		x		x	
Comparing Growing Locations <i>(High School)</i>	93			x	x	
Photosynthesis <i>(High School)</i>	107		x		x	
It all Begins with Soil <i>(Elementary 3-5)</i>	115			x	x	
Composting for Better Soil <i>(Elementary 3-5)</i>	121		x		x	
Yo Seeds, Wake Up! <i>(Elementary K-5)</i>	130		x		x	
Soil Testing 1, 2, 3 <i>(Middle School)</i>	134		x		x	
Germination Research <i>(Middle School)</i>	140		x		x	
Sorting Out Potting Soil <i>(High School)</i>	144			x		
Gardening Economics and Efficiency <i>(High School)</i>	152					x
Learning About Integrated Pest Management <i>(Elementary)</i>	160		x		x	
Why Plants Need Water <i>(Elementary K-5)</i>	169				x	
Make Room for Raddy <i>(Elementary K-5)</i>	173		x		x	
Plant Doctor – Challenges with Growing Plants <i>(Middle School)</i>	180			x	x	
Fertilizer Figures <i>(High School)</i>	188			x	x	
A Bug’s Life <i>(High School)</i>	205		x		x	
What are we Eating? <i>(Elementary K-5)</i>	222	x			x	
The Healthy Hop ‘n Shop <i>(Elementary K-5)</i>	228	x			x	
Safety First <i>(Middle School)</i>	233	x	x			
It’s All in a Label <i>(Middle School)</i>	240	x			x	
Choosing Foods <i>(High School)</i>	246	x				
Food Safety <i>(High School)</i>	254	x				

