Introduction to Hydroponic Plant Production Systems

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What is hydroponics?

Growing plants hydroponically means that:

Plants grow without soil…

…in a water-based nutrient solution

…in materials that give plants the support they need…to thrive in a growth chamber with a delivery system that gets the nutrient solution to the plant roots…

…with either natural or artificial lighting.

Hydroponics has been around for over 2000 years… but technologies give it a new spin today!

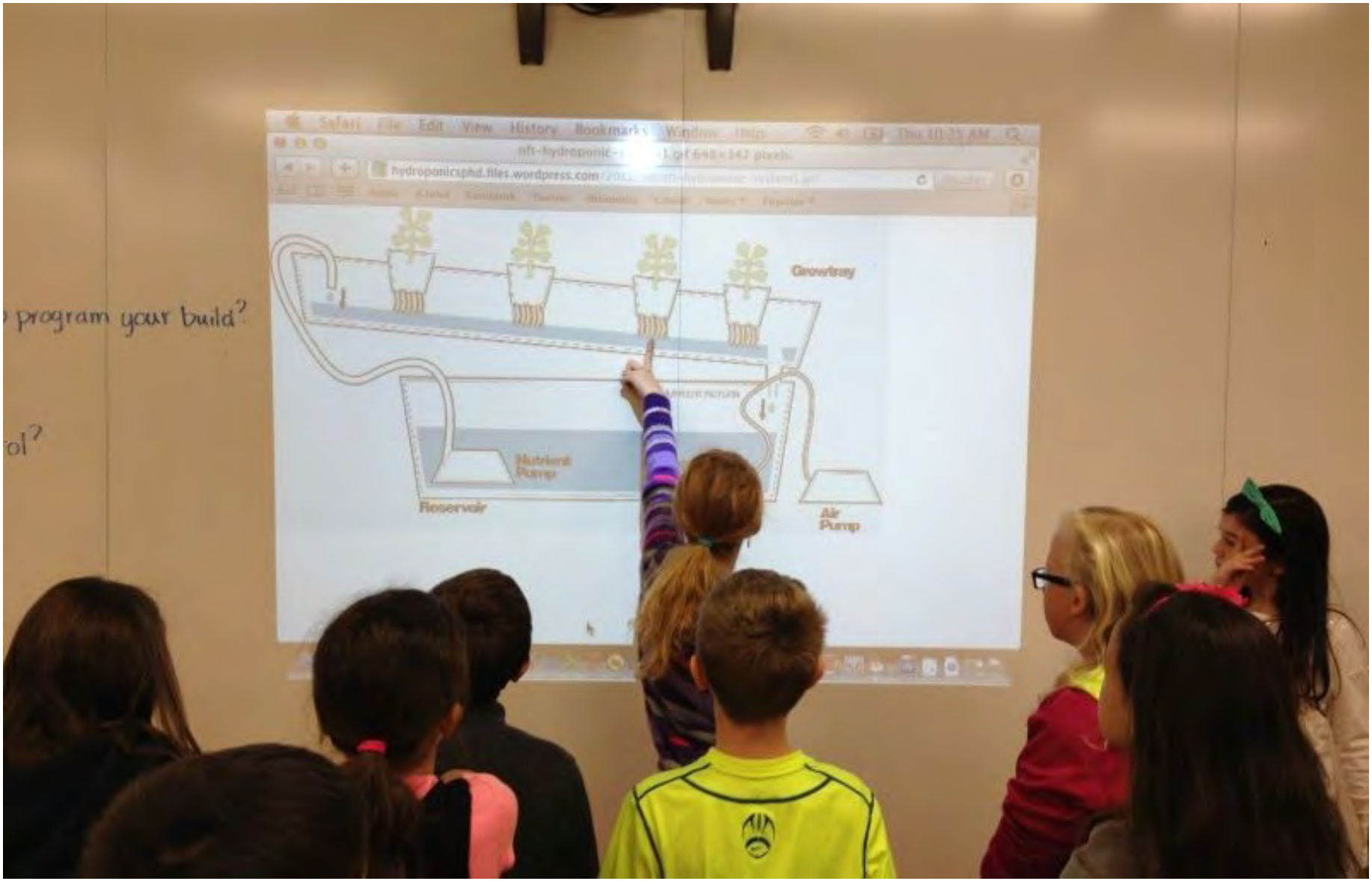

Image credit: Grow-It-To-Go project, South Fayette School District, PA

Here's one example of a technology-managed hydronic system…

Hydroponic: Advantages & Disadvantages

1. Healthier plants – having a near-perfectly balanced diet
2. Healthier consumers – less need to use herbicides, fungicides, and pesticides
3. Higher Yields – without water and nutrient stresses, plants grow faster and can be grown more compactly
4. Conservation – preventing evaporation and runoff
5. Year-round production schedule

1. Initial set up costs can be high
2. Because plants share nutrient fluids, diseases and pests can quickly move from plant to plant
3. Maintenance requirements can increase, depending on the system used and crop
4. A power outage can destroy a crop
5. Initial set up requires technical knowledge, time, and commitment

Teacher-friendly hydroponic systems

Types of Hydroponic Systems

- Passive
- Active
- Water Culture
- Media-Based

Information and diagrams from KidsGardening.org

PASSIVE SYSTEMS

These systems use no energy to move nutrients and water. They can be as basic as a perlite-filled flowerpot that is hand-watered regularly with nutrient solution. Passive systems often use a "wicking" material to draw up the liquid nutrients, or they simply suspend the plants in the solution with an air space around some of the root zone. They can be media-based or pure water-culture systems.

ACTIVE SYSTEMS

A hydroponic system is active if it relies on some type of energy (usually electricity via a pump) to move the nutrients in and out of the root zone area and to provide aeration. These systems, which can also be either media- or water-based, are generally used for larger plants (e.g., tomatoes and cucumbers) and tend to be more sophisticated. In recirculating or recycling systems, the nutrient solution is conserved by being recirculated either manually or electrically through the medium. These systems require closer monitoring of pH, nutrient concentration, and so on. Systems with pumps to aerate and deliver more oxygen to roots tend to produce healthier plants more quickly than do passive systems.


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Media-Based Systems

These types of hydroponic systems rely on some material, such as gravel, aggregate, perlite, vermiculite, or rockwool to support the plants and the roots in the nutrient solution. Such systems can be active or passive and may or may not recycle the nutrients.

Following are descriptions of some common types of media-based systems.

WICK SYSTEMS (PASSIVE)

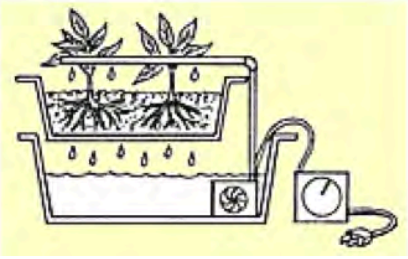
This is probably the simplest media-based system and a good one for exploring capillary action. A nutrient mix is drawn into the medium through nylon or cotton wicks immersed in a reservoir. This is commonly used in schools where the biggest challenge is making sure the plant roots get sufficient air and that the nutrient mix is diluted with water when the level drops.

EBB AND FLOW SYSTEMS (ACTIVE)

The plants and medium are flooded up to six times per day with the nutrient mix, then allowed to drain. As it drains, the system draws oxygen into the medium. These systems often incorporate automatic timers, but can be flooded by hand if you are very consistent. After several cycles, you must wash the roots and tank to remove any built-up, crusted salts.

TOP-FEED OR DRIP SYSTEMS (ACTIVE)

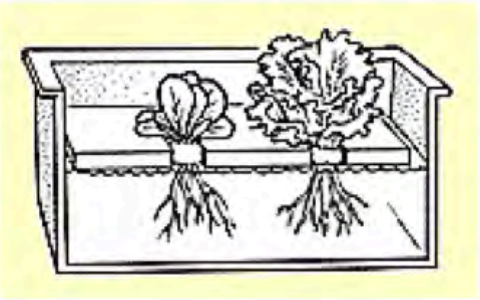
A timer-controlled pump delivers the nutrient mix on a regular schedule through "emitters" (pipes with holes) to the top of the plant medium and allows the mix to drip down into a catch basin below.



Wick-based systems

Water-Culture Systems

These systems do not use any medium other than water, so they require a support material such as wire mesh to keep the plants from drowning. These systems rely on regular contact between plant roots and the nutrient solution. Leafy crops like lettuce and herbs tend to do better in water culture than do fruiting crops like tomatoes, cucumbers, or peppers.

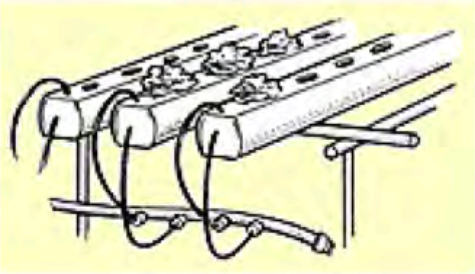


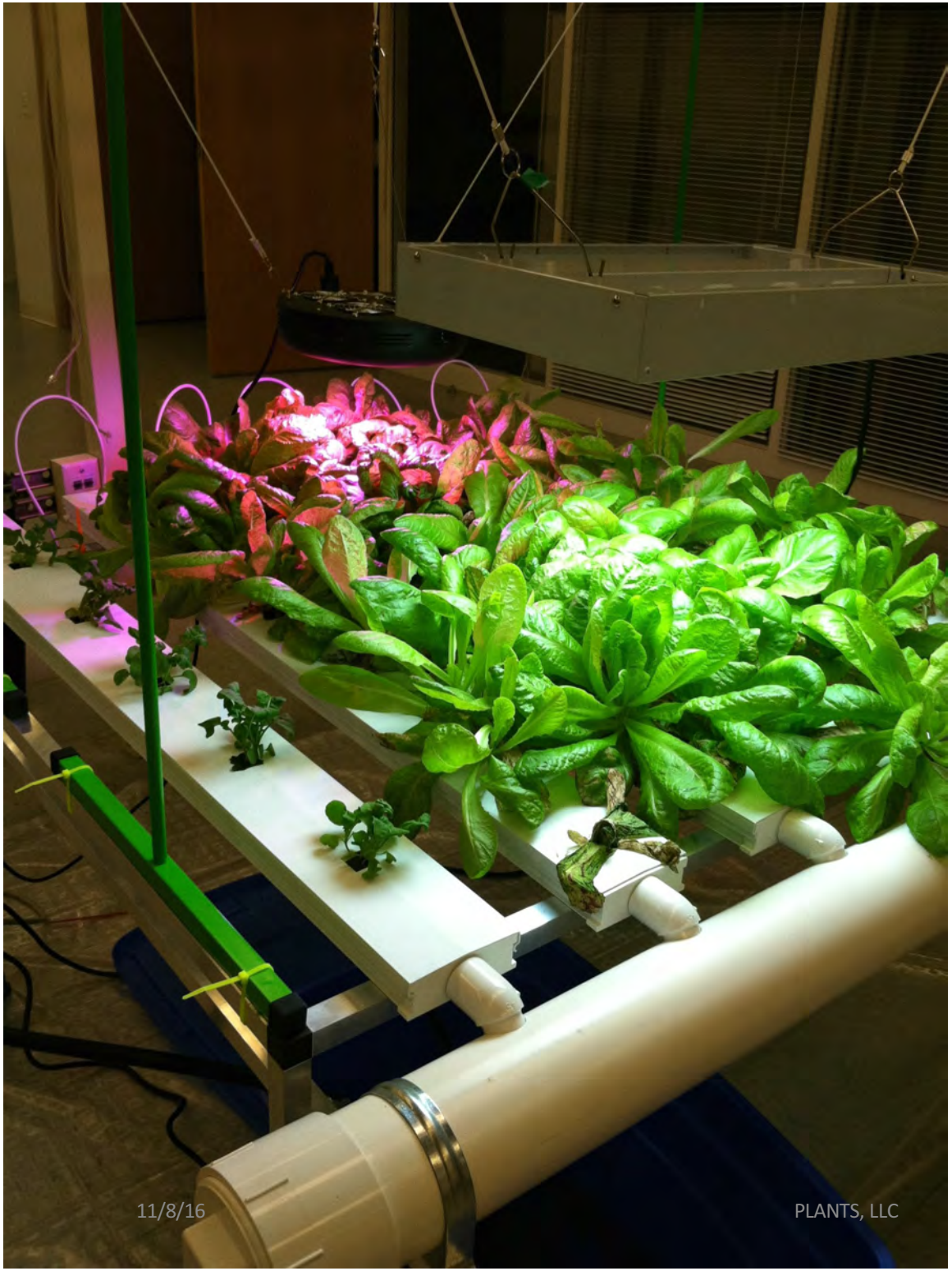
RAFT SYSTEM (ACTIVE OR PASSIVE)

In this system, plants float on rafts above a reservoir of nutrient solution. (Styrofoam rafts work well in the classroom.) The tips of the roots reach the liquid and the holes cut in the raft for the plants allow some air exchange. Many raft systems also aerate the water automatically, to provide the roots with greater exposure to oxygen.

NFT (NUTRIENT FLOW TECHNIQUE) (ACTIVE)

Plants are suspended in the nutrient mix, which is pump-circulated past the roots, aerating the solution. Commercial growers often place seedlings directly into rockwool cubes within holes cut in PVC pipe channels.






AeroGarden 3

WV STEM standards addressed through hydroponics activities in the classroom

Science

Grade-appropriate life science and earth science and physical science

Matter and Energy in Organisms and Ecosystems

Structure, Function, and Information Processing

Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

Technology

21st Century Learning Skills and Technology Tools Content Standards and Objectives for West Virginia Schools

Engineering

Engineering design

Math

Content targets grade-appropriate number and operation measurement, and geometry

Exploring plant mineral requirements

- The primary mineral nutrients plants require are **nitrogen** (N), **phosphorus** (P), and **potassium** (K).
- Secondary mineral nutrients include **calcium** (Ca), **magnesium** (Mg), and **sulfur** (S).
- Plants also need these micronutrients **boron** (B), **copper** (Cu), **iron** (Fe), **chloride** (Cl), **manganese** (Mn), **molybdenum** (Mo), and **zinc** (Zn).
- See interactive periodic table of plant nutrients at: http://www.cropnutrition.com/nutrient-knowledge
- See ***Plant Nutrition Activity***

Periodic Table of Crop Nutrients

Learn about the 17 essential plant nutrients and their roles in plant health. All crops must have an adequate supply of each of these 17 nutrients to produce optimum yields. In accordance with The Law of the Minimum, if one or more nutrients are lacking in the soil, crop yields will be reduced, even though an adequate amount of other elements is available. Crop yields may be limited by the element that is in shortest supply, so it helps to understand the key nutrients that are needed to make your crop thrive.

Click through the interactive Periodic Table of Crop Nutrients on the left to see the key benefits of each nutrient. Use the tabs to dig deeper into each nutrient, and see photos of nutrient deficiencies in common crops.

Studies of plant response to different types of **light** spectrums.

The image at left shows how four types of lettuce seeds respond to red, blue and white LED lighting.

The next image compares lettuce grown under florescent lighting on the left and red, blue, and white LED lighting on the right.

Explore using different materials to support plant growth.
For example, compare Vermiculite and Perlite as materials for seed germination.

This comparison includes 4 types of salad greens:

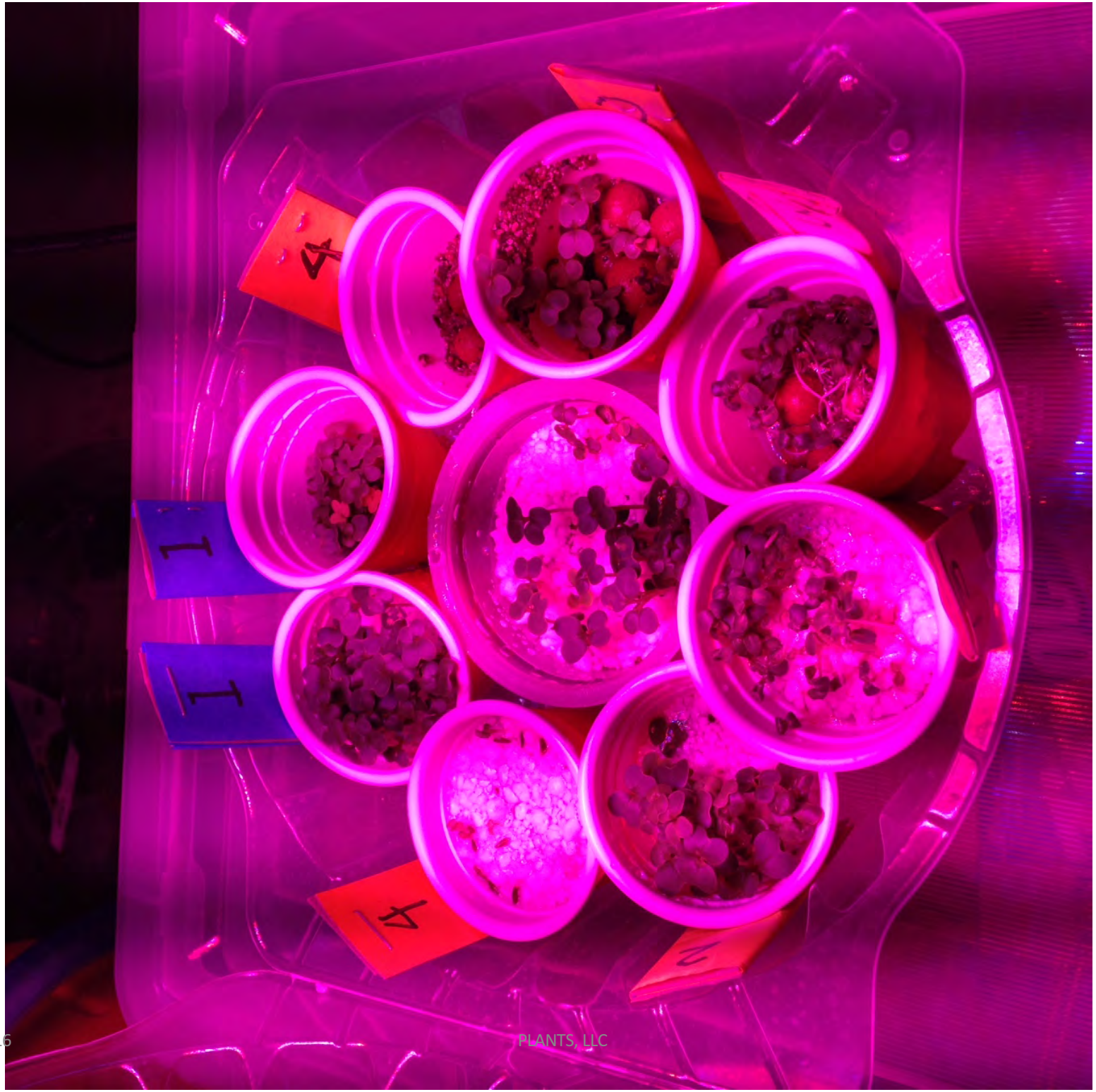
Plant1 - Brasica rapa var chinensis

Plant2 - *Brassica rapa* var. *perviridis*

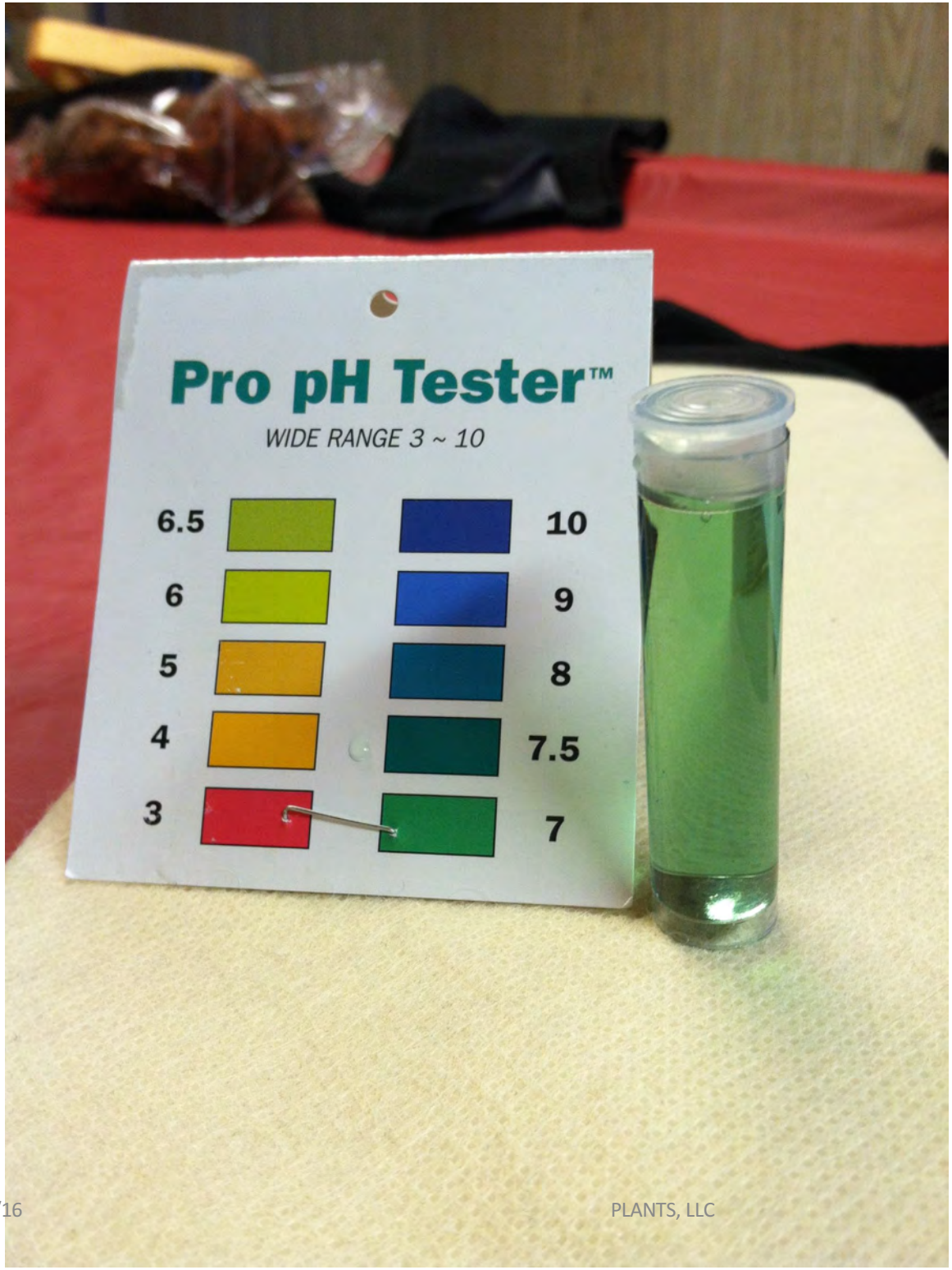
Plant3 – *Lactuca sativa var. longifolia*

Plant4 – *Lactuca sativa* ‘Grand Rapids’

Plants at Day6 viewed in natural light…



Plants at Day6 viewed in under LED (high energy) lighting



Explore water quality analysis using simple and/or more complex technology tools.


Leslie


bluelab guardian
monitor
Conductivity
units
270
EC/CF
TDS
(ECx500)
ppm
(ECx700)
Temperature
units
21
°C
°F
pH
pH
cal
6.5
7
4/10
www.getbluelab.com

Students design **Arduino controls** to monitor hydroponic system functions and processes such as:

- pH
- Temperature
- Electrical conductivity
- Water level
- Data logging

Use of IP WebCam for Plant Growth Images

- Images of hydroponic system can be accessed via app remotely.
- Saved images can be captured as still images or as video.

Compare & contrast the characteristics of different plant species and varieties.

OUTREDGEOUS Romaine Lettuce
Lactuca sativa

DEFENDER MT0 OG
Romaine Lettuce - Lactuca sativa

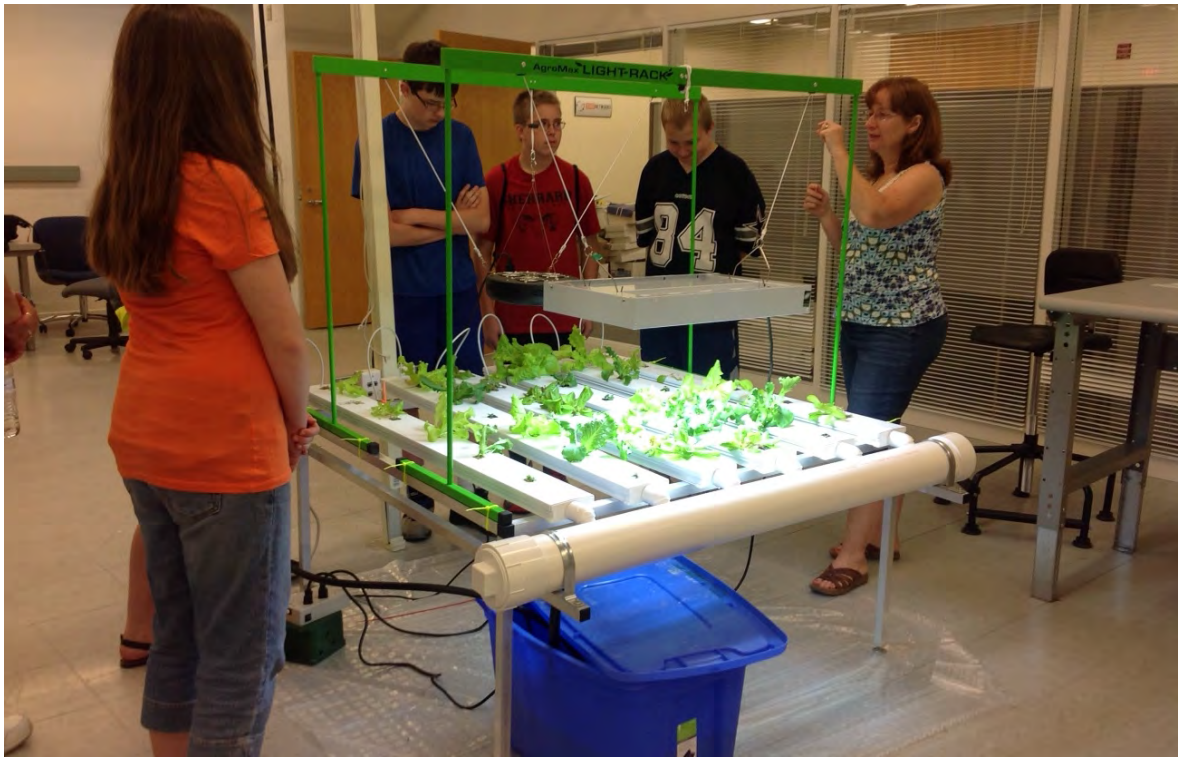
CELINET OG MT0
Summer Crisp Lettuce - Lactuca sativa

ARUGULA - Arugula Rocket

Grand Rapids (leaf)
Lactuca sativa (heirloom variety)

Forellenschluss -Austrian Heirloom Romaine- LECHUGA Forellenschluss

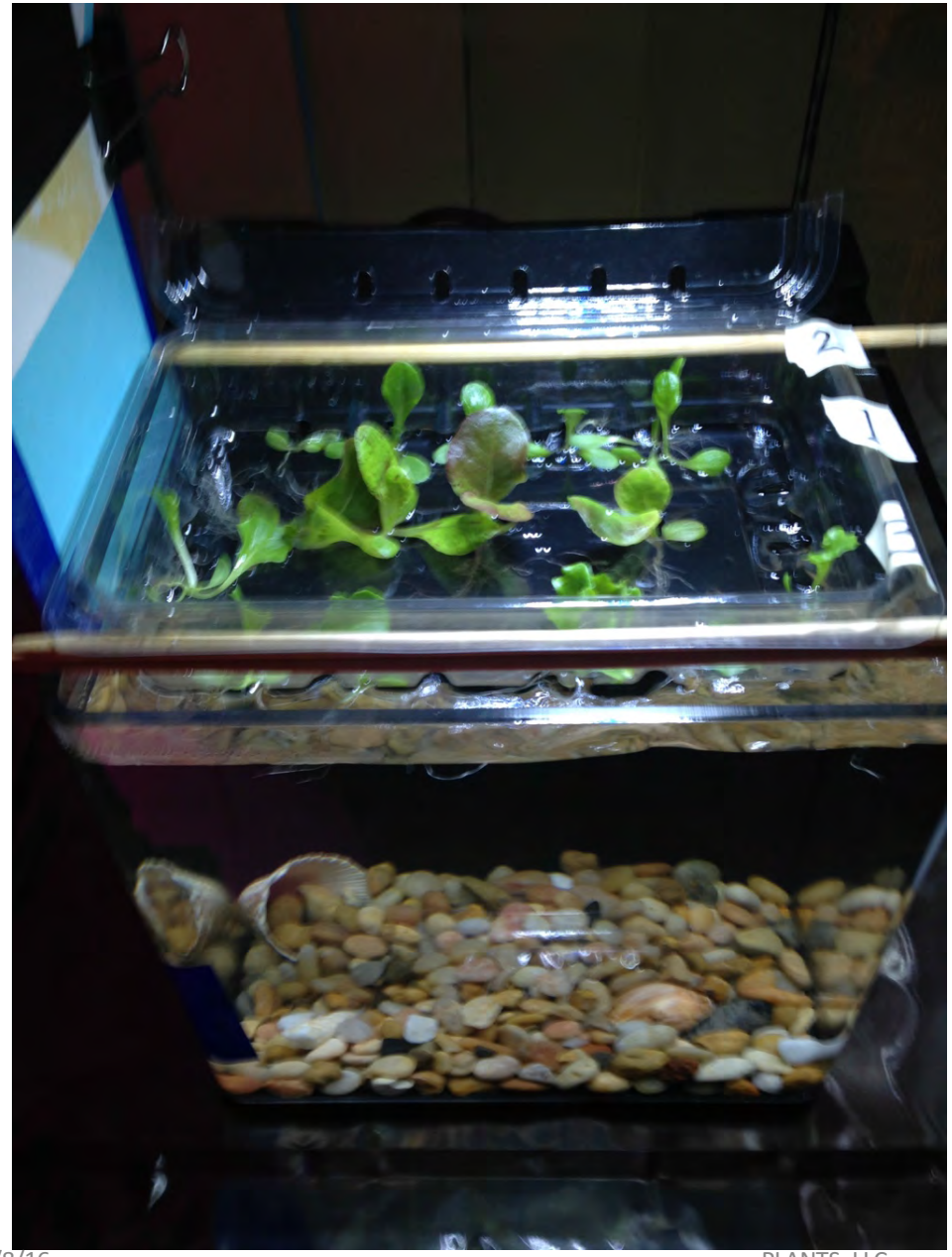
Set Up an NFT System in 5 Steps



1. Prepare seedlings
2. Analyze water
3. Prepare nutrient solution
4. Install seedlings
5. Monitor plants, nutrient solution, lighting

DIY Bucket Bubbler System: Read more at http://e-learningtalk.com

Aquaponics

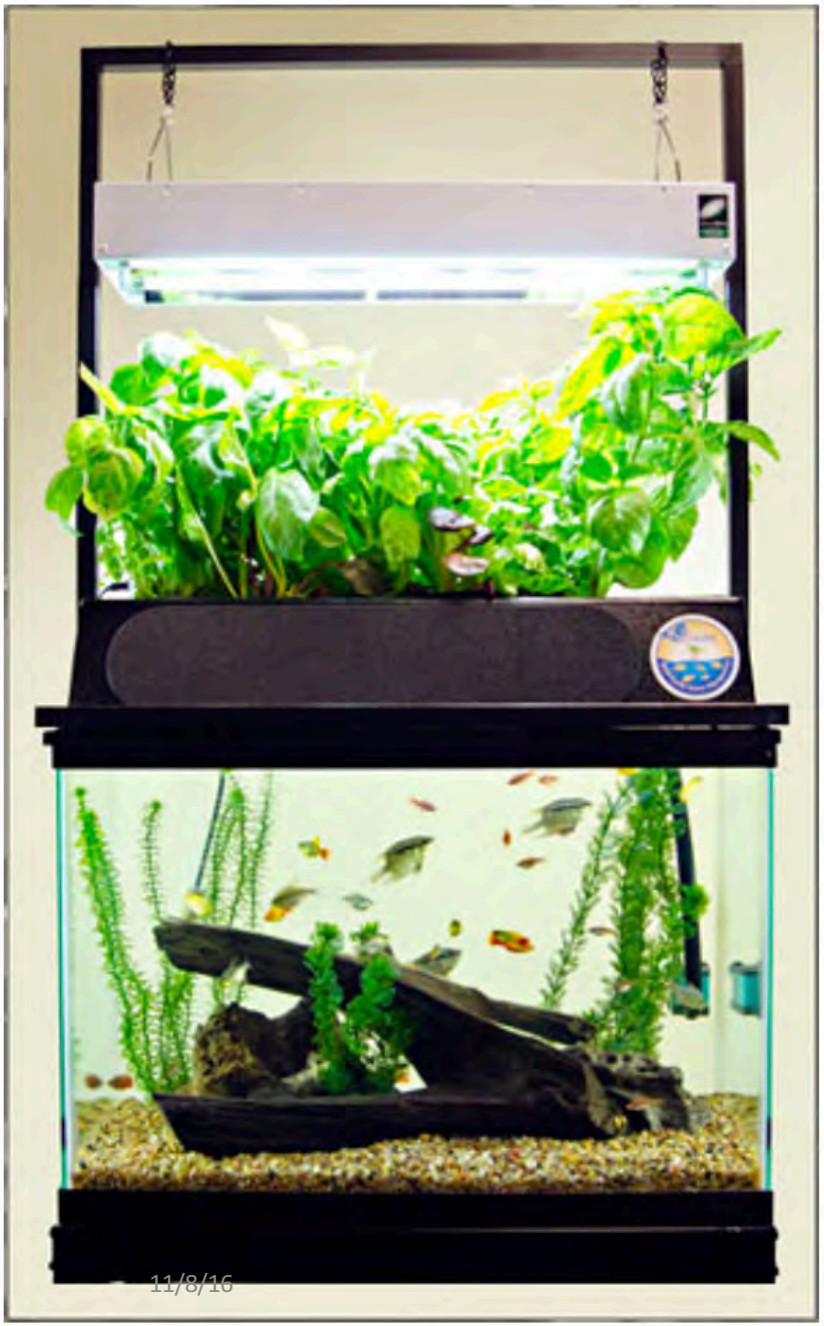


Aquaponics combines the hydroponic production of plants and the aquaculture production of fish into a sustainable agriculture system.

Aquaponics uses natural biological cycles to supply nitrogen and minimizes the use of nonrenewable resources.

Aquaponics provides economic benefits that can increase over time.

Aquaponics



Sustainable **Opportunities**:

- biological nitrogen production rates of 80 to 90 $g \cdot m^{-3}$ per day,
- nitrate nitrogen from trickling biofilters, and
- plant uptake of aquaculture wastewater.

Yielding improved water, nutrient use efficiency, and conservation

Challenges:

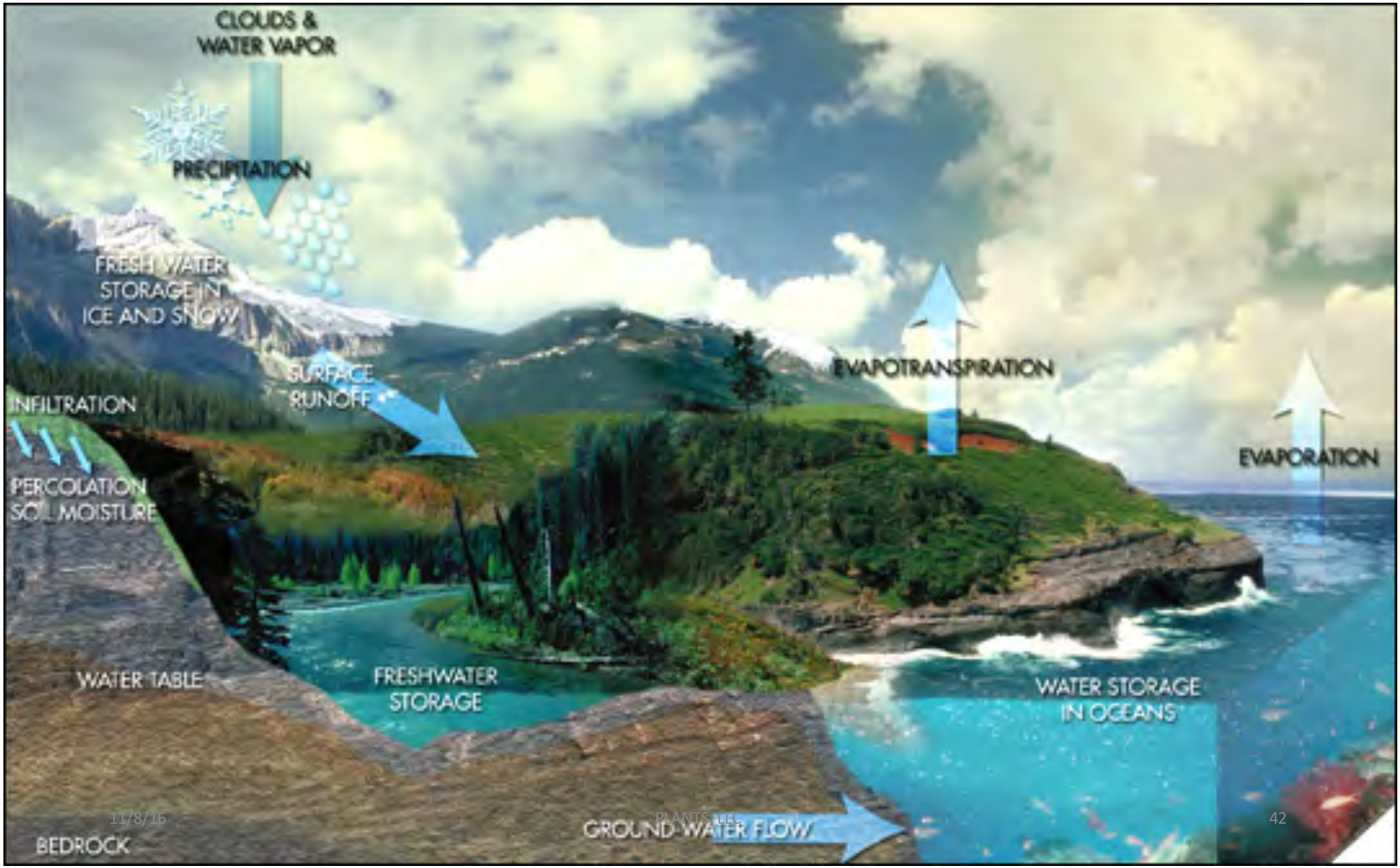
- balancing the system to optimize growth for 3 organisms,
- maximizing production outputs, and
- minimizing effluent discharges to the environment.

Introduction to DIY Aquaponics

A simple DIY Aquaponics system to introduce key elements of successfully integration of

- Plants
- Fish and
- Healthy bacteria

What role do plants play in Earth's water cycle?



Hydroponics technologies are applied by NASA to support humans in space-–i.e., this Veggie Machine is used on the ISS

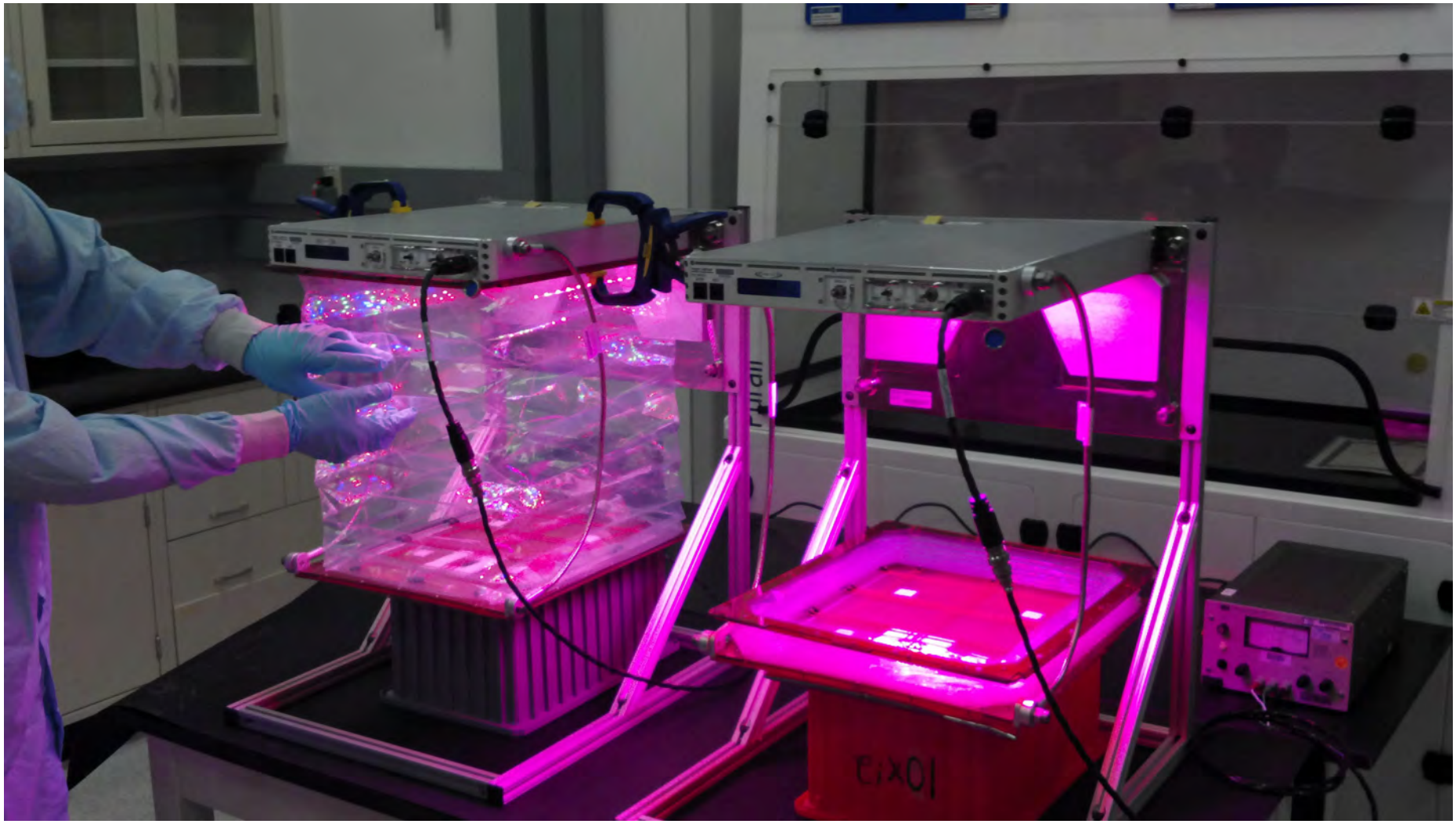


Image credit: NASA Space Station Research

Water: a critical factor for life as we know it

Image credit:
Earth Observatory

e-LearningTalk

Promoting science, technology, engineering, art & math (STEAM) education and sustainability practices.

Technical services include workshops, demonstration training, online professional development, research, and program evaluation.

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