**The Classroom Indoor Garden**

**A part of the**

**Alaskan Adolescent Nutrition Project**

**by**

**Carol McCarty, RN, BSN**

**in collaboration with**

**Liz Snyder, MPH, PhD**

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**The Classroom Indoor Garden**

**Introduction**

**Adolescent health is the reason**

A nutritionally adequate diet, including at least five servings of fruits and vegetables a day, helps protect people from chronic diseases, such as heart disease, diabetes, and overweight/obesity. Surveyed Alaskan youth self-report eating less than the recommended five servings a day of fruits and vegetables, mirroring national youth survey results (CDC, 2012). In response to this trend, Healthy People 2020 (2012) initiatives call for an increase in fruits and vegetables (particularly green, leafy and yellow vegetables) in adolescents’ diets.

Schools are recognized as an important environment in which adolescents acquire knowledge that influences decisions made in their adult life. Many schools have used garden-based learning as a tool to implement a wellness program. The benefits of garden-based learning include the fun of watching plants grow from seed to maturity and then eating the harvest. This real-time exposure to fresh fruits and vegetables, steeped in flavor and texture, provides a prime opportunity for discussions of nutrition and the importance of fruits and vegetables in the diet. However, Alaska’s climate limits the suitability of garden-based learning, unless the garden is brought indoors.

**Teaching with an indoor garden**

The following five lesson plans are intended to be used together with an indoor garden as a complete teaching packet. Adolescent health is the overall goal of this program and is emphasized in the fifth lesson. The lessons are:

1. Seed Planting and Monitoring Seed Growth
2. Setting up Hydroponics Hardware and Transplanting the Seedlings
3. Plant Care and Plant Growth Monitoring
4. Yield Harvest and Yield Measures
5. Eating Yield and Human Nutrition from Plants

The lessons start at the beginning with seed propagation and proceed to harvest and yield consumption. Along the way, students will discuss relevant terms and complete activities emphasizing science, mathematics, language arts, and health. Data collection and analysis is emphasized with each lesson, and useful data collection templates are included. Helpful hints are included at key decision points in the lesson plan; for example, which seeds are most likely to produce larger yields. Consider assigning specific tasks to student subgroups who would assume responsibility for determining when to transplant, when to harvest, assessing plant health (including for pest infestations), pH monitoring, and water/nutrient level monitoring.

The lessons can be easily adapted to different grade levels by increasing the level of complexity of data collection and analysis, and of researching the topics. The themes can be kept as narrow as the class viewpoint or expanded to the greater community, and, some of the topics can be expanded to a world view. In addition, each lesson includes a section where other activities are suggested as extensions of the basic lesson activities.

The lessons are intended to continue over one or two semesters. Two semesters are recommended in order to maximize the yield from the plants and to allow for the ripening of fruits, if the students select fruiting plants. A basic timeline, from planting to harvest, is included.

**About vertical drip hydroponic units**

Vertical drip hydroponic (VDH) units are the technology allowing gardens to flourish even in the winter. VDH use vertical space for the plants, thereby minimizing required floor space. VDH, coupled with full-spectrum artificial lights, can overcome the limitations of cold climate and lack of direct sunlight.

VDH units vary in price and size. The photographs included in the lessons illustrate the process using one brand of vertical drip hydroponics system. There are others on the market and any of them will suffice (see Appendix A for a list of VDH websites). These websites also offer important information about the nutrient and light requirements when using hydroponic systems, along with plant selection guides and other helpful advice. Deciding how many units to buy depends on the number of students, your classroom size, and your budget. If your classroom is small, consider using a closet or conference room as the garden area. Visit the Farm to School Program website ([www.farmtoschool.org/AK](http://www.farmtoschool.org/AK)) for grant opportunities available for funding your indoor garden.

**And lights**

You will need to purchase full-spectrum lights for your garden if you intend to use it during the winter months. The websites listed in Appendix A may include light systems to accompany the VDH units you purchase. Lighting apparatus are also available in local garden supply stores. The number of lights you need will depend on how many VDH units you buy. Hanging the lights vertically maximizes the plant exposure and increases the likelihood of more than one VDH unit receiving light exposure. Reflectors that surround the lights and VDH units increase the total available light for the plants. Large pieces of aluminum foil-lined cardboard create lightweight, inexpensive reflectors.

**Seeds and other considerations**

Seeds and peat pellets are available from local gardening centers or on-line. A Google search for vegetable seeds brought up many seed supply websites. Another search for peat pellets brought up several sources. The recommended plant nutrient solution and growing medium are usually supplied with the VDH units. If not, they are available from the VDH suppliers. Test kits for pH may be provided with the units; if not, the kits are commonly available from the VDH suppliers. Be sure to also include the yield measuring equipment (quilting ruler and digital food scale) in any funding requests.

**References**

CDC (2012). Youth Online: High School YRBS. Alaska 2011 and United States 2011 Results. Retrieved from: <http://www.cdc.gov/yrbss>.

Healthy People 2020 (2012). Healthy People 2020 summary of objectives. Retrieved from <http://www.healthypeople.gov/2020/topicobjectives2020/pdfs/HP2020objectives.pdf>.

**Sample Semester Timeline**

This sample timeline is based on a 15 week semester and is only a guide. The timing to introduce a lesson remains flexible and is based on the nature of the classroom and other variables, such as the plants selected.

**Week 1:** Use this week to introduce the project and to guide the students in seed selection.

Gather the materials.

**Week 2:** Begin Lesson 1 by planting the seeds and establishing the classroom procedures for the

monitoring and measuring work. Develop forms and decide on the documentation

format.

**Week 3:** Continue with Lesson 1 and monitor seedling growth, keeping an eye out for the

optimal time to transplant into the hydroponics units.

**Week 4:** Implement Lesson 2 because the seedlings will most likely be ready for transplanting

this week. Develop forms and decide on the documentation format for the remainder of

the program. Analyze Lesson 1 data.

**Week 5:** Implement Lesson 3, assign student tasks, and monitor plant growth.

**Week 6:** Continue with Lesson 3. Analyze Lesson 2 data.

**Week 7:** Combine Lesson 3 and Lesson 4 because the first harvest of the most rapidly growing

plants may be ready. Analyze growth and harvest data periodically throughout the next

eight weeks.

**Week 8:** Continue with Lessons 3 and add the social and economic aspects (such as cost per

servings) of Lesson 4, and add Lesson 5 for the serving size aspects of the consumed

foods.

**Week 9:** Continue Lessons 3, 4 and the nutritional aspects in Lesson 5. Analyze economic data.

**Week 10:** Continue Lessons 3, 4, and 5.Analyze serving size data.

**Week 11:** Continue Lessons 3, 4, and 5. Analyze nutritional data.

**Week 12:** Continue Lessons 3, 4, and 5. Continue data collection and analysis and exploration of

specific topics under each lesson through week 14.

**Week 13:** Continue Lessons 3, 4, and 5.

**Week 14:** Continue Lessons 3, 4, and 5.

**Week 15:** Dismantle the project and clean the hydroponics units.

**Modified version**

The middle school and high school curriculum for teaching science is crowded with required topics and teachers may find that the enclosed suggested lessons are too extensive for their classroom. *The Classroom Indoor Garden* lessons are easy to modify and suggestions for modification are included in each chapter. While any part of the lesson plan can be modified, the modifications suggested in each chapter allow for classwork with a focus on providing an indoor garden for food production.

Teachers who are interested in a modified lesson plan need only select the procedures that support the desired learning objectives. Procedures that emphasize the indoor garden are listed first for each lesson and all learning extensions as well as Lesson 5 can be ignored in a modified version.

**Lesson 1: Seed Planting and Monitoring Seed Growth**

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**Suggested Grade Levels:** 7-12

**Time**

This will take 2.5 class periods (45 minutes each), plus 5 minutes a day of observation until the seedlings are transplanted.

**Teaching Goal**

To introduce students to the fun of raising edible plants while studying seed plant reproduction and the germination process.

**Learning Objectives**

1. To explore the plant life cycle by selecting vegetable/fruit seeds, planting the seeds, and providing nutrient and light to promote germination.
2. To discuss and document the experience of this exploration of the plant life cycle.
3. To understand terms relevant to the plant life cycle and the process of planting seeds to grow food.

**Alaska Standards**

Concepts of Life Science 1, 2

History and Nature of Science 2

Number System 3

Ratios and Proportional Relationship 2, 3

Science and Technology 1

Science as Inquiry and Process 3

Statistics and Probability 3

**21st Century Skills**

Collaboration

Cooperation

Creativity

Organization

Problem solving

Social responsibility

**Introduction**

This first lesson plan sets the stage for the four lessons that follow. The seedlings will be transplanted into the hydroponic units and be allowed to mature for classroom harvests and picnics.

**Background for Teachers**

Planting seeds of edible plants selected by the students will give them hands-on experience in life sciences and open the door to the multitude of teaching topics therein. Use this lesson to discuss your own and the students’ gardening experiences, particularly in Alaskan gardens. Plant genetics can be introduced and re-explored in lesson Number 3. For example, if both red and green lettuce seeds are planted, the genetic variations will be evident in the mature plants.

Seed selection will be an important task for the students. A key factor is the suitability of the plant for the growing system. In general, green, leafy vegetables grow well in hydroponic systems, and root vegetables perform poorly. Keep in mind that while green, leafy vegetables grow rapidly and continue to produce yield for many weeks, flowering vegetables such as broccoli take weeks to mature to a flower, and fruiting plants such as tomatoes must flower before developing the fruit over several weeks. Your growing system will have recommended plants, expected time to maturity, and other suggestions for seed selection. Appendix B lists seed selection considerations.

Your classroom size and layout will influence how to arrange the starter trays. If there is a large enough window, the sill is suitable for exposure to sunlight (see *Window Sill Gardening* at [www.agclassroomm.org/ak](http://www.agclassroomm.org/ak)). Alternatives include using the full-spectrum lights over a table or shelf. Depending on the time of year, a combination of sunlight and full-spectrum lights may be required. The seedlings will do well with up to 12 hours a day of full-spectrum lights.

**Procedure**

1. Assist students in seed selection based on characteristics such as genetic variation, taste preference, new flavors, and suitability for the growing system.
2. Plant seeds according to package instructions into peat pellets and place in potting trays. The trays are necessary to hold the water for the pellets to absorb.
3. Arrange trays under full spectrum lights, or on a windowsill for sunlight, and assist students in determining hours of light per day.
4. Daily care for seedlings and monitor growth.
5. Assist students in development of a form or a journal to record growth data. Recorded data should include the date planted, the date of first leaves, dates of watering, plant height measurements, date of second leaves, and date ready for transplanting. A sample data collection template, suitable for copying as many times as needed, is included in this lesson plan.
6. Record the growth data and analyze it. The analysis can include a comparison between the differing seedlings for date of first leaves, plant height measurements, date of second leaves, and date ready for transplanting.

**Extensions**

1. Student food journals for one week, to be repeated at the end of the semester to see if there is any change in eating habits.
2. Start a class book that chronicles the experience of the five lessons.
3. Determine the scientific classification of the selected plants.
4. Establish experiments for groups of students to measure the results of changed variables. For example, variations in the amount of water or in the amount of light will affect seedling growth measurements.

**Terms to Discuss** (See Appendix G)

Fruit

Germination

Humidity

Light spectrum

Plant reproduction and genetics

Plants

Propagation

Seeds

Soil

Temperature

Vegetable

Transpiration

**Materials**

Full spectrum lights

Labels (Popsicle sticks, for example)

Peat seed starting pellets (the kind that contain compressed peat and expand in water, for example, the Jiffy 7, available on line)

Potting trays

Selected seeds (consider green leafy vegetables, herbs, broccoli, and tomatoes)

Starter plants (only if you plan to grow strawberries)

Water containers (recycled gallon-sized juice containers work well)

**References**

Agriculture in the Classroom, Alaska Edition

Kernodle, U. Window sill gardening. Retrieved 14 July 2012 from [www.agclassroom.org/AK](http://www.agclassroom.org/AK)

Science of Life Explorations

A guide to Food and Fiber Systems Literacy

**Assessment**

1. The student participated in the exploration of the life cycle of plants.
2. The student documented the seed planting and germination process.
3. The student understands the terms discussed.

**Modified version**

Student involvement in planting the seeds and growing the starts will help capture their interest in the indoor garden. Procedures 1 through 4 are appropriate for a modified version of Lesson 1.

**Lesson 1: Sample Template for Seedling Growth Monitoring**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Plant name and number:** | | | | | | | | | | | |
| **Date planted in seedling mixture:** | | | | | | | | | | | |
|  | | | | | | | | | | | |
| **Date** |  | |  |  | |  |  |  |  |  |  |
| Daylight hours |  | |  |  | |  |  |  |  |  |  |
| Artificial light hours |  | |  |  | |  |  |  |  |  |  |
| Temperature |  | |  |  | |  |  |  |  |  |  |
| Humidity |  | |  |  | |  |  |  |  |  |  |
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| Quantity of water added |  | |  |  | |  |  |  |  |  |  |
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| Plant height |  | |  |  | |  |  |  |  |  |  |
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| Date plant appears above soil: | | | | | | | | | | | |
| Date 1st leaf set: | | | | | | | | | | | |
| Date 2nd leaf set: | | | | | | | | | | | |
| Date transplanted: | | | | | | | | | | | |
| Notes: | | | | | | | | | | | |

**Lesson 2: Setting up Hydroponics Hardware and Transplanting the Seedlings**

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**Suggested Grade Levels** 7-12

**Time**

This will take 1.5 class periods (45 minutes each).

**Teaching Goal**

To introduce students to vertical drip hydroponics (VDH) and to transplanting seedlings for growth to maturity in the VDH units.

**Learning Objectives**

1. To properly assemble the VDH units, arrange the VDH floor plan, place the seedlings into the units, and determine the appropriate nutrient and light levels.
2. To discuss and document the process.
3. To understand the advantages and drawbacks of VDH and the determined floor plan.

**Alaska Standards**

Number System 3

Science as Inquiry and Process 3

Statistics and Probability 3

Writing Standard for Science 1, 2, 3, 4

History and Nature of Science 1, 2, 3, 4

Concepts of Life Science 1, 2

Science and Technology 1, 3

Ratios and Proportional Relationship 2, 3

**21st Century Skills**

Collaboration

Cooperation

Creativity

Organization

Problem solving

Social responsibility

**Introduction**

During this lesson, students will assemble the VDH units and fill the water/nutrient reservoir following instructions included with the unit. Caution: the VDH reservoir can hold as much as 10 gallons of water and students must be careful not to overexert while filling the units. Plan to fill the reservoirs in one gallon increments. The plants are then placed into the VDH units and the pump and light timers are set. The anatomical study of plants is introduced.

**Background for Teachers**

Hydroponics technology is being used in many places around the world (and in space) to bring fresh foods to people during all seasons. Discuss the potential for hydroponics to help Alaskans achieve a balanced diet despite the extreme climatic conditions. Chemical fertilizers are a must for hydroponics because of food safety concerns. Discuss the components of chemical fertilizers. Fertilizers provide plant nutrients for growth and reproduction. Plants use their root system to reach and integrate water and nutrients from their surroundings. The plant root system plays a vital role in a hydroponic growing system. The growth medium is strictly a place to anchor the plant and to provide a reservoir of nutrient-rich water. As the roots take-up the water, the water-soluble nutrients are also absorbed.

The classroom layout will influence the floor plan for the VDH units. Considerations for the floor plan include the number of VDH units and lights available, experimentation variables, and the plants selected. VDH units can be placed adjacent to each other in order to maximize the available lighting and minimize floor space. Variations in light, heat, or place in the room may be used as experimentation variables. Specific plants may need to be grouped in the VDH units in order to maximize yield. For example, spinach may bolt if exposed to 12 hours of light, while lettuce, broccoli, and tomatoes thrive with 12 hours of light exposure. Appendix C lists floor plan considerations.

Students can be actively involved in deciding where to place plants in the VDH units. Over several weeks, the plants will grow large and those that grow more rapidly may overshadow the slower growing plants. VDH units make use of vertical space and plants such as tomatoes can be encouraged to hang down over the edge, or can be strung up towards the ceiling. Broccoli tends to remain upright, as does lettuce and spinach, becoming bushier and taller. Herbs such as mint and sweet basil grow upright and bushy, while dill simply grows upright.

**Procedure**

1. Determine times planned for nutrient pumps to run and for full spectrum lights to be on.
2. Assemble VDH units.
3. Number each tower and each tier on the tower, and then alphabetically letter each corner of the tier. This will provide a reference number for each plant, such that the plants can be identified by number, and to assist in determining plant location when experimenting with variables such as available light. (See Appendix C).
4. Arrange floor plan for units which allows for optimum use of the lights. Consider hanging the full-spectrum lights in a vertical orientation in order to expose the plants on Tier 1 to as much light as the plants on Tier 4.
5. Following instructions included with the VDH unit, mix water with nutrient and fill the reservoirs.
6. Decide on optimal plant arrangement.
7. Plant VDH units.
8. Position reflective surface panels around the VDH-light assembly in a way that maximizes the light exposure to the plants. Remember that the plants surround the tower and that they will use as much light as can be directed to them. A box-like, movable configuration that encloses the whole assembly is optimal (see appendix C).
9. Set timers and start.
10. Document process in a journal, including illustrations of plant placement. A sample data collection template, suitable for copying as many times as needed, is included in this lesson plan.
11. If needed, create new plant growth monitoring forms. Plant height and progress toward maturity (such as flowering) indicate plant growth.
12. Begin daily monitoring of VDH units, and plants.
13. Record and analyze growth measurements (See Lesson 3).

**Extensions**

1. Continue class book to document the process.
2. Establish experiments for groups of students to measure the results of changed variables (See Lesson 3).

**Terms to Discuss** (See Appendix G)

Components of growth medium

Hydroponics

Plant anatomy

Plant nutrients (particularly potassium, phosphorous, nitrogen; also trace minerals)

Root anatomy

Roots

**Materials**

Full spectrum lights (Determine the number of lights by considering the number of VDH units you plan to use and the room layout. Plan to maximize the lights by hanging them vertically, by overlapping light coverage between VDH units, and by strategically hanging light reflectors behind the lights.)

Light reflectors (these can be made from large pieces of aluminum foil-lined cardboard)

Plant growth medium as recommended by the specific unit

Plant nutrient solution as recommended by the specific unit

Vertical drip hydroponics units (from 4- 6 units, including hardware, water pump, and instructions)

Water and water/ nutrient mix containers (recycled gallon-sized juice containers work well)

**References**

Agriculture in the Classroom, Alaska Edition, [www.agclassroom.org/AK](http://www.agclassroom.org/AK)

Science of Life Explorations

A guide to Food and Fiber Systems Literacy

**Assessment**

1. The student participated in the VDH assembly process.
2. The student documented the process of VDH assembly and transplanting the seedlings.
3. The student understands the terms discussed.

**Modified version**

Set-up procedures for the hydroponic units and for the full spectrum lights are important for the success of the indoor garden. Procedures 1 through 9 are appropriate for a modified version of Lesson 2.

**Lesson 2: Sample Plant Transplant into VDH Template**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tower number: Date of transplant:** | | | | | | | | | |
| **Location in VDH tower** |  |  |  |  |  |  |  |  |  |
| **Plant name/number** |  |  |  |  |  |  |  |  |  |
| **Monitoring date** |  |  |  |  |  |  |  |  |  |
| Temperature |  |  |  |  |  |  |  |  |  |
| Humidity |  |  |  |  |  |  |  |  |  |
| Hours of daylight |  |  |  |  |  |  |  |  |  |
| Hours of artificial light |  |  |  |  |  |  |  |  |  |
| pH |  |  |  |  |  |  |  |  |  |
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| pH treatment amount |  |  |  |  |  |  |  |  |  |
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| Water/nutrient level |  |  |  |  |  |  |  |  |  |
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| Water/nutrient quantity added |  |  |  |  |  |  |  |  |  |
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| Notes |  |  |  |  |  |  |  |  |  |

**Lesson 3: Plant Care and Plant Growth Monitoring**

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**Suggested Grade Levels** 7-12

**Time**

This will take 1 or 2 class periods (45 minutes each), plus 5 minutes a day of observation until the final harvest.

**Teaching Goal**

To expose students to the experience of plant care while monitoring its growth and to the experience of what it takes to grow food successfully.

**Learning Objectives**

1. To explore plant growth needs.
2. To discuss and document the process of tending plants in VDH.
3. To measure and analyze plant growth.
4. To understand terms relevant to plant anatomy.

**Alaska Standards**

Concepts of Life Science 1, 2

History and Nature of Science 2, 3, 4

Number System 3

Ratios and Proportional Relationship 2, 3

Science and Technology 3

Science as Inquiry and Process 3

Statistics and Probability 3

**21st Century Skills**

Collaboration

Cooperation

Creativity

Organization

Problem solving

Social responsibility

**Introduction**

The third lesson in this series focuses on plant growth in the VDH units.

**Background for Teachers**

Over the weeks that the plants are growing, various topics can be discussed including plant parts. Leaves and flowers can be examined and dissected. Genetic variations can be noted and explored. Students will determine when to harvest, measure the harvest, and analyze the harvest data. All harvests can be eaten as a class picnic (see lesson 5).

Hydroponic gardens are not immune to pests, including aphids, spider mites, molds, and mildew. While small-scale gardens such as yours are less likely to attract pests, they may arrive on plants not associated with your garden, such as decorative plants in the building. If an infestation is noticed, use only food grade treatments to control the pest. The hydroponic system dealers listed in Appendix A offer safe pest control solutions. You can make insecticidal soap solution to spray onto the infected plants. Appendix D contains a list of the symptoms of common pest problems and the soap solution instructions.

**Procedure**

1. Daily assess the plants for growth and health. Record plant health, any treatments required, and the effectiveness of the treatments.
2. Daily assess the VDH for pH and water/nutrient level. Adjust pH and add water/nutrient as needed. Record the pH, amount of water/nutrient mix added, and any pH adjustments needed.
3. Determine when to harvest, for example, every two weeks.
4. Measure and analyze plant growth and data from all harvests. Record plant height or maturity indicators, such as date of flowering. Conclusions about plant growth characteristics can be drawn from comparisons of differing plants. A sample data collection template, suitable for copying as many times as needed, is included in this lesson plan.
5. Document process.

**Extensions**

1. Document plant growth milestones in an interesting way such as *Crop Circles* from the California Foundation for Agriculture in the Classroom at [www.cfaitc.org/cropcircles/](http://www.cfaitc.org/cropcircles/).
2. Monitor results from any experiments established, or start an experiment with the nutrient/water mix or the light as a variable.
3. Continue class book to document findings.

**Terms to Discuss** (See Appendix G)

Flower

Flower anatomy

Infestation

Leaf anatomy

pH

Plant nutrients

**Materials**

pH test kits

Plant nutrient solution

Soda bicarbonate (baking soda)

Water and water/nutrient mix containers (recycled gallon-sized juice containers work well)

**References**

Agriculture in the Classroom, Alaska Edition

[www.agclassroom.org/AK](http://www.agclassroom.org/AK)

Crop Circles. California Foundation for Agriculture in the Classroom. Retrieved 14 July 2012 from [www.cfaitc.org/cropcircles/](http://www.agclassroom.com).

Science of Life Explorations

A guide to Food and Fiber Systems Literacy

**Assessment**

1. The student participated in the exploration of plant growth needs.
2. The student documented plant care in a VDH.
3. The student participated in the measurement and analysis of plant growth.
4. The student understands the terms discussed.

**Modified version**

The students will want to maintain plant health and growth in their indoor garden. Procedures 1 through 3 are appropriate for a modified version of Lesson 3.

**Lesson 3: Sample Post-transplant Monitoring of Plants in VDH Template**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Plant name/number:** | | | | | | | | | |
| **Location in VDI tower:** | | | | | | | | | |
| **Monitoring Date** |  |  |  |  |  |  |  |  |  |
| Daylight hours |  |  |  |  |  |  |  |  |  |
| Artificial light hours |  |  |  |  |  |  |  |  |  |
| Temperature |  |  |  |  |  |  |  |  |  |
| Humidity |  |  |  |  |  |  |  |  |  |
| Size |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Harvest date |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Yield |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Plant health |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Infestation treatment |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Date flowers open |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Flowers pollinated |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Date fruit growing |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Fruit size |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Notes (see back) | | | | | | | | | |

**Lesson 4: Yield Harvest and Yield Measures**

****

**Suggested Grade Levels** 7-12

**Time**

This will take 1 (45 minute) class period.

**Teaching Goal**

To introduce students to plant maturity indicators, yield analysis, and the economic impact of an indoor garden.

**Learning Objectives**

1. To explore the determinants of plant maturity.
2. To discuss and document the process of harvest.
3. To measure the yield.
4. To study the economic implication of an indoor garden.
5. To understand terms relevant to harvest of the yield.

**Alaska Standards**

Concepts of Life Science 1, 2

History and Nature of Science 1, 2, 3, 4

Number System 3

Ratios and Proportional Relationship 2, 3

Science and Technology 1, 3

Science as Inquiry and Process 3

Statistics and Probability 3

**21st Century Skills**

Collaboration

Cooperation

Creativity

Organization

Problem solving

Social responsibility

**Introduction**

The fourth lesson focuses on harvesting the yield after the work of growing the plants. This lesson can be used several times during the growing phase of the plants, because some plants, such as lettuce, can be harvested every two weeks or so.

**Background for Teachers**

Discuss the indicators of when a plant is mature enough to harvest, the best way to harvest a plant, and define yield. The type of yield depends on the type of plant. For example, lettuce is a fast growing leafy plant that can tolerate multiple cuttings of its leaves for harvests. In comparison, the edible part of a strawberry is a fruit which takes longer to develop and results in a much smaller volume of yield. The students can calculate the cost of a plate of salad from the grocery store as compared to one from the indoor garden. Another calculation can be done by comparing yields from various crops such as lettuce and spinach, or lettuce and strawberries. The theme of food economics can expand to Alaskan communities and on into related topics such as world hunger.

**Procedure**

1. Determine plant maturity indicators and best method of harvest.
2. Harvest.
3. Measure and analyze the harvest data. Record harvest dates and the weights of the yield from each type of plant. Conclusions can be made from the comparison of harvested yields from differing plants. A sample data collection template, suitable for copying as many times as needed, is included in this lesson plan.
4. Document the results.

**Extensions**

1. Continue the experimentation with different variables.
2. Continue the class book documenting the process.
3. Explore economics related to world hunger (see *Feeding Minds, Fighting Hunger, A World Free from Hunger* at [www.agclassroom.com](http://www.agclassroom.com)).

**Terms to Discuss** (See Appendix G)

Aesthetics (palatability, taste, texture)

Economic indicators such as “cost per serving” and “cost comparisons”

Yield

**Materials**

Coffee filters

Digital scale

Quilting ruler

**References**

Agriculture in the Classroom, Alaska Edition

[www.agclassroom.org/AK](http://www.agclassroom.org/AK)

Science of Life Explorations

A guide to Food and Fiber Systems Literacy

**Assessment**

1. The student actively participated in determining aspects of plant maturity.
2. The student documented the process of harvest and yield measurement.
3. The student displayed an understanding of the economic contribution of an indoor garden.
4. The student understands the terms discussed.

**Modified version**

Garden harvest and eating the produce is the reward for work. Procedures 1 and 2 are appropriate for a modified version of Lesson 4.

**Lesson 4: Sample Harvest Measurement Template**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Plant number |  |  |  |  |  |  |  |  |  |
| Plant name |  |  |  |  |  |  |  |  |  |
| Type of yield, vegetable or fruit |  |  |  |  |  |  |  |  |  |
| 1. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 2. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 3. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 4. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 5. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 6. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 7. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 8. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
| 9. Date of harvest |  |  |  |  |  |  |  |  |  |
| Yield weight |  |  |  |  |  |  |  |  |  |
| Number of servings |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Cumulative yield |  |  |  |  |  |  |  |  |  |
| Cumulative servings |  |  |  |  |  |  |  |  |  |
| Notes | | | | | | | | | |

**Lesson 5: Eating Yield and Human Nutrition from Plants**

****

**Suggested Grade Levels** 7-12

**Time**

This will take 1 (45 minute) class period and 15 minutes for any of the harvest picnics.

**Teaching Goal**

To expose students to the experience of eating the produce they grew for themselves and the concepts of food taste, texture, and nutrition.

**Learning Objectives**

1. To discover and analyze the nutritional aspects of the foods planted and harvested from the VDH.
2. To understand serving sizes of fruits and vegetables.
3. To document descriptions of the palatability of the foods and its characteristics such as flavor and texture.
4. To understand terms relevant to food aesthetics and nutrition.

**Alaska Standards**

History and Nature of Science 3, 4

Number System 3

Ratios and Proportional Relationship 2, 3

Science as Inquiry and Process 3

Statistics and Probability 3, 4

Writing Standard for Science 1, 2, 3, 4

**21st Century Skills**

Collaboration

Cooperation

Creativity

Organization

Problem solving

Social responsibility

**Introduction**

This is the fun part, the harvest and the eating of the foods, which is a good time to talk about nutrition and the importance of fruits and vegetables in the diet.

**Background for Teachers**

Picnics of the harvested foods will generate discussion of food quality, especially when it is fresh and hand grown. Over-processed foods lose nutrients and gain excess calories. Many people have more than adequate caloric intake, but remain malnourished because they are missing the phytonutrients found in plant foods. This is the reason why the Food Pyramid emphasizes eating fruits and vegetables every day.

Plants are flavorful, low-calorie, nutrient-rich foods. The phytonutrients of particular importance include vitamins and minerals. Plants are important sources of Vitamins A and C. Plants are low in sodium and rich in potassium. Plants vary in protein, carbohydrate and fats, but are cholesterol free. Most plants provide B vitamins, iron, and calcium. See Appendix F for more nutrient information.

It is one thing to say “Eat five servings a day of fruits and vegetables” and another to understand what that actually means. People may underestimate their fruit and vegetable intake because they may have difficulty identifying all the places they are served (such as the fruit in jam or the carrots in stew) or because they do not understand what a serving looks like. Serving sizes are identified in several websites, including the National Institutes of Health ([www.nih.gov](http://www.nih.gov)), and a Google search for food serving sizes will bring them up. However, the visual references to food serving sizes are culturally specific and subject to improvement. Appendix F includes a food serving size reference chart.

**Procedure**

1. List the harvested foods and the nutrients found in each of the foods. Food nutrients are listed in the *Nutritive Value of Foods* (Gebhardt & Thomas, 2002) found at [www.usda.gov](http://www.usda.gov). A sample data collection template, suitable for copying as many times as needed, is included in this lesson plan.
2. Analyze the importance of the harvested foods in a complete daily diet, and why phytonutrients are important to health.
3. Discuss malnutrition and its causes.
4. Discuss the importance of daily fruits and vegetables in the diet.
5. Write an essay and/or give a report of this food growing experience.

**Extensions**

1. Have students keep the second week-long food journal to compare to the first food journal and analyze for changes.
2. Select a phytonutrient and describe why it is important for human health, what are important food sources of the nutrient, and compare the level of this nutrient in a variety of foods.
3. Explore malnutrition around the world (see *Feeding Minds, Fighting Hunger, A World Free from Hunger* at [www.agclassroom.com](http://www.agclassroom.com)).
4. Determine the caloric content of a peanut by burning it (see *Fat and Happy* at [www.pbs.org/saf/1110/teaching/teaching.htm](http://www.pbs.org/saf/1110/teaching/teaching.htm)).
5. Create a poster or website that illustrates examples of fruit and vegetable serving sizes using easy to understand reference points.

**Terms to Discuss** (See Appendix G)

Calories

Food processing

Food Pyramid

Malnutrition

Nutrition

Phytonutrients

Serving size

Trace minerals

Vitamins

**Materials**

Flatware

Place to wash produce

Serving plates

**References**

Gebhardt, S.E. & Thomas, R. G. (2002). Nutritive Value of Foods. United States Department of Agriculture, Agricultural Research Service, Home and Garden Bulletin Number 72. Retrieved 14 July 2012 from <http://www.usda.gov>.

Agriculture in the Classroom, Alaska Edition

[www.agclassroom.org/AK](http://www.agclassroom.org/AK)

Science of Life Explorations

A guide to Food and Fiber Systems Literacy

[www.pbs.org/saf/1110/teaching/teaching.htm](http://www.pbs.org/saf/1110/teaching/teaching.htm)

[www.sparkpeople.com](http://www.sparkpeople.com)

[www.usda.gov](http://www.usda.gov)

**Assessment**

1. The student participated in the food tasting.
2. The student is able to identify proper serving sizes for fruits and vegetables.
3. The student provided a description of the food tasting experience.
4. The student understands the terms discussed.

**Modified version**

None of the lesson 5 procedures are needed for a modified version.

**Lesson 5: Sample Template for Nutrient Content of Harvested Food**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Date:** | | | | | | | | | | | |
| **Plant number** |  |  |  |  | |  |  | |  |  |  |
| **Plant name** |  |  |  |  | |  |  | |  |  |  |
| Measure of harvested food |  |  |  |  |  | |  |  | |  |  |
|  |  |  |  |  | |  |  | |  |  |  |
| **Nutrient** | **(Use your yield measure to calculate the nutrient level for your food)** | | | | | | | | | | |
| Measure of edible portion (USDA table) |  |  |  |  | |  |  | |  |  |  |
| Water (g) |  |  |  |  | |  |  | |  |  |  |
| Calories (kcal) |  |  |  |  | |  |  | |  |  |  |
| Protein (g) |  |  |  |  | |  |  | |  |  |  |
| Total fat (g) |  |  |  |  | |  |  | |  |  |  |
| Carbohydrates (g) |  |  |  |  | |  |  | |  |  |  |
| Total dietary fiber (g) |  |  |  |  | |  |  | |  |  |  |
| Calcium (mg) |  |  |  |  | |  |  | |  |  |  |
| Iron (mg) |  |  |  |  | |  |  | |  |  |  |
| Potassium (mg) |  |  |  |  | |  |  | |  |  |  |
| Sodium (mg) |  |  |  |  | |  |  | |  |  |  |
| Vitamin A (IU) |  |  |  |  | |  |  | |  |  |  |
| Thiamin (mg) |  |  |  |  | |  |  | |  |  |  |
| Riboflavin (mg) |  |  |  |  | |  |  | |  |  |  |
| Niacin (mg) |  |  |  |  | |  |  | |  |  |  |
| Ascorbic acid (mg) |  |  |  |  | |  |  | |  |  |  |
|  |  |  |  |  | |  |  | |  |  |  |
| Notes | | | | | | | | | | | |

**Reference:** The website <http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/hg72/hg72.2002.pdf> has a list of the nutrients for individual foods.

**Appendix A**

**Hydroponics Web Sites**

This is not a complete list of websites offering hydroponic systems. It is offered as a starting place to become familiar with the idea of vertical drip hydroponic systems and the information contained in the websites.

[www.4hydroponics.com](http://www.4hydroponics.com)

[www.hydroponicshabitat.com](http://www.hydroponicshabitat.com)

[www.hydrowholesale.com](http://www.hydrowholesale.com)

[www.seedsetc.com](http://www.seedsetc.com)

[www.vertigro.com](http://www.vertigro.com)

**Appendix B**

**Seed Selection Considerations**

* Fruit versus vegetable: fruiting plants will take longer to mature and will have a reduced yield compared to green leafy vegetables.
* Flavor: consider green, leafy herbs for a flavor spark to your yield.
* Time to mature: woody plants such as rosemary will take much longer to mature.
* Similarity of selected plants: if all of the selected plants produce green, leafy vegetables or herbs, the requirements for lighting the nutrient are likely to be similar and the plants are compatible for one VDH tower. Likewise if all are fruiting plants, the same holds true.
* These are general rules only. For example, spinach is more sensitive to light and warmth than other green, leafy plants and may require a separate tower.
* Lettuce and its’ relatives tend to do very well in hydroponics. Some interesting lettuce plants include: endive, arugula, radicchio, kale, mustard green, chard, spinach, water cress and other cresses, miner’s lettuce, chicory, and sorrel.
* Herbs that do well in hydroponics include: chives, sweet basil, dill, mint, parsley, and sage.
* Both strawberries and tomatoes do very well in hydroponics, and respond to manual fertilization of the flower.

**Appendix C**

**Tower layout Idea (Side View)**

* **Tower # 2, 4, & 6:**
  + Tier 1: tomatoes
  + Tier 2: chives
  + Tier 3: pink blossom strawberries & white blossom strawberries
  + Tier 4: dill & sweet basil
* **Tower 3, & 5:** 
  + Tier 1: broccoli
  + Tier 2: mint & rosemary
  + Tier 3: spinach
  + Tier 4: arugula & red leaf lettuce
* **Tower 1:**
  + Tier 1: red leaf lettuce & tomato
  + Tier 2: mint & red leaf lettuce & arugula
  + Tier 3: spinach
  + Tier 4: arugula & red leaf lettuce

1

2

3

Tier 4

**Floor Plan Ideas**

**Tower # 5**

Each tier has four plant sections (the corners) labeled a, b, c, and d in a consistent manner.

**Tower # 4**

Tier # 1 is located closest to the water/nutrient reservoir and the tier numbers ascend.

**Tower # 1**

Each tower consists of four tiers.

**Tower # 2**

Towers abut together for the smallest footprint.

**Tower # 3**

All towers have an 18 by 18 inches water/nutrient reservoir.

**Tower # 6**

Each tier rotates 450 on the one below so all corners are exposed for planting. See Figure 2.

Figure 1: Overview of the assembled lab. The ovals represent the vertically hanging light fixtures, four each four foot lights on the sides, and two each two foot lights on the ends. A four foot overhead, two bulb fluorescent light hung over the top. A movable reflective surface enclosed the whole assembly.

Figure 2: Tower schematic, overhead view.

Tier # 3

Tier # 4

Tier # 2

Tier # 1

Reservoir

**Appendix D**

**Common Pests, Symptoms of Pests, and Insecticide Soap Making**

Daily plant inspections are important to determine if there are symptoms of poor plant health. For example, the plants may become infested with aphids or mites. These small insects can be seen on the plants, or the leaves are puckered and twisted with sticky honeydew present. Treatment will need to be safe for humans, as this is a food crop. It is safe to use a soap spray to control the infestation. To make the soap spray, mix from 1 teaspoon to several tablespoons of Ivory Liquid soap per gallon of water. Start at the lower concentration and adjust the strength to maximize pest control while avoiding plant damage.

Atthowe, H., Gilkeson, L.A., Kite, L.P., Michalak, P.S., Pleasant, B., Reich, L., & Scheider, A.F. (2009). Organic pest and disease management. In F. M. Bradley, B.W. Ellis, & D.L. martin (Eds.), *The organic gardener’s handbook of natural pest and disease control: A complete guide to maintaining a healthy garden and yard the earth-friendly way. A Rodale organic gardening book* (pp. 345-392)*.* New York: Rodale.

**Appendix E**

**Harvest Guide**

* Determining the proper harvest time for plants varies with the desired yield. Edible leaves can be harvested as soon as they are large enough. The leaves should be carefully cut from the main plant, making sure that enough leaves remain for the plant to continue to grow. Leaf lettuce can be carefully cut across the plant, and the leaves will re-grow from the middle of the plant.
* Broccoli should be harvested when the buds are the size of a pea, even if the head of the broccoli remains small.
* Fruits such as strawberries and tomatoes change color and become soft to the touch.
* Websites that contain information on what determinants to look for on specific food plants are:

[www.theiowagardener.com/harvesting\_fruits\_and\_veggies.html](http://www.theiowagardener.com/harvesting_fruits_and_veggies.html)

[www.gardening.about.com/od/vegetablpatch/a/HarvestTimes.htm](http://www.gardening.about.com/od/vegetablpatch/a/HarvestTimes.htm)

[www.gardening.cornell.edu/factsheets/vegetables/harvestguide.pdf](http://www.gardening.cornell.edu/factsheets/vegetables/harvestguide.pdf)

**Example of a yield table**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Plant** | **# of plants** | **Unit** | **29 Nov 10** | **13 Dec 10** | **3 Jan 11** | **18 Jan 11** | **Total yield** | **Yield per plant** |
| **Arugula** | **8** | **0.5 oz. Servings** | **2** | **5.5** | **3** | **3.4** | **13.9** | **1.75** |
| **Basil** | **6** | **tablespoons** | **1.5** | **10** | **12** | **14** | **37.5** | **6.25** |
| **Broccoli** | **8** | **ounces** |  |  |  | **7.5** | **7.5** | **0.9** |
| **Chives** | **12** | **tablespoons** | **2** | **13** | **6** | **6** | **27** | **2.25** |
| **Dill** | **6** | **tablespoons** | **1** | **5** | **5** | **5** | **16** | **2.7** |
| **Lettuce** | **9** | **0.5 oz. Servings** | **3** | **8** | **5.2** | **7.6** | **23.8** | **2.7** |
| **Mint** | **5** | **ounces** | **0.5** | **1.7** | **0.5** | **0.8** | **5** | **1** |
| **Rosemary** | **4** | **ounces** |  |  |  | **<0.1** | **<0.1** | **<0.1** |
| **Spinach** | **10** | **0.5 oz. Servings** |  | **1** | **1** | **1.6** | **3.6** | **0.36** |
| **Strawberry, pink** | **6** | **each** |  |  |  | **1** | **1** | **<1** |
| **Strawberry, white** | **6** | **each** |  |  |  | **4** | **4** | **<1** |
| **Tomato** | **14** | **each** |  |  |  | **4** | **4** | **<4** |

**Cost Calculation Examples**

Costs:

* Cost per VDI unit: $200.00 + $ 50.00 S & H. Unit has a 3 year guarantee = $19.24 for 2 week period.
* Average cost per light fixture: $40.00 x 7 = $280, with 15,500 average hours projected operating life = $280/1292 (12 hour) days= $0.22 per day x 14 = $3.08 per 2 week period. ([www.energysavers.gov](http://www.energysavers.gov/))
* Lighting cost per day for 7 florescent fixtures operating 12 hours per day: $0.36 x 14 days = $5.04 for 2 weeks
* Cost of running the pumps for 3 each 15 minute periods per day: less than $0.01 x 14 days = $0.14 for 2 weeks.
* Cost of heating: Based on a winter residential natural gas heating bill = $141 per month = $70.50 for 14 days.
* Total cost per 2 week period with heat included: $19.24+ 3.08+ 5.04 + 0.14 + 70.50 = $98.00.
* Without adding in heat: $27.50.

**Appendix F**

**Nutrient Information**

Macro-nutrients include carbohydrates, protein, and fats. The macro-nutrients are consumed in relatively large quantities. Micro-nutrients are consumed in much smaller quantities, and include the essential vitamins and minerals. For example:

Vitamin A is important for immune function, vision, reproduction and cellular communication. Vitamin A supports cell growth and differentiation. For more information see <http://ods.od.nih.gov/factsheets/VitaminA-HealthProfessional/>.

Vitamin C, an antioxidant, is needed for growth and repair of tissues. For more information see <http://www.nlm.nih.gov/medlineplus/ency/article/002404.htm>.

Calcium is needed for healthy teeth and bones, blood clotting, a normal heart beat, and the proper functioning of the nervous, muscular, and hormonal systems. For more information see <http://www.nlm.nih.gov>.

Potassium is needed for regulation of the bodies acid-base balance, protein synthesis, muscle building, body growth, and for the normal electrical activity of the heart. For more information see <http://www.nlm.nih.gov>.

The estimated average requirements for dietary nutrients, Dietary Reference Intakes (DRIs), are at [www.usda.gov](http://www.usda.gov) in a table based on gender and age. The micro-nutrients are listed in this table. Please view <http://www.whqlibdoc.who.int/publication/2004/9241546123.pdf> for complete information regarding the role of micro-nutrients in human health.

**Food Serving Sizes**

A website, [www.sparkpeople.com](http://www.sparkpeople.com), contains the following table for fruit and vegetable serving size references as based on the serving sizes from the National Institutes of Health ([www.nih.gov](http://www.nih.gov)).

|  |  |  |
| --- | --- | --- |
| **Examples** | **One serving equals** | **About the size of** |
| Raw fruit | ½ cup raw, canned, frozen fruit | Billiard ball |
| Dried fruit | ¼ cup raisins, prunes, apricots | An egg |
| Juice | 6 oz. of 100% fruit or vegetable juice | Hockey puck |
| Raw vegetable | 1 cup leafy green, baby carrots | Baseball |
| Cooked vegetable | ½ cup cooked broccoli, potatoes | Billiard ball |

**Appendix G**

**Glossary**

**Aesthetics**: Pertaining to, involving, or concerned with pure emotion and [sensation](http://dictionary.reference.com/browse/sensation) as opposed to pure intellectuality. <http://www.dictionary.reference.com>.For the purposes of this exercise, discuss aspects of palatability, taste, and texture of the food and preference for this food, or a lack of preference.

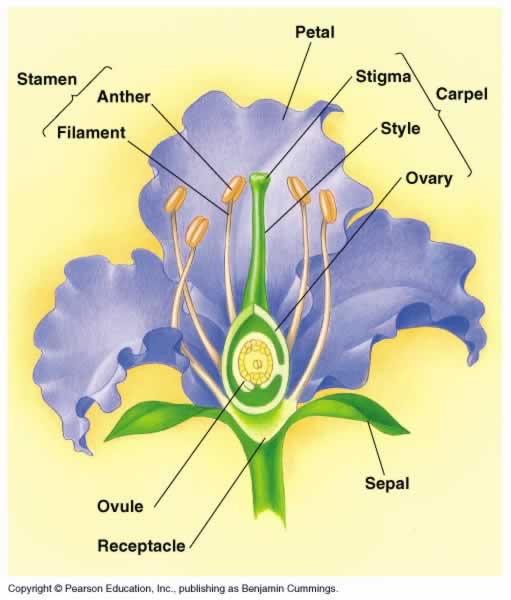
**Calories**: 1. Thermodynamics: a. (Also called [gram calorie](http://dictionary.reference.com/browse/gram+calorie) or small calorie[)](http://dictionary.reference.com/browse/small+calorie)an amount of heat exactly equal to 4.1840 joules. A large calorie, or kilocalorie, is equal to one thousand small calories. 2. Physiology: a. a unit equal to the [kilocalorie](http://dictionary.reference.com/browse/kilocalorie), used to express the heat output of an organism and the fuel or energy value of food. b. a quantity of food capable of producing such an amount of energy. <http://www.dictionary.reference.com>. The topic of “calories” allows for a discussion of the energy value of food, why this is expressed as calories, and how calories relate to nutritional adequacy.

**Components of growth medium**: In hydroponics, the growth medium is a sterile medium having enough structure and composition to provide adequate root anchorage and oxygenation while allowing for water and nutrients to bathe the roots. Gravel, sand, peat, vermiculite, perlite, pumice, mixtures of these materials, or like materials can be used. Particle size, shape, and porosity determine the medium’s moisture retention capacity; the more porous the material, the higher the water retention. Availability, cost, quality, cleanliness, and the crop to be grown are determinants of medium selection. Resh, H.M. (1990). Hydroponics: Home food gardens. New Jersey: Newconcept Press.

**Economic indicators**: The price of consumer goods, such as food, is a reflection of the economy as a whole and is evidenced by the consumer price index. <http://www.wikipedia.org>. The family food budget is directly influenced by these costs. Exercises such as determining the “cost per serving” of foods and running “cost comparisons” of food from the store versus homegrown, can illustrate the costs of food production and the added costs within a food system.

**Flower:** The part of a seed plant comprising the reproductive organs and their envelopes if any, especially when such envelopes are more or less conspicuous in form and color. <http://www.dictionary.reference.com>.

**Flower anatomy**: The illustration shows the names of the parts of a flower. Compare the illustration to a dissected real flower and discuss the functions of the parts. <http://www.jp7numeracy.blogspot.com>.



**Food processing**: Any deliberate change in a food that occurs before it’s available for us to eat. <http://www.foodinsight.org>. The table from this website provides examples of food processing and which foods fall into each category. This website also includes information regarding food processing and questions people have about nutrition, expense, and other concerns.

|  |  |
| --- | --- |
| **Type of Food** | **Examples** |
| Foods that require little processing or production (also called “minimally processed”). | Washed and packaged fruits and vegetables; bagged salads; roasted and ground nuts and coffee beans |
| Foods processed to help preserve and enhance nutrients and freshness of foods at their peak. | Canned tuna, beans and tomatoes; frozen fruits and vegetables; pureed and jarred baby foods |
| Foods that combine ingredients such as sweeteners, spices, oils, flavors, colors, and preservatives to improve safety and taste and/or add visual appeal. (Does not include “ready-to-eat” foods listed below.) | Some packaged foods, such as instant potato mix, rice, cake mix, jarred tomato sauce, spice mixes, dressings and sauces, and gelatin |
| “Ready-to-eat” foods needing minimal or no preparation. | Breakfast cereal, flavored oatmeal, crackers, jams and jellies, nut butters, ice cream, yogurt, garlic bread, granola bars, cookies, fruit chews, rotisserie chicken, luncheon meats, honey-baked ham, cheese spreads, fruit drinks and carbonated beverages |
| Foods packaged to stay fresh and save time | Prepared deli foods and frozen meals, entrées, pot pies and pizzas |

**Five Common Questions about Processed Foods** (<http://www.foodinsight.org>.)

**Q:** Are processed foods safe?

**A:** Yes, in fact processing foods often makes them safer. For example, heating foods helps remove harmful bacteria. Pasteurization is a common heating process applied to milk to kill harmful organisms. Canning and freezing foods such as meats, fruits and vegetables helps them to stay fresher longer.

**Q:** Do processed foods cause obesity?

**A:** Most nutrition experts agree that no one type of food causes obesity – obesity results from consuming more calories than the body uses, regardless of where the calories come from. To maintain a healthy weight, it’s important to balance calories consumed with regular physical activity and to only occasionally enjoy single portions of treats such as fried foods, snack chips, desserts, candy, fruit drinks and soft drinks. Some processed foods may actually aid with weight management because they include ingredients that reduce the calorie content of foods, such as low-calorie sweeteners.

**Q:** Do processed foods lack nutrition?

**A:** Because processed foods include such a wide range of products, their nutritional values vary widely, too. For instance, frozen vegetables can be more nutrient-rich than fresh because they are picked and frozen at their nutritional peak. Furthermore, processed foods that are fortified with vitamins, minerals or other nutrients can help people reach the recommended intake levels for those nutrients. An example is orange juice fortified with calcium and vitamin D. Some processed foods, such as fried foods, desserts and candy, supply calories but few other nutrients.

**Q:** Are processed foods expensive?

**A:** Again, the wide range of choices means a wide range of prices. For instance, buying frozen strawberries might be less expensive than buying fresh strawberries out of season, but preparing tomato sauce with home-grown tomatoes in season might be less expensive than buying jarred tomato sauce.

**Q:** Are any processed foods natural?

**A:** The U.S. Food and Drug Administration (FDA) doesn’t define the term “natural” on food labels, but generally allows the term if the food doesn’t contain added colors, artificial flavors, or other synthetic substances. According to that definition, numerous processed foods could be considered “natural.” These include many fruit and vegetable products, grain and dairy products, and meat, poultry and fish products. A few examples are packaged cooked and uncooked chicken, potato chips, rice, frozen spinach and jarred applesauce.

**Food Pyramid:** The Food Guide Pyramid is an outline of what to eat each day based on dietary recommendations. An interactive pyramid and serving sizes are at <http://www.nal.usda.gov>. The pyramid is not a rigid dietary prescription; rather, it is a general guide toward healthful eating. See <http://fnic.nal.usda.gov> for food guides for special diets, including vegetarians, and those featuring ethnic/cultural foods.

**Fruit:**1.Any product of plant growth useful to humans or animals. 2. the developed ovary of a seed plant with its contents and accessory parts, as the pea pod, nut, tomato, or pineapple. 3. the edible part of a plant developed from a flower, with any accessory tissues, as the peach, mulberry, or banana. <http://www.dictionary.reference.com>.

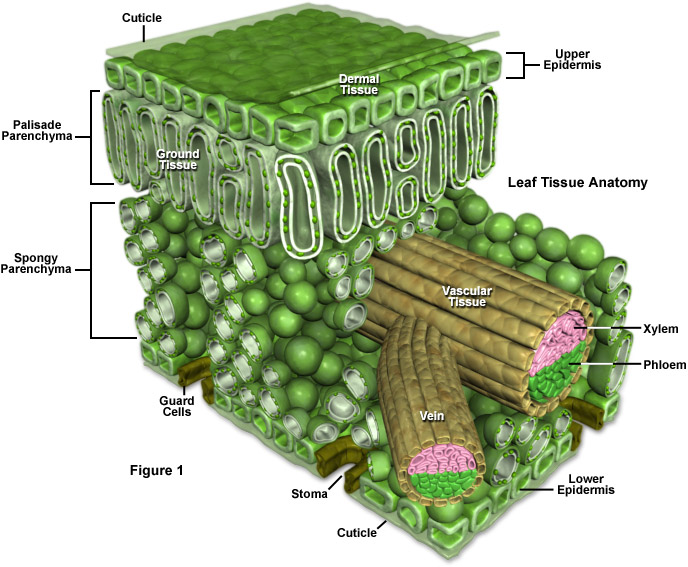
**Germination:** 1.To cause (seeds or spores) to sprout or (of seeds or spores) to sprout or form new tissue following increased metabolism2. to grow or cause to grow; develop. <http://www.thefreedictionary.com>.

**Hydroponics:** The cultivation of plants in a nutrient-rich solution, rather than in soil, and under controlled conditions of light, temperature, and humidity. <http://www.thefreedictionary.com>.

**Humidity:** Humidity is the amount of moisture in the air. The relative humidity is the amount of moisture in the air as a percentage of the most moisture that could be in the air at a certain temperature. If the air has half the amount of moisture it could have then the relative humidity is 50%. When it is raining or snowing and the maximum amount of moisture has evaporated into the air then the relative humidity will be at 100%. The relative humidity tends to be highest in the morning since cooler air cannot evaporate as much moisture as warmer air. In weather forecasting, the humidity aloft is often more important than the humidity at the surface. When the relative humidity is 100% through a deep layer of the atmosphere and air is rising then precipitation will occur. A relative humidity above 80% will feel humid especially in mild or warm air. A relative humidity below 30% will feel dry. <http://www.theweatherprediction.com>.

**Infestation:** To live as a parasite in or on. <http://www.thefreedictionary.com>.

**Leaf anatomy:** The illustration shows the names of the parts of a leaf. Compare the illustration to a dissected real leaf and discuss the functions of the parts. Retrieved from <http://www.bobsbeanblog.edublogs.org>.



**Light spectrum:** The entire spectrum, considered as a continuum, of all kinds of electric, magnetic, and visible radiation, from gamma rays having a wavelength of 0.001 angstrom to long waves having a wavelength of more than 1 million km. <http://www.dictionary.reference.com>. **Full-spectrum light** is light that covers the [electromagnetic spectrum](http://en.wikipedia.org/wiki/Electromagnetic_spectrum) from [infrared](http://en.wikipedia.org/wiki/Infrared) to near-[ultraviolet](http://en.wikipedia.org/wiki/Ultraviolet), or all wavelengths that are useful to plant or animal life; in particular, [sunlight](http://en.wikipedia.org/wiki/Sunlight) is considered full spectrum, even though the solar spectral distribution reaching Earth changes with time of day, latitude, and atmospheric conditions. "Full-spectrum" is not a technical term when applied to an [electrical](http://en.wikipedia.org/wiki/Electrical)[light bulb](http://en.wikipedia.org/wiki/Light_bulb) but rather a marketing term implying that the product emulates natural light. Products marketed as "full-spectrum" may produce light throughout the entire spectrum, but actually do not produce an even spectral distribution, and may not even differ substantially from lights not marketed as "full-spectrum. <http://www.wikipedia.org>.

**Malnutrition:** Malnutrition is the condition that develops when the body does not get the right amount of the [vitamins](http://medical-dictionary.thefreedictionary.com/Vitamins), minerals, and other nutrients it needs to maintain healthy tissues and organ function. Malnutrition occurs in people who are either undernourished or overnourished. Undernutrition is a consequence of consuming too few essential nutrients or using or excreting them more rapidly than they can be replaced. Overnutrition results from eating too much, eating too many of the wrong things, not exercising enough, or taking too many vitamins or other dietary replacements. Poverty and lack of food are the primary reasons why malnutrition occurs in the United States. Ten percent of all members of low income households do not always have enough healthful food to eat.<http://thefreedictionary.com>.

**Nutrition:** 1. The process by [which](http://dictionary.reference.com/browse/which) organisms take in and utilize food material. 2. food; nutriment. <http://www.dictionary.reference.com>.

**pH(Potential of Hydrogen):** A measure of the degree of the acidity or the alkalinity of a solution as measured on a scale (pH scale) of 0 to 14. The midpoint of 7.0 on the pH scale represents neutrality, i.e., a "neutral" solution is neither acid nor alkaline. Numbers below 7.0 indicate acidity; numbers greater than 7.0 indicate alkalinity. It is important to understand that pH is a measure of intensity, and not capacity; i.e., pH indicates the intensity of alkalinity in the same way temperature tells how hot something is - but not how much heat the substance carries. The pH scale is logarithmic which means that moving on (unit either way on the pH scale results in a 10 fold increase in the degree of alkalinity or acidity. <http://www.parish-supply.com>.

**Phytonutrients:** A bioactive plant-derived compound (as resveratrol or sulforaphane) associated with positive health effects. <http://www.merriam-webster.com>.

**Plant anatomy:** The area of plant science concerned with the internal structure of plants. Within the field of plant anatomy are (1) physiological plant anatomy, which is concerned with the links existing between plant structure and internal processes; (2) ecological plant anatomy, which is the study of environmental effects on plant structure; (3) pathological plant anatomy, which is the study of the effect of disease-producing agents of a biological, physical, and chemical character on plant structure; and (4) comparative, or systematic, plant anatomy, which introduces the comparative study of representatives of the different systematic groups (taxa)—species, genera, families, and so forth—for clarification of their phylogenetic bonds. <http://thefreedictionary.com>.

**Plant nutrients:** The [chemical elements](http://en.wikipedia.org/wiki/Chemical_element) that are necessary for growth. In 1972, E. Epstein defined 2 criteria for an element to be essential for plant growth:

1. in its absence the plant is unable to complete a normal life cycle or
2. that the element is part of some essential plant constituent or metabolite, this is all in accordance with [Liebig's law of the minimum](http://en.wikipedia.org/wiki/Liebig%27s_law_of_the_minimum). There are 17 essential plant nutrients. Carbon and oxygen are absorbed from the air, while other nutrients including water are obtained from the soil. Plants must obtain the following mineral nutrients from the growing media:

* the primary macronutrients: nitrogen (N), phosphorus (P), potassium (K)
* the three secondary macronutrients: calcium (Ca), sulphur (S), magnesium (Mg)
* the macronutrient Silicon (Si)
* the micronutrients/trace minerals: boron (B), chlorine (Cl), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), [molybdenum](http://en.wikipedia.org/wiki/Molybdenum) (Mo), nickel (Ni), selenium (Se), and sodium (Na)

The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.2% to 4.0% (on a dry matter weight basis). Micro nutrients are present in plant tissue in quantities measured in parts per million, ranging from 5 to 200 ppm, or less than 0.02% dry weight. <http://wikipedia.org>.

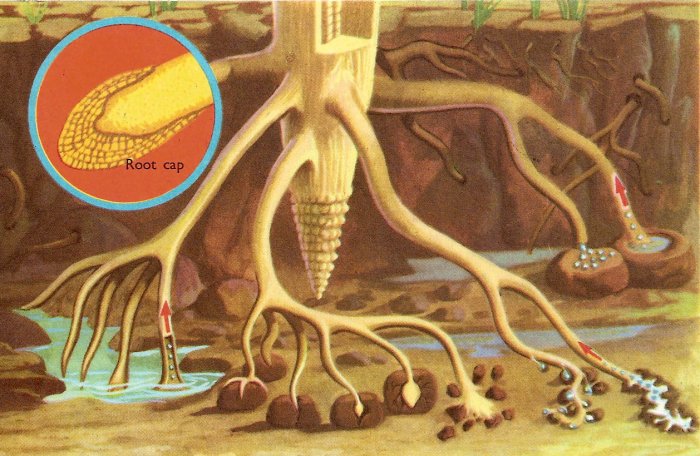
**Plant reproduction and genetics:** The production of offspring by organized bodies. **Asexual reproduction:** reproduction without the fusion of sexual cells. **Cytogenic reproduction:** production of a new individual from a single germ cell or zygote. **Sexual reproduction:** reproduction by the fusion of a female [gamete](http://medical-dictionary.thefreedictionary.com/gamete) and a male [gamete](http://medical-dictionary.thefreedictionary.com/gamete)*(bisexual r.)* or by development of an unfertilized egg *(unisexual r.).***Somatic reproduction:** production of a new individual from a multicellular fragment by fission or budding. <http://www.thefreedictionary.com>. **Genetics:** The branch of [biology](http://en.wikipedia.org/wiki/Biology) that deals with [heredity](http://en.wikipedia.org/wiki/Heredity), especially the mechanisms of hereditary transmission and the variation of inherited characteristics among similar or related [organisms](http://en.wikipedia.org/wiki/Organisms). <http://www.wikipedia.org>.

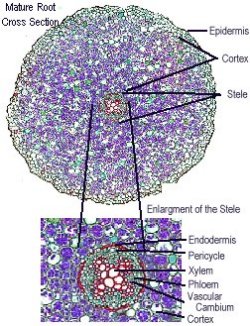
**Plants:** Any of various [photosynthetic](http://en.wikipedia.org/wiki/Photosynthetic), [eukaryotic](http://en.wikipedia.org/wiki/Eukaryotic), multicellular [organisms](http://en.wikipedia.org/wiki/Organisms) of the kingdom [Plantae](http://en.wikipedia.org/wiki/Plantae) characteristically producing [embryos](http://en.wikipedia.org/wiki/Embryos), containing [chloroplasts](http://en.wikipedia.org/wiki/Chloroplasts), having [cell](http://en.wikipedia.org/wiki/Cell_%28biology%29) [walls](http://en.wikipedia.org/wiki/Cell_wall) which contain [cellulose](http://en.wikipedia.org/wiki/Cellulose), and lacking the power of [locomotion](http://en.wikipedia.org/wiki/Animal_locomotion). <http://www.wikipedia.org>.

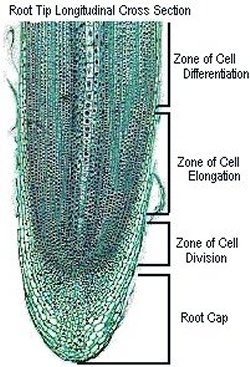
**Propagation:** 1.To cause (an organism) to multiply by any process of natural reproduction from the parent stock. 2. to reproduce (itself, its kind, etc.), as an organism does. 3. to transmit (hereditary features or elements) to, or through, offspring. <http://www.dictionary.reference.com>.

**Roots**: the descending axis of a plant, as contrasted with the stem, the ascending axis. In most plants the root is underground, but in [epiphytes](http://encyclopedia2.thefreedictionary.com/epiphyte) the roots grow in the air and in hydrophytes (e.g., cattails and water lilies) they grow in water or marshes. Roots function to absorb water and dissolved minerals from the soil, to anchor the plant, and often to store food. There are two main types of root system: the tap-root system, in which there is a main primary root larger than the other branching roots; and the diffuse (or fibrous) root system, in which there are many slender roots with numerous smaller root branches. Tap roots are characteristic of most trees and of many other plants, including the carrot, parsnip, radish, beet, and dandelion. The grasses (e.g., corn, rye, and alfalfa) have diffuse roots; in the sweet potato some of the larger fibrous roots swell to store food—although these should not be confused with the tuber of the Irish potato, which is a modified underground [stem](http://encyclopedia2.thefreedictionary.com/stem). Root systems often far exceed in mass the aboveground portions of the plant: alfalfa roots sometimes reach 40 ft (12 m) in length, and the combined length of all the roots of a mature rye plant has been measured at 380 mi (612 km). These ramified root systems are important agents in preventing soil erosion. Roots grow primarily in length; only the older roots may develop a cambium layer that increases their diameter. Protecting the constantly growing tip of the root is a cap of cells that break off as the root probes through the soil; they are replaced by new cells from a layer of meristematic tissue just behind them. In the center of the root the cells formed earlier by the embryonic cells of this layer differentiate into storage tissue and xylem and phloem vessels to conduct [sap](http://encyclopedia2.thefreedictionary.com/sap) upward to the leaves and back down to nourish the root cells. On the surface of the epidermis of the growing portion of the root, tiny cellular projections called root hairs extend into the soil to absorb water and minerals. Although root hairs are less than 1-3 in. (.84 cm) long, their great number enables the plant to collect enormous quantities of water, most of which is promptly lost into the air by transpiration. In spite of their slenderness and delicate structure, the spiraling forward thrust of the root tips and the pressure of their expanding cells is sufficient to split solid rock. <http://www.thefreedictionary.com>.

**Root anatomy:** The illustrations show the anatomy of roots and their function. All pictures are found at <http://www.daviddarling.info/encyclopedia/P/plant_root.html>.







**Seeds:** The fertilized ripened ovule of a flowering plant containing an embryo and capable normally of germination to produce a new plant; broadly**:** a propagative plant structure (as a spore or small dry fruit). <http://www.merriam-webster.com>.

**Serving size:** 1. The portion of food used as a reference on the [nutrition](http://www.medterms.com/script/main/art.asp?articlekey=10192) label of that food.  
2. The recommended portion of food to be eaten. <http://www.medterms.com>.

**Soil:** A natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment. The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose. Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 2.5 meters) for the growth of rooted plants. The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of horizons near the Earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. For purposes of classification, the lower boundary of soil is arbitrarily set at 200 cm. <http://www.soils.usda.gov>.

**Temperature:** a. The degree of hotness or coldness of a body or environment. b. A measure of the average kinetic energy of the particles in a sample of matter, expressed in terms of units or degrees designated on a standard scale. <http://www.thefreedictionary.com>.

**Trace minerals:** A substance, such as a vitamin or mineral, which is essential in minute amounts for the proper growth and metabolism of a living organism. <http://www.thefreedictionary.com>.

**Transpiration**: The process of [water](http://en.wikipedia.org/wiki/Water) movement through a [plant](http://en.wikipedia.org/wiki/Plant) and its [evaporation](http://en.wikipedia.org/wiki/Evaporation) from aerial parts especially from [leaves](http://en.wikipedia.org/wiki/Leaf) but also from [stems](http://en.wikipedia.org/wiki/Plant_stem) and [flowers](http://en.wikipedia.org/wiki/Flower). Leaf surfaces are dotted with pores which are called [stomata](http://en.wikipedia.org/wiki/Stomata), and in most plants they are more numerous on the undersides of the foliage. The stomata are bordered by [guard cells](http://en.wikipedia.org/wiki/Guard_cell) and their stomatal accessory cells (together known as stomatal complex) that open and close the pore. <http://www.wikipedia.org>.

**Vegetable:** a. A plant cultivated for an edible part, such as the root of the beet, the leaf of spinach, or the flower buds of broccoli or cauliflower. b. The edible part of such a plant. <http://www.thefreedictionary.com>.

**Vitamins:** Organic components in food that are needed in very small amounts for growth and for maintaining good health. The vitamins include vitamin D, vitamin E, vitamin A, and vitamin K, or the fat-soluble vitamins, and folate (folic acid), vitamin B12, biotin, vitamin B6, niacin, thiamin, riboflavin, pantothenic acid, and vitamin C (ascorbic acid), or the water-soluble vitamins. Vitamins are required in the diet in only tiny amounts, in contrast to the energy components of the diet. The energy components of the diet are sugars, starches, fats, and oils, and these occur in relatively large amounts in the diet. <http://www.thefreedictionary.com>.

**Yield:** An amount yielded or produced; a product. <http://www.thefreedictionary.com>.