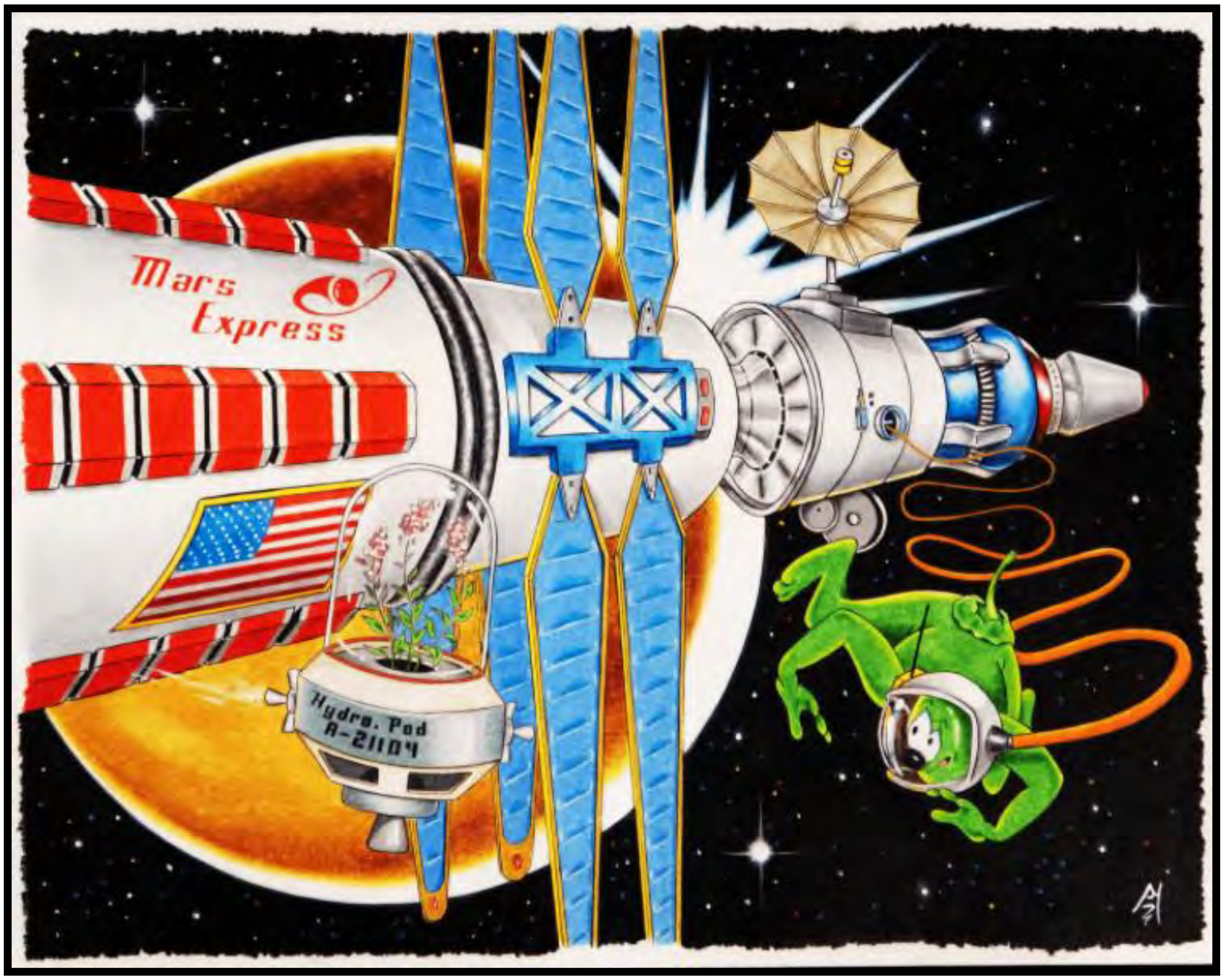
Hydroponics for the Next Generation: A Learn-by-Doing Curriculum Based Model

Doña Ana County Cooperative Extension Service, New Mexico State University

Doña Ana County Farm & Livestock Bureau



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LESSON PLANS

General structure:

- **LESSON**
- **ACTIVITY & VIDEO:** Group work/image construction/building/fulfilling ESL & special needs
- **JOURNAL:** Activities using scientific words (can also incorporate Quizlet/Wordo/Kahoot etc.)
- **(9) LESSON PLANS**

Lesson 1. Introduction: Why Hydroponics

- Agriculture, sustainable agriculture, & hydroponics definitions
- Hydroponics in arid regions for water conservation and climate change resiliency tactics. The connection between us and plants: caring for plants = caring for ourselves = caring for the planet. Conventional versus hydroponics production.
- Full cycle – collect the seeds for the next season

Lesson 2. Seedling Germination & Fertilizer

- What is seedling germination?
- What plants grow well in hydroponic systems
- Fertilizer, plant nutrition, nutrient cycling, hydroponics media

Lesson 3. Introduction: Building a Hydroponics System

- How to build a hydroponics system (check for local/online component pricing)
- Your maintenance role
- Life lessons: video your progress and learning lessons & share them with your classmates and school

Lesson 4. Lighting

- Why do plants need light?
- Hydroponics lighting: mimicking our natural systems
- How to build and install your hydroponics lighting and timer

LESSON PLANS CONTINUED

Lesson 5. Plant Biology & Harvesting

- Plant parts and size, pollination
- Indeterminate & determinate; perennial & annual
- Plant harvesting

Lesson 6. Water pH & Plant needs

- Why plants need water
- pH
- Plant nutrients & taste test: hydroponics versus conventional

Lesson 7. Aeration

- The importance of plant aeration
- Plant aeration preferences
- Troubleshooting potential aeration issues in your hydroponics system

Lesson 8. Food Nutrition & Engineering

- What plants provide us
- Why we eat plants
- Create your own meal with what you grow!

Lesson 9. Life Lessons: Build Your Hydroponics Business!

- Business 101: Online games
- Who sells produce and why?
- How you can build your very own hydroponics business!

Lesson 1

INTRODUCTION: WHY HYDROPONICS

Vocabulary

-Hydroponics

-Hydroponics advantages

-Hydroponics disadvantages

-Climate change mitigation & resiliency tactics

-Arid region & water conservation

-How to create a hydroponics maintenance chart

Lesson 1 INTRODUCTION: WHY HYDROPONICS

OBJECTIVES

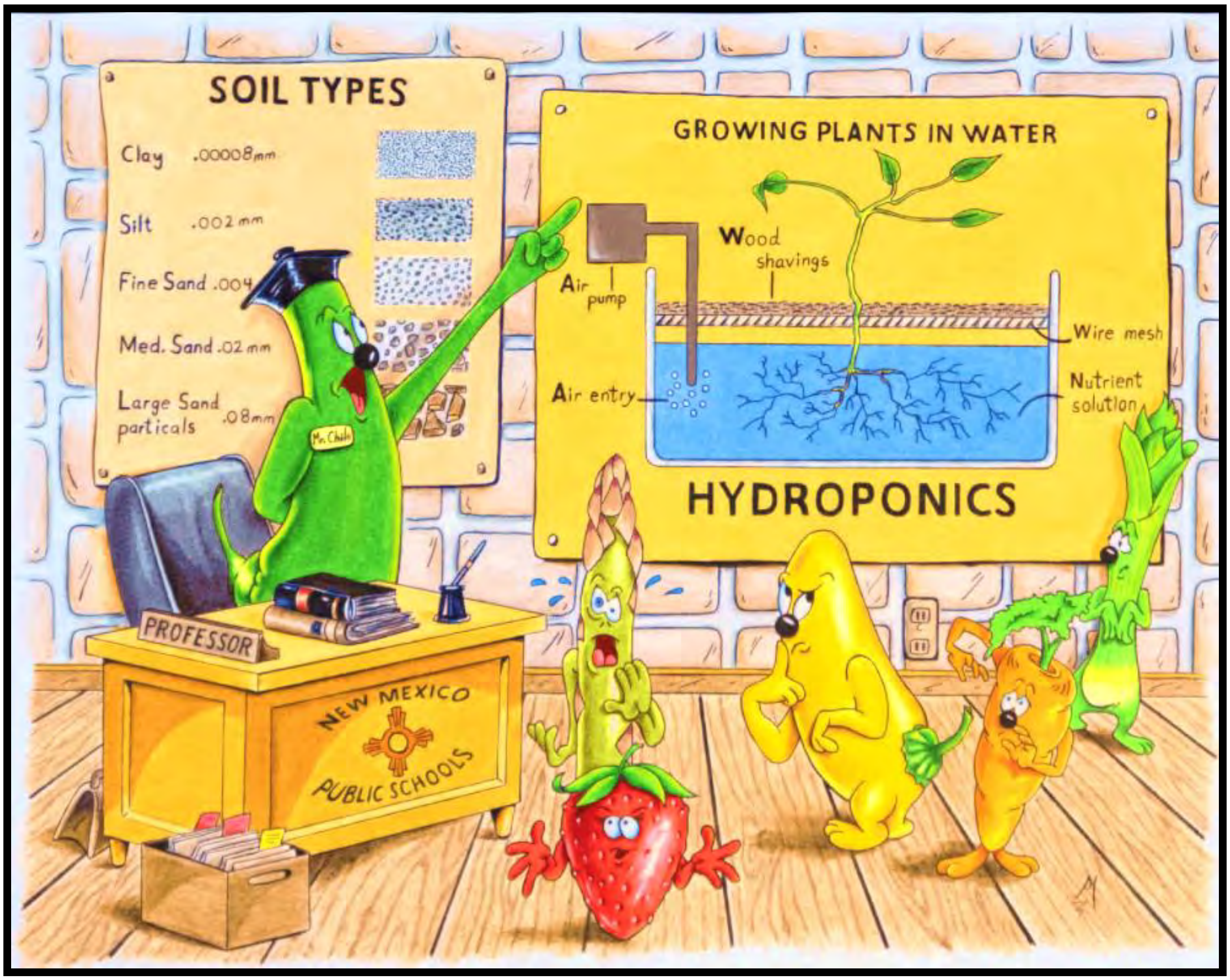
- To define hydroponics, generally understand how hydroponics systems work and the learn-by-doing process
- To understand hydroponics vocabulary and provide at least (3) advantages and disadvantages of hydroponics systems
- To provide explanations of hydroponics implications on crop production in arid regions, water conservation, human-plant interconnections, and as a climate change mitigation and resiliency strategy
- To be able to explain why the production of plants, and optimized efficiency, is important
- To understand the overall maintenance needs of the hydroponics system; create a hydroponics maintenance chart; and identify each student's hydroponics germination, establishment, seed-saving, and maintenance roles
- **Next Generation Standards: MS-PS3-3**
- **MS-PS3-3 Energy**. Students who demonstrate understanding can: **MS-PS3-3**. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

What is Agriculture?

What is Sustainable Agriculture?

What is Hydroponics?

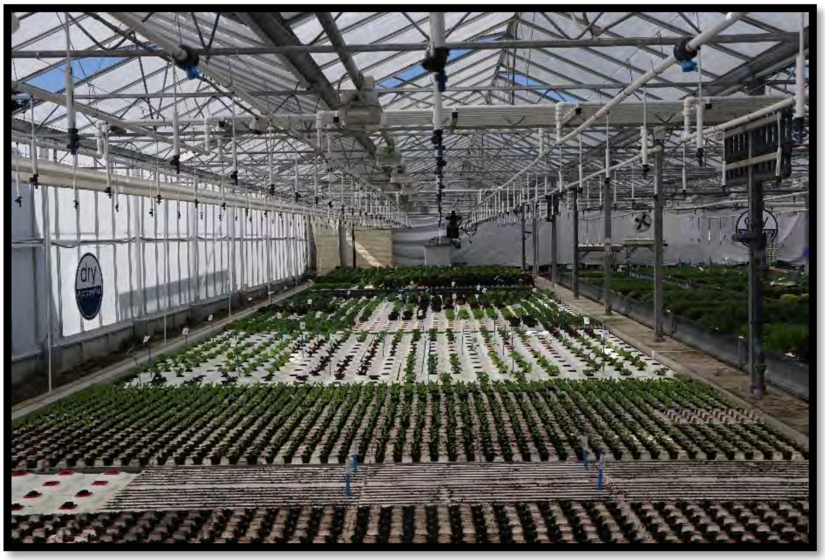
Hydroponics is a method of growing plants without the use of soil. There are many forms of hydroponics, including commercial production and vertical towers etc. We will build one kind of hydroponic system. Herbs (such as thyme, cilantro, and basil) and green leafy plants (including different kinds of lettuce, spinach, collard greens, and cabbage), and dwarf/determinate tomatoes grow well; root crops (such as carrots, potatoes, and beets) can also be grown, but with some modifications.



Professor Juan-Carlos Benito del Chile Verde (PhD, DAC-FLB),

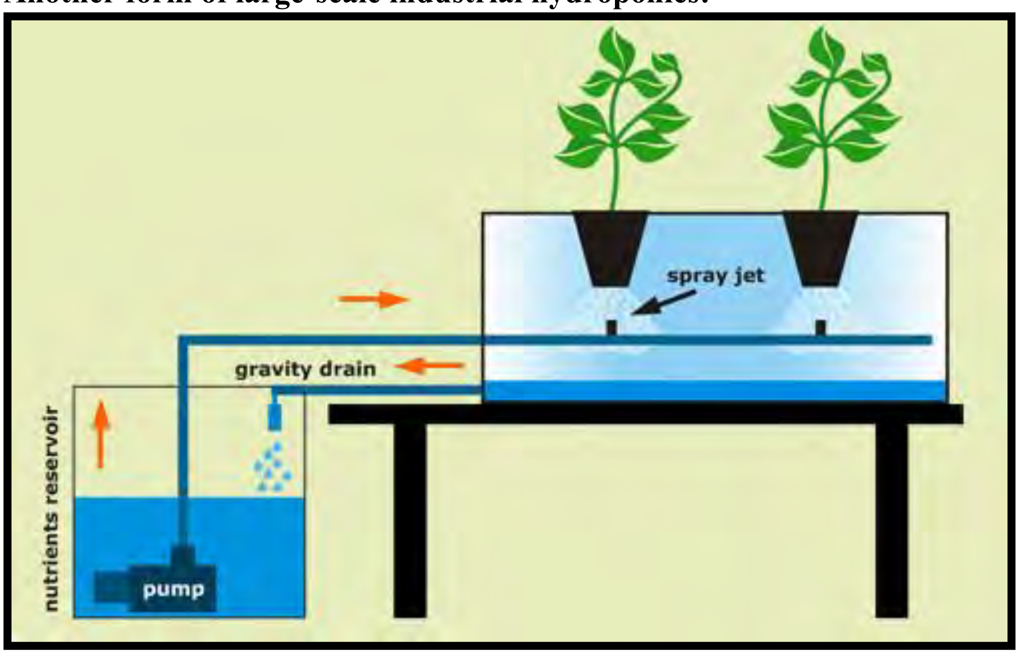
"Now Class, Learning to Grow Plants Hydroponically is Easy?"

One simple form of hydroponics!



Images provided by Jeff Anderson

Another form of large-scale industrial hydroponics!



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VIDEO FROM ADRIAN GAYTAN (ZIA MIDDLE SCHOOL, Las Cruces NM):
https://spaces.hightail.com/space/WfrClJ8wws

Advantages/Pros

- Climate control (of temperature, humidity, pests, light, climate pressures)
- Crops can be grown year-round; water-saving – huge for productive arid regions!
- Much less water loss than outdoor/soil production systems
- Can be done on a large-scale; as human populations continue to grow; best food production practices are going to become critical
- Nutrient maximization/nutrient cycling/how this works: unlike soil systems, there is very little (if any) nutrient loss
- No weeds – no need for chemicals (providing cost and environmental benefits!)
- Can be cost-effective (low-term cost inputs, better return on investments)
- There may be less labor and mechanical inputs (depending on the scale) than intensive industrial agriculture

Disadvantages/Cons

Summarized from: Max. (2019, May 13). *20 advantages & disadvantages of hydroponics that you should know*. Retrieved from https://www.greenandvibrant.com/advantages-disadvantages-of-hydroponics

- Some technical knowledge is needed
- Long return for investment/initial costs
- May not be as nutritious as soil produced food depending on inputs
- Less diversification of crops (in order to provide the same required nutrients and management etc.)
- Although pest and disease may be better managed, they may spread more quickly in a confined area and with one or two primary crops being grown.

Hydroponics is Learn-by-Doing

- Hydroponics incorporates every STEM field - Science, Technology, Engineering, and Math - in a fun, real world food-growing project that all students can learn from and relate to.
- The students do the work.
- Students can create a daily task sheet and print and laminate it for the classroom, which includes measuring, writing reports, and vocabulary to learn (this is crucial to understanding and communicating the parts and system of hydroponics).
- The students are creating a potentially profitable product – business and marketing aspects can be discussed and shared with others! Also think about, community gardens, growing food for those in need (the homeless and elderly), communication with likeminded individuals, or groups, networking, collaboration, individual and community growth toward resource-maximization, learning, innovating etc.
- Students can brainstorm recycled or used materials options, i.e., two-liter bottles as grow towers (this is also a lesson on waste management/recycling/re-purposing).
- Independent student research projects can be facilitated: designing various systems and taking what they've learned into the community; building online forums (Twitter, Facebook, websites, online handouts etc. STEM TECHNOLOGY STANDARD).

- Keep student groups to a minimum (break into groups of 3-4 individuals per group) so it is hands-on for everyone.

Importance to Arid Regions, Water Conservation, & Climate Resiliency

- Space-saving: how does this relate to growing human populations?
- Much less water used: research how much water conventional agriculture uses
- Much less overall chemical (fertilizer, herbicide, insecticide) and labor inputs than conventional agriculture practices because there are far less problems to manage
- Local food production mitigates (lessens the severity of) climate change impacts by eliminating the need to process and transport food long distances using factories and vehicles that combust fossil fuels
- New Mexico is an arid, productive region and must conserve water today and into the future as climate change impacts may make our water resources more scarce and less reliable
- The connection between us and plants: caring for plants = caring for ourselves and others = caring for the planet:
- How are we connected to plants?
- Do we rely on plants for food?
- Do we rely on plants for oxygen?
- Do we rely on plants for our clothing and building materials for our homes, schools, and stores?
- How is caring for plants caring for ourselves?

VIDEO: Ag water conservation: https://www.oecd.org/agriculture/topics/water-and-agriculture/

Full Cycle – Collect the Seeds for the Next Season VIDEO
https://www.youtube.com/watch?v=KPLQFkiMips

CLASS ACTIVITY: build a journal with recycled paper (collect at least 20 pieces of paper that has only been used on one side, stack the paper, fold it in half length wise then staple it to create your journal)

CREATE YOUR OWN HYDROPONICS MAINTENANCE CHART (LABEL THE BELOW CHART WITH HEADINGS AND DATES)

Students can create a large, laminated class chart and separate group charts (with fun group vegetable related names) to monitor:

- Weekly and overall photos and journaling of plant heights and diameters
- Hydroponics water height and pH reading
- Visual and photo-journaling assessment of overall plant health
- Seedling germination maintenance (**Seedling Germination & Fertilizer lesson**)

- For ESL/special needs: one student can dictate while the other student writes/journals with drawings.
- **Once per month**: change out the water system and add new fertilizer (lesson here on why we do this – (**Seedling Germination & Fertilizer lesson**)

HOMEWORK: Collect from home: <u>Recycled plastic yogurt containers</u> can work as an alternative to purchasing the hydroponic cups: measure and create holes (with a 1–2-centimeter radius per hole) at the bottom of the yogurt containers, so the plant roots can grow and reach the hydroponic system water. You can also purchase 3” plastic net pots for ready use.

<u>JOURNAL</u>

Draw and/or explain to your partner/group a hydroponics system and a soil system (comparing the two plant growing methods), with lighting, plants, plant parts, nutrient source, and how the water moves throughout the system.

General Answer Response, Hydroponics vs. Conventional In-Ground plants.

Images provided by: Jeff Anderson

What are (3) advantages and (1) disadvantage of a hydroponics system?

General answer response:

Advantages: Climate control (of temperature, humidity, pests, light, climate pressures), crops can be grown year-round; water-saving – huge for productive arid regions!, much less water loss than outdoor production systems – the water is recycled, can be done on a large-scale; as human populations continue to grow, best food production practices are going to become critical, nutrient maximization/nutrient cycling/how works: unlike soil systems, there is very little (if any) nutrient loss, no weeds – no need for chemicals (providing cost and environmental benefits), can be cost-effective (low initial and low-term cost inputs), unlike intensive industrial agriculture, there may be less labor and labor inputs with hydroponic production (depending on the scale).

Disadvantages: Some technical knowledge is needed, long return for investment, may not be as nutritious as soil produced food, less diversification of crops (in order to provide the same required nutrients and management etc.), and although pest and disease may be better managed, they may spread more quickly in a confined area and with one or two primary crops being grown.

LESSON ONE SUPPLIES CHECLKIST: Introduction - Why Hydroponics?

Class Activity #1 - Build A Journal Out of Recycled Paper

Supplies:

- 20 + pieces of paper that have only been printed on one side/student.
- Heavy Duty stapler
- Heavy Duty staples
- Markers/colored pencils for decorating journal (optional)

Class Activity #2 - Create A Hydroponics Maintenance Chart

Supplies:

- Poster Board
- Rulers/Yardstick
- Pencils
- Sharpie/or writing device.

Homework for LESSON TWO –

#1 - Bring one clean, dozen-size egg carton per student.

#2 - Start to collect for students, (2) - 1 quart plastic milk cartons for fertilizer experiment.

Lesson 2

SEEDLING GERMINATION & FERTILIZER*

Vocabulary

-Germination

-Fertilizer & growing media

-Organic vs. Inorganic

-Plant macro, secondary, and micro nutrients

-Plant deficiencies & Mulder's Chart

-Fertilizer conversions

Lesson 2 SEEDLING GERMINATION & FERTILIZER*

with multiple activities, this lesson could potentially be split into two lessons.

SCIENCE, TECHNOLOGY, MATH AND ENGLISH STANDARDS

OBJECTIVES

- To be able to understand and define various terms, including germination, fertilizer, plant media, and macro, secondary and micronutrients
- To prepare and plant seeds for germination
- To understand soil textures and relevance with plant production
- To understand and **define fertilizers as salts** and list (1) plant sensitive to salts and (1) salt tolerant plant
- To generally define a plant deficiency
- To understand and practice fertilizer ratios and measurements
- **Next Generation Standards: MS-ESS3-5; MS-LS2-1; MS-LS2-3; MS-LS2-4 and common core math standards**

What is germination? Germination is the process by which an organism grows/sprouts from a seed.

VIDEO*: How to germinate your seeds in egg cartons – LIFE LESSON STANDARD: https://www.youtube.com/watch?v=SJB7Lg9wae8

***IMPORTANT**: make sure to follow the seed depth directions on the back of the seed packets to know how far down in the soil media you need to plant your seeds.

Monitoring and troubleshooting: water moisture should be monitored almost every day (its ok if you skip a day or so over the weekends, etc.). Don't over, or under water your egg carton seedlings; the rule of thumb is the soil media should be about as moist as a "wrung-out sponge". Also, use a low-pressure watering can, or spray mister, to water the seedlings as you don't want to disturb the soil media and growing seedlings.

Supplies needed:

- Depending on how many seedlings you are wanting to germinate, you may only need to purchase a 2-lb bag of seed starter potting soil
- Seeds can be purchased or brought from home harvested vegetable seeds, etc.
- Egg cartons
- Watering can (with low-pressure distribution spout, or misting spray bottle)

ACTIVITY 1: "Seed to Harvest"

ONGOING JOURNALING: assessment and data collection (over time)

MATHEMATICS: measure and record each plant height and diameter and create an excel chart on various plant growth rates

HOMEWORK 1: Collect egg cartons from home to germinate the seeds in.

HOMEWORK 2: Grow a seedling at your home; radishes and lettuce grow well!

FERTILIZATION

- Plant nutrition
- Nutrient cycling
- Hydroponics media

SCIENCE STANDARDS

Just like you and I, plants require nutrients to grow and thrive. We require many of the same nutrient's plants require – in fact, this is where we get our nutrients from! Nutrients are made available to plants in either **organic forms (living or once living material e.g., compost) or inorganic forms (non-living material e.g., minerals).** However, plants can only utilize the inorganic forms of nutrients. Synthetic fertilizers are an inorganic form of nutrients. Organic material is converted to plant available forms by microorganisms – this process is called **mineralization. Organic fertilizers are derived from once-alive organisms, including plants.** All ecosystems naturally cycle and recycle nutrients via the soil; plants take up nutrients throughout their life span (via leaves, twigs, bird droppings etc. dropping to the soil floor and when they die, nutrients are returned to the soil). Hydroponic systems require organically or synthetically derived **liquid fertilizer** inputs.

Fertilizers are salts. Many salts (such as nitrates and potassium) are essential plant nutrients. Salts are a common and necessary part of the soil. Salts come from mineral weathering, inorganic fertilizers, soil amendments, and water. However, too many salts can inhibit growth for some plants, while too little salts can inhibit growth for other plants.

Some plants are more sensitive to salts (they generally won't grow well in higher salt media), including: beans, onion, radish, and lettuce.

Some plants are less sensitive to salts (they will generally grow well in higher salt media), including: beets, asparagus, squash, and spinach.

Summarized from: Kotuby-Amacher J., Koenig R., & Boyd Kitchen (2000, March). *Salinity and plant tolerance.* Retrieved from: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1042&context=extension_histall

Commonly used growing media (a non-reactive material to grow plants in) for hydroponic systems includes: coconut fiber, expanded clay, perlite, rockwool, potting soil, peat moss and sand

Your hydroponic system will employ expanded clay. What is a special property of clay? Clay is the tiniest of soil texture classes and, compared to silt and sand, it can hold the most water.

EXPERIMENT/MATH/SCIENCE/SUSTAINABILITY STANDARDS: following this video, with a recycled bottle, build a funnel system and see which media holds more water. https://www.youtube.com/watch?v=Vpi2-NTgbc8

Rockwool

Clay Beads

Peat Moss

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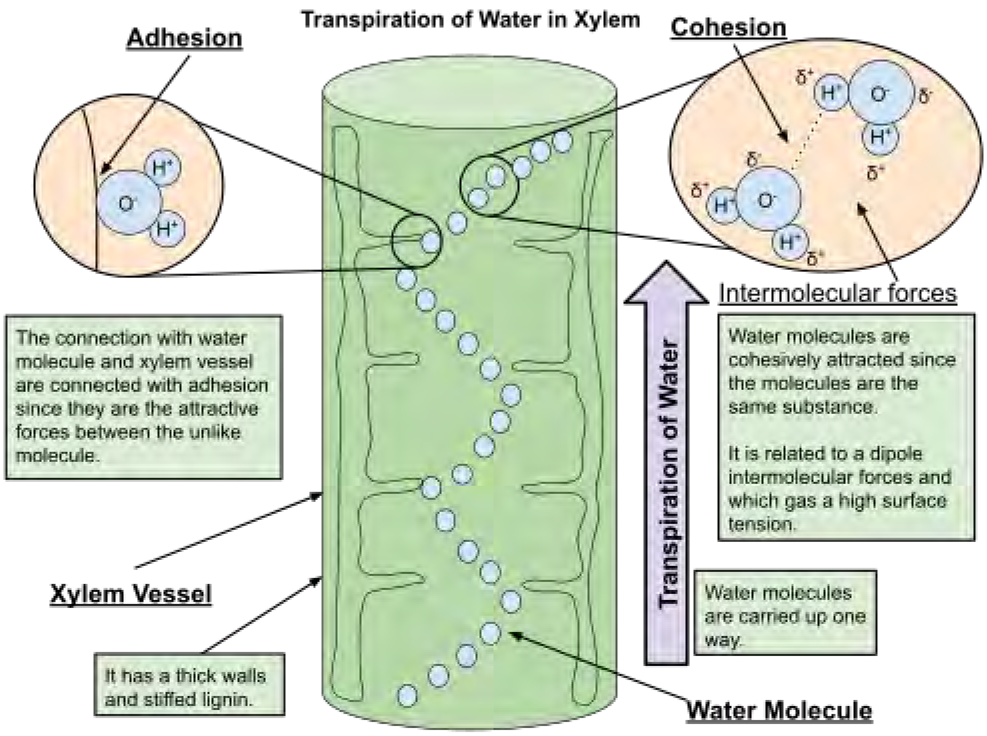
Soil Texture Triangle

Plant macronutrients are considered primary plant nutrients and are used in the largest amounts by plants, they are: Nitrogen (N), Phosphorous (P), and Potassium (K).

Nitrogen (N) is critical for plant chlorophyll production and photosynthesis processes. Nitrogen is also vital for plant amino acid production, the building blocks of proteins.

Phosphorus (P) facilitates photosynthesis, respiration, energy storage and transfer and many other processes in the plant. Phosphorus is also vital to the formation of the seed. Phosphorus is needed throughout the life span of the plant, with much of the phosphorus need taking place during accelerated plant growth and the production of fruit.

Potassium (K) regulates the opening and closing of the stomata (a very small opening in plant leaves and stems where various gas exchange takes places). Potassium is essential for production of Adenosine Triphosphate (ATP), a form of plant energy source that facilitates chemical processes.



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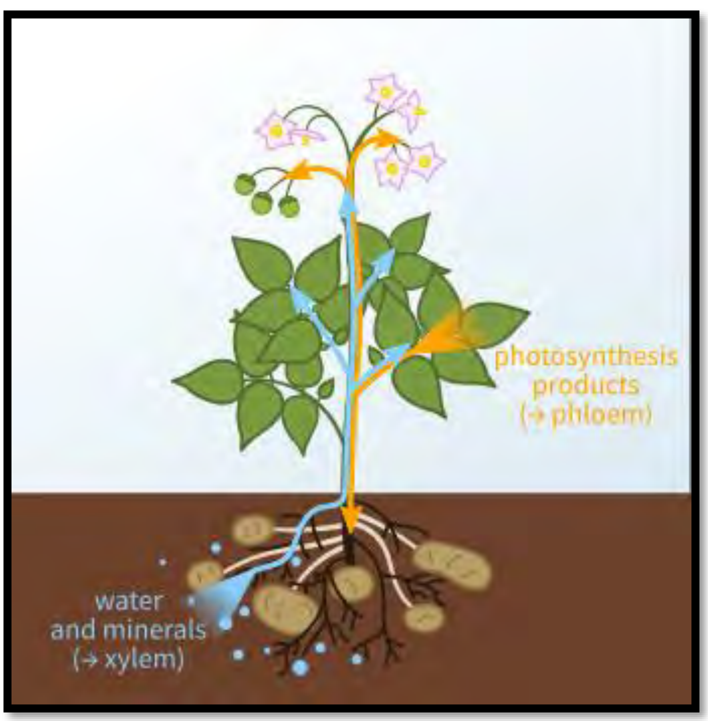

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Plant secondary & micronutrients

Secondary nutrients are required in moderate amounts by plants. The plant secondary nutrients are Calcium (Ca), Magnesium (Mg), and Sulfur (S). Secondary nutrients are as vital as primary nutrients for plant growth, but they are needed in lesser quantities. However, every plant is different, and it should be noted that all plants require slightly different amounts of nutrients to grow and thrive.

Ca helps to neutralize organic acids that form during plant metabolism, in addition to assisting in cell division, cell wall formation and growth-regulating enzymes.

Mg is essential for enzymes that support plant growth and chlorophyll.

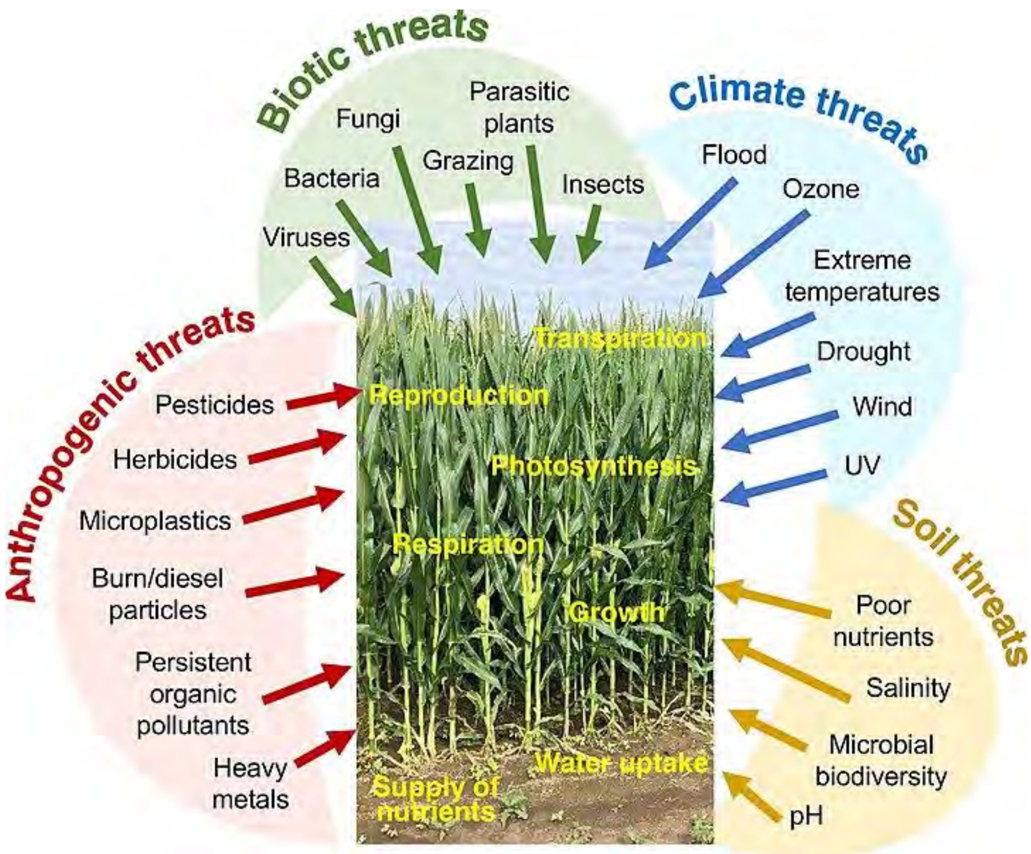
S is an essential component of chlorophyll. Sulfur also facilitates amino acid production and directly influences **leguminous (nitrogen fixing plants, such as beans and peas)** plants and seed production. Sulfur can be attributed to the pungent odor in garlic and onions!

Micronutrients are required in trace/"micro" amounts for plant growth, but are still vital for plant production. Plant micronutrients are: Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Zinc (Zn), Nickel (Ni) and Chloride (Cl).

- Boron (B) directly influences plant cell membrane structure and function.
- Copper (Cu) activates enzymes and reactions in many plant growth processes.
- Iron (Fe) is essential for plant energy transfer, nitrogen processes, and cell formation.
- Manganese (Mn) plays a direct role in photosynthesis and plant enzyme reactions.
- Molybdenum (Mo) is required for nitrogen processes.
- Zinc (Zn) affects plant yield, activates enzymes, used in the conversion of starches to sugars, and in plant cold tolerance.
- Nickel (Ni) is associated with plant Nitrogen metabolism.
- Chloride (Cl) influences energy reactions in plants.

Plant deficiency symptoms

The image below highlights common **plant deficiencies and threats.**



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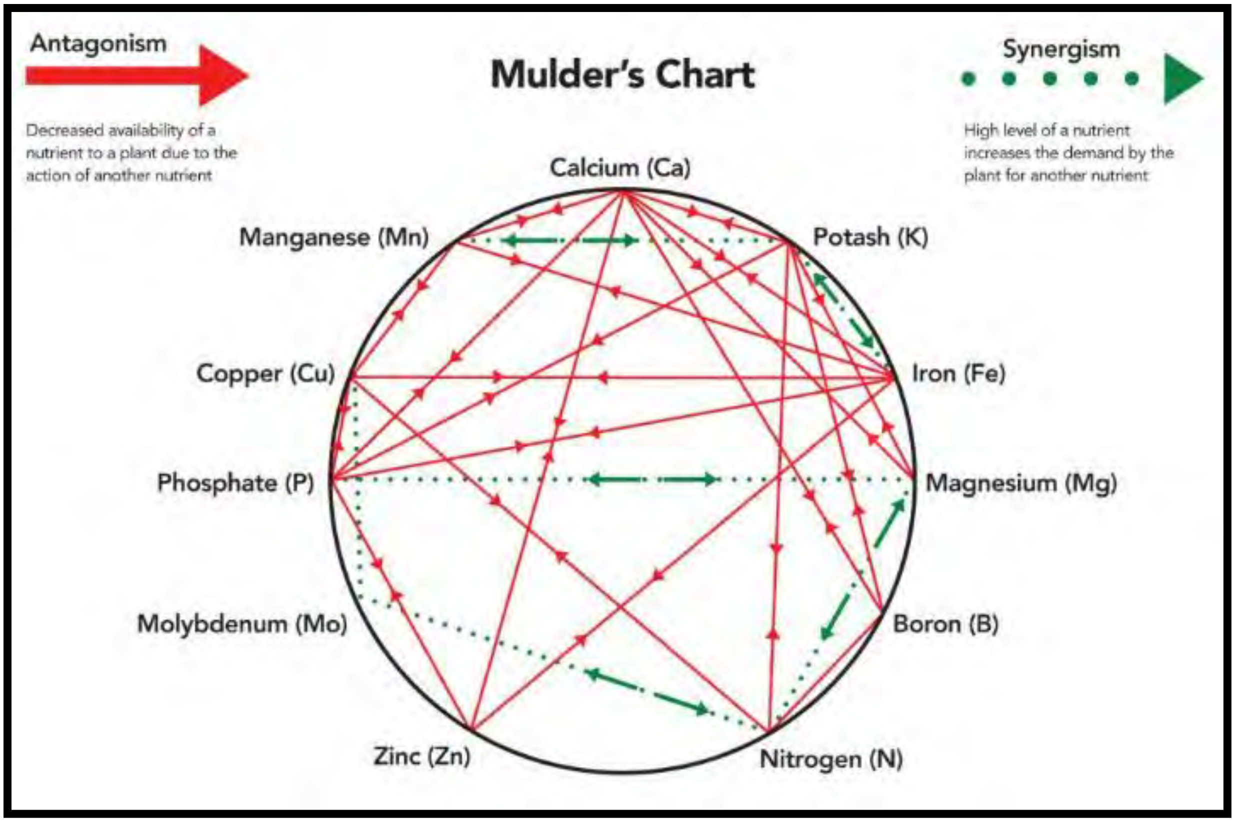

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MATH & ENGINEERING/TECHNOLOGY STANDARDS

Synthetic fertilizers are human produced forms of nutrients, through complex chemical reactions, technology, and engineering. On bags of synthetic fertilizer, N-P-K is listed as a percent of total amount of each element (I.e., 10-8-6 is 10% N, 8% P_2O_5, and 6% K_2O).

Optimal ppm for liquid fertilizers is 50-250 ppm, depending on the stage of the plant and plant varieties as some plants are more sensitive to fertilizer salts.

Summarized from: Mattson, N. (2018). *Edible alert*. Retrieved from: http://www.e-gro.org/pdf/E305.pdf

ACTIVITY 1: Supplies needed: (2) bags of synthetic fertilizers with different NPK ratios, a measuring cup, a measuring spoon, a scientific scale (that can measure in grams) and gloves for each student.

GROUP ACTIVITY: With gloves on, feel and look at the different fertilizers. What do you notice about their shapes, colors and sizes? Why do you think the two different kinds of fertilizers don't look exactly the same? Note this in your journal. Now, read the directions on the back of the fertilizer bag and practice properly measuring the ratio amounts of fertilizer needed per container size. Use the measuring soon to measure out 1 gram. Use the measuring spoon to measure out the amount of fertilizer needed for various plant container sizes.

ACTIVITY 2:

General conversions:

Conversions 1 gallon = 3.785 Liters

1 ounce = 28.35 grams

1 gram = 0.03527 ounces

1 pound = 454 grams

1 kilogram = 1,000 grams

1 gram = 1,000 milligrams

1 ppm (part per million) = mg/kg (**TIP TO REMEMBER**: how many milligrams are there in a kilogram? This equals parts per million) (1 Kilogram = 1,000,000 Milligrams)

1 ppm = 1 mg/L

NOTE: A fertilizer contains only some fraction of an element.

Example: In this case, calcium nitrate contains 15.5% nitrogen. To calculate how many mgs are needed per 1 L of water, divide the target value by the percent of the element. Using commercial calcium nitrate (15.5-0-0), to supply 100 ppm N.

ANSWER: 100 mg/L (ppm) N / %N 100 mg/L N / 0.155 [this is the percent N in calcium nitrate] = 645 mg of calcium nitrate in 1 L of water

Great job! However, in our case, the fertilizer also contains calcium, so let's calculate the ppm (or mg/L) of calcium supplied by using 645 mg of calcium nitrate in 1 L of water. This is calculated by multiplying the total mg/L of fertilizer used by the percent calcium (19% Ca): 645 mg/L calcium nitrate x 0.19 (% Ca) = 122.6 mg/L (ppm) Ca.

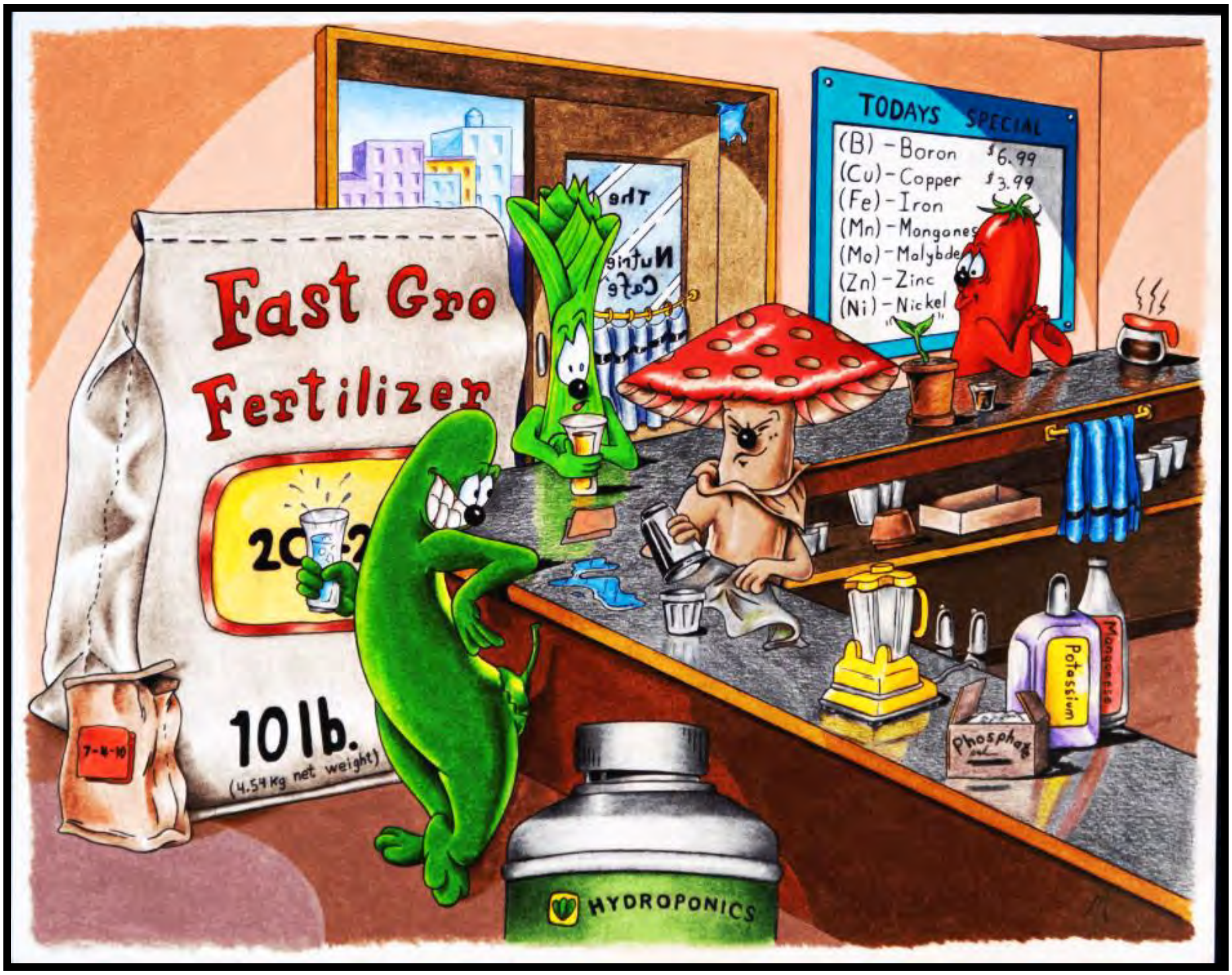
ANSWER: Therefore using 645 mg of calcium nitrate in 1 L of water, provides 100 ppm N and 122.6 ppm Ca.

Let's try one more example. How many mg of magnesium sulfate (9.7% Mg, 13% S) do you need to provide 40 ppm Mg? And how many ppm S does this supply?

ANSWER: 40 mg/L Mg / 0.097 = 412 mg of magnesium sulfate in 1 L of water.

ANSWER: 412 mg/L magnesium sulfate x 0.13 = 53.56 mg/L S (ppm S)

JOURNAL



"What's Kind of Mineral Water are You Serving Today?"

What does the (16-8-8) mean on the fertilizer bag image below? Compare and contrast the bagged (dry fertilizer) with our liquid fertilizer being used in the hydroponics system.

Images provided by: Jeff Anderson

Answer response: 1. The dry fertilizer provides: 11% Nitrogen, 6% Phosphorus as P_2O_5, 5% Potassium as K_2O. 2. The FloraNova Grow liquid fertilizer provides: 7% Nitrogen, 4% Phosphorus as P_2O_5, 10% Potassium as K_2O.

VIDEO OPTION (Organic fertilizer – make your own!): https://www.youtube.com/watch?v=0cUc_FKQq7M

- **Why do plants need nutrients?**
  General answer response: To grow and thrive

- **How do plants get nutrients?**
  General answer response: In inorganic forms (i.e. minerals or synthetic fertilizers) and nutrient mineralization of organic materials

- **What is the primary form of nutrient application for hydroponic systems?**
  General answer response: Synthetic fertilizers

- **What are macro, secondary and micronutrients?**
  General answer response: nutrients needed by plants in various quantities to sustain the health and life of the plant from seedling to life cycle completion.

- **What is one macronutrient, one secondary nutrient, and one micronutrient and what do each provide for a plant?**
  General answer response: see above.

LESSON TWO SUPPLIES CHECLKIST: Seedling Germination & Fertilization

Class Activity #1 - Planting seeds, and germination

Supplies:

- 1 empty dozen-sized egg carton/student to take home or raise in school – teachers' decision.
- 2# bag of *seed starter* potting soil
- Variety of vegetables, or herb packets, (dwarf sizes work best)
- Plastic spoons
- 9" X 13" foil cake pan/student to collect water under egg cartons
- Popsicle sticks cut in half for labeling.
- Sharpies to label plants
- Small spray bottles
- Scissors
- Toothpicks

Class Activity #2 - Fertilizer

Supplies:

- 2 small bags of water-soluble fertilizer *with different N-P-K ratios*
- 1 large box of disposable gloves (consider 2 sizes)
- Plastic spoons
- Digital kitchen scale - must be able to measure in grams.
- Disposable bathroom cups
- Two empty clean plastic 1 quart milk cartons
- Wet wipes to clean at the end of activity.
- Large zip-top bag for used equipment.

Homework for LESSON THREE –

#1 - Bring clean 5.3oz plastic yogurt containers X 12 (Optional)

Lesson 3

BUILDING A HYDROPONICS SYSTEM

Lesson 3 BUILDING A HYDROPONICS SYSTEM

OBJECTIVES

- To be able to differentiate the various parts of the hydroponics system and how to assemble each part of the system.
- To generally understand the cost, longevity factors, and potential funding sources of this hydroponics system
- To be able to use social media and video production to showcase the progression of this hands-on project.
- **Next Generation Standards: MS-LS2-1; MS-LS2-3; MS-LS2-4 and common core math standards**

Hydroponics assembly (SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS STANDARDS):

Hydroponics longevity and funding factors:

- Print supply and estimated cost spreadsheet and maintenance chart; during summer vacation who maintains it? Janitorial staff and/or engaged volunteer students.
- Funding: State Ag Departments; Communities; Farm & Livestock Bureaus; selling student-grown produce; Conservation Districts (i.e. the Water District); students can create educational posters as a funding marketing tool. Basil grows well and is a high return on investment crop.

SYSTEM SET-UP INSTRUCTIONS:

From left to right: Traci Curry (NM *Ag in the Classroom* Director, Southern Region) and Jeff Anderson (Doña Ana County Extension Agent)

Vocabulary

-Hydroponics aeration & water

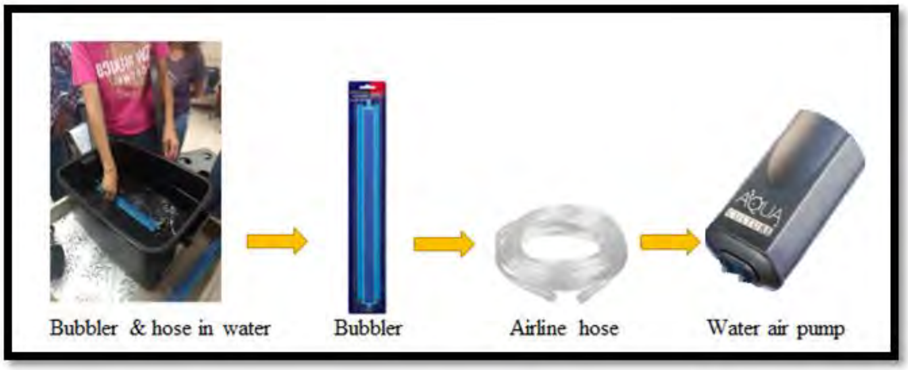
-Hydroponics fertilizer

-Bubbler stone, airline, air pump

- NPK synthetic fertilizer

-Grow pot & media

-Experimental design



Aeration and water:

- Same as in a soil system, plants require oxygen for gas exchange (see the AERATION lesson plan)
- Insert an airline hose into one end of the bubbler and one into the air pump port (and repeat for the second airline hose); plug the air pump into an outlet to test air flow - be careful the cord isn't in a walking path and keep electricity away from the water to prevent electrocution
- Fill the hydroponics container with water (with a measuring container -- the amount of water needs to be known) to approximately 2/3 full or enough for your shortest plant root to reach
- Place the bubbler and airline hose in the hydroponics container containing measured water, then plug the air pump in to activate the aeration system

Fertilizer:

- Per the instructions and the amount of water used, pour the required amount of liquid fertilizer in the hydroponics container and mix

Container and grow net pot placement:

- Cut holes in the lid of your hydroponics container to just fit the brim (the widest part) of your grow net pots, (use a 3" hole borer to drill holes in lid for 3" net pots)
- Use a sharpie pen to make an outline for each of the grow net holes on the container lid; space each of the holes approximately 3 inches apart
- Put the lid on top of the hydroponics container and place each 3" grow net pot in a hole

Growing media and plant placement:

- A container and growing media is needed for plants to grow hydroponically (see the SEEDLING GERMINATION & FERTILIZER lesson)
- Pre-germinate seeds in rockwool grow cubes using a medium-large clear plastic recycled container and water. Do not over sow grow cubes with too many seeds. Thin plants to

one per cube once germination is complete. Seeds need plenty of light as soon as they germinate, observe what happens if insufficient light occurs (i.e., spindly, week plants that lodge easily)

- Place one plant in one grow net pot (be sure the roots appear through the bottom of the rockwool cubes first), and surround the plants with hydrotone pellets, to fill the voids in the net pot. Keep net pots, plants and rockwool cubes moist until roots begin growing into the water/nutrient aerated solution in the tote container
- Be sure to check that each of the roots can touch the nutrient rich water, or are spritzed by the nutrient solution as they grow into it <u>(if not, if you will need to add more water and fertilizer)</u>

<u>SUPPLIES</u>:

An ~19-gallon plastic container (with locking lid)

Images provided by: Jeff Anderson

3.0" grow net pots (approximately 6-8) and/or recycled yogurt containers (punch holes in the bottom of the yogurt containers)

Image provided by: Jeff Anderson

Grodan MINI-BLOCKS, plant starter cubes and Hydrotone Expanded Clay Pebbles.

Photos by Jeff Anderson/**Grow media**

(2 Pack) Aqua Culture Aquarium Bubble Stone, 14-Inch, Airline hose, Photos by Jeff Anderson

Photos provided by: Jeff Anderson

Aquarium air pump

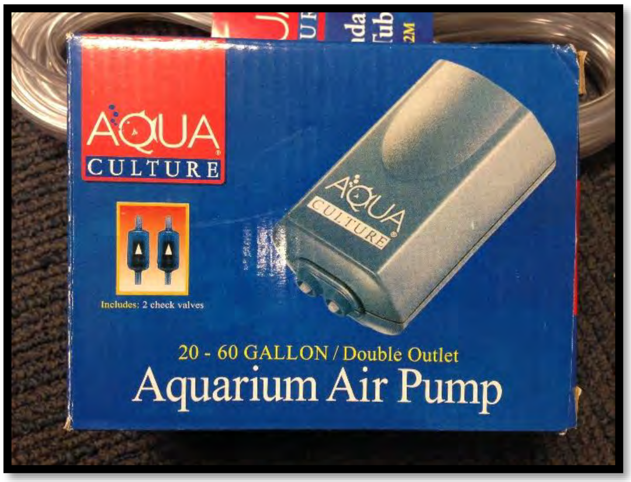


Image provided by: Jeff Anderson

An N-P-K nutrient solution of 7-4-10

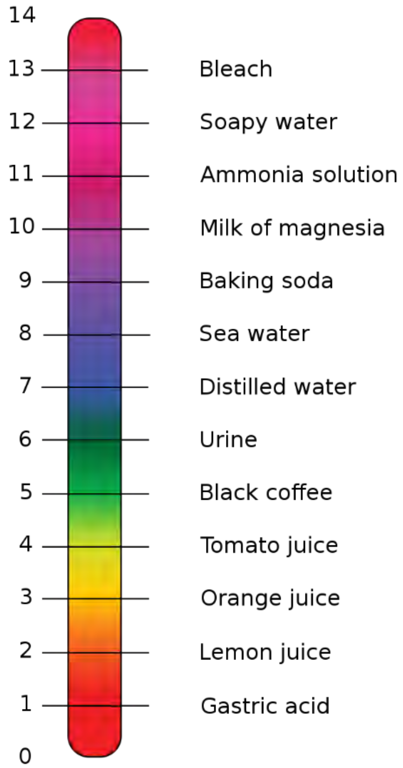
Image provided by: Jeff Anderson

Electrical timer, photo: Jeff Anderson

General Hydroponics pH Test Kit

Image Provided By: 12 rana mehul 0012, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)

Image Provided by: Bordercolliez, This file is made available under the Creative Commons CC0 1.0 Universal Public Domain Dedication.



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Photos provided by: Jeff Anderson

“Aren’t You Supposed to Assemble According to the Instructions Provided”

How to Build the Hydroponics Frame for the Light Unit

Container and PVC lighting frame & necessary tools/parts

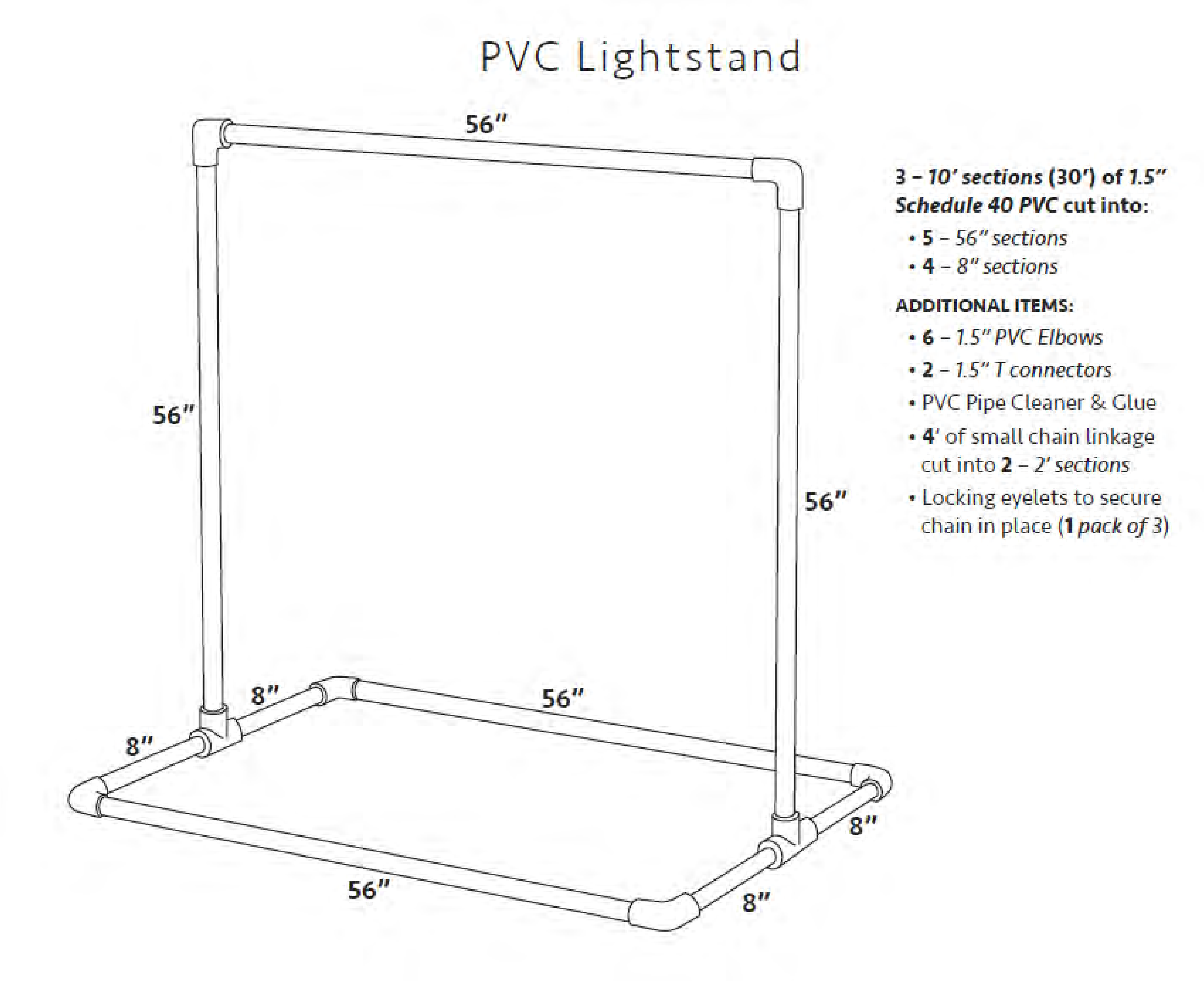
- Drill for power tool attachments,
- Approximately 19-gallon black tote with locking lid
- 3” Drill Borer Bit and shank to drill holes in hydroponics container lid for net pots
- Hacksaw to cut PVC pipe
- Drill bit, (¼”) to drill holes above handle sides for poly air lines to enter hydro unit
- Scissors to cut poly air lines
- File, or sandpaper to smooth cut edges of PVC 1.5” pipe

- Phillips, and/or flathead screwdriver
- Basic pliers
- Sharpie
- Measuring cups, and/or measuring spoons for fertilizer mixing
- PVC 1.5” (pipe, joints, and PVC glue)
- Cutting pliers to cut chain to correct lengths

S.T.E.M. Challenge:

Design and Create a Lighting Stand with the Following Parts List.

- 3-10’ Sections of 1.5” Schedule 40 PVC Pipe
- 6 - 1.5” PVC Elbows
- 2 – 1.5” T connectors
- PVC Pipe Cleaner and glue



Drawing Provided By: Evan Evans, Innovative Media Research and Extension, NMSU

Example lesson plan for scientific research:

The below is adapted from: (2019, July 22). *Lesson 9: What do plants need?* Partnership for Reform through Investigative Science and Mathematics. Retrieved from:

https://hilo.hawaii.edu/affiliates/prism/documents/Lesson9Whatdoplantsneed.pdf

https://www.kohalacenter.org/docs/resources/hpsi/HawaiiHeritageSeedProject_Lessons1-2.pdf

GUIDE STUDENTS THROUGH THE BRAINSTORMING PAGE:

a. SCIENTIFIC QUESTION: What are you investigating?

1. Instruct students to write out their scientific question. It will be some version of "Can plants grow without sunlight?"

2. Then ask them to make it much more specific, guiding them to a hydroponically designed experiment: "Can lettuce plants live with artificial light?" or "Will varying forms of artificial lighting produce varying sizes of lettuce plants?"

3. Note that these questions lead to two different experiments. The first is much simpler and is basically "observational" with the standard hydroponics lighting. The second requires two or more treatments - an experimental and a control - and is therefore considered a true "experiment".

4. Tell students to write their scientific questions on their design worksheet after it is approved.

b. EXPERIMENTAL DESIGN: What will your group do to find the answer to their question?

1. Have students write down ideas and drawings in their journals.

2. If you have computers, allow students to search the Internet for ideas, by simply entering their topic (i.e., "growing plants with various forms of light." Sometimes adding the word "classroom" or "lesson" will pull up classroom experiments).

3. Encourage simplicity but challenge the student groups to include details. What forms of alternative lighting will be used; how many lettuce plants will be utilized? How much will this all cost? For how long will the experiment be conducted?

4. Does everyone agree with the experimental design and experimental questions?

5. How often will experimental measurements be taken? What is the metric of measurement (i.e., plant height and diameter over time, etc.)?

6. Have one student write the plan on the maintenance sheet, as all group members reach consensus on the research project.

c. PREDICTIONS: What do you think will happen?

1. Have the students tell each other what they think will happen.

2. Discuss whether their predictions are based on past observations, realistic and relevant. ("I think lettuce plants grown in the dark will glow in the dark" is probably not realistic or sincere).

3. Have one student write the predictions on the maintenance worksheet.

d. DATA: How will you record what happened?

1. Measurements require a data sheet, including a calendar of anticipated date measurements.

2. Otherwise, the "what happened", with images, space on the maintenance/design sheet should suffice for general observations relating to plant growth and lighting.

3. See the graphing tutorial on Excel for examples.

e. MATERIALS: What do you need?

1. Students need to make a list of all the materials they think they will need. Remind them to think about the other plant projects and investigations they have conducted, to help think of the required materials.

2. Review their list and help make it complete. You will need these lists to gather the materials.

f. PRESENT PROPOSALS

1. Allow each student group to stand before the class and present their research proposal.

2. Explain that the whole class is going to help make this project a success by offering constructive comments and ideas.

3. Solicit suggestions from the other students, reminding them that the idea is not to criticize or reject the other group's ideas, but to add to its helpfulness and design success.

JOURNAL

Life lessons: video your progress and learning lessons & post them on YouTube, Twitter, Facebook etc.

What materials are needed for a simple hydroponics system and why are these materials needed?

General answer response: wood for the frame and materials to cut the wood to the proper dimensions; a container with a lid to hold the plants and cups; cups to hold the plant, media and nutrient solution.

LESSON THREE SUPPLIES CHECKLIST: Building A Hydroponic System

Class Activity - Build a hydroponic unit and lighting frame stand.

Supplies:

- Battery-operated drill with extra battery
- 3” hole boring bit to drill holes in tote box cover to hold 6 net pots/unit, (12 total).
- Safety goggles and gloves
- Face masks for any dust/particulates
- 19-gallon black tote with locking lid
- Sandpaper
- Plastic spoons
- Scissors
- Sharpie
- Regular and/or cutting pliers.
- Tarp for floor
- 2 (2 air-valve) aquarium pump/bubblers.
- Air hose (10’ – 15’)
- 4 bubble stones (9” – 12” long)
- Clean plastic 5.3oz yogurt containers (X12) or use pre-made 3” net pots.
- Electric timer for lighting
- 4 plug power strip
- Hydroponic pH test kits
- Water hose or water pitcher to fill hydroponic units.
- Measuring cup and measuring spoons.
- Fertilizer

LESSON THREE SUPPLIES CHECKLIST: Light Frame Stand, Parts Required

Supplies:

- 3-10' Sections of 1.5" Schedule 40 PVC Pipe
- 6 - 1.5" PVC Elbows
- 2 – 1.5" T connectors
- PVC Pipe Cleaner and glue
- Hacksaw
- 4' of small chain to suspend lighting unit.

**See curriculum for building instructions*

Lesson 4

LIGHTING

'HYDROPONICS AND LIGHT'

Vocabulary

-Lighting

-Plant light requirements

-Photosynthesis

-Light spectrum

-Artificial lighting

- Protons

-Incandescence, LED's, CFL's, florescence

Lesson 4 LIGHTING

HYDROPONICS AND LIGHT

OBJECTIVES:

- To learn about photosynthesis
- To understand and define why plants need light
- To understand the light spectrum
- To understand how hydroponics lighting mimics the suns light
- **Next Generation Standards: MS-ESS3-1; MS-ESS3-2 and common core math standards**

A T-4 LED grow lighting system is sufficient, or newer LED ready to go lights work just as well. Choose an LED fixture that matches the length of your tote(s). Newer lighting systems come in 2' and 4' lengths with white, blue, and red LED lights that you can control to match grow/flower cycles.

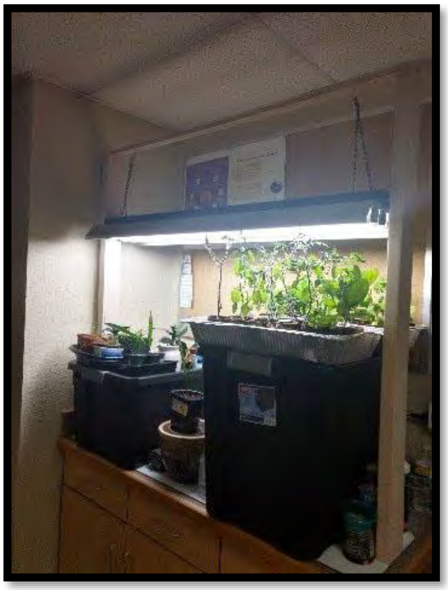
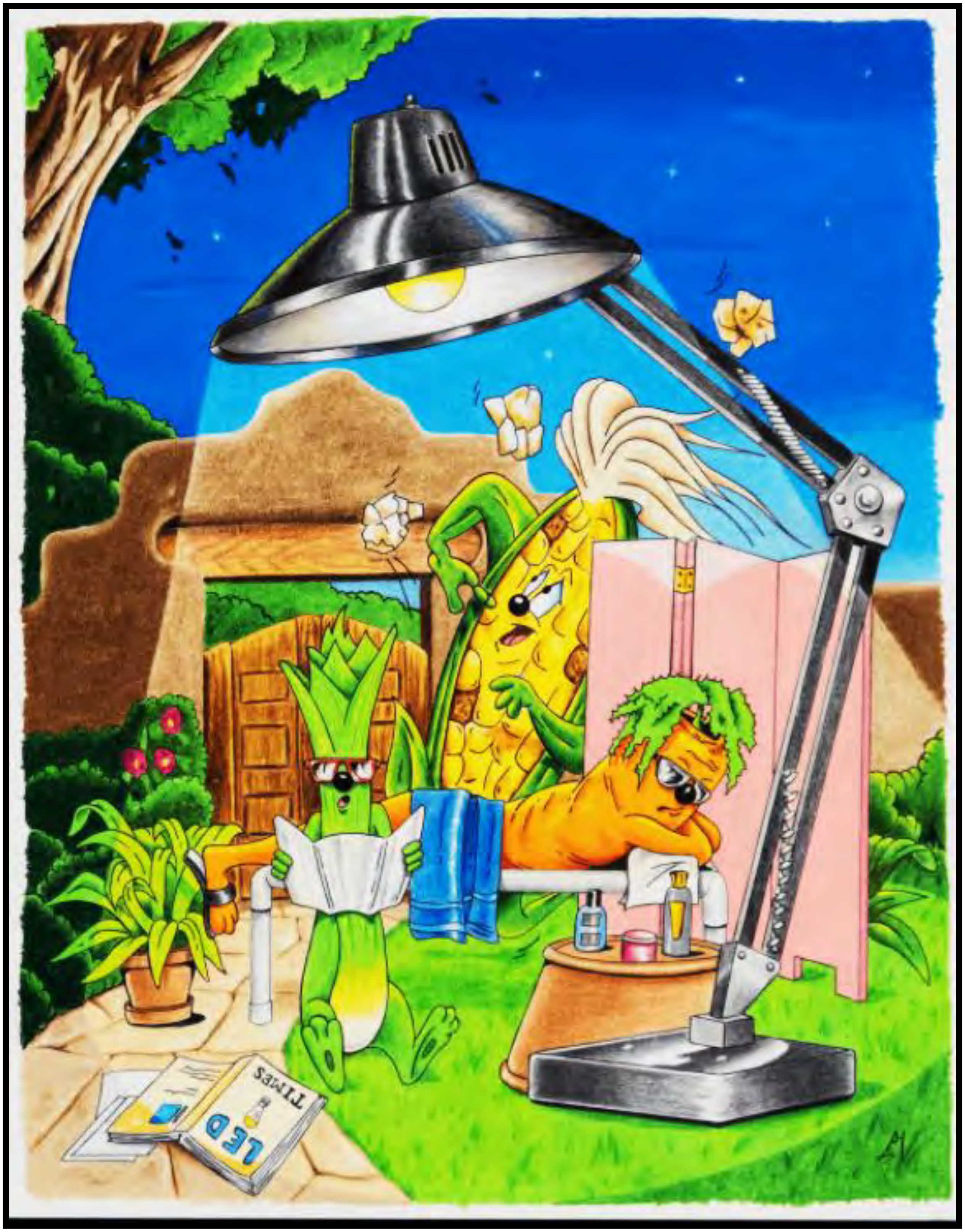


Image provided by: Jeff Anderson

LIGHTING: LESSON PLAN

For some herbs, a sunny window may be enough lighting; any other plant varieties may require supplemental lighting. Outdoors, a vegetable garden needs (at minimum) 4-6 hours of direct sunlight, in addition to approximately 8 more hours of indirect light. For a hydroponics system, around 14-15 hours of artificial light is required, followed by 8-10 hours of darkness. **Plants require darkness, just like us, in order to metabolize (process/utilize new cells, store energy and eliminate waste by products) and rejuvenate.**

https://conference.ifas.ufl.edu/aitc/presentations/Session%202/Hooked%20on%20Hydroponics%20in%20the%20Classroom/Chybion%20(all%20files%20combined)handout.pdf).

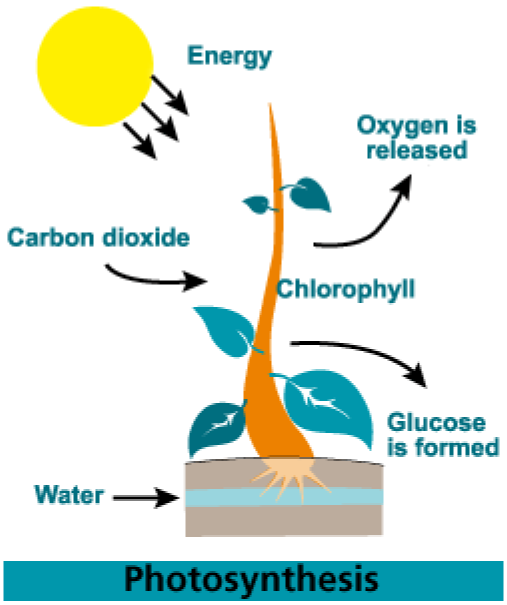


"The Right Spectrums of Light Brings Out My Best Colors"

SCIENCE STANDARDS

Why plants require light

Plants require light to conduct **photosynthesis** - a conversion of carbon dioxide to oxygen and plant components needed for plant growth and cellular respiration (see image below).



The following 10 points summarize photosynthesis (provided by https://www.ck12.org/book/CK-12-Biology-Concepts/section/2.23/):

INSTRUCTORS: FOCUS ON GRADE RELEVANT DEFINITIONS HERE

Photosynthesis, The Light Reactions, (<iframe width="551" height="317" src="https://www.youtube.com/embed/SnnmmKApT-c" title="The Light Reactions of Photosynthesis" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture; web-share" allowfullscreen></iframe>)

1) $6CO_2 + 6H_2O$ + Light Energy → $C_6H_{12}O_6 + 6O_2$

2) Autotrophs store chemical **energy** in **carbohydrate** food molecules they build themselves. Most autotrophs make their "food" through photosynthesis using the energy from the **sun**.

3) Photosynthesis occurs in the **chloroplast**, an organelle specific to plant **cells**.

4) The **light reactions** of photosynthesis occur in the thylakoid membranes of the **chloroplast.**

5) **Electron** carrier molecules are arranged in **electron transport** chains that produce ATP and NADPH, which temporarily store chemical energy.

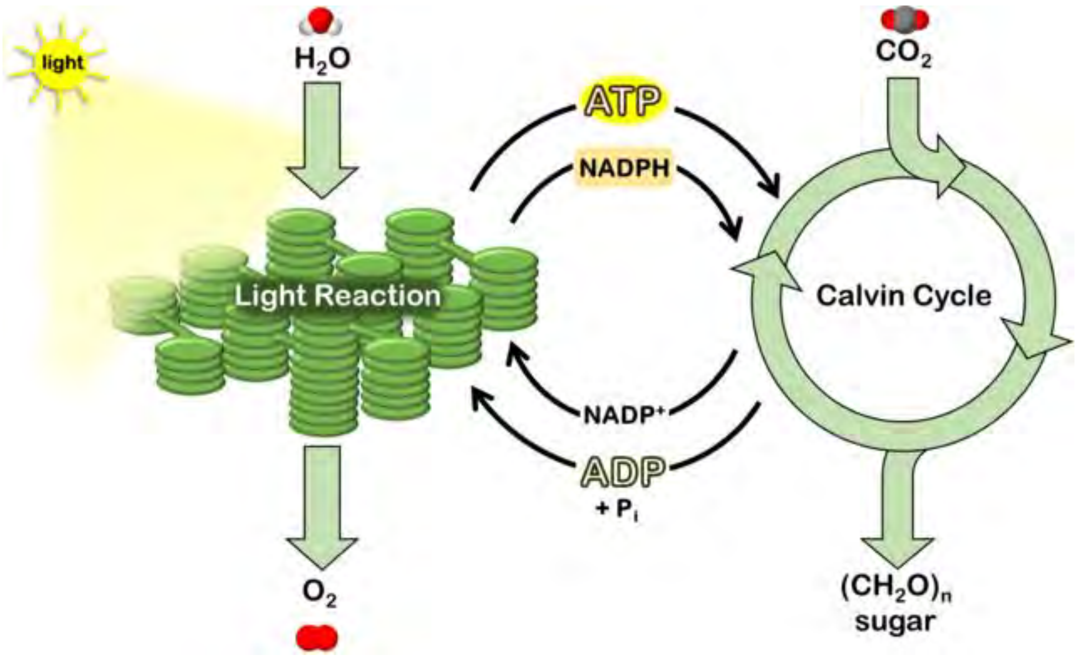
6) The **light reactions** capture energy from sunlight, which they change to chemical energy that is stored in molecules of NADPH and ATP.

7) The **light reactions** also release oxygen gas as a waste product.

8) The reactions of the **Calvin cycle** add carbon (from carbon dioxide in the atmosphere) to a simple five-carbon molecule called RuBP.

9) The **Calvin cycle** reactions use chemical energy from NADPH and ATP that were produced in the light reactions.

10) The final product of the **Calvin cycle** is glucose (sugar).

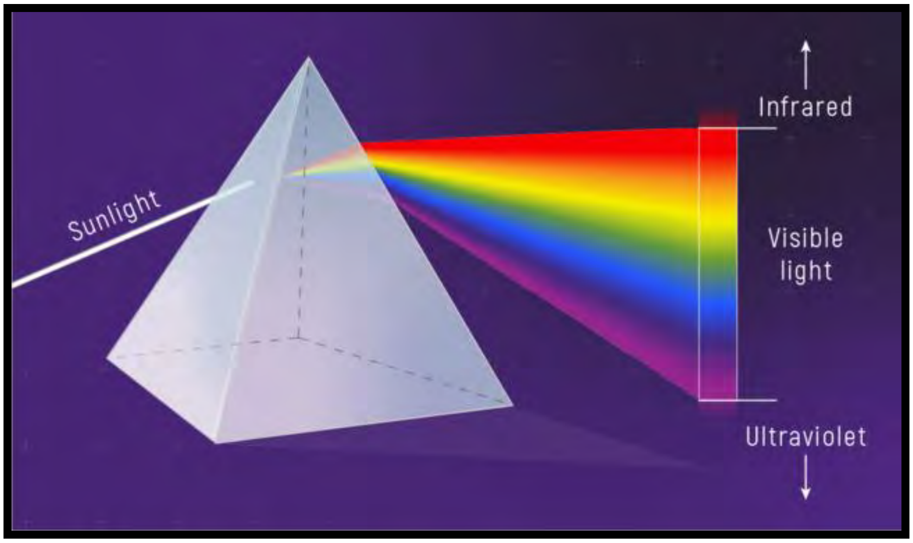


The Calvin Cycle image was provided by: ELaurent, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

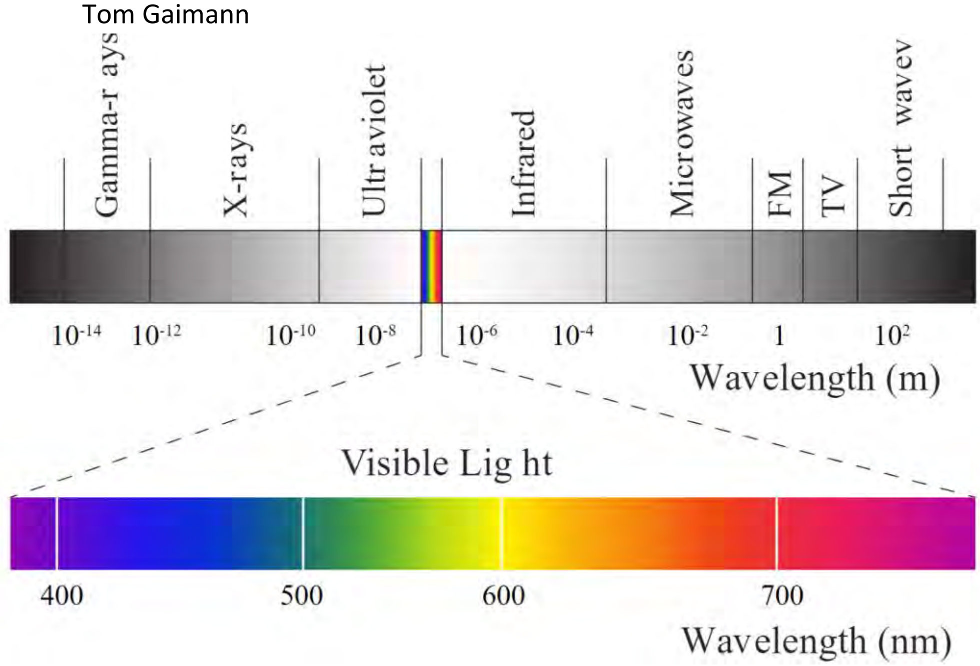
Light spectrum

Light acts like a wave. A light wave is defined by **wavelength and frequency**. The frequency is how quickly a wave moves up and down. A wavelength is the distance between two frequency peaks/points. Wavelength and frequency have an inverse relationship; a low frequency means a long wavelength and vice versa. Humans have created various ways to mimic the natural wavelengths of the sun, to wavelengths produced artificially, via lightbulbs. Note what colors you see below and what color we generally experience with lighting.

The images below highlight the various wavelengths of sunlight, LEDs, incandescent lighting, and CFL's.


Infrared
Sunlight
Visible light
Ultraviolet

Tom Gaimann


Gamma-r ays
X-rays
Ultr aviolet
Infrared
Microwaves
FM
TV
Short wavev
10^{-14} 10^{-12} 10^{-10} 10^{-8} 10^{-6} 10^{-4} 10^{-2} 1 10^{2}
Wavelength (m)
Visible Lig ht
400 500 600 700
Wavelength (nm)

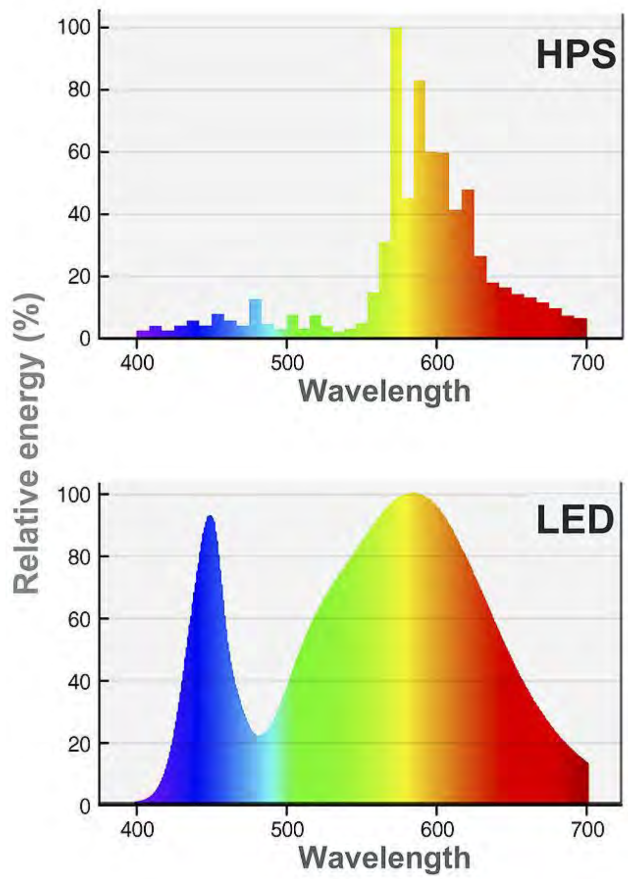


Image Provided by: Lamiot, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)

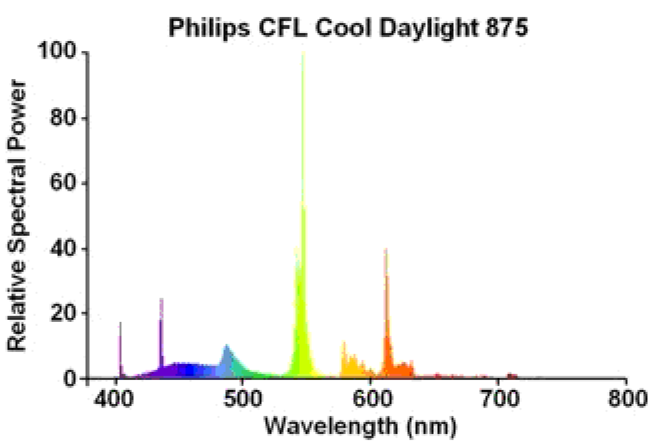


Image Provided By: Gerben49 at Dutch Wikipedia, This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. **Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0)**

How does artificial light mimic the sun's light?

Positive (transmitted by protons) and **negative (transmitted by electrons)** are the two primary electric charges. Differing charges attract each other. The net charge of an isolated system constitutes an electric charge as a "conserved property", transferred by **subatomic particles (is smaller than atom and includes protons, electrons, and neutrons)**. If the matter constitutes more electrons than protons it will have a negative charge, if there are fewer it will have a positive charge, and if there are equal numbers it will have a neutral (no) charge.

TRY IT OUT! Static electricity can be produced by rubbing together two different materials, such as rubbing rubber (on the bottom of your shoes) with carpet or a balloon with your hair!

Flowing electrons through a conductor carry electric charge; this is what creates electricity and power for artificial lighting. In contrast, the natural light produced by the sun is due to **nuclear fusion (the subsequent release of energy)** from the suns mass conversion of hydrogen to helium.

White light that we experience with lighting is a combination of all colors in the color spectrum. Objects in our everyday lives only appear one color or another because of how they reflect and absorb certain colors of light. For example, a red apple looks red because it reflects red light and absorbs blue and green light. Mimicking the color spectrum of the sun's wavelengths, we experience white light with article lighting.

MATHEMATICS AND SCIENCE STANDARDS

Light spectrum lesson provided by:
https://www.ducksters.com/science/experiment_light_spectrum.php

Purpose: To learn about the light spectrum and discover the colors of white light.

Materials

- white paper plate
- ruler
- compass
- 1 yard of string
- crayons
- scissors
- pencil
- science journal

Procedure

1) Use the compass to draw a circle around the inner edge of the paper plate. If the plate has a rippled area around the edge, draw the circle inside this edge.

2) Make a small pencil mark at the center of the plate. Stick the pointed end of the compass onto the plate and draw a circle.

3) Using scissors, cut out the circle.

4) Starting from the mark at the center of the plate, use a ruler to draw three straight lines out to the edge of the plate so that you make three equal pie-shaped sections on the plate. Color one section red, one section green, and the last section blue.

5) Lay your ruler across the center of the circle. Use your pencil to mark the point 3 cm to the left of the center and another point 3 cm to the right of the center.

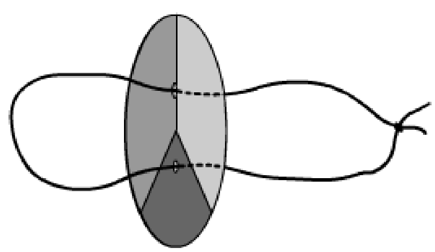
6) Use your pencil to punch a small hole at each point.

7) Thread the string through the holes (in one hole and out the other) and tie the ends of the string together, forming a loop that passes through the two holes of the plate. See the diagram below.

8) Center the paper plate on the string and twist the plate around until the twist is tight and meets your fingers holding the string.

9) Pull the twisted ends of the string apart so that the string unwinds and observe the colors on the plate.

10) Record your observations in your journal.



Ducksters. (2023). Kids Science Projects and Experiments: Light Spectrum. *Ducksters*. Retrieved from https://www.ducksters.com/science/experiment_light_spectrum.php

Conclusion and Questions

What happened to the colors on the plate?

General answer response: The red, green, and blue colors appeared white.

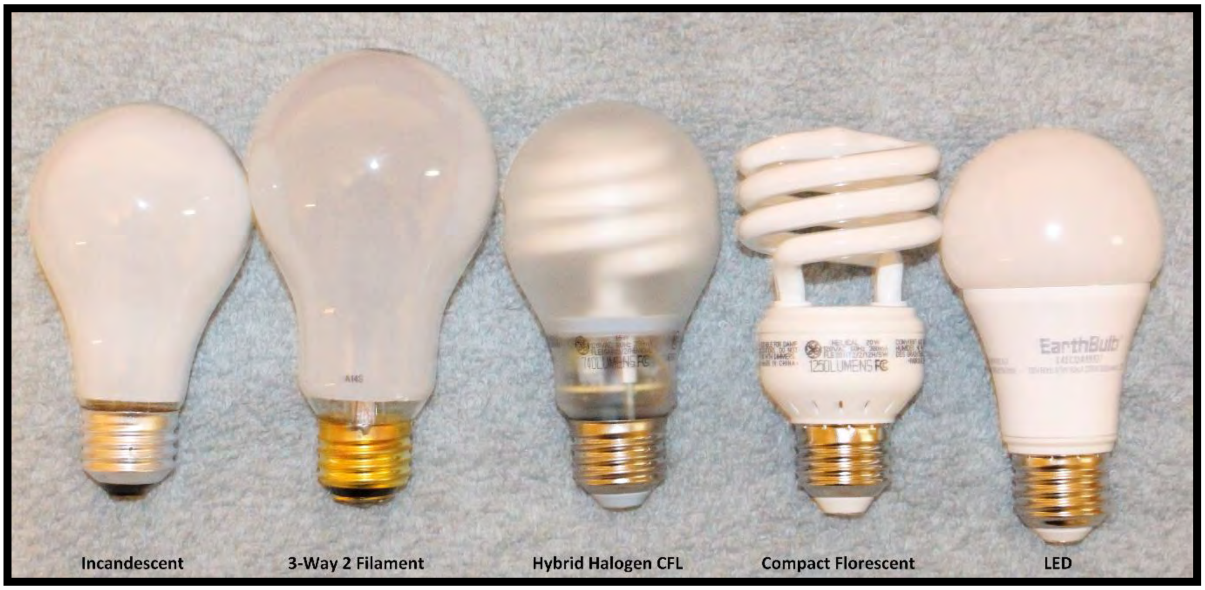
Why do you think this happened?

General answer response: The primary colors, red, green, and blue, turn white when mixed together. White light that we experience with lighting is a combination of all colors in the color spectrum. Objects in our everyday lives only appear one color or another because of how they reflect and absorb certain colors of light.

Reference: NASA SciFiles

TECHNOLOGY/ENGINEERING STANDARDS

How incandescent, fluorescent and LED lighting works



How standard incandescent lighting works:

An incandescent light bulb/incandescent lamp is electrically generated light that operates by heating a wire filament to a high enough temperature that it glows with light energy (**incandescence**). The metal filament does not **oxidize (a chemical reaction with oxygen that causes metal to corrode)** due to the glass or fused quartz that surrounds the filament and is filled with **inert gas (a gas that does not undergo chemical reactions)**. Electric current is fed through the wire in the glass; this is why light bulbs are used in a socket with electrical connections. Incandescent bulbs are produced in a range of sizes and **voltage ratings (a range of forces/pressure/potential differences between two points in an electric charge, expressed in volts).** Incandescent bulbs are significantly less efficient than other types of electric lighting, such as LEDs. Incandescent bulbs convert less than 5% of energy into light; most of the supplied energy is converted into heat. TEST: feel the heat energy surrounding an incandescent bulb, but be careful – do not directly touch an incandescent bulb as it may burn you!

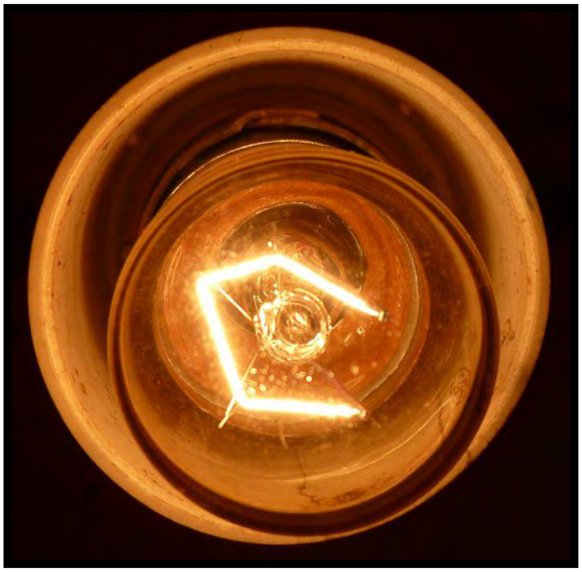


Image Provided By: No machine-readable author provided. Markswaterhouse assumed (based on copyright claims).

How Light Emitting Diodes (LEDs) Work

Image Provided By: Loadmaster (David R. Tribble), This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)

How Light Emitting Diodes (LED's) Work:

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwil462Z7_3sAhUCRa0KHXiODVUQFjAQegQIARAC&url=https%3A%2F%2Felectronics.howstuffworks.com%2Fled.htm&usg=AOvVaw2Nj1JaRcbacMOQAJ0EzYXt

and a video,

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=video&cd=&cad=rja&uact=8&ved=2ahUKEwiM5aDj9P3sAhVlmK0KHc0qCh0QtwIwAHoECAEQAg&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DBH9LI973H8w&usg=AOvVaw1xwcduf8WoqCPzG1oNfxF6

Fluorescent lamps work by **ionizing (a substance/molecule/atom is converted to an ion)** mercury vapor in a glass container. Electrons in the gas then emit photons at **UV** (ultraviolet) frequencies. The UV light is then converted into visible light via a phosphor coating in the tube.

VIDEO on the light spectrum: https://www.youtube.com/watch?v=9Vsl0Iom3S0

JOURNAL

ESL/Special needs: sketch this and/or share with each other how this plant is living indoors without any sunlight?

What is metabolize/metabolism?

General answer response: the chemical processes that occur within a living organism in order to maintain life.

What is a wavelength?

General answer response: Within the light spectrum, a wavelength is the distance between two frequency peaks/points.

Why do plants require light?

General answer response: to photosynthesize

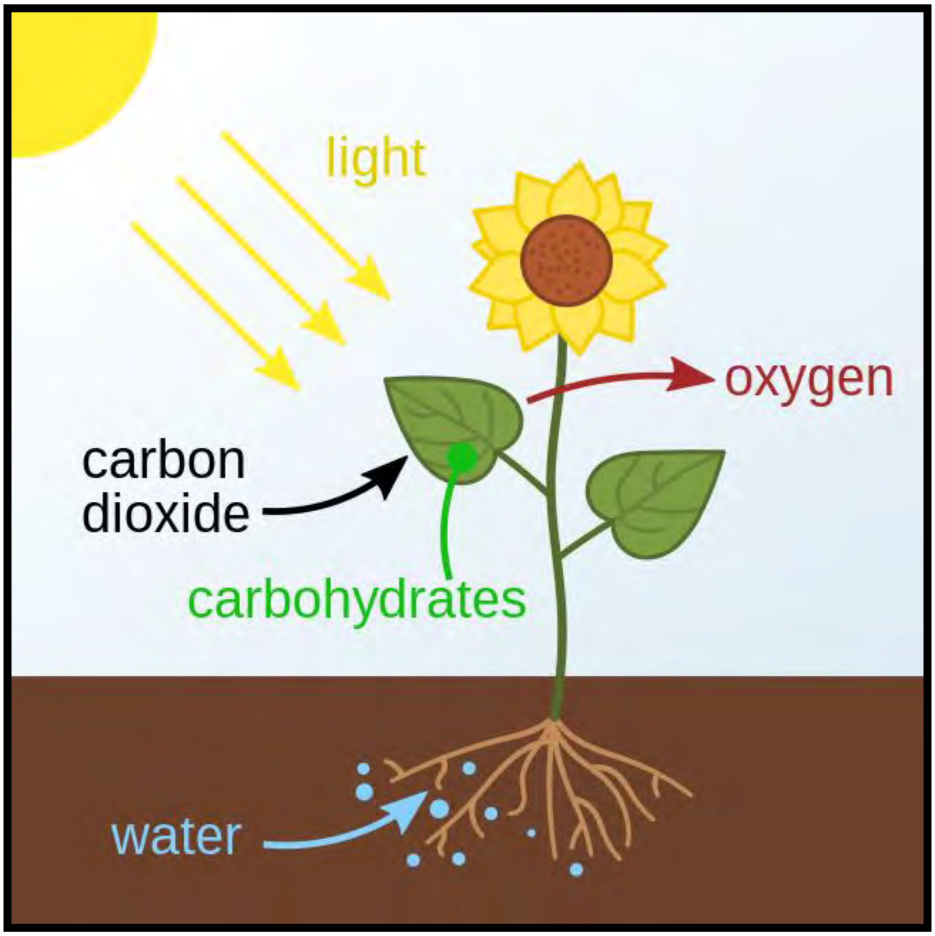
How does artificial lighting mimic natural sunlight?

General answer response: utilizes light wavelengths produced by electricity to provide light

How does more energy-efficient LED and florescent lighting work compared to a less energy-efficient incandescent light bulb?

General answer response: LEDs use light emitting diodes; florescent lighting uses gas; standard incandescent heats a filament to produce light.

ESL/special needs: Can you explain to a partner what this image represents (partner write in the journal what is being explained):



LESSON FOUR SUPPLIES CHECKLIST: Hydroponics and Light

Class Activity - Light spectrum lesson

Supplies:

- One white paper plate/student
- Rulers
- Mathematical compass
- One yard length of string/student
- Crayons
- Scissors
- Pencils

Homework for LESSON FIVE - each student brings a live herb plant or fresh vegetable (teacher may also contact produce manager at Sprouts to donate fresh vegetables)

Lesson 5

PLANT BIOLOGY & PLANT HARVESTING

Vocabulary

-Plant flowering

-Plant pollination

-Plant fruit, seed, stem, leaf & root

- Rooting vs. non-rooting vegetables

-Seed saving

Lesson 5 PLANT BIOLOGY & PLANT HARVESTING

OBJECTIVES

- To understand and define basic plant parts, plant physiology, and what plants need to grow
- To understand plant pollination and self-pollinating plants in hydroponic systems
- To understand and define rooting and non-rooting vegetables and how this relates to hydroponic system applications
- To know how to trouble shoot some potential hydroponic system issues
- **Next Generation Standards: MS-ESS3-5; MS-LS2-1 and common core math standards**

FUN GAME & VIDEO PROVIDED BY:
https://www.youtube.com/watch?v=ufXT89oKQ1s

SCIENCE & ENGLISH STANDARDS.

What do plants need to grow?

Plants need energy from the sun, water, and carbon, derived from the air as carbon dioxide, to grow. Plants also require nutrients to grow (see the FERTILIZER lesson).

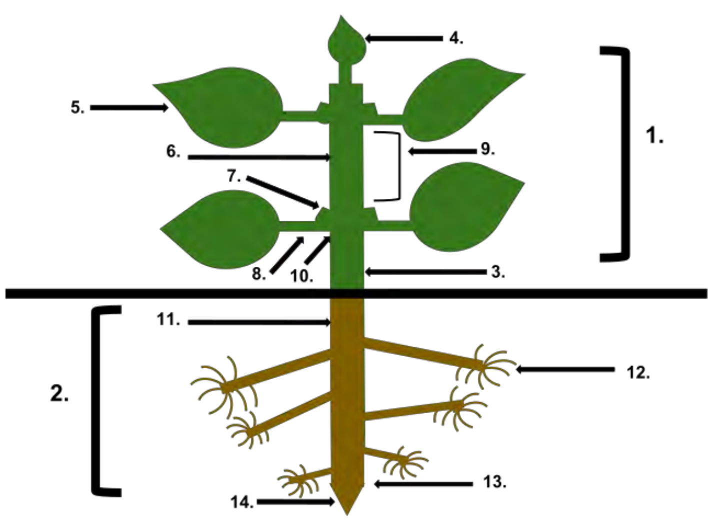


Image provided by: Bigman24225, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

What does it mean when plants flower?

Plants flower as a means of reproduction. Bright flowers attract potential pollinators (such as bees, beetles, and birds) and also allow for the pollen to enter the flower and fertilization (seed production) to take place.

GROUP BRAINSTORM: Which flowers are you more attracted to? Why? Do you think, like us, pollinators are attracted to fragrant flowers? If you could smell both flowers and base your choice of preference only on appearance, which would you choose? Which types of flowers do you think pollinators would be more attracted to?

Image provided by Jeff Anderson

Image provided by Jeff Anderson

Image provided by Jeff Anderson

What is pollination?

Pollination occurs when various creatures, including bees, bats, birds, butterflies, moths, beetles, and water or the wind carries pollen from one flowering plant to another or within flowers. Pollination is the transfer of pollen from a male part of a plant to a female part of a plant, allowing for fertilization and the production of seeds.

Root vs. Non-root vegetables

Non-root vegetables (also known as *fibrous roots*) are the vegetables that do not grow underground in the soil, their vegetable parts are formed above the soil line. Some of the non-root vegetables include corn, beans, peas, spinach, corn, and tomatoes. Leafy lettuces are examples of non-root vegetables.

Root vegetables, also known as taproots, tubers, rhizomes, corms, bulbs, etc. include: turnips, garlic, radishes, carrots, potatoes, onions, sweet potatoes, and beets for example.

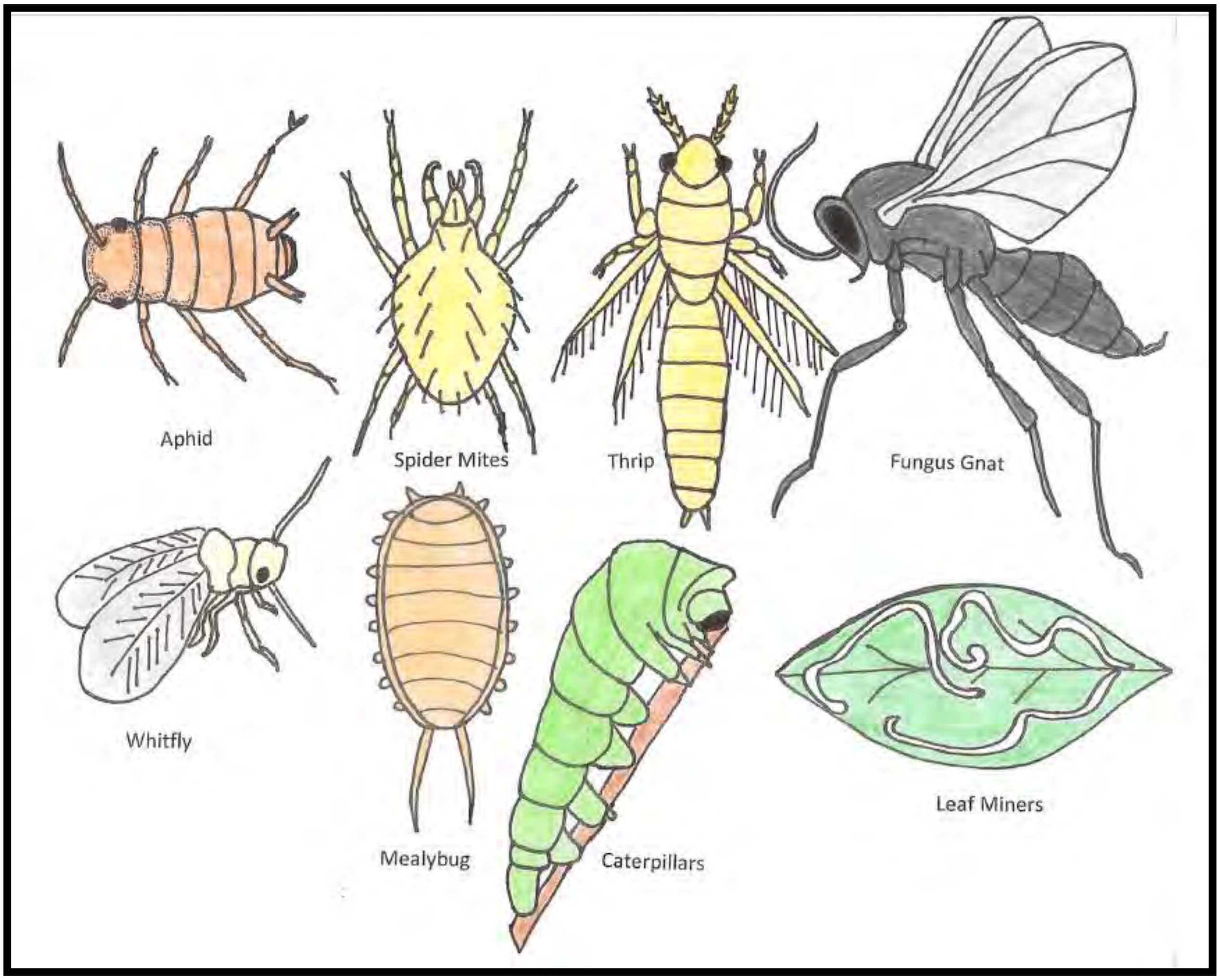
JOURNAL: What is your hypothesis on what would grow better in the hydroponics system – rooting or non-rooting vegetables? Why?

How do the plants in our hydroponics system pollinate without the help of pollen that is carried by different creatures and the wind?

Self-pollination is in reference to a flowering plant that is able to pollinate itself. A self-pollinating flower has both male and female reproductive parts. Pollen on the male flower part transfers to the female part of the flower to complete fertilization. Pollinators may or may not be necessary.

Seed saving – full circle!: In agriculture, landscaping and gardening, seed saving is the practice of saving seeds for use from year to year. This a great way to preserve the heritage of the seeds, create a full circle system, and save you money! You can harvest the seeds from your produce once dried and save them in a cool dry place (such as a recycled plastic/glass container on a shelf) to use for your next batch of hydroponics.

Troubleshooting: If you see any of the more common pests in the image below in your hydroponics system you may want to start the system over again or contact your County Extension Agent for advice on how to control these pests.



Problem Insects in Hydroponics Systems, (insects not actual size).

Image provided by: Adrian Walker, Las Vegas, Nevada

Image provided by: Shelby Gillette

Troubleshooting: What should you do if plants (e.g., tomatoes) need more structural support (the plant is falling over)? **ENGINEERING STANDARDS** - you can use recycled materials such as a piece of wood, string, or non-sharp metal to create a structure to support the growing plant.

Images provided by: Pauline E Edit this at Structured Data on Commons, This file is licensed under the Creative Commons Attribution-Share Alike 2.0 Generic license. **Attribution-ShareAlike 2.0 Generic (CC BY-SA 2.0), Attribution: *The vegetable plot, walled garden, Scampston Hall* by Pauline E.**

Images provided by: Mænsard Vokser, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

"He May be Cranky Ma'am, but all of His Parts Seem to Be in the Right Places"

HOMEWORK & CLASS ACTIVITY: Bring in a live plant or vegetable to share from home: share in class, define plant parts and students can guess what the plant or vegetable is. For the vegetable -- clean, cut and distribute the vegetable to eat amongst all students (ratio/fraction **MATH STANDARDS**). If some of your hydroponically grown food is ready, taste test the difference between the store bought and your hydroponically grown produce. **TIP FOR THE TEACHER**: *Sprouts Grocery Store, or another grocery store*, may be able to donate some store-bought produce for the activity and comparison taste testing.

JOURNAL

ESL/special needs:

Write or share what each of the following image's show (taproot or fibrous root) and what would <u>not</u> grow well in the hydroponics system:

Image provided by: Xufanc, This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. **Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0)**

Image provided by: https://www.wikidata.org/wiki/Q16506987, Ayotte, Gilles, 1948-, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

Image provided by**:** Jonathunder, This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. **Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0)**

Image provided by**:** Banana patrol of hydroponically grown vegetable roots, Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled *GNU Free Documentation License*. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. **Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0)**

LESSON FIVE SUPPLIES CHECKLIST: Plant Biology and Plant Harvesting

Class Activity - Identify plant parts.

Supplies:

- cutting boards
- Knives suitable for small children (non-sharp edges)
- Small paper bags for seed collection

Lesson 6
WATER, pH, & PLANT NEEDS

Vocabulary

-Turgor

-Cavitate

-Capillary action

-Adhesion, Cohesion

-pH

Lesson 6 WATER, pH, & PLANT NEEDS

OBJECTIVES

- Be able to describe what water is and what it facilitates for the plant
- Be able to define plant turgor, cavitate, and capillary action
- To develop an understanding of adhesion and cohesion
- Be able to understand pH and the concept of plant nutrients becoming more and less available with varying pH
- **Next Generation Standards: MS-PS1-4**

SCIENCE STANDARDS

How plant watering with hydroponics works

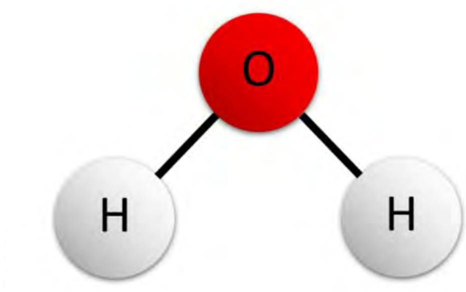


Image Provided By: MsKDinh, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

The water in a hydroponics system allows plants to take up nutrients. Water is made of two hydrogen molecules and one oxygen molecule. Plants also need water for photosynthesis and to stay upright (this is known as plant **turgor**)!

What is cavitate? This is the loss of plant turgor (plant structure) with extreme water loss; roots can also die. However, sometimes plants can come back from this.

What is Capillary Action?

You've just come in from playing outside in the hot sun and you pour yourself a cold glass of water. But before you can drink it, you accidentally knock over the glass and spill some water. You grab a paper towel and put it over the puddle on the floor. The water quickly soaks into the paper towel and the floor is dry. You've just employed **capillary action** to clean up the spilled water! **Capillary action** is a process during which a liquid, such as water, moves up something solid, such as a thin tube (e.g., plant roots) or into a material that is made of very small holes. This is due to three primary forces: cohesion, adhesion, and surface tension (information provided by/adapted from:

Summarized from: Sieverson, D. (2003-2019). *Capillary action lesson for kids*. Retrieved from: https://study.com/academy/lesson/capillary-action-lesson-for-kids.html

Adhesion happens when molecules stick or *adhere* to a solid substance, like a paper towel or the sides of a thin hallow tube, and the water is pushed up. This is what happens when water, along with very tiny, mineralized nutrients, move up the plant root system. **Cohesion** is when the molecules stick to themselves. When a molecule sticks to itself it pulls another water molecule up with it, like a chain.

ACTIVITY 1: Capillary Action Lesson (compiled and adapted from): Sieverson, D. (2003-2019). *Capillary action lesson for kids*. Retrieved from: https://study.com/academy/lesson/capillary-action-lesson-for-kids.html

Group Activity. Supplies needed: mugs or cups, paper towels, and water

TRY IT! Water moving **up** a paper towel due to capillary action!

Image Provided By: M-na-druhou, This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license. **Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0)**

"Jump in Mr. Onion, Graduate Student Mr. Celery Says the pH is Just Right for Us"

Photo: Jeff Anderson

VIDEO 1: you can see how plants take up nutrients through water and their plant stem systems using water, food coloring, small containers, and celery! Isn't it awesome how water moves up (it's capillary action!)? https://www.youtube.com/watch?v=oiBLKRjr4Mc

VIDEO 2: Soil water holding capacity https://www.youtube.com/watch?v=w1r336ykE9E

pH Activity:

pH is a scale used to measure how **acidic** (also known as acidity) or **basic** (also known as alkaline/alkalinity) a solution is, ranging from a scale of 0-14. Acidic solutions have a lower pH (below 7), basic solutions have a higher pH (above 7), and neutral solutions have a pH of 7.

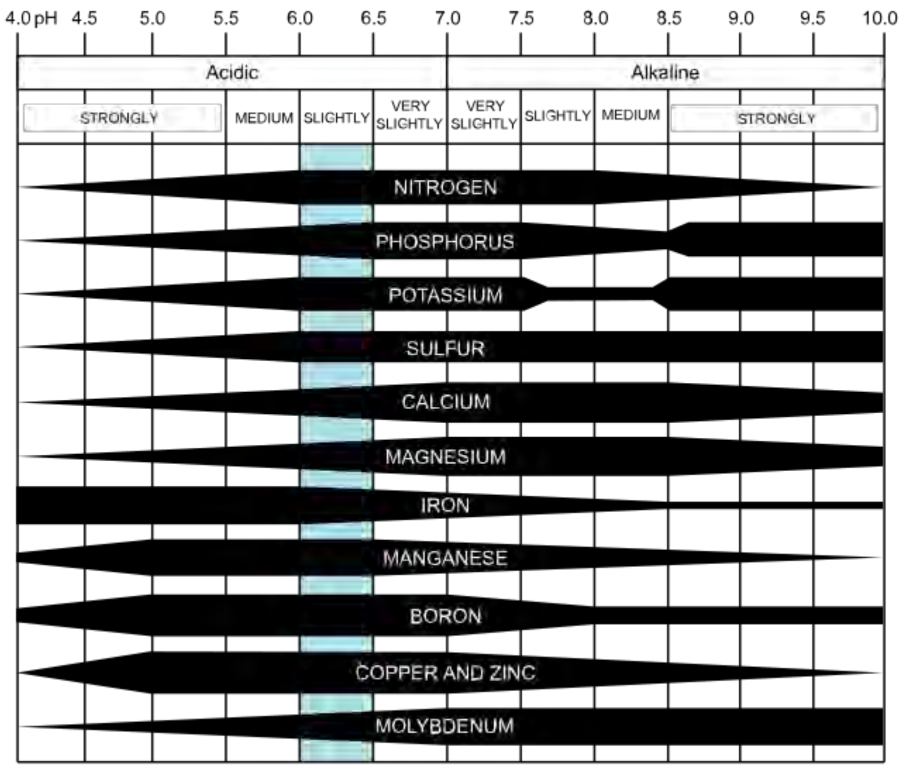
Supplies needed:

- Vinegar, water, and baking powder (dissolved in water)
- Small containers to pour/mix multiple samples of vinegar, water, and baking powder
- pH strips

ACTIVITY 1: use the pH strips to measure the various levels of liquid pH and in your journal **rank** each liquid from most to least acidic.

Acidity and alkalinity affect the nutrients available in the soil and also the hydroponics systems. This chart highlights which nutrients are available with varying levels of acidity.

ACTIVITY 2: Reading the chart below, write down in your journal (1) plant nutrient that is only available at high pH and plant nutrient that is only available at low pH.



JOURNAL

BRAINSTORM! What, aside from capillary action, leads to water loss over time?

General answer response: evaporation

Why do plants need water to function?

General answer response: water facilitates plant nutrient uptake

What is pH and how does it affect plant nutrient availability?

General answer response: it’s a measurement of acidity and alkalinity. Some plant nutrients are not available in different pH ranges.

LESSON SIX SUPPLIES CHECKLIST: Water, pH, And Plant Needs

Class Activity #1 - Capillary Action

Supplies:

- One cup or mug/student
- Water
- Paper towels
- Watercolors
- Paint brushes

Class Activity #$2 - Measuring pH

Supplies:

- Small disposable bathroom cups
- White vinegar
- Tap water
- Baking powder
- Sharpies
- pH strips

Lesson 7

AERATION

Vocabulary

-Aeration

-Soil aeration

-Compaction

-Aeration & the hydroponics system

Lesson 7 AERATION

OBJECTIVES:

- To define aeration
- To understand the mechanisms of soil aeration
- To relate soil aeration with hydroponics aeration
- To understand the functions of the components of the hydroponics aeration system
- **Next Generation Standards: common core math standards**

What is aeration? Aeration is a process where air is introduced into a medium/material

Most plants can't subsist in water; there must be an exchange of gases, namely oxygen. Lettuces and water crest like to have roots wet; however, most plants do not like their roots wet constantly. Air is constantly moving throughout a healthy soil system. Roots penetrating the soil, organisms moving throughout the soil, and water moving through the soil, creates spaces in the soil system that allows for air movement, and exchanges of gases.

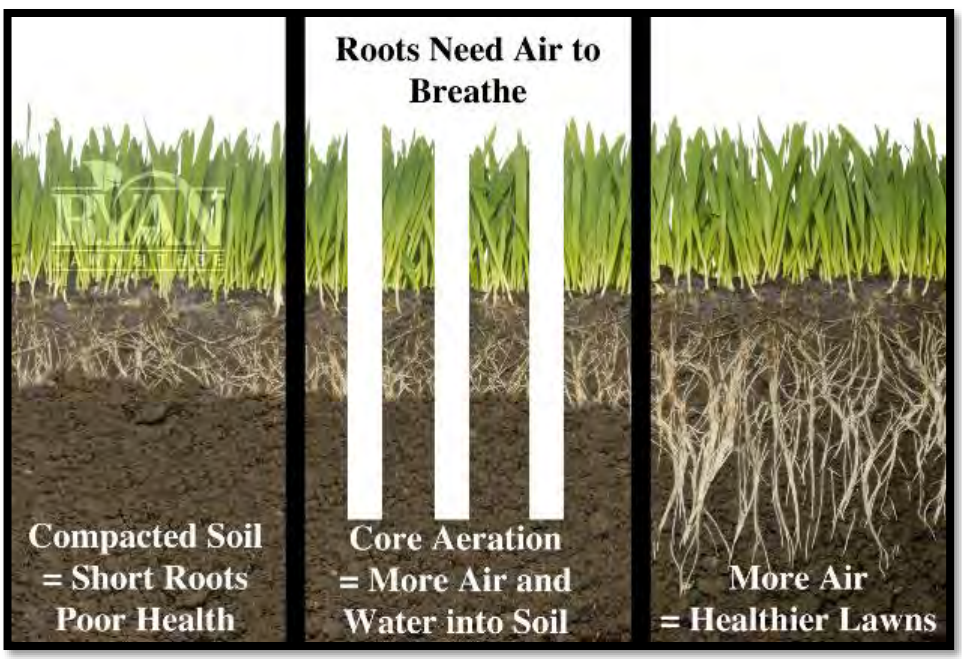


Image from: https://ryanlawn.com/the-benefits-of-aeration/

SENT ONLINE COMMENT FOR PHOTO PERMISSION 8-8-2019

"It's the Oxygen Bubbles in the Water that Keeps it so Refreshing."

SOIL/AIR OUTDOOR ACTIVITY

JOURNAL

Soil Air

All that is needed for this experiment is a can of spray polyurethane and some soils clods.

Spray the clod and wait a minute or two before dropping the clod in a jar of water. Watch the bubbles. Air will bubble from some clods for up to 20 minutes or more.

Soil clods from surface soils from orchards, pastures, and lawns generally will have a high soil air content and will bubble longer.

Soil clods from subsoils, or soils from conventionally cultivated fields will generally have lower soil air content and will bubble less.

Provided by: USDA Natural Resources Conservation Service. (2019). Soil Air. Retrieved from: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054301

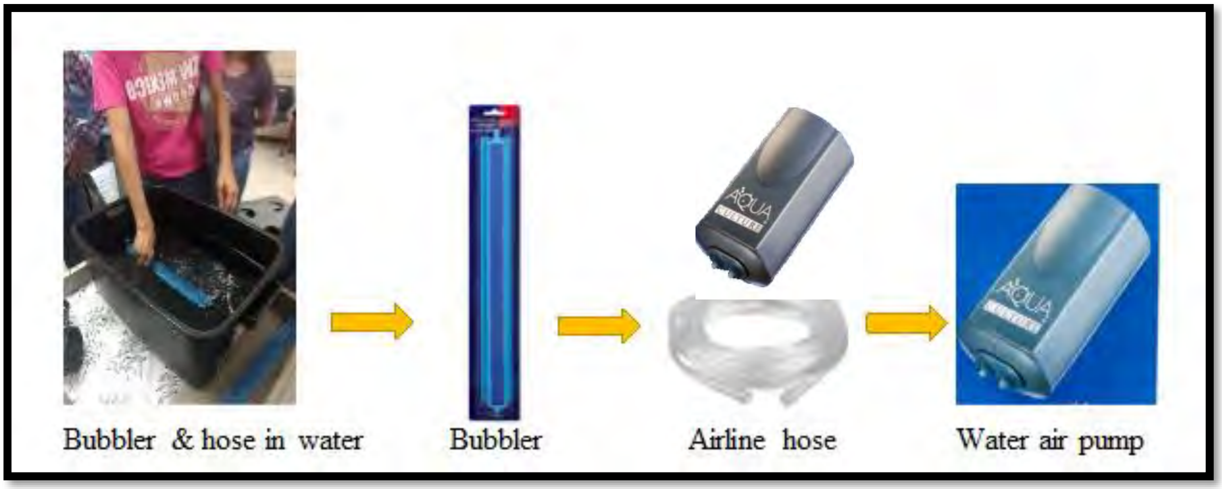
Supplies needed: a sample of outdoor soil/s, a can of sheer gloss, a mason jar, and water.

Discuss with your partner: what is causing the bubbles in the water?

Trouble-shooting brainstorming: What if you see mold in the hydroponics system water? What does this mean?

General answer response: the system may not be getting enough air circulation (the stagnant water may be creating mold) – check to see if all parts of the aeration system is working!

What is the function of each component of the hydroponics aeration system? How does your hydroponics aeration system mimic the natural soil aeration system?



Math and journaling activity: measure your hydroponics plant roots at the beginning and at the end of your project and record these numbers on your data chart.

LESSON SEVEN SUPPLIES CHECKLIST: Aeration

Class Activity - Soil/Air

Supplies:

- Clear glass jar with tight-fitting lid
- Hand shovel
- Soil
- Tap Water

Homework for LESSON EIGHT - Determine how much produce is needed for next week's meal.

Lesson 8

FOOD NUTRITION & ENGINEERING

Vocabulary

-Proteins

-Fats

-Carbohydrates

-Vitamins & minerals

-Cultural food factors

-Geographical food factors

-Food preparation & measurements

Lesson 8 FOOD NUTRITION & ENGINEERING

OBJECTIVES:

- To develop a general understanding of food nutrition, and the primary role of proteins, carbohydrates, fats, and vitamins and minerals in our diet
- To develop an understanding of which foods provide proteins, carbohydrates, fats, and vitamins and minerals in our everyday diet
- To use ratios and fractions to construct a meal from the hydroponics system
- To develop a cultural background of where the engineered meals come from
- To connect growing food at school with the impact on everyday food choices and options at home
- **Next Generation Standards: 1-SS-1 NM and common core math standards**

The below information is summarized from:

Australian Government, Department of Health (April 6, 2019). *Vegetables and legumes/beans.* Retrieved from: https://www.eatforhealth.gov.au/food-essentials/five-food-groups/vegetables-and-legumes-beans

Breastcancer.org (February 4, 2016). How your body gets nutrients from foods. Retrieved from: https://www.breastcancer.org/tips/nutrition/healthy_eat/nutrients

Understanding Nutrition 10th Edition by Ellie Whitney and Sharon Rady Rolfes

SCIENCE STANDARDS - Why do we eat food? What does food provide us? Nutrients, vitamins, and minerals for our bodies to grow and thrive!

Students growing their own food, in an innovative way such as hydroponics production, may cultivate greater confidence in food production. This may also contribute to increased willingness to try new vegetables and fruits and integrate fresh produce into everyday diets.

MATHEMATICS, ENGINEERING/TECHNOLOGY

- Mathematical ideas of percentages, ratios, fractions, and pie charts
- Construction of a meal design utilizing a hydroponics system

"The Correct Answer for 'Nutrition Facts' Is…"

Proteins provide our bodies amino acids — the protein building blocks that help our body's cells function. Proteins help bodies create new cells and hormones and enzymes, repair older cells, and keep our immune systems functioning optimally. If you don't have enough protein in your diet, you are more likely to get sick and your body will take longer to recover from illnesses.

Low-fat high protein sources include: lean meats, chicken, turkey, fish, and low-fat dairy products, nuts, beans, dark and leafy greens (such as broccoli, spinach and kale), and legumes (such as garbanzo beans, lentils, and peas).

Carbohydrates

Carbohydrates provide instant energy — they go into our blood stream as glucose (blood sugar), which our body uses for immediate energy, and then converts the rest into a fat source for our body.

Breads and pastas, grains, vegetables and fruits, cereals and crackers, peas, and lentils are all good sources of carbohydrates. Many of these are also excellent fiber sources, which your digestive system needs to function. Both white and brown sugar and other sweeteners are also carbohydrates, but these types of carbohydrates tend to be high in calories and don't provide vitamins, minerals, or other benefits. Whole grains (such as whole grain bread and pasta) are healthier sources of carbohydrates than refined grains and sugars. Fruits and vegetables are also carbohydrates.

Fats

Fats are our "energy reserves" and give our bodies the fatty acids needed to produce new cells and hormones. Vitamins A, D, E, and K are what is known as fat-soluble vitamins, meaning they need some fat to be absorbed into our bodies.

Saturated fats come from animal fat and example of unsaturated fat include: nuts, some fish, and oils.

Vitamins and Minerals

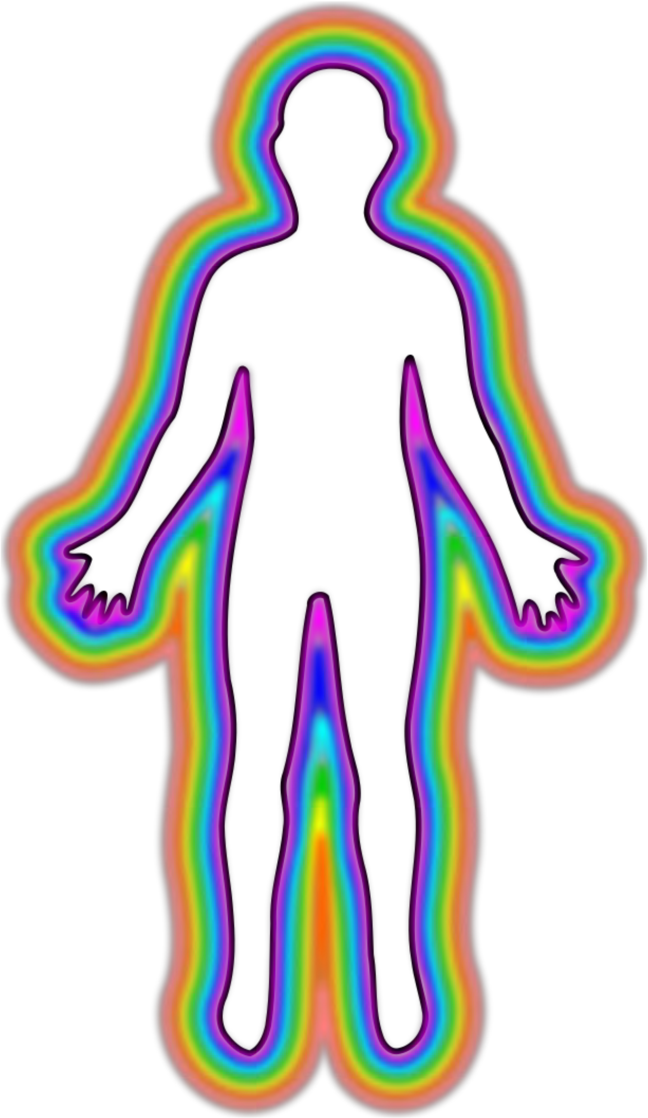
Vitamins come from the food we eat and help our bodies utilize energy, in addition to keeping vision, skin, nails, and hair health. Many vitamins and minerals come from fruits and vegetables.

Minerals come from elements and help regulate our body's internal processes. The element **potassium**, for example, helps our muscles function properly and **calcium** helps our bones and teeth.

Nutrition Guide

Per 100g	Healthiest Eat more often	Fairly healthy Eat in moderation	Least healthy Eat in small amounts
Total fat	Less than 3g *Milk, yoghurt & ice-cream*: Less than 2g *Cheese*: Less than 15g	5g-20g	More than 20g
Saturated fat	Less than 3g	3g-5g	More than 5g
Sugar	Less than 5g	5g-15g	More than 15g
Sodium	Less than 120mg	120-600mg	More than 600mg
Dietary Fibre	Choose foods (e.g. breads and cereals) with more than 3g ***per serve***.		

ACTIVITY: Draw an outline of your body and what proteins, carbohydrates, fats, and vitamins and minerals provide your body, and give (1) food example of each.



CULTURAL & GEOGRAPHY STANDARDS: students can do KWL Methods (Know, Want-to-know, and Learned), exercises beforehand, and then ask the students where they think quesadillas and couscous originate from, followed by open students discussions, and having students show, or draw on the map where Mexico, and the Mediterranean regions are located.

Vegetarian Quesadillas

Image provided by: Kari Sullivan from Austin, TX, This file is licensed under the Creative Commons Attribution 2.0 Generic license. **Attribution 2.0 Generic (CC BY 2.0)**

Use a spatula to transfer the quesadilla to a pan and turn the pan on medium-low. Flip the quesadilla, allowing the quesadilla to cook, approximately 2 minutes on each side, before putting it on a plate to cool.

Mediterranean Couscous Salad with Vegetables and Feta

Images provided by: On Left by, T.K. Naliaka, This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. **Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)**

On Right by, Suzette - www.suzette.nu from Arnhem, Netherlands, This file is licensed under the Creative Commons Attribution 2.0 Generic license. **Attribution 2.0 Generic (CC BY 2.0)**

What is couscous? Couscous is a form of pasta made from semolina granules, derived from durum wheat, and is part of the typical North African and many Middle Eastern palates. Couscous may not look like other pastas you have tried, but it is very tasty (some people say it has a buttery flavor!), high in protein (compared to many forms of rice and pasta), and cooks quickly!

Substitutes for couscous: If you don't have couscous on hand or if you prefer, you can substitute this dish with quinoa, and various pastas and rice.

Serves (approximately) 5 people (math standards): determine the amount of each ingredient needed for the number of people in your class; you may need to double or triple the recipe depending on the number of people being served <u>and</u> how much to serve each person.

Ingredients:

FROM YOUR HYDROPONICS SYSTEM & CLASSROOM:

3 cups (about 1 1/2 pints) tomatoes, diced

2 cucumbers, seeded and diced

2 green, yellow, or red bell-peppers, seeded and diced

2 cups hot water (you can heat a bowl of water in the microwave)

WHAT WILL NEED TO BE BROUGHT FROM HOME OR PURCHASED AT A STORE:

1 1/2 cups instant couscous (a 10-ounce box)

6 ounces of feta cheese or Cotija Cheese, crumbled (if desired)

1 can beans (garbanzo or black bean etc. and drain and rinse first)

3 teaspoons salt

1 teaspoon pepper

To prepare:

- Pour the couscous into a large pot (with a lid)
- Boil 2 cups of water (in the microwave, if needed) and carefully pour the hot water into the pot of couscous
- Stir, with a fork, to separate any clumps
- Allow the couscous to absorb the hot water in a pot, **<u>with the lid on top</u>**, until tender (approximately 5 minutes)
- Remove the lid, fluff the couscous with the wooden fork, and allow to cool (with the lid off)
- Wash your hands and the hydroponically grown vegetables, and on a cutting board carefully dice all vegetables into bite-size pieces
- Add the diced vegetables, can of beans (if desired), feta or other cheese, and salt and pepper to taste, into the large pot with the cooked couscous
- Partition the dish amongst all students (you need to do the math here – you may need to make two batches of the recipe)

JOURNAL

INTAKE AMONG LAS CRUCES NM MIDDLE SCHOOL STUDENTS

1) Have you ever grown vegetables or fruit before? If so, what kind?

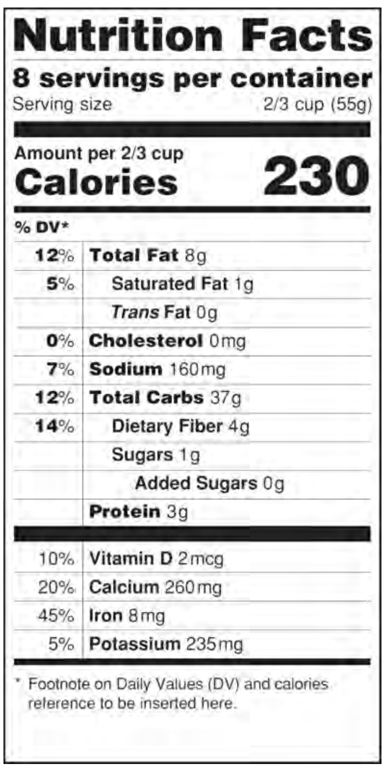
2) How often do you eat vegetables or fruit?

3) How many times daily, vegetables:

4) How many times daily, fruit:

Nutrition Facts (provided by Google): Does this label look familiar? Required by US law, all food products must be labeled with its contents and nutrition facts. Have you wondered what food labels mean?

With a partner or in a group: discuss what the below label means, in terms of nutritional content and what this provides your body. Also, discuss as a class, what you don't understand – you can learn from each other! Research online



Nutrition Facts

8 servings per container
Serving size 2/3 cup (55g)

Amount per 2/3 cup
Calories 230

% DV*	
12%	**Total Fat** 8g
5%	Saturated Fat 1g
	Trans Fat 0g
0%	**Cholesterol** 0mg
7%	**Sodium** 160mg
12%	**Total Carbs** 37g
14%	Dietary Fiber 4g
	Sugars 1g
	Added Sugars 0g
	Protein 3g
10%	**Vitamin D** 2mcg
20%	**Calcium** 260mg
45%	**Iron** 8mg
5%	**Potassium** 235mg

* Footnote on Daily Values (DV) and calories reference to be inserted here.

Image provided by: U.S. Food and Drug Administration, Unless otherwise noted, the contents of the Food and Drug Administration website (www.fda.gov) —both text and graphics— are public domain in the United States. [1] (August 18, 2005, last updated July 14, 2015)

<u>LESSON EIGHT SUPPLIES CHECKLIST</u>: Food Nutrition and Engineering

Class Activity #1 - Nutrition

<u>Supplies:</u>

- One sheet white paper/student
- Color pencils

Class Activity #2 - Make Lunch - Mediterranean Couscous Salad with Vegetables and Feta (Serves 5)

<u>Supplies:</u>

- Printed copies of the recipe
- 1 ½ pint of tomatoes
- 2 cucumbers
- 2 bell peppers (any color)
- 10 oz box of couscous
- 6 oz feta or Cotija cheese
- 15 oz can black or garbanzo beans
- Large pot with tight-fitting lid for couscous
- Salt
- Pepper
- Cutting boards
- Knives
- Microwave-proof measuring cup
- Strainer
- Can opener
- Large serving bowl
- Large fork for couscous
- Bowls and plasticware for diners
- Serving spoons

Lesson 9
LIFE LESSONS: BUILD YOUR OWN HYDROPONICS BUSINESS

Vocabulary

-Business

-Supply & demand

-Buyer & producer

-Global production & hydroponics translations

-Environmental and economic factors

Lesson 9 LIFE LESSONS: BUILD YOUR OWN HYDROPONICS BUSINESS

OBJECTIVES:

- To understand the basic principles of business
- To develop an understanding of hydroponics vegetable production and sales
- To research, sketch, and develop an understanding of global crop production and translations to hydroponics systems
- **Next Generation Standards: MS-ESS3-3 kids can start their own business!:** https://www.youtube.com/watch?v=3QvmH0xky5E
- **FREE LESSONS AND TEACHERS' GUIDES:** http://www.practicalmoneyskills.com/teach/lesson_plans

Activity 1: Play some business games!

Basic business principles state that you need a buyer first and then a product – what does this mean? Who purchases plants and why? Students can apply developed skills toward brainstorming and developing their own business ideas and apply these skills in their everyday lives.

Students can practice developing basic business skills here, and play online **BUSINESS GAMES** – which encompass math, English and other common core standards: http://www.bschool.com/little-entrepreneurs-business-for-kids/

Activity 2: Develop your own hydroponics business: math and English standards.

Sketch out from buyer to producer (you!) how you would develop a hydroponics business. Questions to think about: who your buyers would be, how much you would charge per product you sell and why (you may need to do some online research on the average price of various produce from your local grocery store and farmers market etc.), how much product you will be producing, and what supplies you would need to keep producing each product at this rate.

Activity 3: Global production: online research, geography, and math standards

Look online and research which of the 7 global continents sell the most of what plant. Using a circumference, geometrically draw the earth and sketch and/or label which areas produce the most of what plant-based goods. Considering the environment of each region, can you take an educated guess as to why certain areas grow certain crops? How are some of these regions affected by the environment, and will these regions be greater impacted by the effects of climate change? Do you think this could change if these areas developed hydroponics systems? Could this grow the demand for the global expansion of hydroponics business development? Why?

<u>Journal</u>

1) What are the basic business principles and what does this mean?

General answer response: a buyer first and then a product; this means we can't create products that won't be purchased so we need to think of what the consumer/buyer wants or needs first

2) What businesses can you think of that sells food?

General answer response: grocery stores, farmers markets etc.

3) Can you and the person to your right think of other ways food can be sold or distributed?

General answer response: creative brainstorming!

"So, this is the Doorway to the World of Better Health and Nutrition."

LESSON NINE SUPPLIES CHECKLIST: Building Your Own Hydroponic Business

Class Activity Option #1 - Play Business Games

Supplies:

- Laptop computer with internet connection

Class Activity Option #2 - Develop hydroponic business plan.

Supplies:

- Laptop computer with internet connection
- paper
- pens/pencils

Class Activity Option #3 - Global Production

Supplies:

- Laptop computer with internet connection
- Paper
- pencil

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- New Mexico Grow Project - Hydroponics Curriculum Piloting Schools
    - Santa Ana Head Start, Bernalillo
    - Algodones Elementary School, Bernalillo
    - McCoy Elementary, Aztec
    - Estancia Upper Elementary, Estancia
    - Robertson High School, Las Vegas
    - Rio Gallinas School for Ecology and the Arts, Las Vegas
    - Hatch Valley High School, Hatch
    - Mesilla Park Elementary, Las Cruces
    - Centennial High School, Las Cruces
    - Sonoma Elementary First Grade, Las Cruces
    - Mescalero Apache High School, Mescalero
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- Artist: Southern New Mexico Correctional Facility, S. Harrison

Thanks for Learning Hydroponics with Us, See You in the Kitchen Soon!"

NM STATE
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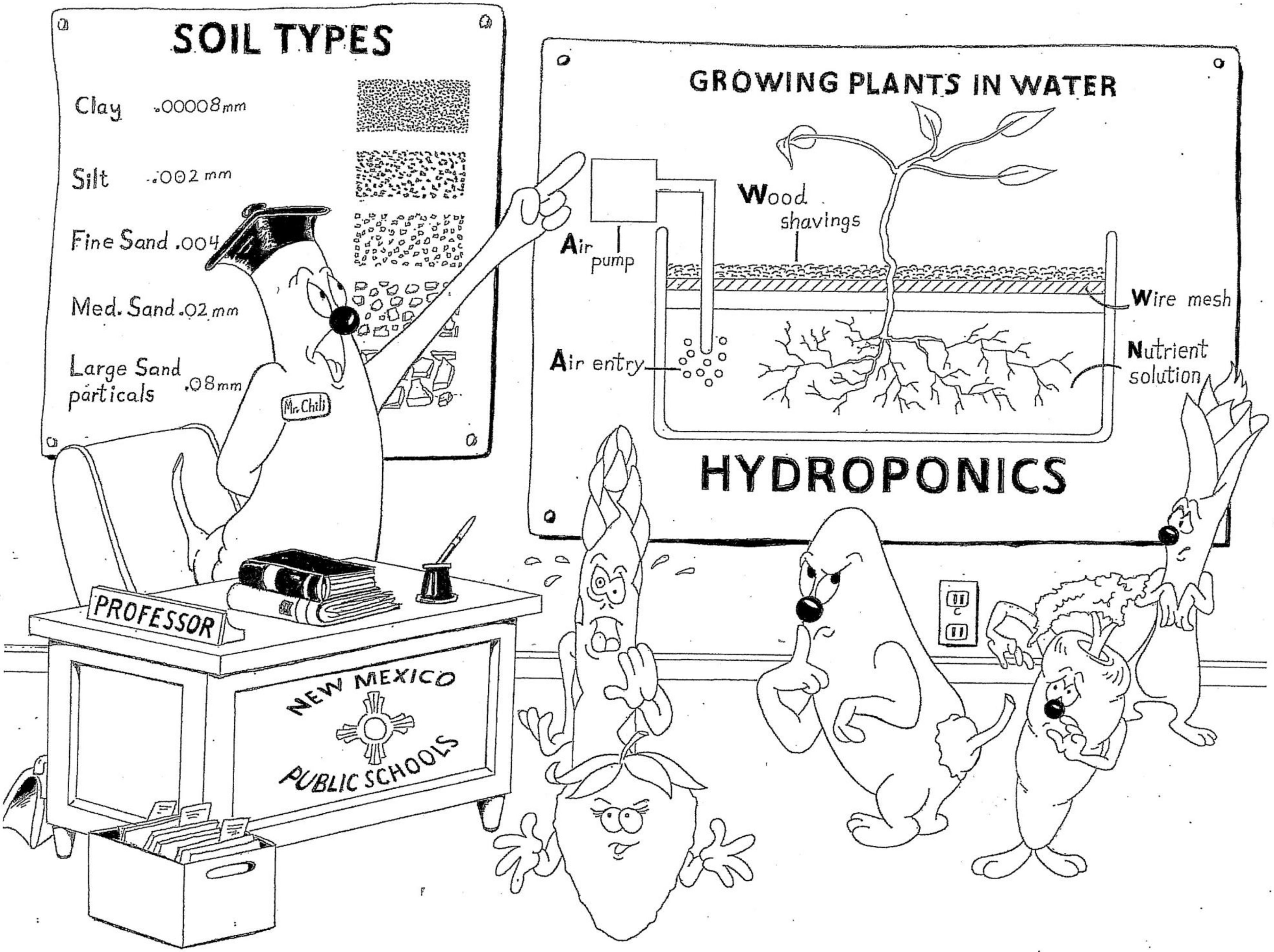
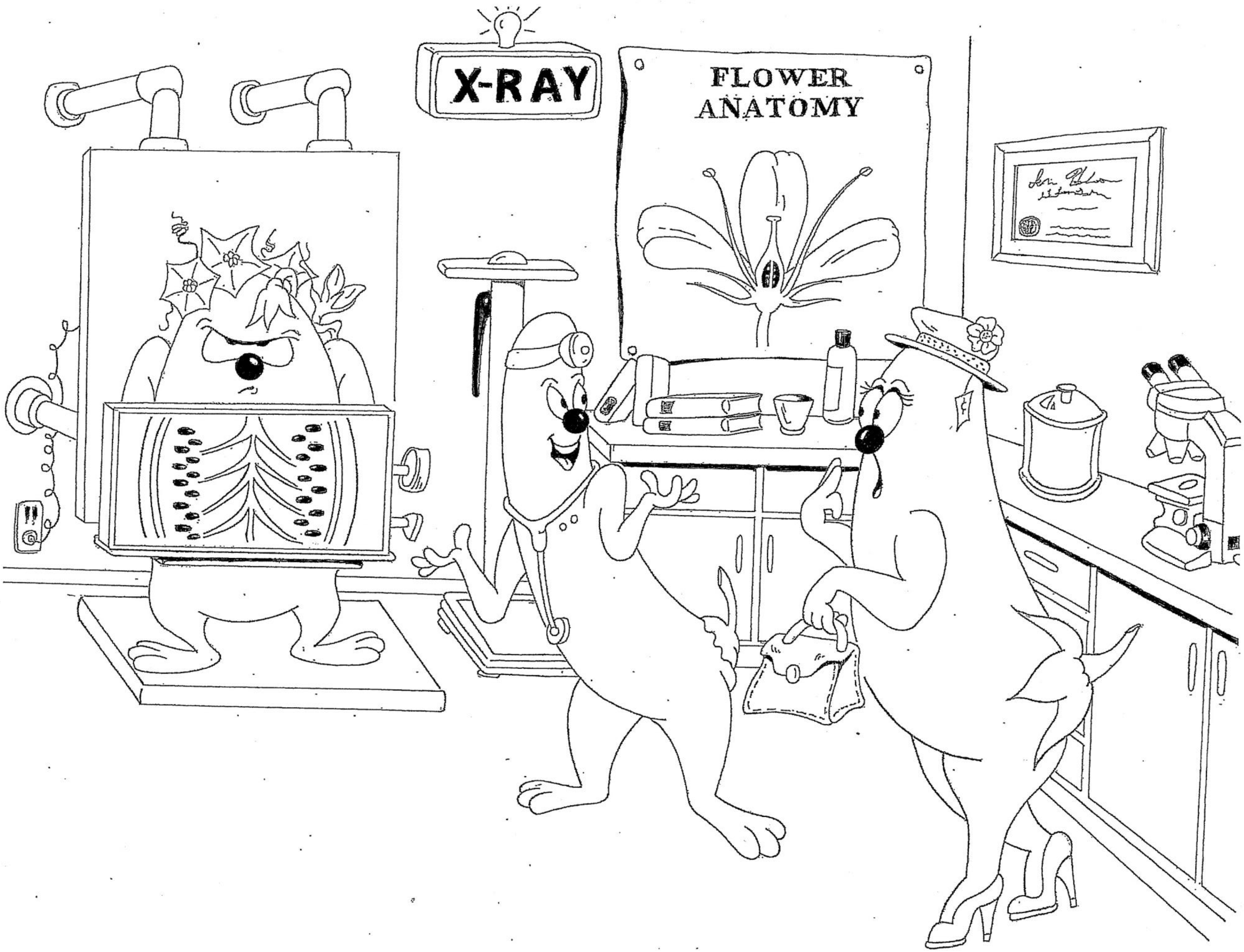
College of Agricultural, Consumer and Environmental Sciences
Cooperative Extension Service
Doña Ana County Extension Office

Doña Ana County Farm Bureau

Black & White Art Provided for Coloring


SOIL TYPES
Clay .00008mm
Silt .002 mm
Fine Sand .004
Med. Sand .02 mm
Large Sand particals .08mm
Mr. Chili
GROWING PLANTS IN WATER
Air pump
Wood shavings
Wire mesh
Air entry
Nutrient solution
HYDROPONICS
PROFESSOR
NEW MEXICO
PUBLIC SCHOOLS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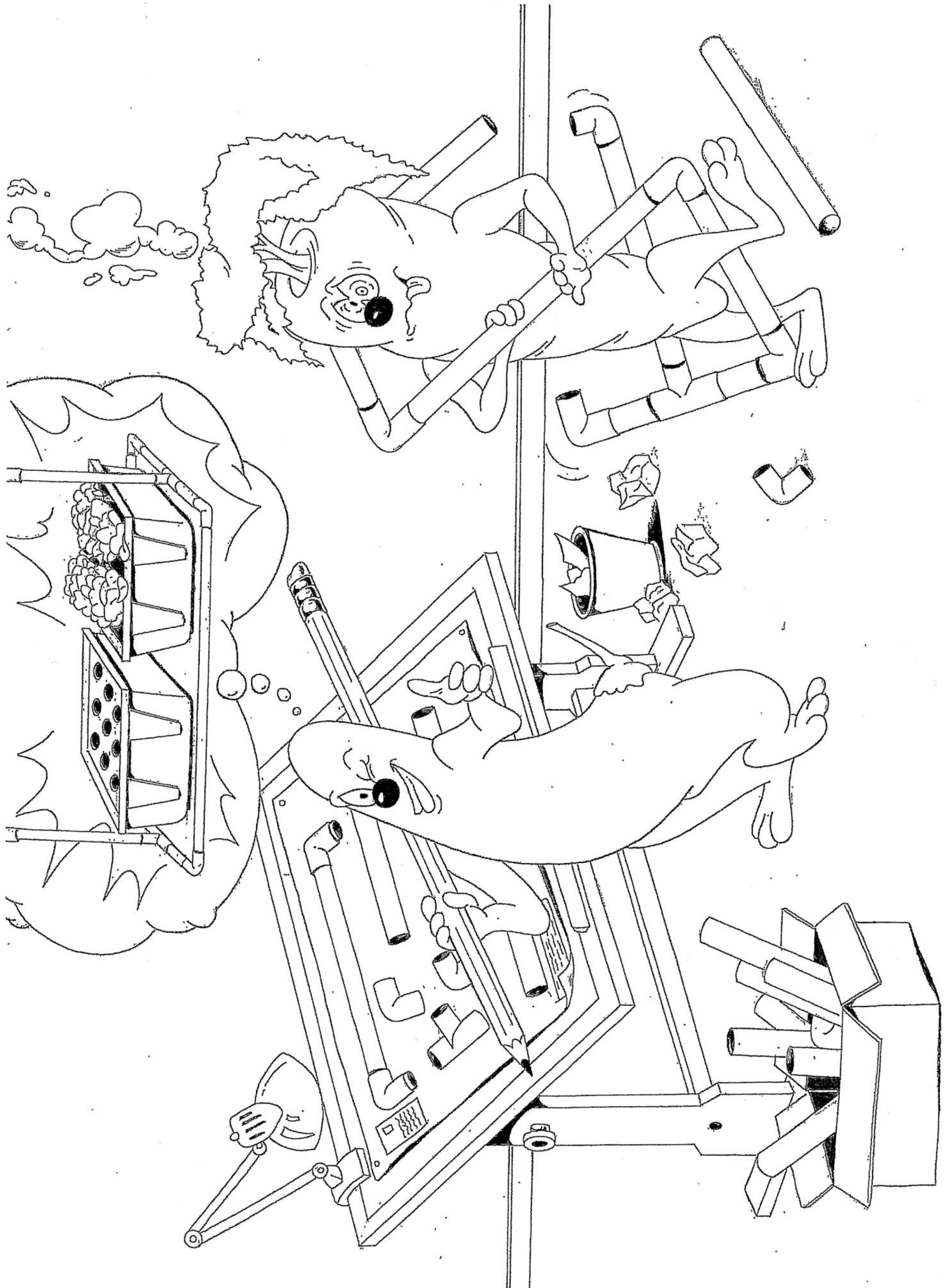
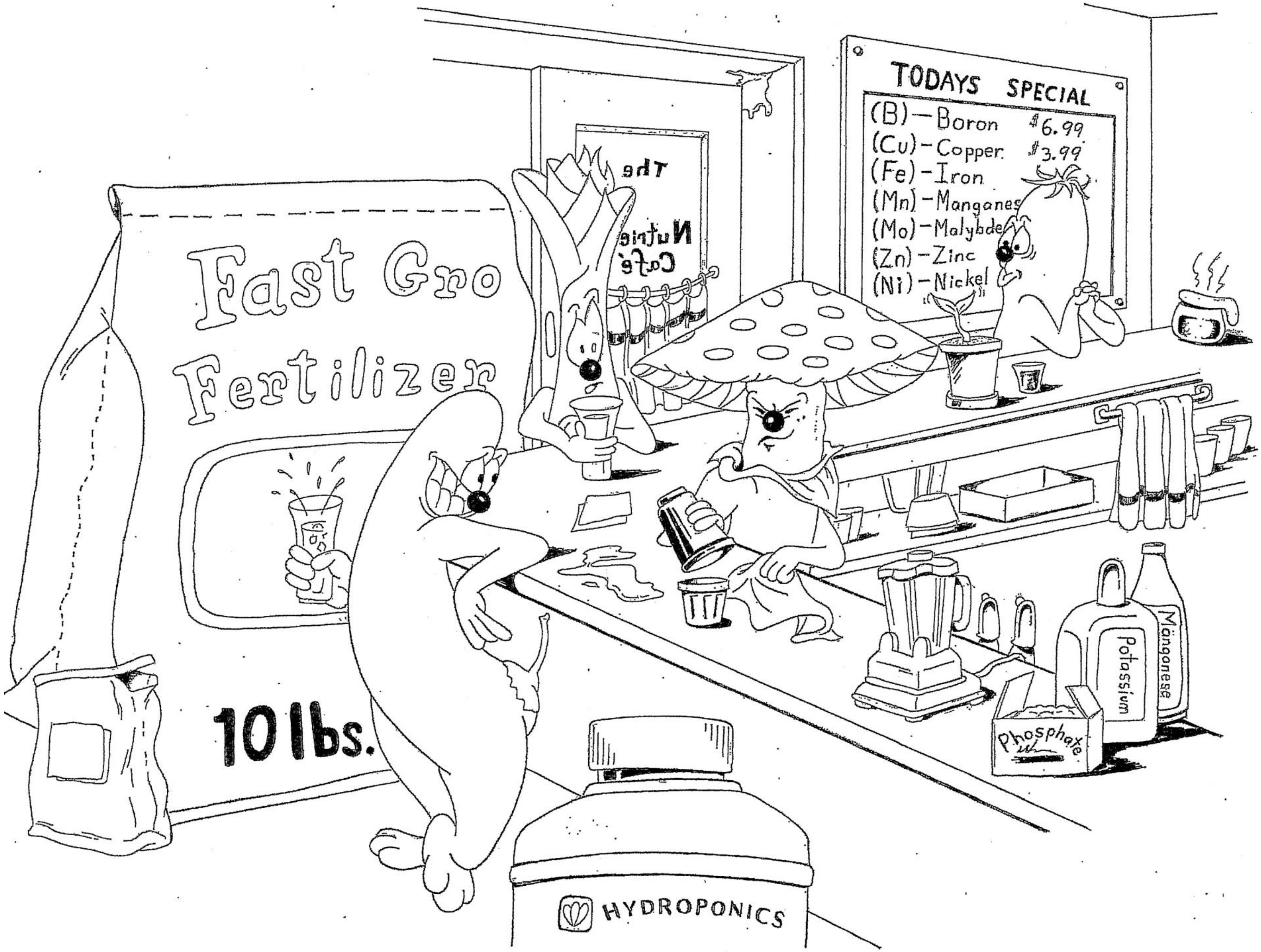
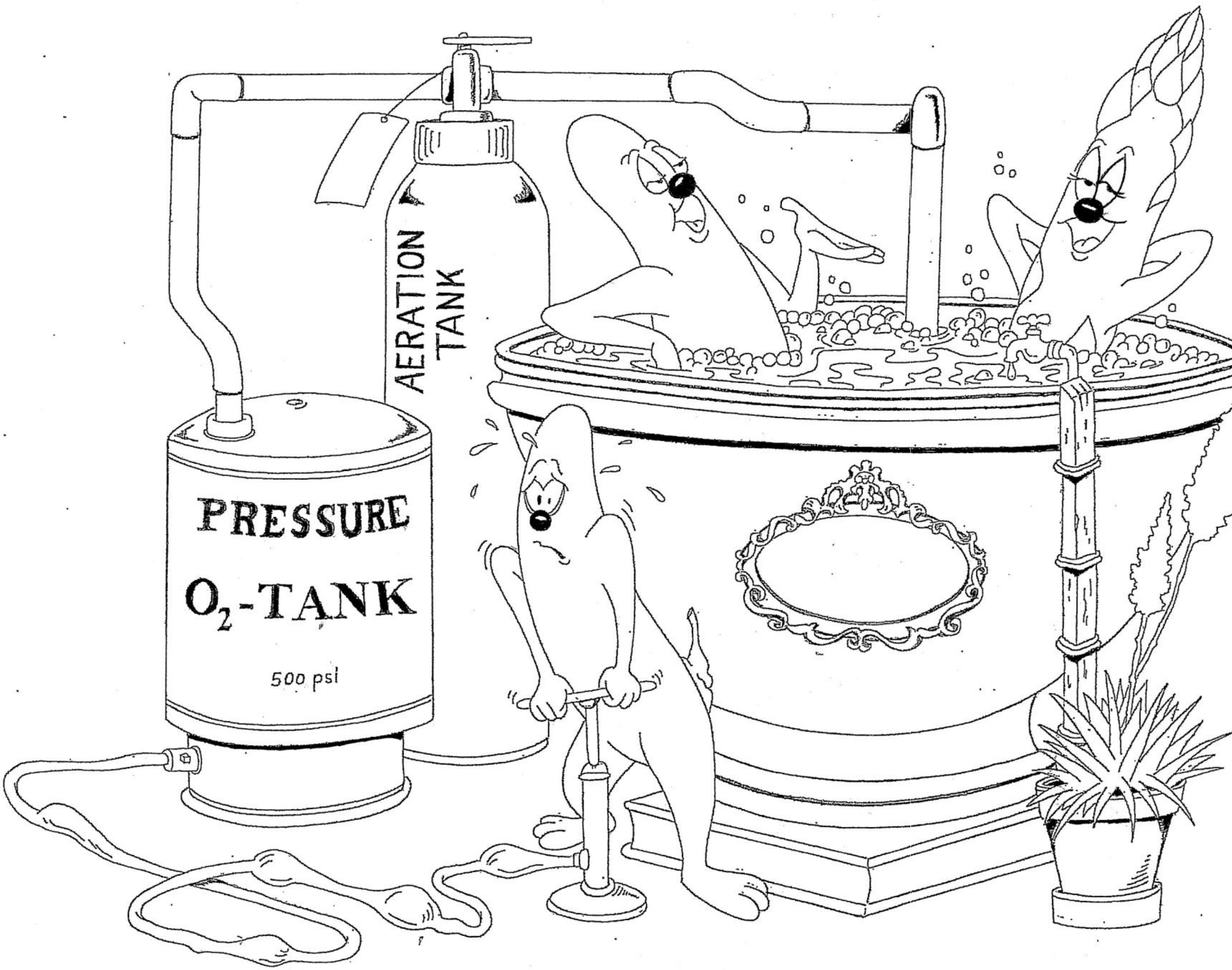
FLOWER
ANATOMY

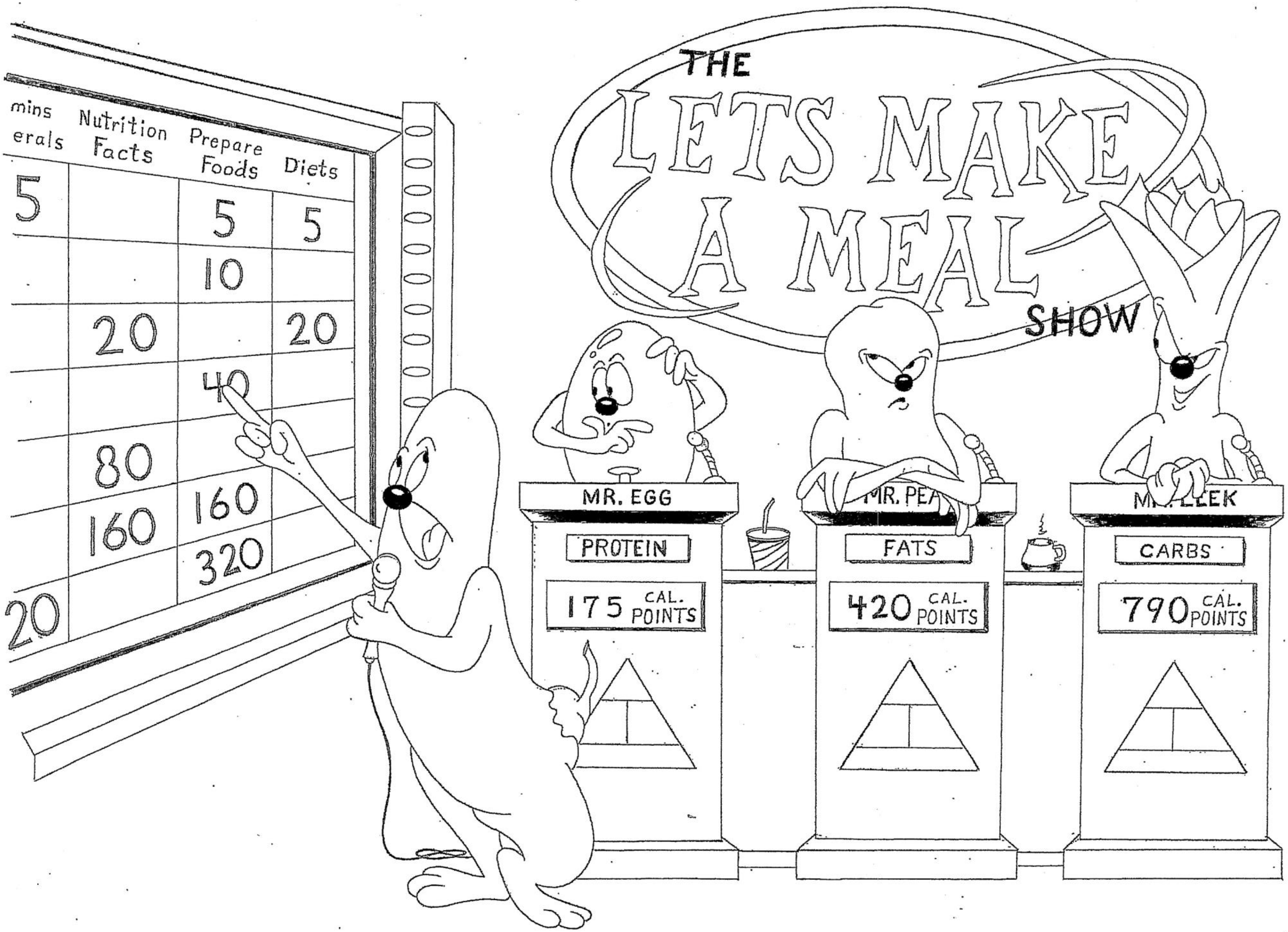



LED TIMES


PH-Stabilizer
12%
10%
PH


TODAYS SPECIAL
(B) — Boron $6.99
(Cu) - Copper $3.99
(Fe) - Iron
(Mn) - Manganes
(Mo) - Malybde
(Zn) - Zinc
(Ni) - Nickel
Fast Gro
Fertilizer
10 lbs.
HYDROPONICS
Potassium
Manganese
Phosphate


AERATION TANK
PRESSURE
O_2-TANK
500 psi


THE
LETS MAKE A MEAL
SHOW
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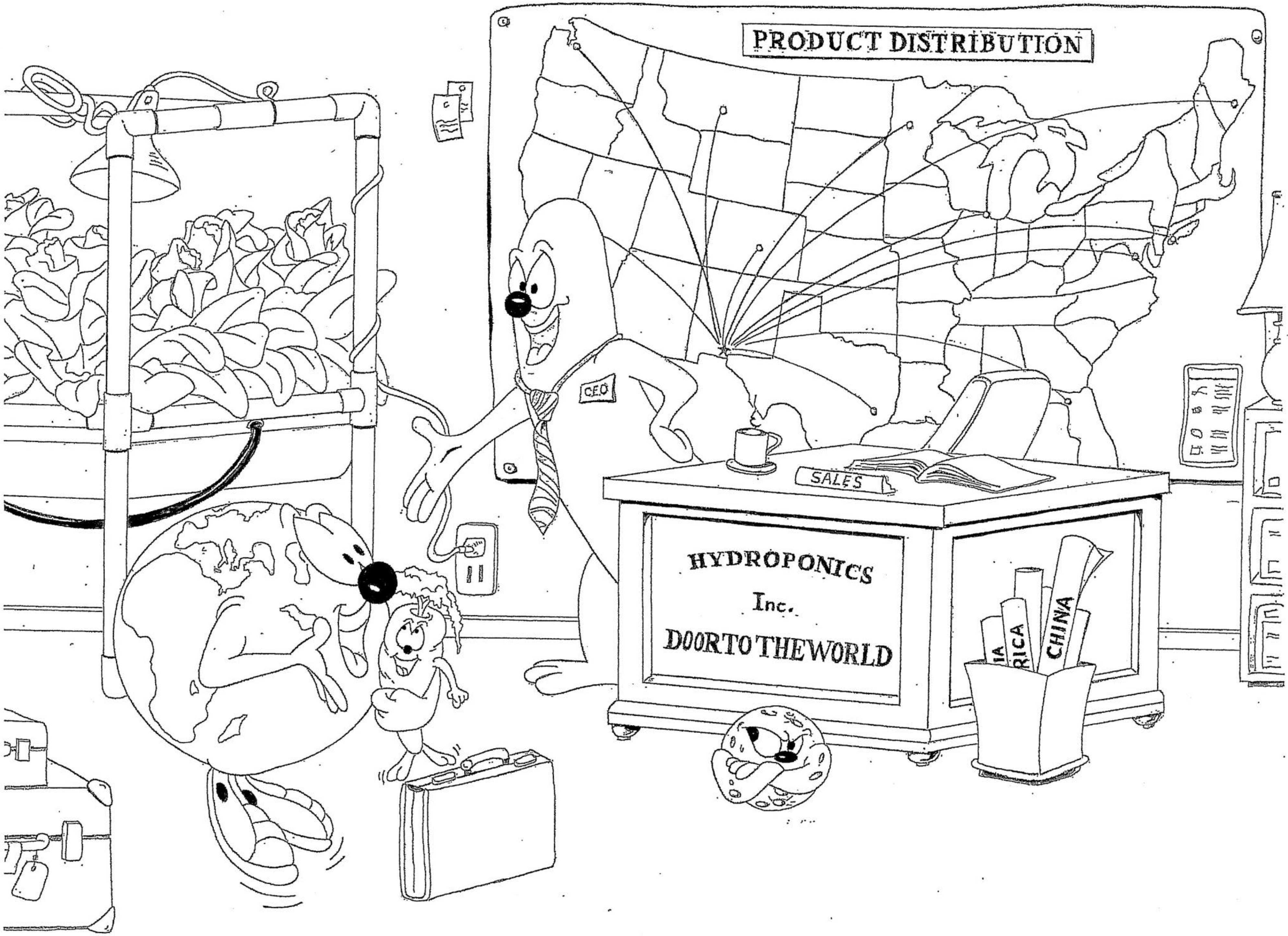
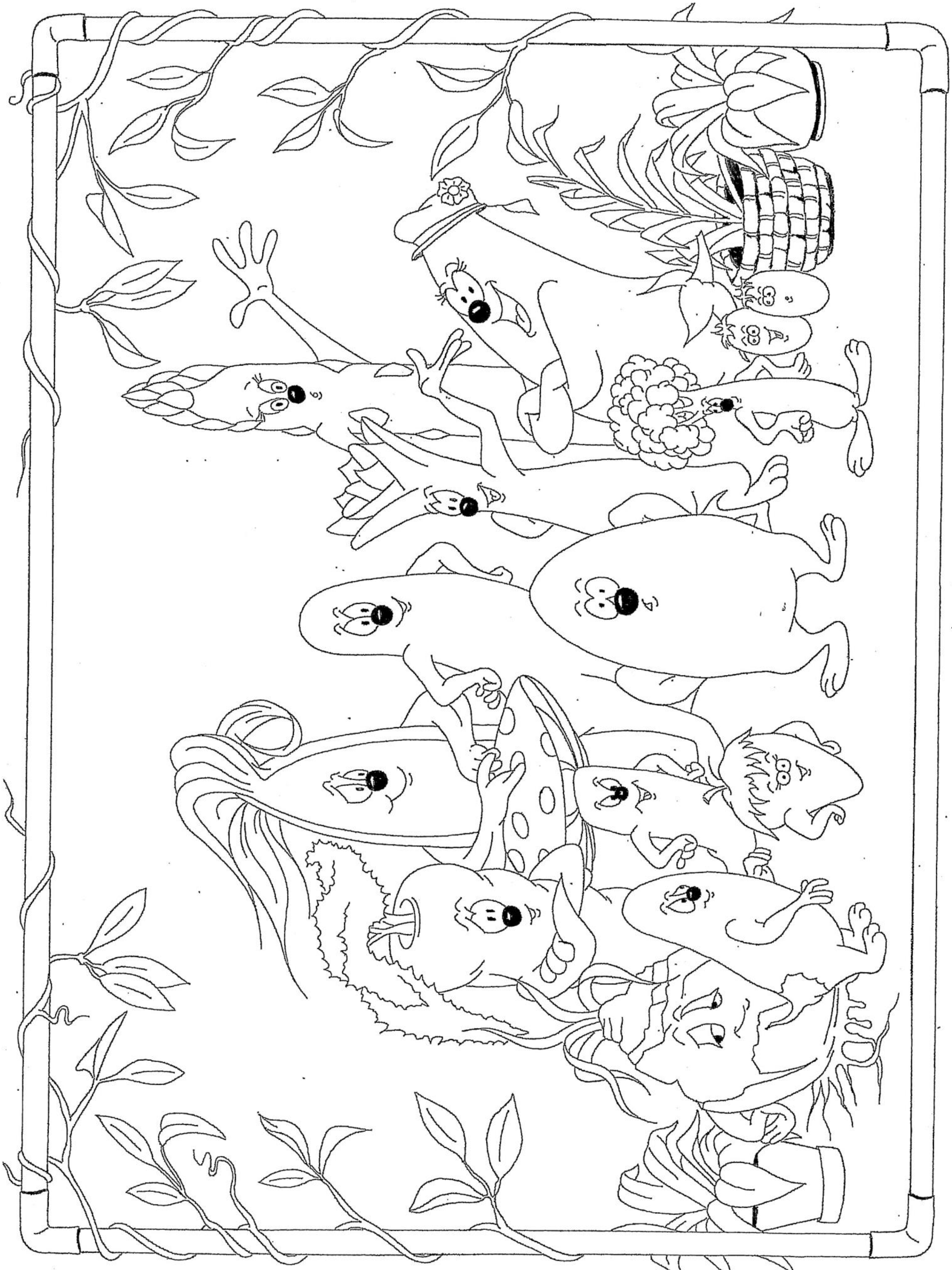
Nutrition Facts
Prepare Foods
Diets
5
5
5
10
20
20
40
80
160
160
320
20
MR. EGG
PROTEIN
175 CAL. POINTS
FATS
420 CAL. POINTS
CARBS
790 CAL. POINTS


PRODUCT DISTRIBUTION
CEO
SALES
HYDROPONICS
Inc.
DOORTOTHEWORLD
RICA
CHINA



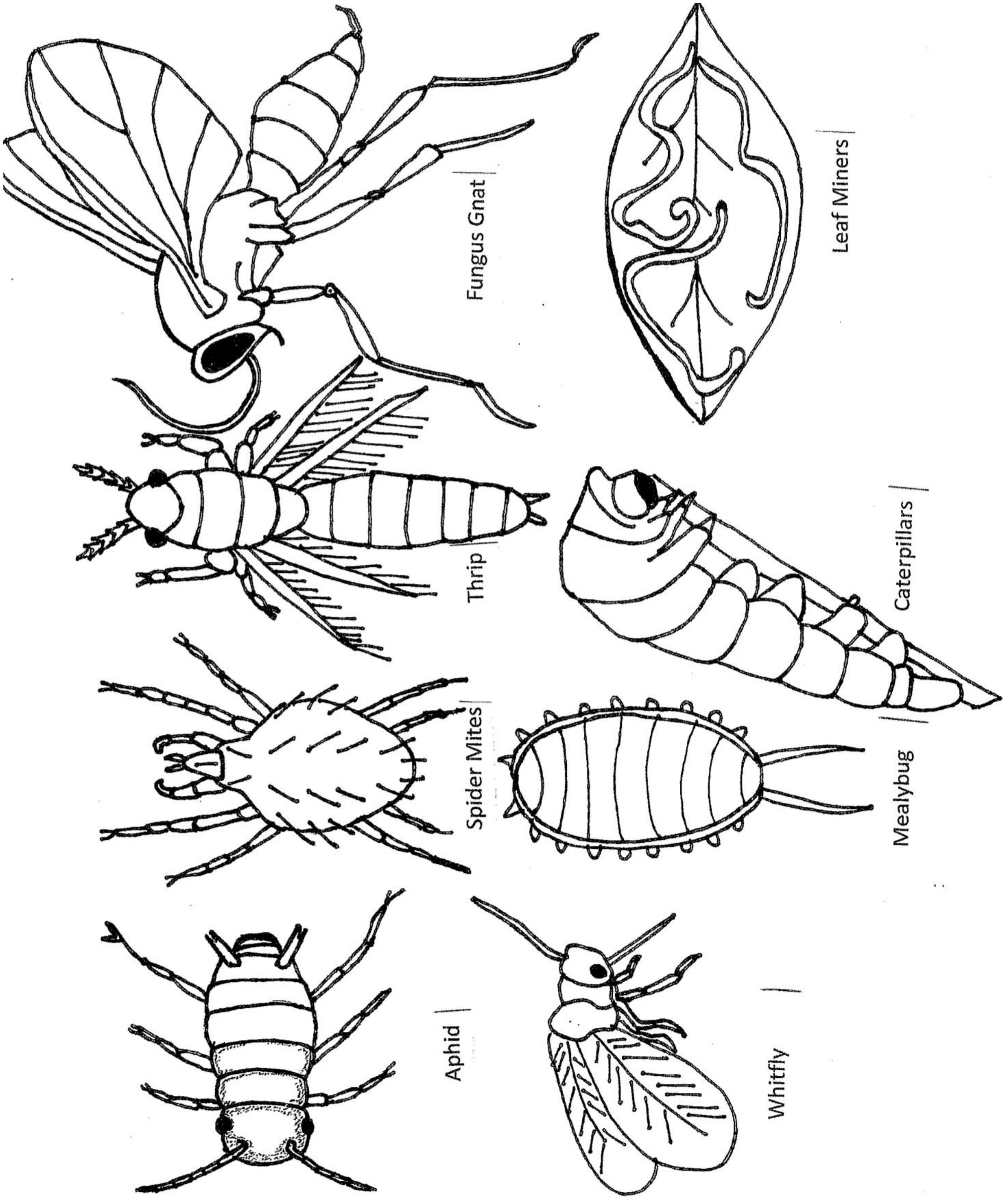


Image provided by: Adrian Walker, Las Vegas, Nevada