Title: Indoor Gardening by Building a Simple Hydroponics
Grade: Middle School
Subject: Science, Math
Time: One hour to construct and plant, additional observation time

Standards: Students will...
Science Standard 1: Understand atmospheric processes and the water cycle.

- Benchmark # 3: Know that the Sun is the principle energy source for phenomena on the Earth's surface (e.g., the water cycle, plant growth).

Science Standard 5: Understand the structure and function of cells and organisms.

- Benchmark # 2: Know that cells convert energy obtained from food to carry on the many functions needed to sustain life (e.g., cell growth and division, production of materials that the cell or organism needs).
- Benchmark # 4: Know that multi-cellular organisms have a variety of specialized cells, tissues, organs, and organ systems that perform specialized functions (e.g., respirations, circulations, excretion, and movement) and that the function of these systems affects one another.
- Benchmark # 9: Know that cells use inorganic compounds (e.g., minerals, water) to make materials that the cells or organism needs.

Science Standard 12: Understand the nature of scientific inquiry.

- Benchmark # 1: Know that there is no fixed procedure called the "scientific method", but that investigations involve systematic observations, carefully collected, relevant evidence, logical reasoning, and some imagination in developing hypotheses and explanations.
- Benchmark # 3: Design and conduct a scientific investigation (e.g., formulate hypotheses, design and execute investigations, interpret data, synthesize evidence into explanations).
- Benchmark # 6: Use tools and techniques to gather, analyze and interpret scientific data.

Mathematics Standard 4: Understand and apply the basic and advanced concepts of measurement.

- Benchmark # 6: Select and use appropriate units and tools, depending on degree of accuracy required, to find measurements for real-world problems.

Mathematics Standard 6: Understand and apply the basic and advanced concepts of statistics and data analysis.

- Benchmark # 5: Use data and statistical measures for a variety of purposes (e.g., formulating and testing hypothesis).
- Benchmark # 6: Organize and display data using tables, charts, graphs, frequency distributions, and plots.
- Benchmark # 8: Understand the same set of data can be represented using a variety of tables, graphs, and symbols and that different modes of representation often convey different messages (e.g., variations in scale can alter a visual message).

Technology Standard 4: Understand the nature of technological design.

- Benchmark # 3: Identify appropriate problems, which can be solved using technological design (e.g. identify a specific need- feeding growing populations, consider the various aspects-

153 Washington Street | Fourth Floor | Walpole | MA | 02032 | 1.888.668.2298

methods of growing food, and consider criteria for a suitable product- various hydroponics systems and their components).
- Benchmark # 5: Implement a proposed design.
- Benchmark # 6: Evaluate the ability of a technological design to meet criteria established in the original purpose (e.g., consider factors that might affect acceptability and suitability for intended users or beneficiaries) suggest improvements, and try proposed modifications.

Technology Standard 5: Understand the nature and operation of systems.
- Benchmark # 1: Know that a system can include processes as well as components.
- Benchmark # 3: Identify the elements, structure, sequence, operation and purpose of systems.
- Benchmark # 4: Assemble and disassemble systems to manage, control and improve their performance.

Technology Standard 6: Understand the nature and use of different forms of technology.
- Benchmark # 3: Know that most technological systems require an input of energy, which is an important consideration both in designing an object or a system and in conserving energy (e.g., so many things require energy that alternative sources to fossil fuels should be used when possible- powering greenhouses for hydroponics systems).

Objectives: Students will be able to...
- Describe the process of the hydroponics, and explain the implications as relates to environmental protection, and increased food production for world populations.
- Identify and describe the basic requirements that plants need for growth and development in a hydroponics system.
- Collect, record, organize and interpret data using a variety of graphic representations.
- Compare and contrast methods of plant growth (e.g., traditional soil growth and hydroponics) and evaluate for purposes of efficiency.

Materials:
- 2 liter soda bottle
- Wick (either pre-made or fashioned from cotton)
- 1-2 teaspoons nutrient solution
- Baking soda, 1 teaspoon
- Juice of one half lemon
- Litmus paper
- Vermiculite
- Cilantro Seeds
- Peat pot, 2”
- Potting Mix
- Water
- Flower pot, 6"
- "Hydroponocs Instructions" worksheet provided below

Overview: Hydroponics is a process for growing plants without the use of soil. Growth rate and food production are both greater for plants that are grown in hydroponics systems. Plants grown using this method take in oxygen and nutrients at a quicker pace, and because the nutrients are mixed directly

153 Washington Street | Fourth Floor | Walpole | MA | 02032 | 1.888.668.2298

into the water in which the plants are grown, they use less energy to absorb them. The plants are then able to use the reserve energy to grow faster and produce flowers/fruit more efficiently.

Plants grown in the Earth use the soil as a means of support. Hydroponics systems require structures, called media, to aerate and support the roots of the plants. There are a variety of growing mediums available, some more effective than others. The type of medium selected often depends on the type of hydroponics system used. Expanded shale works well in an ebb and flow type of system. Perlite, vermiculite and various types of sand work best in wick systems, and rockwool is suitable for almost any type of hydroponics system.

For the purpose of this lesson the wick system will be used. The wick system is a passive type of hydroponics that does not use a pump or any moving parts. A reservoir holds the water and nutrient mixture. One end of the wick, similar to that of a candlewick, is placed into the reservoir. The wick absorbs the nutrient mixture and transports it to the roots of the plant through the use of the growing media.

Many fruits, vegetables, flowers and herbs grow well in hydroponics systems, including, green leafy vegetables, tomatoes, strawberries, beans, squash, cucumbers, leeks, peppers, roses, carnations, and most herbs. However, not all plants grow well in hydroponics systems when started from seed and need to be transplanted in the seedling stage for optimum growth. In this lesson, students will grow cilantro from seed. Since this herb does not like to be transplanted, it can be sown directly into the hydroponics garden. It takes a week to ten days to germinate and its leaves can be harvested in approximately six weeks. Plants will grow anywhere from 18 to 24 inches in height.

Hydroponics gardening is beneficial to the environment and to man. Hydroponics plants are seldom bothered by pests and are less prone to disease. As a result pesticides are seldom used, which minimizes the impact to the environment and provides for a healthier source of food. While hydroponics gardens generate carbon dioxide, this can be minimized in several ways. Rather than using fossil fuels to provide heat and artificial light, wind and solar power can be used to generate the necessary power. Any additional CO2 created inside the greenhouse is naturally absorbed by the plants and transformed into food and oxygen during the process of photosynthesis. Commercial hydroponics greenhouses are typically located in close proximity to the communities they service, eliminating the need for long distance transport and further CO2 emissions. Also since these plants are grown in a water and nutrient solution, they actually waste less water than soil grown plants, and topsoil erosion is obviously a non issue. As arable land becomes more and more scarce, hydroponics may be the solution man turns to in order to feed the expanding populations in areas around the world.

Kid's Speak: Hydroponics is a way to grow plants without soil. Since soil usually provides plants with the support and the nutrients they need to grow, plants grown hydroponically need different ways to deal with these issues. In a hydroponics system plants grow in a water and nutrient solution. This mixture, along with a medium, such as sand or vermiculite used for support, provide the plants with the basics they need to growth and develop. Hydroponics is a healthy way for people to grow food, and may be one solution that will help starving people around the world.

Eco-Fact: Lettuce is one of the easiest hydroponics crops to grow. Seeds need to be germinated in a starter, such as vermiculite, but once the lettuce plants have at least four leaves they can be

transplanted into their permanent home. Lettuce plants need very little space to grow and as many as 16 plants can be grown in a one square yard of space.

Procedures:

Before Creating a Hydroponics System:

- Review the basics needs of plants, their specific structures and how the structures support growth and development.
- Introduce the hydroponics process, its potential benefits to man and the environment, and how it differs from growing plants in soil. Plants grown hydroponically need a growing medium, adequate temperature control, proper lighting (e.g., LED or HID- high intensity discharge), and a nutrient solution with the proper pH balance. The letters pH stands for Potential of Hydrogen. The range of pH is from zero, which is the most acidic, to fourteen, which is the alkaline base. A solution with a pH of 7 is neutral. Typically, when growing plants hydroponically a pH of 5.5 to 6.2, which is slightly acidic, is recommended, but this can vary from species to species. Litmus paper is used to test pH of a solution.
- Develop a T chart with students to compare the two methods of growing plants. Discuss the similarities and differences of the two methods.
- Explain to students that as land for agricultural purposes becomes scarce around the globe, the need to find solutions for growing food becomes more important. Hydroponics is one potential solution to this problem. Tell students that they are going to conduct an experiment to determine which method of growing plants is more effective. They will create a hydroponics system, and use it and the traditional soil method to grow cilantro plants from seeds. Cilantro is an annual herb similar to flat leaf parsley.

Procedure for Creating a Hydroponics System:

1. Cut the top off the 2-Liter bottle. Try to cut at the point where the bottle first reaches its widest circumference.
2. Put the top upside down, so the neck and lid face the bottom of the inside of the bottle.
3. Add enough water so that it always touches the bottle's neck. See diagram of steps 1-3.
4. Add the nutrient solution.
5. Use the litmus paper to test the water's pH balance. Cilantro plants prefer a pH close to neutral, 6.5 to 7.5. If the pH is higher than 7.5, it is too basic and needs an acid. Add the juice of half a squeezed lemon to the solution. If the pH is too low the solution is too acidic. Add 1 tsp of baking soda.
6. Add the wick. Make sure it extends into the neck.
7. Add the growing media. Vermiculite is a traditional media and has a medium capability of transporting water. See diagram of steps 6-7.
8. Add the cilantro seed. Keep in mind that seeds need to be spaced at least six inches apart; do not place too many seeds in the system.
9. Place in a well-lit area. Refresh the water solution weekly. Cilantro is hardy, has minimal light requirements and will withstand low temperatures. If it is too hot, the plant, once grown will flower quickly, and go to seed. At this point the leaves turn bitter and the seed is the only useful part

Planting Seeds in Soil:

1. Wet the peat pot before filling.

153 Washington Street | Fourth Floor | Walpole | MA | 02032 | 1.888.668.2298

2. Fill the pot two thirds of the way up with vermiculate.
3. Add seed to the pot. Cover with vermiculite. Follow the directions on the seed package.
4. Mist gently until vermiculite it moist. Keep the mixture moist, but do not over water.
5. Place the pot in a warm place in full sun.
6. Keep plant well watered, but not too wet. Cilantro can tolerate drier conditions better than wet conditions.
7. Once the seedling has matured, about six weeks, it can be transferred outdoors (once the last frost has passed) or into a larger pot with potting soil.

For Potted Plants:

8. Fill the pot with moistened soil, about two thirds of the way. Cilantro does not like to be disturbed, so gently break off the bottom of the peat pot to free the roots. Place it into the center of the pot and surround and top with more soil.
9. Water once or twice a week. Cilantro prefers morning sun and afternoon shade. Add fertilizer once every few weeks.

During the Growth Process:

- Students will keep a growth journal, making daily observations and illustrations of both cilantro plants, and recording a) the time it takes for each plant to sprout, and b) the daily height measurements.
- After approximately six weeks students will harvest leaves from each plant and record notes regarding their appearance, scent, and if acceptable, their taste.
- Some leaves should be harvested and retained for use. Plants should be allowed to flower, (approximately eight to ten weeks) and go to seed. Seed should be gathered and tested as above.
- Students will make and add to a T chart throughout this stage to show how each plant has progressed through its life cycle.

After Creating a Hydroponics System:

- Once students have observed and recorded the life cycle of the cilantro plants, the will make Venn Diagrams to compare and contrast the two methods of growth and determine which method, if any, appears to be the most effective.
- Students will discuss the outcomes of the experiments and evaluate the possibilities for using hydroponics systems to feed growing populations around the globe, identifying the benefits and possible drawbacks.

Adaptations:

- Have students experiment with the following: different materials for the wicks, different materials for the growing media, and different types of plants.

Extensions:

- Use the leaves and seeds (known as coriander), either fresh or dried, in cooking projects.
- This project and other hydroponics systems use materials that we usually throw away. Please see the Waste Reduction Lessons in the National Green Week section of this GEF website for more ways to recycle your trash.
- For tips on dietary guidelines and healthy eating habits visit the USDA Food Pyramid.

153 Washington Street | Fourth Floor | Walpole | MA | 02032 | 1.888.668.2298