****

**Alaska Indoor Gardening Curriculum**



**Hydroponic Plant Growth Lesson**

**Author/Source:** Mel Sikes, Alaska Ag in the Classroom

Jr Master Gardener Handbook

**Suggested Grade Levels:** 3-12th Grade

**Time:** 45 minutes to 1 hour

**Teaching Goal:**

To introduce students to the needs of plants and how they grow.

**Learning Objectives:**

To introduce students to hydroponics and the features of hydroponic systems. Help students to make the connection between the plant needs and how they are met in a hydroponic system.

**Core Ideas:**

* Plant Anatomy
* Plant Life Cycles
* Plant Dynamics (circulation and nutrient uptake)
* Hydroponics
* pH Testing
* Photosynthesis
* Pollination
* Nutrient Uptake
* Lighting Systems
* Recording Scientific Data in Tables
* Standardized Science Measurements
* Drawing Conclusions from Experimentation (hands-on, observation, drawing, and note-taking)

**Alaska State Science Standards:** 3-LS4-4, 4-LS1-1, 5-PS3-1, 5-LS1-1, 5-LS2-1, MS-LS1-5, MS-LS1-6, MS-ETS1-1, HS-LS1-2, HS-LS1-5, HS-LS2-3, HS-LS2-5, HS-ESS3-4

**NGSS Standards:** 3-LS1-1, 3-LS4-3, 4-LS1-1, 5-PS3-1, 5-LS1-1, 3-5-ETS1-1, MS-LS1-5, MS-LS1-6, MS-LS2-1, MS-LS3-3, MS-ESS3-3, HS-LS1-5, HS-LS2-7, HS-ESS2-6, HS-ESS2-7, HS-ESS3-4, HS-ETS1-1

**Materials Needed:**

* Copies of the “How Does a Plant Grow” and “pH in Hydroponics” information pages
* Copies of plant lights pictures
* Plant and Root Growth Observation worksheets
* pH testing strips
* Hydroponic nutrient bottles
* Water, white vinegar and other liquid substances like Coca-Cola or fruit juice
* Small cups
* Pencils

**Vocabulary:**

1. *Carbohydrate:* any of various neutral compounds of carbon, hydrogen, and oxygen (as sugars, starches, and celluloses) most of which are formed by green plants.
2. *Chlorophyll:* A green pigment that captures light energy for photosynthesis.
3. *Nutrients:* Plants must obtain the following mineral nutrients for their growing medium. They need nitrogen, phosphorus, potassium, calcium, sulfur, and magnesium.
4. *Oxygen:* A reactive element that is found in water, rocks, and free as a colorless tasteless odorless gas which forms about 21% of the atmosphere. Oxygen is capable of combining with almost all elements, and that is necessary for life. Also a by-product of the photosynthesis process.
5. *Photosynthesis:* The process by which plants, algae, and some bacteria use sunlight, carbon dioxide, and water to make food.
6. *pH:* Stands for power of hydrogen, which is a measurement of the hydrogen ion concentration in the plants. Plants grow best in a slightly acidic pH range of 6 to 7.
7. *Roots*: Anchor the plants in the soil and absorb nutrients and water that are needed by the rest of the plant.
8. *Seeds:* Contain plant material that can develop into another plant.
9. *Stems:* Support the upper part of the plant and act as a transport system for nutrients, water, sugar, and starches.

**Background for Teachers:**

All plants require sunlight, water, soil (nutrients), and air in order to grow and be healthy. Energy received from the sun or from artificial sunlight is used to convert carbon dioxide and water into food. When plants carry out photosynthesis, they take in carbon dioxide from the atmosphere and release oxygen for us to breathe. When plants do not receive the things they need to live and grow, they will either die or be stunted in their growth. In hydroponics the food (nutrients) is provided in a nutrient solution (water mixed with either liquid or powdered nutrients developed for growing plants). The Light can be either natural light or artificial light. Artificial light can be controlled and makes it possible to grow plants at any time of the year.

**Procedure:**

**Part 1: Discuss Plant Growth and Needs**

1. First ask students what their basic needs to live are. Generate a list with the class that includes food, water, air, shelter, space, warmth, clothing. List these on the board under the title Human Needs. Ask if they have needs similar to plants. Ask if plants need anything that people do not. Discuss plant needs. Write the word LAWNS vertically on the board. Ask the students if they know what each letter might stand for. Review the word “acronym” if it is appropriate for your classroom instruction.

 L – Light

 A – Air

 W – Water

 N – Nutrients

 S – Space

1. Write photosynthesis, air, and nutrients on the board. Tell the students that as a class, you are going to write a few sentences that define these vocabulary words and how plants use them.

****Photosynthesis:**

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation). This chemical energy is stored in carbohydrate molecules, such as sugars, which are synthesized from carbon dioxide and water. In most cases, oxygen is also released as a waste product. Photosynthesis is largely responsible for producing and maintaining the oxygen content of the Earth's atmosphere, and supplies all of the organic compounds and most of the energy necessary for life on Earth.

Ask the students to help you summarize the purpose of photosynthesis on the board. Consider writing something like: “Photosynthesis is the process that allows plants to make it’s own food.”

**Air:**

Ask students to help write a summary for air. Confirm their ideas that they suggest. It’s possible that a student will suggest a summary that is appropriate to write down. If no one does, read the following:

All plants need air (oxygen and carbon dioxide) Some people think that only the visible part of the plant needs air. Not true. In order for the plant to grow and produce properly, the roots need air as well. This is why we have an air stone in the system.

After reading, ask the students to help you write a summary for air. Consider writing down something similar to: “Plants need air in order to grow and produce successfully.”

**Ask students what nutrients they think plants need to grow properly. Write the Big 3 under the word nutrients on the board; nitrogen, phosphorous, and potassium.** Tell the students that the big 3 are the most important nutrients for plant growth and explain their purpose.

**Nutrients for Plant Growth:**

The Big 3

* N- Nitrogen for the production of leaves, stem growth, and building plant cells.
* P – Phosphorus for the development of flowers, fruits, and healthy root growth.
* K – Potassium for photosynthesis

Tell the students that there are other important nutrients that are still very important. We call them “minor nutrients.” Explain these nutrients, but do not add them to the board.

**Minor Nutrients** – still very important

* Sulphur to heighten the effectiveness of phosphorus and for plant energy.
* Iron for the production of chlorophyll.
* Manganese for the absorption of nitrogen and energy transference.
* Zinc for energy transference.
* Copper for producing chlorophyll.
* Boron for cell wall stability.
* Magnesium for producing chlorophyll and distributing phosphorous.
* Calcium for root growth and the absorption of potassium.
* Chlorine for photosynthesis.
* Molybdenum for assistance in chemical reactions.

Look at the bottle of nutrients that you will be using, discuss it with the students. Read the label, determine the amount of nutrients you should be adding to your system to be most efficient.

**Part Two: What is Hydroponics and Does It Work**

1. Discuss how hydroponics is growing plants with nutrient filled water and not in soil. Hydroponics uses a system of controlled agriculture including what kind of nutrients a plant gets, the amount of light a plant receives, the amount of warmth a plant is grown in, the amount of air movement surrounding the plant. All elements of growth are controlled by the grower.
2. Discuss how this level of control contributes to increased growth rates by providing a consistent access to nutrients and light. On the other hand, hydroponics benefits stem from lowered issues with uncontrolled situations like storms, wind, lack of rain, or pests.

**Part Three: Running the Hydroponic System**

1. Nutrient Monitoring, pH Testing: Explain to the students that in a hydroponic system, all the parts of the system have to be set up and monitored carefully so that the plants can access all the things it needs to be healthy. Explain that as a class, they are going to practice monitoring the water for nutrients and pH.A pH meteror strips are a useful monitoring tool that will help you keep track of what’s going on with your hydroponic nutrient mixture. This tool allow you to monitor nutrient concentrations in the liquid you’re feeding your plants. Like pH, nutrient concentration, which is measured in parts per million (ppm), can fluctuate in the dynamic environment of a hydroponic system. Too few nutrients and plants go hungry; too many, and they begin to sustain damage from over-fertilization. This can result in yellow leaves, singed leaves, stunted growth and defoliation.

A basic hydroponic food contains about 20 nutrients plants need to grow. Concentrations of these important ingredients aren’t detectable through a visual inspection, but they can still be evaluated. A fluctuation in the pH of the water can help to indicate the presence of either a nutrient deficiency or overabundance. Look at the pH info sheet and discuss different plant pH ranges.

Using pH test strips

* Step 1- Fill a clean vial with the water to be tested.
* Step 2- Remove a test strip from the kit, being careful not to get it wet before placing it in the glass.
* Step 3- Dip the pH test strip into the water for several seconds. Refer to the instructions for the pH test kit for exact time. There is no need to stir the strip.
* Step 4- Remove the pH strip after the recommended time. Hold the test strip level and wait for the color indicator on the end of the strip to finish changing.
* Step 5- Take a reading of the pH by comparing the color indicator on the test strip to the chart that came with the pH test kit. Different colors indicate different levels of pH.
* Step 6- Dispose of the used test strip. It cannot be used again.
* Repeat with the vinegar and other liquids to see the difference.

 2**.** Lighting:

Discuss lighting options with the students. Have examples of different lights to look at. Artificial lighting is a big theme in hydroponics. Poor lighting kills plants faster than almost any other type of deficiency. When you garden outdoors, nature does the heavy lifting for you by providing full-spectrum, diffused light. When trying to re-create that abundant light source, you have to make some practical considerations. It isn’t just a matter of choosing fixtures and bulbs that provide enough light. That would be almost as simple as picking a sunny spot in your garden to grow tomatoes! Hydroponic lamps are available in light wavelengths that approximate full-spectrum light or only certain portions of the light spectrum, typically the blues and reds preferred by plants as opposed to the greenish-yellow wavelengths human eyes are sensitive to.

1. **Fluorescent** somewhat inefficient, must be kept close to the plants.
2. **LED Lights –** Energy efficient, low heat output, long lasting

The type of illumination a grow light produces may be more suited to different plants or different phases in a plant’s life cycle. Cool or blue-spectrum light (430-450 nm) encourages leaf, root and stem development, while red-spectrum light (640-680 nm) enhances flowering and fruiting.

***Lights must be kept on a consistent schedule. A timer is a very good idea.***

 **5.** Temperature

Plants grow well only within a limited temperature range. Temperatures that are too high or too low will result in abnormal development and reduced production. Warm-season vegetables and most flowers grow best between 60° and 75° or 80° F. Cool-season vegetables such as lettuce and spinach should be grown between 50° and 70° F.

 **6.** Monitoring of Plant Growth

Talk about how important it is to monitor the growth of the plants. Discuss ways to make observations on how the plants are doing. Introduce the observation worksheets. Have students fill out the seedling observation page and store them in a folder so you can return to this observation recording each week.

**Extensions:** Do You Know the Parts of Plants?, Setting Up the Hydroponic System, Indoor Gardening Lighting Systems Handout,

**References:**

**Books:**

*The Budding Botanist (AIMS Activities Grades 3-6) Investigations with Plants*

by Evalyn Hoover, Howard Larimer, Sheryl Mercier, Michael Walsh, Dave Youngs and Beverly Tillman 2009 ISBN: 1-881431-40-1

*The Classroom Hydroponic Plant Factory*

by Foothills Hydroponics, inc. 2010 ISBN: 0-9669557-1-4

*Gardening Indoors with Soil and Hydroponics*

by George Van Patten 2007 ISBN: 978-1-878823-32-8

*How to Hydroponics*

by Kenneth Roberto 2014 ISBN: 0-9672026-1-2

*Hydroponic Basics: The Basics of Soilless Gardening Indoors*

by*George F. Van Patton 2004 ISBN: 978-1-878823-25-0*

*Plant Plumbing: A Book About Roots and Stems* (Growing Things)

by Susan Blackaby 2003 ISBN: 1-4048-0109-X; ISBN: 978-1-4048-0385-5

**Websites:**

*Illinois ACES College of Agricultural, Consumer and Environmental Sciences* <http://www.aces.uiuc.edu/vista/html_pubs/hydro/require.html>

*Gardening Know How* <https://www.gardeningknowhow.com/special/children/how-plants-grow.htm>

*Simply Hydroponics and Organics*:[*http://www.simplyhydro.com/system.htm*](http://www.simplyhydro.com/system.htm)

**How Does a Plant Grow?**

****

There are 4 different processes that are involved in the growth of a plant.

***1. Photosynthesis:*** is the process of making food (sugars) from water, light, carbon dioxide, and mineral compounds.

Chlorophyll is the green pigment of plants and photosynthetic algae and bacteria that traps sunlight for photosynthesis. Chlorophyll, light, carbon dioxide, and water are needed to create the chemical reaction that produces sugars. The sugar produced consists of 6parts Carbon, 12 parts Hydrogen, and 6 parts Oxygen. The sugar is used by the plant to make materials that make up the structures of the plant using enzymes and proteins.

**2. Respiration:** Plant respiration is the opposite of photosynthesis, which is a biological process performed by green plants that creates oxygen and releases it into the air. During respiration, plants absorb free molecules of oxygen (O2) and use them to create water, carbon dioxide, and energy, which helps the plant grow. Respiration gives the plant energy and allows other processes to occur including making complex foods such as carbohydrates, the movement of water and nutrients around the plant, making nutrients into cells or plant tissues, assisting the movement of plant foods around the plant.

**3. Transpiration:** Transpiration is the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers. Water is necessary for plants but only a small amount of water taken up by the roots is used for growth and metabolism. The remaining 97–99.5% is lost by transpiration. The remaining % is used in photosynthesis and for cell moisture and growth.

Leaf surfaces are dotted with pores called stomata, and in most plants they are more numerous on the undersides of the foliage. The stomata are bordered by guard cells and their stomatal accessory cells (together known as stomatal complex) that open and close the pore.[2] Transpiration occurs through the stomatal apertures, and can be thought of as a necessary "cost" associated with the opening of the stomata to allow the diffusion of carbon dioxide gas from the air for photosynthesis. Transpiration also cools plants, changes the pressure of cells, and enables mass flow of mineral nutrients and water from roots to shoots, basically as water is lost to the air, it is replaced by water drawn into the roots.

**4. Absorption:** The absorption of water by plants is essential for various metabolic activities. Land plants get their water supply from soil which serves as the source of water and [minerals]. Most absorption happens in the roots. Root hairs are essential to this process and can increase and their presence can increase absorption rates.

**tensions:** Ways to extend the lesson with additional suggested activities.

**ssessment:**

**pH in Hydroponics**

Although it is perhaps one of the most overlooked aspects, pH is very important in hydroponic and organic as well as regular soil gardening. pH is measured on a scale of 1-14 with 7 being neutral. Acids are lower than 7 and alkalis (bases) are above 7. pH is the measurement of alkalinity or acidity. It can also determine the availablility of nutrients to the plants.

Plants will take up nutrients much faster when the water is slightly acidic, between 5.8 and 6.5. You can change the pH of the water if necessary. To increase acidity of the water, add vinegar or acetic acid. To reduce the acidity of water, add hydrated lime, soda ash, or just plain baking soda.

pH testing is best done with Bromthymol blue or an electronic pH tester. Litmus paper can be used but it isn’t very accurate for hydroponic use, but is fine in a pinch. If your Bromthymol blue shows light to medium green, it’s good. If it goes yellow, that is bad and you must change it as it indicates a pH below 6.0.

Check your pH every few days regularly.

Nitrogen is most avaliable between a pH of 6-8, out of this raing reduces the availability. Iron is available at its maximum at a pH up to 6, but too much iron can be bad for a plant.

|  |  |
| --- | --- |
| Crop | pH ideal range |
| Bean, snap | 5.5-6.8 |
| Bean, Lima | 5.5-6.8 |
| Cucumber | 5.5-6.8 |
| Lettuce, head | 6.0-6.8 |
| Lettuce, leaf | 6.0-6.8 |
| Pepper, sweet | 5.5-6.8 |
| Spinach | 6.0-6.8 |
| Tomato | 5.5-6.8 |
|  |  |

****

**Florescent Lighting**

****

 **Compact Florescent**

****

 **T-5 Lights in a shop light**

**LED Lighting**

****