Hydroponic Basics

Start to Building a Lesson Plan For Years K-6

I refuse to use “grades” because it suggests “harvesting”

Plants Need

1. Light: provide energy for photosynthesis, which makes sugars using equal parts water (H_2O) and carbon dioxide (CO_2) and releases an equal measure of oxygen (O_2).
2. Water (H_2O): absorbed via the roots for photosynthesis, keep the plant turgid (stiff), provides nutrient transport and lowers leaf temperature.
3. Nutrients: minerals needed for growth
4. Carbon Dioxide (CO_2): from air for sugar production and building block of cells
5. Oxygen (O_2): from air, during extended periods without sunlight, plants will consume their sugar supply and need Oxygen to reverse photosynthesis
6. Proper Temperature
7. Space to grow

Plants Need Nutrients

	Essential Nutrient	Function
Macronutrients From Water/Air	Carbon (C)	Proteins, protoplasts, enzymes, Photosynthesis
	Hydrogen (H)	Photosynthesis
	Oxygen (O)	Photosynthesis, sugar consumption
Macronutrients From Soil or Solution	Nitrogen (N)	Proteins, protoplasts, enzymes
	Phosphorous (P)	ATP, ADP, basal metabolism
	Potassium (K)	Water relations, energy relations, cold hardiness
	Calcium (Ca)	Cell structure, cell division, cell elongation
	Magnesium (Mg)	Chlorophyll, enzymes
	Sulfur (S)	Proteins, protoplasts, enzymes
Micronutrient From Soil or Solution	Boron (B)	Sugar translocation, cell development, growth regulators
	Chlorine (Cl)	Photosynthesis
	Copper (Cu)	Enzyme activation
	Iron (FE)	Chlorophyll synthesis, metabolism, enzyme activation
	Manganese (Mn)	Hill reaction-photosystem II, enzyme activation
	Molybdenum (Mo)	Nitrogen fixation, nitrogen use
	Nickel (Ni)	Iron metabolism
	Zinc (Zn)	Protein breakdown, enzyme activation

https://www.extension.uidaho.edu/publishing/pdf/CIS/CIS1124.pdf

Nutrient Lookout – A Major Problem

- What is it? A “term describing deficiencies in a plant’s ability to absorb nutrients”

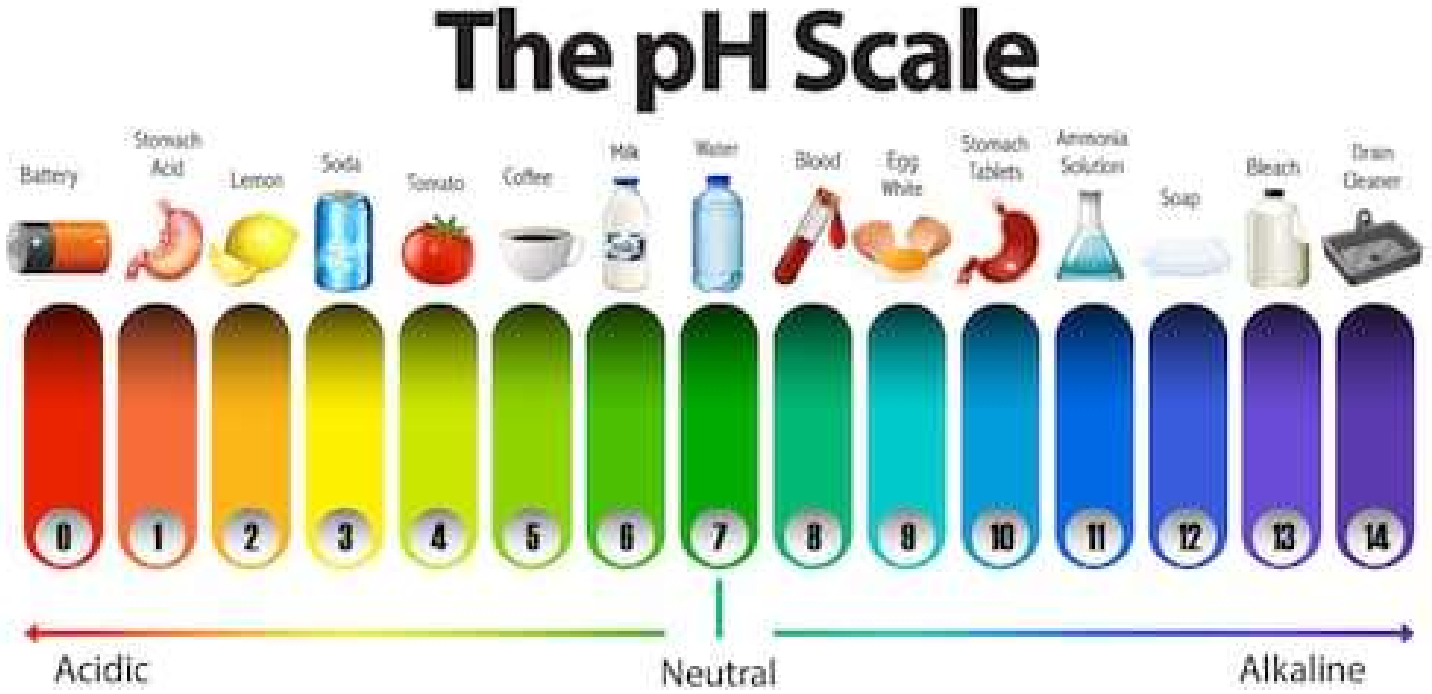
- Why? “Sub-optimal pH levels in the nutrient solution or reactions involving the dissolved nutrients, which remove their availability to be absorbed”

Nutrients becoming Useless

Even though They ARE Present

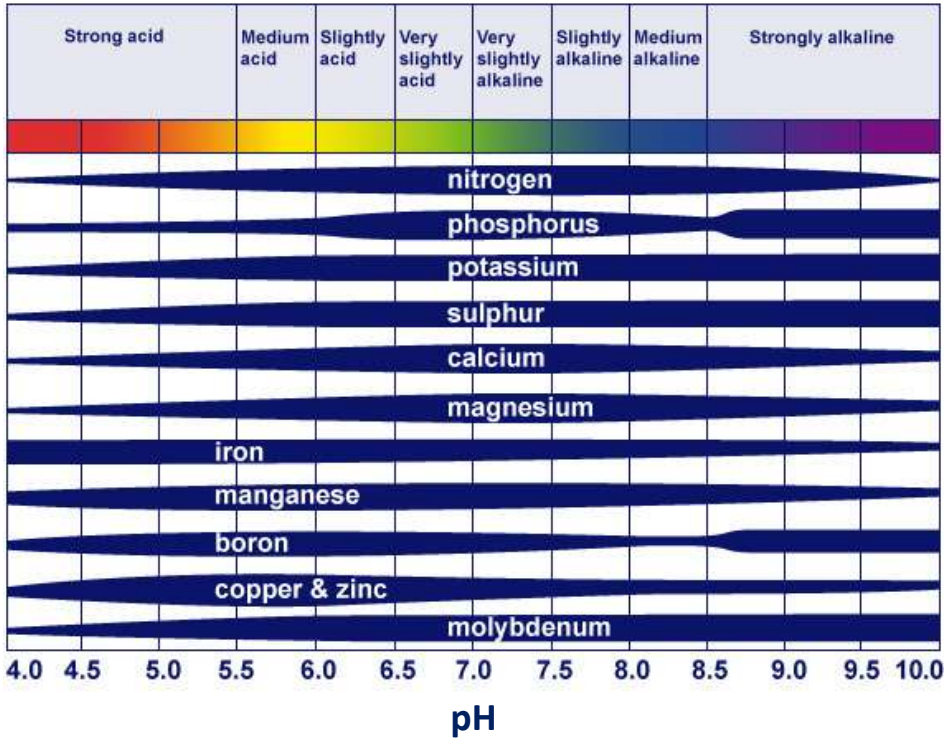
What is pH (potential Hydrogen)

A scale showing the relative concentration of Acidic or Alkaline present



Roots Absorb Nutrients

- To be absorbed by the roots, nutrients must first be in solution
- Rate of absorption by roots depends on the pH of the solution, which varies by plant



https://futureharvest.com/blogs/articles/nutrient-lockout-for-dummies-part-2

https://www.oysoco.com/hydroponics/10-hydroponics/60-everything-you-need-to-know-about-nutrient-lockout

Controlling pH and Prepare Water

- If starting with city supplied water, let water stand for 1 day to let dissolved gaseous chlorine to escape
- Determine desired pH, normally 6.0 to 6.5 range, slightly acidic
- Determine pH of solution (water initially) using a test kit or a meter
  - To lower pH - use pH Down solution, which is a stronger corrosive acid
  - To raise pH – use pH Up solution, which is a stronger alkali
  - Amount depends on how much water one is trying to balance, may start using drops, not measuring cups
- Retest and add more pH Up or pH Down until the desired level is reached

Acceptable Concentration of Nutrients

- Dissolved nutrients are salts

- Concentration can be measured by electric resistance
  - Conductivity Factor (cF) (10CF)
  - Electro-Conductivity (CF) (milliSiemens)
  - Positive Ions (PPM) (ppm – parts per million)

- Temperature and regional climate conditions affect pH of water

Comparison of pH & Salinity for Various Crops – Hydroponic Applications

Plants	pH	cF	EC	PPM
Ambra radicchio	5.5-6.5			
Artichoke	6.5-7.5	8-18	0.8-1.8	560-1260
Asparagus	6.0-6.8	14-18	1.4-1.8	980-1260
Bean (Common)	6	20-40	2-4	1400-2800
Beans (Italian bush)	6.0-6.5			
Beans (Lima)	6.0-6.5			
Beans (Pole)	6.0-6.5			
Beetroot	6.0-6.5	8-50	0.8-5	1260-3500
Broad Bean	6.0-6.5	18-22	1.8-2.2	1260-1540
Broccoli	6.0-6.5	28-35	2.8-3.5	1960-2450
Brussell Sprout	6.5-7.5	25-30	2.5-3.0	1750-2100
Cabbage	6.5-7.0	25-30	2.5-3.0	1750-2100
Capsicum	6.0-6.5	18-22	1.8-2.2	1260-1540
Carrots	6.3	16-20	1.6-2.0	1120-1400
Cauliflower	6.0-7.0	5-20	0.5-2.0	1050-1400
Celery	6.5	18-24	1.8- 2.4	1260-1680
Collard greens	6.5-7.5			
Cucumber	5.8-6.0	17-25	1.7-2.5	1190-1750
Eggplant	5.5-6.5	25-35	2.5-3.5	1750-2450
Endive	5.5	20-24	2.0-2.4	1400-1680
Fodder	6	18-20	1.8-2.0	1260-1400
Garlic	6	14-18	1.4-1.8	980-1260
Leek	6.5-7.0	14-18	1.4-1.8	980-1260
Lettuce	5.5-6.5	8-12	0.8-1.2	560-840
Marrow	6	18-24	1.8-2.4	1260-1680

Plants	pH	cF	EC	PPM
Okra	6.5	20-24	2.0-2.4	1400-1680
Onions	6.0-6.7	14-18	1.4-1.8	980-1260
Pak Choi	7	15-20	1.5-2.0	1050-1400
Parsnip	6	14-18	1.4-1.8	980-1260
Pea	6.0-7.0	8-18	0.8-1.8	980-1260
Peas (Sugar)	6.0-6.8			
Pepino	6.0-6.5	20-50	2.0-5.0	1400-3500
Peppers	5.8-6.3	20-30	2.0-3.0	1400-2100
Bell peppers	6.0-6.5	20-25	2.0-2.5	1400-1750
Hot Peppers	6.0-6.5	30-35	3.0-3.5	2100-2450
Potato	5.0-6.0	20-25	2.0-2.5	1400-1750
Pumpkin	5.5-7.5	18-24	1.8-2.4	1260-1680
Radish	6.0-7.0	16-22	1.6-2.2	840-1540
Spinach	5.5-6.6	18-23	1.8-2.3	1260-1610
Silverbeet	6.0-7.0	18-23	1.8-2.3	1260-1610
Sweet Corn	6	16-24	1.6-2.4	840-1680
Sweet Potato	5.5-6.0	20-25	2.0-2.5	1400-1750
Swiss chard	6.0 6.5			
Squash (Summer)	5.0-6.5			
Squash (Winter)	5.0-6.5			
Taro	5.0-5.5	25-30	2.5-3.0	1750-2100
Tomato	5.5-6.5	20-50	2.0-5.0	1400-3500
Turnip	6.0-6.5	18-24	1.8-2.4	1260-1680
Zucchini	6.0	18-24	1.8-2.4	1260-1680

https://growguru.co.za/blogs/hydroponic/ph-ppm-ec-water-for-hydroponic-plants

How to Fix Nutrient Lockout

- Important to flush (remove impurities) hydroponic systems regularly, because salt and precipitate builds over time
- Drain all solution and tip away. Perhaps outdoors for disposal
- Clean reservoir thoroughly, using some kind of scraper if necessary
- Circulate system with plain water to remove all impurities. Slightly acidic flushing agents are available to break salts down. Throw away
- Repeat and fill with plain water for 24 hours while the system runs continuously, adjust pH accordingly, run another 24 hours and the discard
- Fill system with pH balanced nutrient solution and let run
- Change nutrient solution every couple of weeks and every other time flush the system
- Flush one week before harvesting crop

https://www.oysoco.com/hydroponics/10-hydroponics/60-everything-you-need-to-know-about-nutrient-lockout

Growing Media

Growing Media	Benefits	Downside
Coco Peat/Coco Coir	• Usually Organic • Sustainable • Compactable, buy compressed – less shipping	• Holds a lot of water, could drown plants
Expanded Clay Pellets	• Reusable • pH Neutral • Do not compact	• Heavy • Drain and dry very fast • Stripped mined (environmental concerns)
Sure-To Grow (plastic)	• Roots embed deeply – medium and plant become one	• Expensive • Not reusable • Need top layer to stay 100% dry to avoid algea
Oasis Cubes	• Inexpensive • No presoaking	• Not sustainable • Not organic • Useful for germination only, not as full growing medium
Perlite	• Lightweight • High oxygen retention	• Too lightweight for certain systems • Stripped mined (environmental concerns) • Potential particle inhalation danger
Starter Plugs	• Compact • Great for starting seeds • Relatively sustainable	• Only suitable for starting seeds or cloning • Expensive
Rockwool	• Great water retention • Easy to dispose of	• Not environmentally friendly • Not healthy to be around • Naturally high pH

Growing Media (Continued)

Growing Media	Benefits	Downside
Grow Stones	• Lightweight • Great air to water ratio • Sustainable	• Hard to clean
Rice Hulls	• Makes us of a byproduct, otherwise wasted • Retains little water	• Decays over time
Pumice	• Lightweight • High oxygen retention	• Too lightweight for certain systems
Sand	• Cheap • Easy to find	• Heavy • Low water retention • Small size may affect certain systems
Gravel	• Very inexpensive • Easy to clean • Drains well	• Heavy • Plant roots can dry out • Not suitable for certain systems
Wood Fiber	• Organic • Holds structure for a long time	• Biodegradable • May not be sterile • May attract pests
Brick Shards	• Inexpensive • Easy to clean • Drains well	• May affect pH • Requires more thorough cleaning • Heavy • Plant roots may dry out

Growing Media (Continued)

Growing Media	Benefits	Downside
Polystyrene Packing Peanuts	• Cheap, often free • Very lightweight • Drain well	• Only polystyrene work – biodegradable packing peanuts turn to slush • Potential for plants to absorb styrene
Vermiculite	• Water retention	• Hard to find • Expensive • Can hold too much water

https://www.epicgardening.com/hydroponic-growing-media/

Types of Hydroponic Systems

- Wick Systems
- Deep Water Culture (DWC)
- Nutrient Film Technique (NFT)
- Ebb and Flow (Flood and Drain)
- Aeroponics
- Drip Systems

https://www.epicgardening.com/hydroponic-systems/

Comparison of Systems

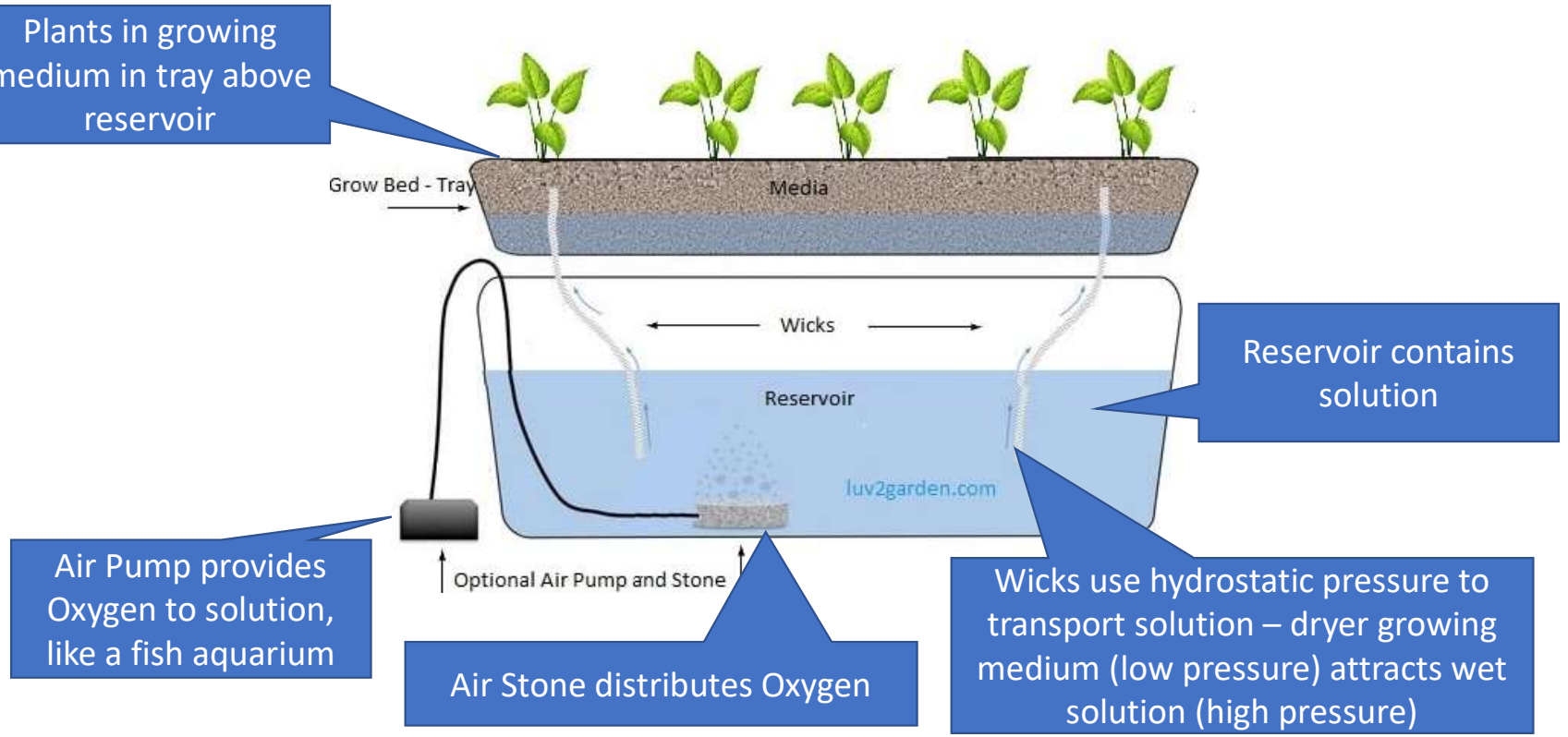
Growing Media	Benefits	Downside
Wick System Wick lifts water to roots using hydrostatic pressure	• Truly “hands off” if set-up correctly • Fantastic for small plants	• Not good for larger plants • Incorrect wick placement can mean death
Deep Water Culture (DWC) System Roots are suspended in the solution to get a constant supply of water, oxygen and nutrients	• Very inexpensive and easy to make at home • Extremely low maintenance • Recirculating, so less wasted inputs	• Does not work well for large plants • Does not work well for long growing periods
Nutrient Film Technique (NFT) System Plants grow in channels with constantly flowing solution, which drains into reservoir	• Minimal growing medium needed • Recirculating system means less waste	• Pump failure (any kind) can ruin crop • Roots can overgrow and clog channels
Ebb and Flow / Flood and Drain System Like DWC or NFT, but plants grow in a medium, which is flooded and then drained	• Efficient use of water and energy • Highly customizable	• Roots can dry quickly if environmental conditions are off, pump fails, or timer fails • Uses a lot of growing medium
Aeroponics System Plants are suspended and frequently misted	• Roots often exposed to more oxygen than submerged systems	• High pressure nozzles fail, roots dry out • Not as cheap or easy to set up
Drip System Solution drips into each plant and excess drains back to reservoir	• High level of control over feeding and watering schedule • Less likely to break • Relatively cheap	• Maybe overkill for a small garden • Fluctuating pH and nutrient levels if recirculating • High waste is using waste system

Nutrient Solution – Common Factor of All Systems

Nutrient Solution consists of

1. Water
2. Nutrients
3. pH adjustment

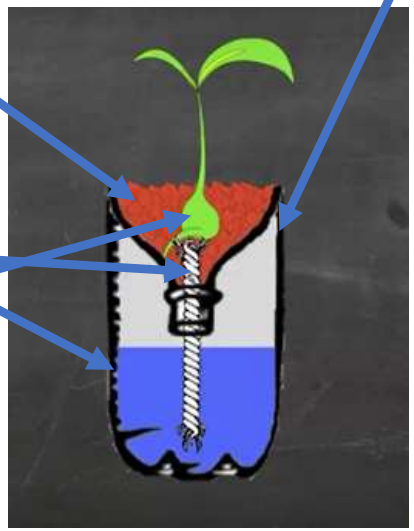
Wick System – Oldest Type of Hydroponics



Wick System – 2 Liter Bottle Experiment

Need

1. 2 Liter Bottle with top removed and inverted
2. Growing Media (Coco Coir)
3. Nutrient Solution
4. Wick Material
5. Aluminum Foil
6. Seedling



Aluminum Foil to wrap the bottle to remove light that can induce algae in the solution

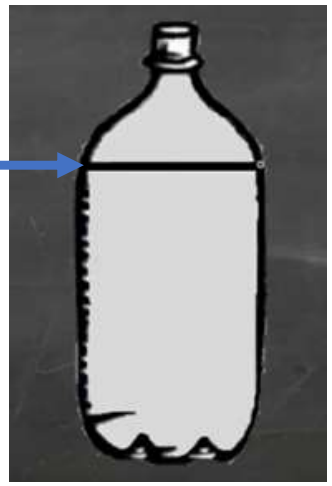
https://www.epicgardening.com/hydroponic-systems/

Wick System – 2 Liter Bottle Experiment

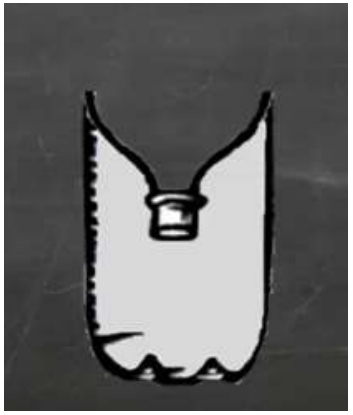
Step 1

1. Identify where the bottle narrows
2. Draw a cut line around bottle
3. Cut along line to remove top
4. May want to insert wick
5. Before inverting top and inserting into the bottle as shown

Cut Bottle where it begins to narrow



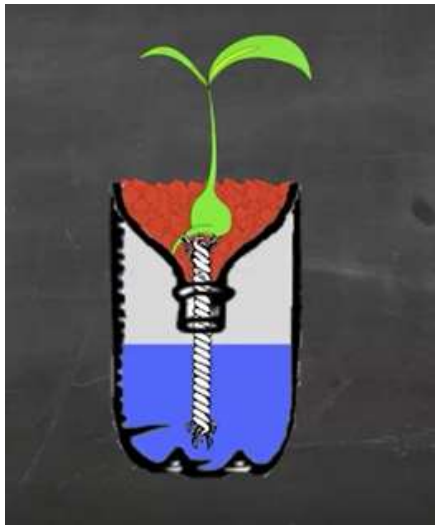
So the top can be inverted and placed into bottom



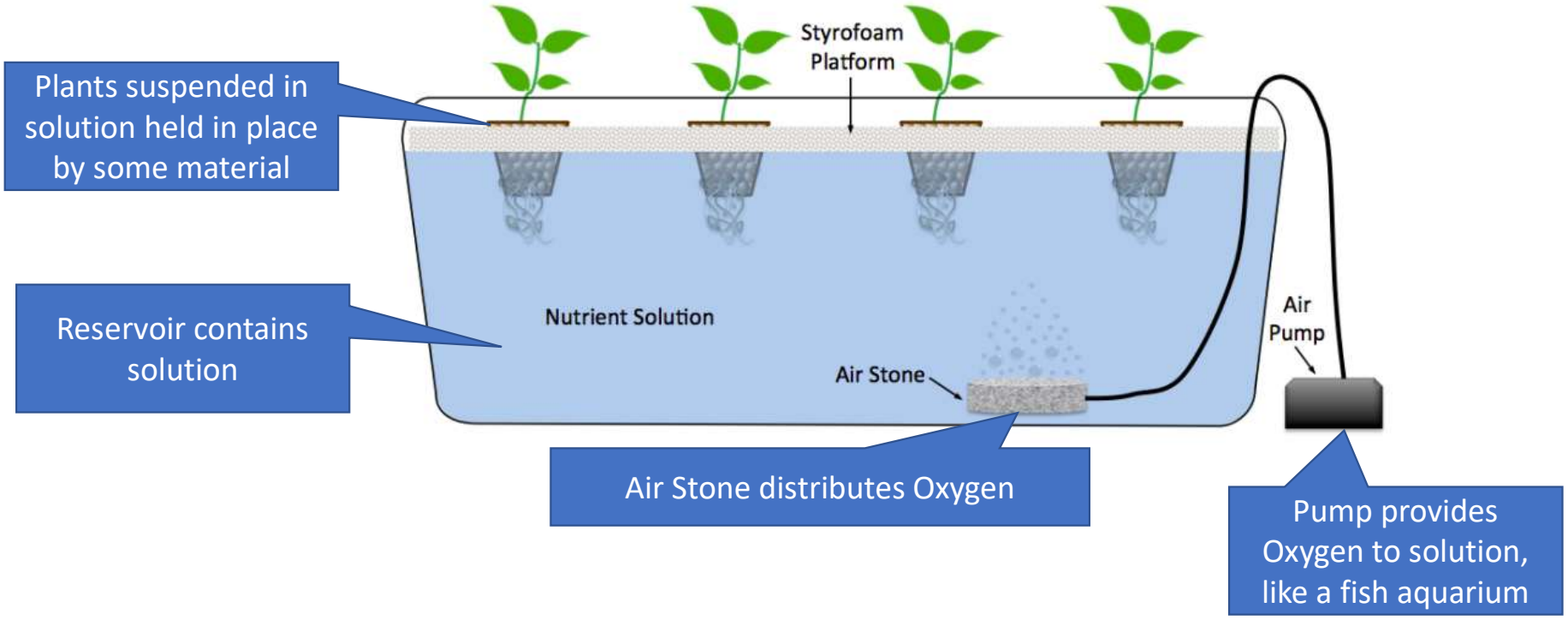
Wick System – 2 Liter Bottle Experiment

Remaining Steps

2. Insert Wick long enough to connect bottom of bottle to the seed
3. Fill bottle with Nutrient Solution to level just beneath the pour spout of the bottle's inverted top.
4. Put Growing Media – Coco Coir in inverted top and place around Wick to hold it secure
5. Plant Seedling
6. Wrap lower bottle with Aluminum Foil



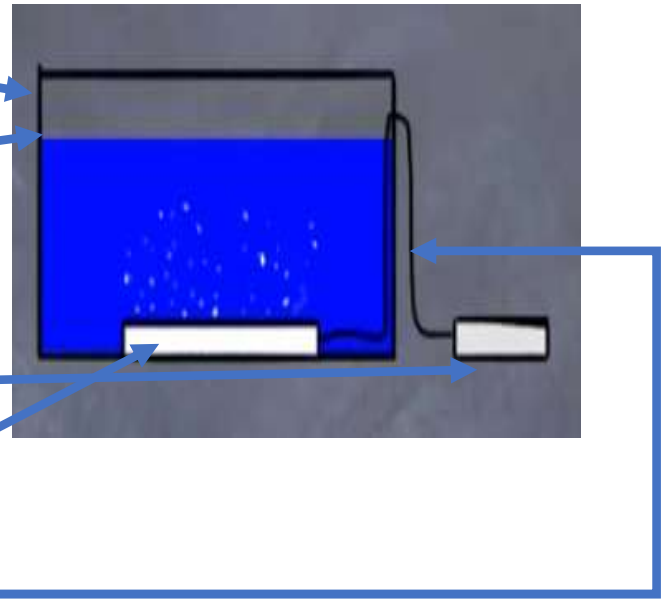
Deep Water Culture (DWC)



Deep Water –Experiment

Steps to Prepare Reservoir

1. Obtain a plastic (opaque) Reservoir with Lid (to be used later)
2. Fill with Nutrient Solution high enough so roots are immersed in Solution
3. Place an Air Pump near Reservoir
4. Connect Air Pump to Air Stone with sufficient Tubing to place Air Stone in Reservoir

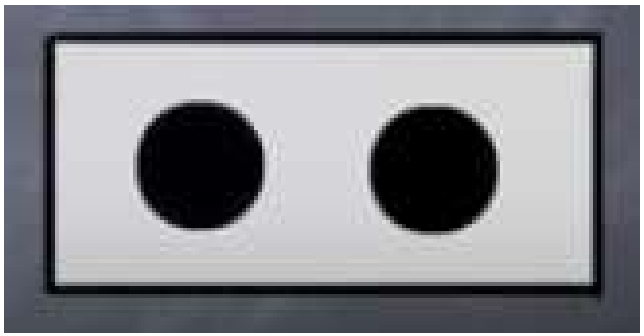


https://www.epicgardening.com/hydroponic-systems/

Deep Water –Experiment

Steps to Prepare Platform for Hold Growing Media

1. Use NetPots, like a plastic basket with lots of wholes for the roots to expand through, to hold the plants
2. Take the Lid of the Reservoir and cut holes large enough to allow the NetPots to access the Solution, but hold the NetPots in place



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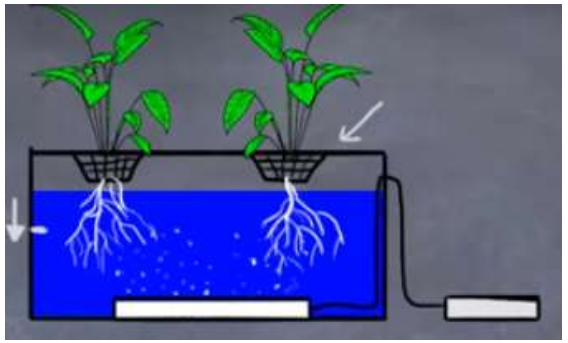
Deep Water –Experiment

Planting Steps

1. Place a Hydroton pellet – expanded clay pellet (pH neutral, inexpensive and reusable) – in each NetPot
2. Place seedling on Hydroton Pellet
3. Insert NetPot into holes of Lid



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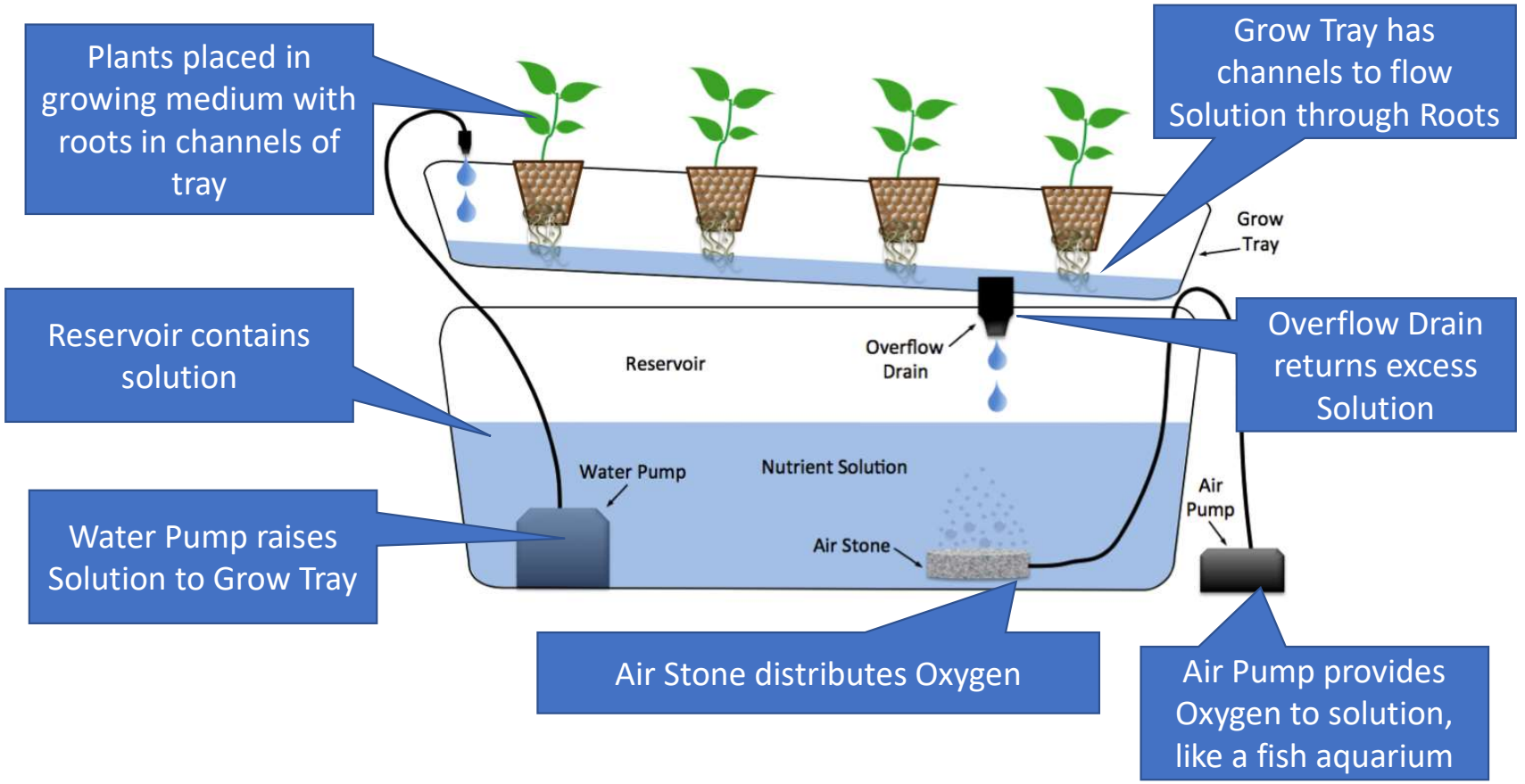
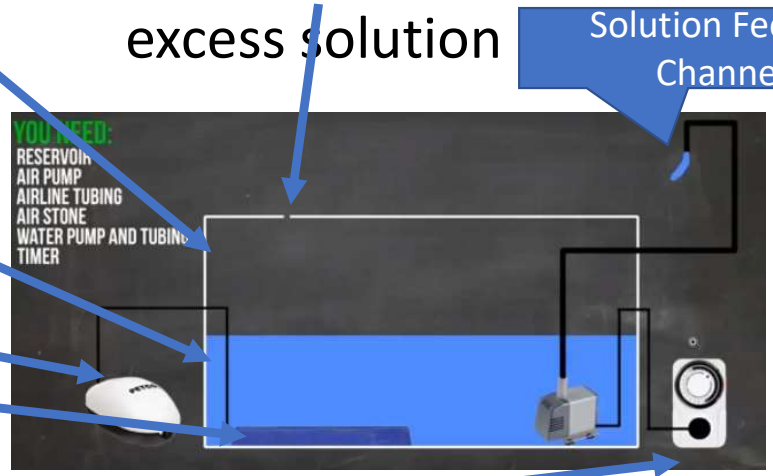
Nutrient Film Technique



Nutrient Film Technique – Experiment

Steps to Prepare Reservoir

1. Obtain a plastic (opaque) Reservoir with Lid
2. Fill with Nutrient Solution
3. Place an Air Pump near Reservoir
4. Connect Air Pump to Air Stone with sufficient Tubing to place Air Stone in Reservoir
5. Place Water Pump in Reservoir
6. Connect Water Pump to Timer and plug Timer into Power source
7. Insert hole for return of excess solution



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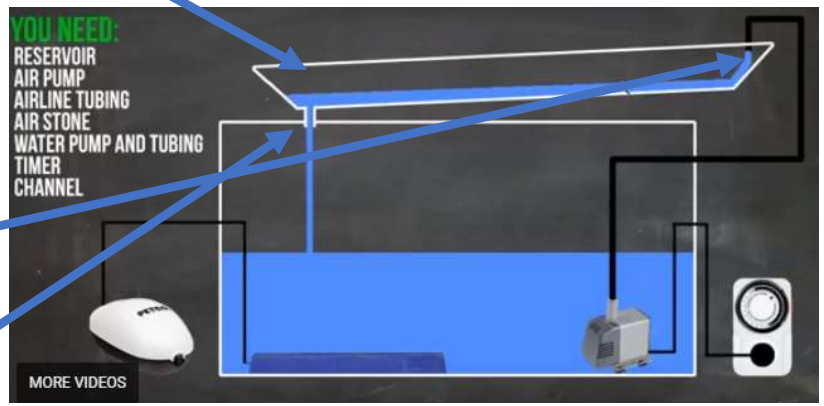
Nutrient Film Technique – Experiment

Steps to Prepare Add Channel(s)

There can be more than one channel

1. Use any enclosed tubing, where the top surface can be cut to position plants
2. Have a 1-30 to 1-40 (drops 1 inch for every 30-40 inches of length(slope to prevent pooling of solution in the channel.
3. Insert a Solution Feed into High End of each Channel
4. Connect a Return Line from each Channel back to the Reservoir



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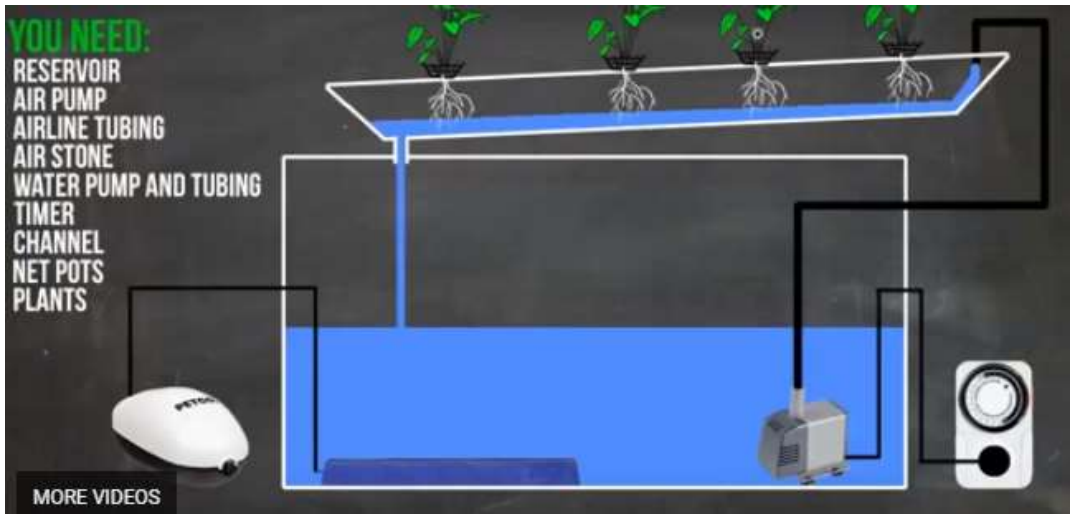
Nutrient Film Technique – Experiment

Planting Steps

1. Cut spaces in top of Channel Tubing for NetPots
2. Insert NetPots in Channel
3. Insert Seedling in NetPots



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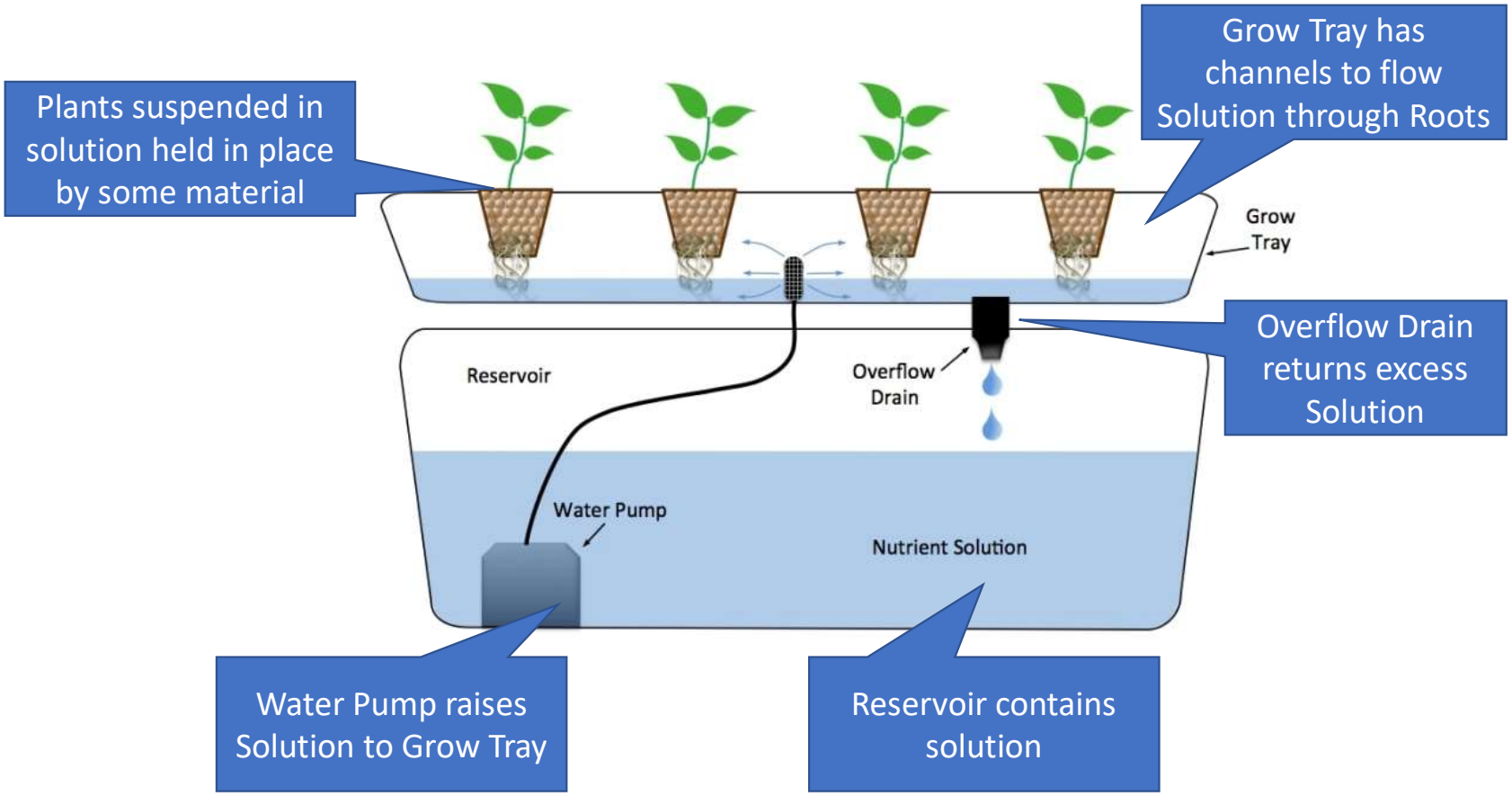
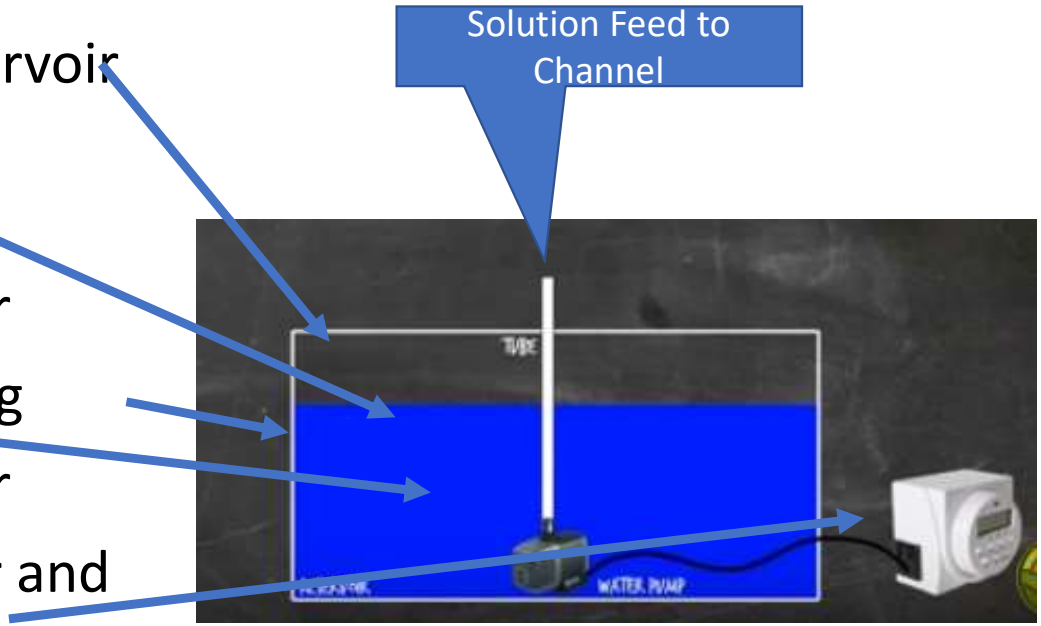
Ebb and Flow


Plants suspended in solution held in place by some material
Grow Tray has channels to flow Solution through Roots
Grow Tray
Overflow Drain returns excess Solution
Reservoir
Overflow Drain
Water Pump
Nutrient Solution
Water Pump raises Solution to Grow Tray
Reservoir contains solution

Ebb and Flow – Experiment

Steps to Prepare Reservoir

1. Obtain a plastic (opaque) Reservoir with Lid
2. Fill with Nutrient Solution
3. Place Water Pump in Reservoir
4. Connect Water Pump to Tubing
5. Place Water Pump in Reservoir
6. Connect Water Pump to Timer and plug in Timer



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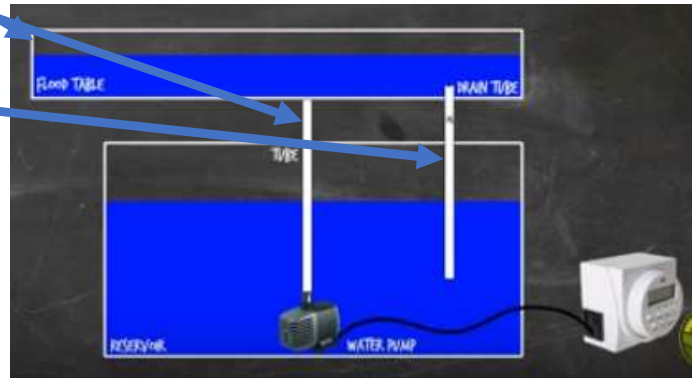
Ebb and Flow – Experiment

Steps to Add Grow Table

1. Procure or create a Grow Table
2. Connect Grow Table Intake from Reservoir
3. Connect Grow Table Return to Reservoir



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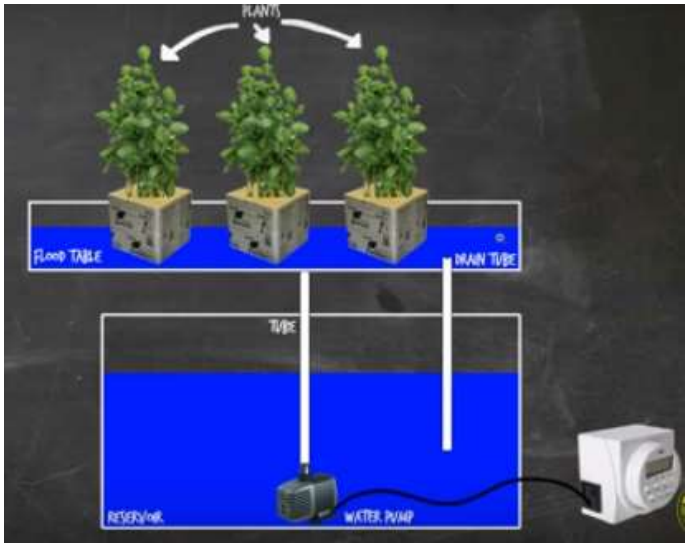
Ebb and Flow – Experiment

Planting Steps

1. Fill Grow Table with Grow Stones to provide structure for Plants and surface area for Roots to adhere
2. Fill with Rockwool or Rapid Rooter Starter Cubes to provide Growing Medium for Seedlings
3. Plant Seedling



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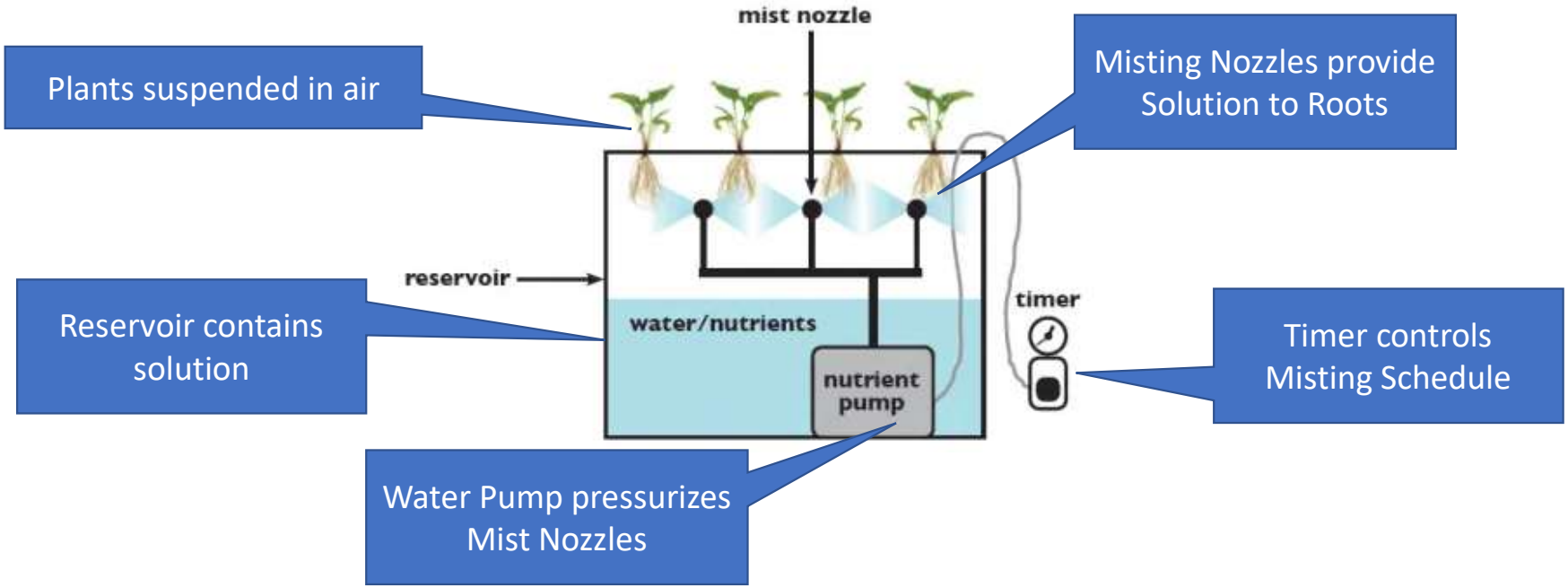
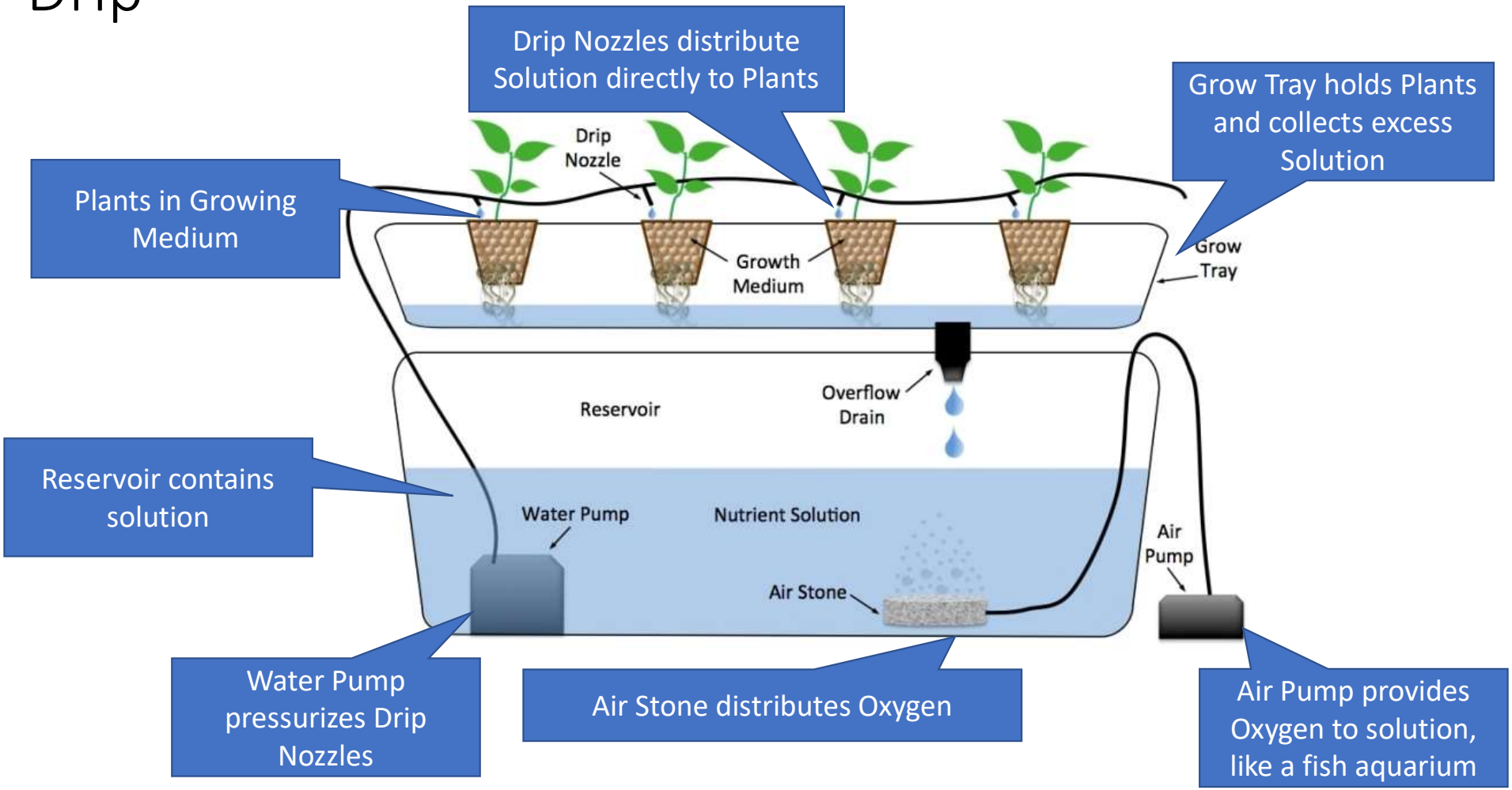
Aeroponics


Plants suspended in air
mist nozzle
Misting Nozzles provide Solution to Roots
reservoir
Reservoir contains solution
water/nutrients
timer
Timer controls Misting Schedule
nutrient pump
Water Pump pressurizes Mist Nozzles

Drip


Drip Nozzles distribute Solution directly to Plants
Grow Tray holds Plants and collects excess Solution
Plants in Growing Medium
Drip Nozzle
Growth Medium
Grow Tray
Overflow Drain
Reservoir
Reservoir contains solution
Water Pump
Nutrient Solution
Air Pump
Air Stone
Water Pump pressurizes Drip Nozzles
Air Stone distributes Oxygen
Air Pump provides Oxygen to solution, like a fish aquarium

Dripper – Experiment

Setup Reservoir and Growing Tray like other System's

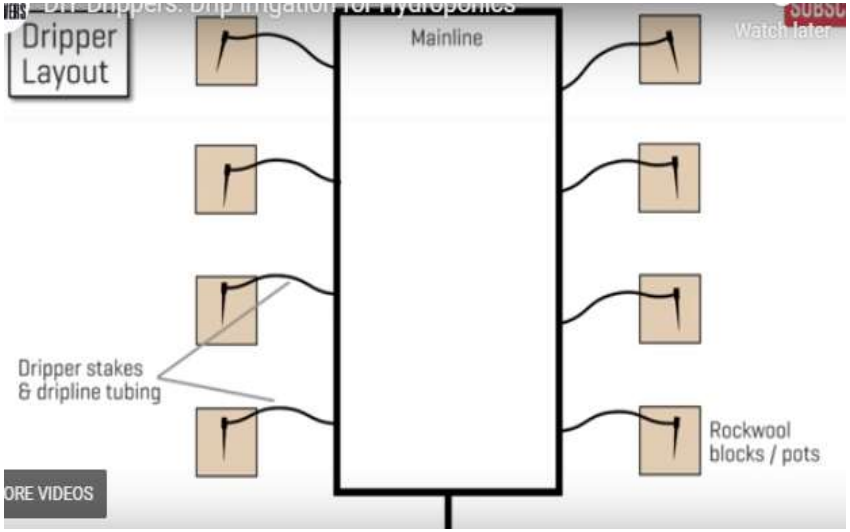
1. Water Pump connect to a drip line
2. Return line connects Growing Tray back to Reservoir

https://www.epicgardening.com/hydroponic-systems/

Dripper – Experiment

Setup Dripping System

1. Create a circular loop of tubing with Dripper Stakes connect to this tubing
2. Connect this loop to the Drip Line connected to the Water Pump

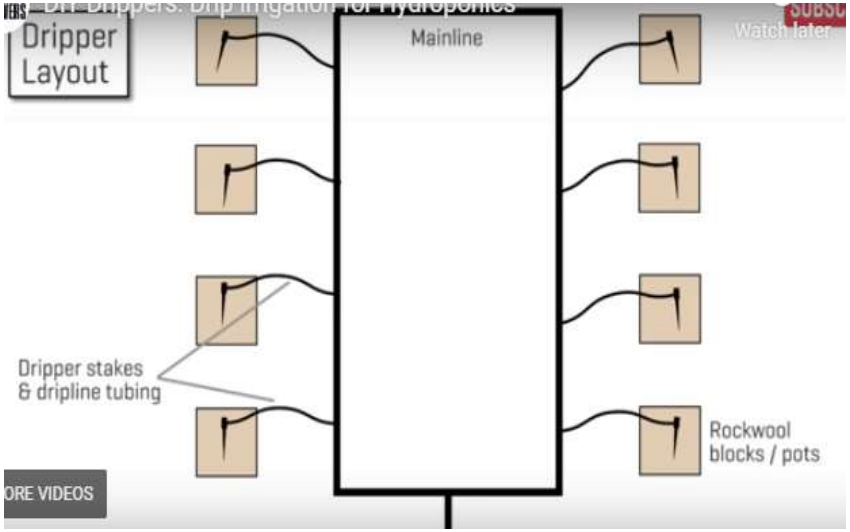


https://www.epicgardening.com/hydroponic-systems/

Dripper – Experiment

Planting

1. Place Growing Medium in Grow Trey
2. Plant Seedlings
3. Insert Dripper Stakes into Each Seedling's Root system



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