The Anywhere/Anytime Garden©

Easy, Versatile, Low Cost Indoor Gardening
Based on Passive Hydroponic Principles

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Forward

What if you could garden almost anywhere and at any time of the year? What if you could grow enough leafy greens, herbs and other veggies for pennies a day in containers that you likely already have at home? Would this interest you if it only required about one hour of your time per week?

If you answered "YES" to the last question, this book is for you.

The *Anywhere Anytime Gard*en is a method for gardening or growing your own food at home hydroponically. This is a system which has evolved over many years, but the basic invention comes from Dr. Bernard Kratky who in 1992 applied for a patent for a "Non-Circulating Plant Growing System." His patent (number 5,385,589) was issued in January of 1995 and has since been used by individuals and commercial growers to produce a large assortment of plants in a variety of conditions both indoors and outdoors. The ingenuity of his invention is that no pumps, motors or electricity are needed, and there is no noise as there would be with conventional active hydroponic systems. It is considered a passive system.

With this system, water does not need to be continuously changed, monitored or replenished. In fact, it is possible to plant your Anywhere Anytime Garden and leave for a three-week vacation and find that you have fresh salads waiting for you upon your return.

Although Dr. Kratky's invention is the basic foundation of The Anywhere Anytime Garden, we have developed a method that makes it possible for all of us to garden at home, in a small apartment, in a basement, in a closet or even in a small travel trailer.

The food that you grow using this method requires 95 percent less water, no energy to be transported long distances, no herbicides or pesticides and is GMO free. It can be eaten within minutes of harvest. You have complete control of what you grow and when you use your harvest.

The Anytime Anywhere Garden is a very cost-effective way to grow your food as well. A large bowl of salad greens uses 2 quarts of water, 4 to 6 seeds, 3 cents of nutrients, and 10 cents of energy for a total cost of about 15 cents.

You may be asking yourself, “Why is it suddenly possible to grow your own food at home so cost effectively?” Although there are several key elements to this answer, the most important one is based on the research done by NASA on growing food in space. It costs NASA roughly $10,000 a pound to send food to the International Space Station and it would not be possible to transport enough food for longer trips… say, to Mars. Food must be grown in space, and research funded by NASA has made this possible. The answer is LEDs. Light Emitting Diodes emit light at very specific wavelengths. By using the appropriate LEDs in our Anytime Anywhere Garden, we can grow healthy meals at home with minimal effort, resources and expense.

Although much of our recent work has been in developing a method for growing indoors without dirt or potting mix, for those of you who prefer to use soil, the information on using LED lighting is the magic that will make your soil produce abundantly. This is how we started our indoor growing and we can tell you that it works great, but just requires a little more work.

We hope you enjoy your Anywhere Anytime Garden as much as we enjoy ours after you read about some of the lessons we have learned. But Jack McGann (One of our most ardent fans) reminds us of the Anywhere Anytime Garden’s one negative: “You get addicted to having your own indoor garden. If you start with a small indoor garden, you will want a bigger one in the future.”

Introduction

"Easy!"

Easy is the word that comes up most often when people are asked about indoor gardening using passive hydroponics. This "Anywhere Anytime Garden" is easy. So, you might be asking yourself, "If it's so easy, why do we need a whole book on the subject?" Good question!

This book is meant to serve several purposes:

- It's an introduction to the easy, cost-effective, anytime, anywhere world of passive hydroponics.
- It explains how and why passive hydroponics are the best way to grow a whole host of leafy greens. microgreens, herbs, veggies, and fruits.
- It explains options you can consider in setting up your "Anywhere Anytime Garden."
- It describes other forms of hydroponic systems that are slightly less passive.
- It lays out and explains the equipment and materials needed to set up your "Anywhere Anytime Garden."
- It takes you step-by-step through the entire process of set-up, planting, growing, harvest, plant care and system care necessary to grow happy and healthy plants.

In short, this book is meant to serve as a one-stop resource directory to get you started on the path to establishing and maintaining your very own "Anywhere Anytime Garden."

And speaking of resources, you will find a resource directory in the back of this book that will tell you where to acquire all the materials you may need to get you going. We say, "the materials you <u>may</u> need" because chances are you already have many of the necessary materials in your home. <u>That's</u> what makes this system of passive hydroponics so great…. because it really is very easy.

Also included in this book are a number of testimonials from people who are practiced passive hydroponic enthusiasts. Some of the people have been growing for years and some are relatively new to the concept of the Anywhere Anytime Garden. These testimonials offer words of encouragement to you who are just considering starting your own garden, and they offer tips for best practices. They offer insight into what plants to grow, which work in different conditions, plus successes and failures that they have experienced. Some of these individuals grow inside only during the winter months and turn their attention to outdoor gardening in the summer, while other grow a wide array of plants indoors year-round.

We hope that this book will become a valuable resource to you, whether you are an experienced indoor gardener or a hydroponic neophyte. Our aim is to give you all the knowledge and support you need to establish a vibrant Anywhere Anytime Garden that will keep you in happy greenery year-round. We like to think that people aren't born with green thumbs: they grow them! Let this book be the nutrient that turns your thumbs a bright healthy green!

How to Use This Book

The straightforward response to "What's the best way to use this book?" is to read it straight through making notes as you go: working along with the text in gathering your passive hydroponic equipment and supplies; setting up your passive hydroponic garden; planting seeds; harvesting your plants for delicious and healthy salads.

This book is being written for everyone from the complete hydroponic novice to the practiced passionate gardener, so the way in which the material is read and used will differ from person to person. But the book is constructed to follow a logical sequence of learning and understanding what passive hydroponics is: how it works; what it takes to make it successful; what you'll need to get started; how to set up your own passive hydroponic garden; how to plant…. In short, the book is built to take you from beginning to harvest.

Note: Several sections of this book are highly technical, such as the sections on water and lighting. Don't let that dissuade you or lead you to believe that passive hydroponics is a complicated endeavor. Quite the contrary. We offer the technical explanations of things like water and light to help you understand more fully the processes of plant growth. While the processes might be complicated, the practice is not. It's SIMPLE!

That said, the book can also be used as a resource directory to remind you about important issues or to point you in the right direction when it comes to equipment and/or materials.

Whatever your experience level, we hope that this book will encourage and inspire you to establish your own passive hydroponic garden and grow, year-round, the greens you enjoy making a greenspace wherever you choose. This is, literally, a guidebook to creating your very own Anywhere Anytime Garden. Enjoy and SEND US PICTURES!

Principles of Hydroponics

Hydroponics Defined

Simply put, hydroponics is the practice of growing plants using only water, nutrients, light, and a growing medium. The word hydroponics comes from the roots “hydro” and “ponos.” “Hydro” is the anglicized form of the Greek “hydor,” which means water. “Ponos” is derived from the Greek word of the same spelling that means labor. One might literally translate “hydroponics” into “water works,” but for our purposes it refers to a method of growing plants without soil.

The History of Hydroponics

There is some debate over when the practice of growing plants without soil actually took root. If you were to do research into the beginnings of hydroponics, you would run into tales of the Hanging Gardens of Babylon, King Nebuchadnezzar (604-561 B.C.), and his concubine Amytis. It was under Nebuchadnezzar II’s reign that the Hanging Gardens of Babylon are said to have been constructed and the famous Ishtar Gate was built. The Hanging Gardens are most explicitly described in a passage from Diodorus Siculus (90-30 B.C.E.) in his work *Bibliotheca Historica* Book II.10:

“…there was also the Hanging Garden, which was built by a later Syrian king to please one of his concubines; for she, they say, being a Persian by race and longing for the meadows of her mountains, asked the king to imitate, through the artifice of a planted garden, the distinctive landscape of Persia. The park extended four plethra on each side, and since the approach to the garden sloped like a hillside and the several parts of the structure rose from one another tier on tier, the appearance of the whole resembled that of a theatre. When the ascending terraces had been built, there had been constructed beneath them galleries which carried the entire weight of the planted garden and rose little by little one above the other along the approach; and the uppermost gallery, which was fifty cubits high, bore the highest surface of the park, which was made level with the circuit wall of the battlements of the city. Furthermore, the walls, which had been constructed at great expense, were twenty-two feet thick, while the passage-way between each two walls was ten feet wide. The roofs of the galleries were covered over with beams of stone sixteen feet long, inclusive of the overlap, and four feet wide. The roof above these beams had first a layer of reeds laid in great quantities of bitumen, over this two courses of baked brick bonded by cement, and as a third layer a covering of lead, to the end that the moisture from the soil might not penetrate beneath. On all this again earth had been piled to a depth sufficient for the roots of the largest trees; and the ground, which was leveled off, was thickly planted with trees of every kind that, by their great size or any other charm, could give pleasure to beholder. And since the galleries, each projecting beyond another, all received the light, they contained many royal lodgings of every description; and there was one gallery which contained openings leading from the topmost surface and machines for supplying the garden with water, the machines raising the water in great abundance from the river, although no one outside could see it being done. Now this park, as I have said, was a later construction."

Though it is often cited as one of the earliest examples of a hydroponic garden, it is clear in this description that soil was used to anchor the large trees and plants of this Wonder of the Ancient World. It's a great story and was probably fabulous to behold, but the Hanging Gardens of Babylon were probably not "hydro" "ponos".

Another example of early hydroponic gardening that is often cited in histories can be found on the highland plateau of central Mexico. The highland plateau is where metropolitan Mexico City is situated. It was here that the Aztecs practiced what was believed to be an early form of hydroponic gardening using a system known as "chinampas."

Chinampas were floating gardens that some historians believe were begun as early as 1400 B.C., though there is no firm proof of them before about 1100 A.D. (Though this still predates Nebuchadnezzar's garden!) The word "chinampas" is very descriptive of the way in which the gardens were constructed. "Chinampas" is combined chinamitl (reed basket) and pan (upon). The gardens were constructed by draining an area of a lake. After the area was drained, reeds were woven over the area and the area was enclosed. The reed basket that was constructed above the lake bed was then filled with sediment from the lake bottom before the area was flooded again.

In this case, the sediment was not used like soil, but more as an anchor for the bed. Crops such as maize, potatoes, amaranth, and chia were grown in these "floating gardens" that were constructed to help feed the hundreds of thousands of people that lived in the central Mexican plain.

The Chinampas may have been closer to the idea of hydroponics than the Hanging Gardens of Babylon were, but the use of lake sediment as an anchor still put the plants in dirt, so this was not true soilless gardening.

The history of hydroponics can now jump forward a couple thousand years to the 17th century and the work of Flemish chemist Jan Baptist van Helmont (1579-1644). He was responsible for some of the earliest recorded research into the growth of plants, though his work was only published posthumously in 1648. In fact, authorities detained van Helmont in 1634 during the Spanish Inquisition for the "crime" of studying plants and other sciences and sentenced him to two years in prison. Van Helmont became known as the first scientist to articulate that there are gaseous substances that differ from ordinary air. In fact, he is also credited with introducing the word "gas" into the scientific lexicon. He is also known for a single experiment he conducted using a willow tree to determine "*from where plants derive their mass*." This research is commonly known as "the 5-year tree experiment."

"But I have learned by this handicraft-operation that all Vegetables do immediately, and materially proceed out of the Element of water onely. For I took an Earthen vessel, in which I put 200 pounds of Earth that had been dried in a Furnace, which I moystened with Rainwater, and I implanted therein the Trunk or Stem of a Willow Tree, weighing five pounds; and at length, five years being finished, the Tree sprung from thence, did weigh 169 pounds, and about three ounces: But I moystened the Earthen Vessel with Rain-water, or distilled water (alwayes when there was need) and it was large, and implanted into the Earth, and least the dust that flew about should be co-mingled with the Earth, I covered the lip or mouth of the Vessel with an Iron-Plate covered with Tin, and easily passable with many holes. I computed not the weight of the leaves that fell off in the four Autumnes. At length, I again dried the Earth of the Vessell, and there were

found the same two hundred pounds, wanting about two ounces. Therefore 164 pounds of Wood, Barks, and Roots, arose out of water onely."

So, Van Helmont states that the tree "arose out of water only," yet his tree still used soil as an anchor. He deduced that the tree took nothing from the 200 pounds of soil the tree was anchored in but did indeed take up water.

In 1699, British scientist John Woodward determined that pure water was not as good for soilless plants when he compared it to water that once had soil soaked in it. This discovery led to the work of French chemist Jean Boussingault in the 1850s and his important understanding of the fact that water can contain the minerals that had been in contact with soil. Boussingault concluded that plants can grow in an inert medium such as silica sand that has been moistened with a solution containing chemicals or nutrients. It was this discovery that led to the first man-made nutrient solution for hydroponic gardening.

The notion of growing plants without soil really started to bloom in the early 20th century when researchers at the University of California, Berkeley continued research in this field and coined the term "hydroponics." Dr. William F. Garicke defined hydroponics as "the art and science of crop production in liquid media." In the late 1920s and early 1930s, Gericke, of the University of California, broadened and expanded his indoor laboratory experimentation to include work on plant nutrition in a more practical nature by growing crops outside. Gericke called what he was working on "hydroponics." This is the first time the word was used to describe plants grown in a soilless environment using water as the primary method of nutrient delivery. Gericke's work is now thought to be the basis of all methods of hydroponic gardening.

Gericke's work coincided with the rise in the use of greenhouses and the use of refrigeration as a means of storing and transporting food grown in one part of the country and shipped to another. Northern California, near Garicke's work at University of California at Berkley, was one of the primary locations for this explosion in agriculture meant to feed a growing country. The use of greenhouses, hydroponics, and refrigeration grew in popularity as it proved vital for providing out-of-season produce to consumers for additional profit.

Various experiments that went on in the early 20th century were of limited success due to the materials they had to work with (gravel, wood, concrete, glass). When plastic became a commonly available building material, interest picked back up, and scientists experimented with new hydroponics concepts.

One of the first commercial uses of hydroponics occurred during the late 1930s. Based on Garicke's research at Berkeley, tanks of mineralized water were used to grow beans, tomatoes and vegetables on Wake Island, a small strip of land in the Pacific Ocean. This island was used as a refueling stop for Pan American World Airlines, and the food grown there was used to feed the airline's staff and crew.

During World War II, the military set up hydroponics units at remote bases in the barren Pacific Islands. These islands were rocky and could not support growing vegetables. Hydroponic gardens helped feed the troops. Vegetables were also grown with hydroponics in Japan and flown in to support the troops during the war in Korea.

Recently, NASA has been doing more intensive experiments with hydroponics as a clean and efficient way to raise food plants in space. Not only do growing plants produce food, they also clean the air and produce oxygen. All of these factors make this a valuable program for NASA and hopefully with more research, we can expect to see new breakthroughs in hydroponics in the near future. According to the NASA.gov website, they are learning more about how varying combinations of light, nutrients, and carbon dioxide impact plant growth. They also are looking at improving yields by combining certain plants instead of only growing one crop at a time.

The idea of passive hydroponics was developed in the mid-1980s by Bernard Kratky of the University of Hawaii and Dr. Hideo Imai. Kratky and Imai determined that plants can survive if a portion of their root system has a source of air. Thus, with the plant anchored in an inert medium, a portion of their roots in humid air, and the bottom of the root system in a nutrient-filled liquid, plant can grow and thrive. This is the basis of the Kratky system of passive hydroponics.

How Does it Work?

Humans have been cultivating plants since approximately 9500 B.C., give or take a thousand years. It makes sense that when we started planting and growing crops we did so in the soil since that is where all vegetation sprouted. It wasn't until the 17th century that we discovered that it is not so much the soil that feeds plants, but the nutrients in the soil that are delivered, for the most part, by water. This is the basis for hydroponic gardening.

Besides nutrients and the water that delivers them to the roots of the plant, the plant also requires light… and not just any light, but sunlight, or light that gives the plant the photosynthetically active radiation (PAR) that the sun delivers.

We'll dive deeper into these three necessary elements (water, nutrients, & light) later in this book, but when you pose the question "How does it work?" and the response is as simple as "Water, nutrients, & light," you can begin to see the simplicity of this system of passive hydroponics.

As was stated in the forward, "… no pumps, motors, or electricity are needed and there is no noise as there would be with conventional active hydroponic systems. With this system, water does not need to be continuously changed, monitored, or replenished. In fact, it is possible to plant your Anywhere Anytime Garden and leave for a three-week vacation to find that you have fresh salads waiting for you upon your return."

Here's the short version:

- Fill a container with water. (Ideally, you can use a 1 quart wide-mouth Mason jar or a similar sized plastic jar.)
- Add the necessary nutrients to the water.
- Fill a 3-inch net pot with wet hydroponic clay pellets to within ½ inch of the top of the pot and place it into the container. (Approximately ½ cup of clay pellets).
- Place 4 to 5 seeds into the net pot and spread them around.

- Add enough clay pellets to just cover the seeds, making sure that the seeds are moistened by the nutrient-filled water.
- Set a timer for the LED grow light to be on for 16 hours a day. (We usually turn them on at 6 a.m. and off at 10 p.m.)
- Place the container(s) under the light so that they are about 6 inches below the bulb. Adjust the light upward as the plant grows.
- Come back in 3 to 6 weeks and begin harvesting your crop.

Again, we'll dive into specifics such as suitable containers, nutrients, lights, etc.… later in this book. Also, we provide a resource directory at the end of the book to help you gather the things you need to get started. But with the nine easy steps provided here, you can grow most, if not all, of the greens you and your family need for healthy salads and herbs at a fraction of the cost you might spend in the grocery store.

Throughout this book we will provide testimonials and green thumb gardening tips from individuals who have been engaged in the practice of passive hydroponic gardening. These gardeners will offer insight, encouragement, and helpful advice to guide you on your way.

Green Thumb Gardening Tip from Jack McGann

Jack has been growing a wide variety of crops in his Michigan City, Indiana home since 2015.

"I have a passive home hydroponic gardening system that uses three Happy Leaf LED 17-inch grow lights with up to 32-quart Ball canning jars under each light. I grow different kinds of leafy plants, including various lettuces, pac choi, kale, basil to name a few. I use 3-inch net pots and rock wool for starting and support. I am using nutrients that promote leaf growth."

Jack built his system himself. "I bought the shelving from Amazon and mounted the lights under the two lower shelves. (I) use bookend type stands for the light on the top shelf. This is where I keep my tall plants like basil. I can get up to 90 plants in 12 square feet of floor space."

"Success is easy, even for a beginner.   I seldom have a plant failure. I would estimate that I consistently have over a 95 percent success rate. Without wind and bugs and extremes in temperature, the plants thrive. They only have to be tended about once per week to add nutrients and to harvest what is ready to pick. It takes me about 1 and a half hours per week to do everything necessary to keep the indoor garden in great shape. That includes replacing plants that have exhausted their life, cleaning the jars, starting new ones and harvesting what is necessary. I usually refill my nutrient container at this time. I use a 2-and-a-half-gallon plastic container for holding my nutrients. This is about how much I need each week to refill the 90 plants. I reuse the nutrients left in the jars that have to be replaced and it seems to work fine. I use CLR cleanser to clean the jars. Some algae grow the longer the plants live, but it does not affect results because the jars are cleaned at the end of the growing cycle.

"Some myths about passive hydroponics have come from the commercial growers with large systems. Algae is a problem for them but not for passive growers. I have never bothered with pH strips and have used plain tap water. I think most people hear about the complexities involved in the commercial growing industry and associate them with passive hydroponics, which is understandable but far from the truth."

Of course, whenever you start a new venture you are sure to make mistakes now and then.

"I did not plan my crop rotation and ran out of basil and my favorite lettuce. I mixed tall and young plants on the same shelf and had to adjust the height of the light but could not do this without causing damage to the taller plants. I tried to grow cilantro and found it does not do well in passive hydroponics. Only one or two shoots grew. When I want cilantro, I grow it in dirt under the same LED lights." *

Words of wisdom from Jack?

"Get started with one light. Keep it simple and stick with what works best …. leafy plants."

"When you achieve success, only then branch out and start experimenting with other crops and nutrients."

"Go to the happyleafled.com web site and keep abreast of the latest ideas in the field of passive hydroponic indoor gardening."

*Some growers report having very good results growing cilantro using clay pellets as opposed to rock wool. Experimentation with materials is the key!

Pros and Cons of Passive Hydroponics

It's only natural when you read a book like this that the pros of passive hydroponic gardening are going to far outweigh the cons. After all, we're putting this book together to extoll the amazing virtues of passive hydroponic gardening! But like everything else, there are also some cons associated with it.

So, here's a short review of the pros and cons of indoor passive hydroponic gardening. You will find most things mentioned here described in some detail later in this book, so this is just by way of review. These pros and cons will vary from person to person and situation to situation. What works for one individual will not work for another. Several common threads on the pro side apply to any type of hydroponic system.

PROS

1. SIMPLICITY

The simplicity of an indoor passive hydroponic garden system cannot be overstated. With very little equipment, very low maintenance, the unlikely threat of pests, and the ease of expansion possibilities, the Anywhere Anytime Garden is, simply put, the simplest of home indoor home garden systems.

2. CAN BE DONE ANYWHERE

Indoor passive hydroponic gardening allows you to have greater control over your garden than conventional outdoor soil-based gardening. With indoor passive hydroponics, you will be able to provide nutrients in the precise combination and mixture that you feel best suit your plants. Also, if you have an indoor system, you can modify and adjust the timing of your light. If you like to tweak even the tiniest variable to try and improve your production, then indoor passive hydroponics is for you.

3. EASY TO MAINTAIN

Without the soil and equipment needed by many hydroponic systems, you will find that indoor passive hydroponics is far less messy than nearly every other type of gardening system. Also, because you're working in a very controlled environment, you really don't have to tend to your plants as often as you might with other systems. Once or twice a week is about all the attention your home crops should need.

4. INCREASED PRODUCTIVITY

Your Anywhere Anytime Garden, fed by a well-balanced mix of nutrients under optimum lighting, will not be subject to the whims of nature. Thus, you can expect to get high productivity out of your plants. Your growth results per square foot will be greater than in outdoor soil-based gardening, and there will be fewer losses due to pests. It has been estimated that an indoor passive hydroponic garden set up on a three-tier shelving unit that takes up approximately 12 square feet of floor space and utilizes three Happy Leaf 17-inch LED grow lights would match or outperform an outdoor garden of approximately 900 square feet. Also, as the notion of “anytime” gardening does, indeed, mean “anytime.” You can grow continually…. ANYTIME…. And thus, enjoy greater productivity.

5. HAVE WE MENTIONED THAT THIS CAN BE DONE ANYTIME?

You no longer have to time all your gardening by the seasons or calendar. After each harvest, you immediately can start a new batch of seedlings for the next crop. Better yet, if you have the space you can start new seedlings a couple of weeks prior to a final harvesting so there is no gap in crop production. With a passive indoor garden system that is under your control for light and temperature, you can have crops from any plants regardless of whether they would normally grow in your region. Fresh fruit and vegetables can be harvested in the middle of winter.

6. EFFICIENT WATER USAGE

While it may seem like a lot of water is used when growing plants hydroponically, it uses less water than conventional soil gardening. If you engage in the practice of passive hydroponics there’s no waste because the water is contained and does not run off. Outdoors, in a soil-based garden, much of the water that goes into the soil eventually soaks beyond the reach of your plants’ roots or is otherwise drained away, unused or evaporates. Passive hydroponics uses roughly 90 percent less water than growing the same plants outside according to a study done at The University of Arizona’s Controlled Environment Agriculture Center. This one fact alone is motivating further research and development into hydroponics in dry climates and areas hit by drought.

It would be helpful to cite a study or two that substantiate the 95 percent figure so you're not just asking the reader to take your word for this.

7. VIRTUALLY PEST FREE

As you are in nearly complete control of the environment, your passive indoor garden can be pest free. Soil-based gardening, even done indoors, can invite a host of bugs into your home. Sure, you can treat your soil and use pesticides (natural or not), but why not just make pests much less likely from the very start? The only circumstance where pests might become an issue is if you have other plants in your home that are growing in dirt or potting mix.

8. LITTLE EXPENSE

You can easily spend several hundred dollars putting a system together, but you do not have to. You can put many parts of a passive indoor hydroponics system together with very inexpensive supplies from your neighborhood hardware store, gardening shop, or even your grocery store. Most of the equipment costs are up front and a one-time investment. Nutrient solutions will have to be purchased regularly. If you don't allow your plants to go to seed, seeds will have to be purchased regularly.

Passive hydroponic gardening is a very low-cost way to grow food. Once your system is up and growing, the cost of a large bowl of leafy greens is about $ .06!

9. EASILY EXPANDABLE

If you build your own simple passive indoor garden system, you can do so with the idea of expansion in mind from the very start. If you start a small jar system with one or two jars growing lettuce, basil, or any other type of leafy greens, it's very easy to add more jars at any time. Expansion is easily done using shelving units or bakers' racks.

CONS

1. SOMEWHAT LIMITED IN WHAT YOU CAN GROW

If you plan to start a passive indoor garden system in your small apartment or in a cramped living space, your plant choices will be limited. In such environments, you should probably not choose to grow long vining squash.

2. EASILY EXPANDABLE BUT STILL SMALL SCALE

Remember, you are a home gardener growing indoors. You will be able to expand your garden given the space that you have, but you are probably not set up for any kind of commercial production. The system described in this book is strictly for the small indoor gardener.

In the end, you will be able to make your passive indoor hydroponic gardening system as simple or complex as you can support. It can be a single jar of water with 1 plant or a greenhouse filled with multiple buckets stacked on many levels of shelving with banks of LED lights. A bank of LED lights is where you have multiple lights strung together to create coverage over a larger space. You can purchase a ready-made hydroponic gardening system, or you can design and build your own.

3. MISCONCEPTIONS: WHAT CAN BE GROWN THIS WAY (AND WHAT CAN'T)

Perhaps the biggest misconception related to the Anywhere Anytime indoor hydroponic garden, especially if you have a system that involves grow lights, is that you might be growing marijuana. Can you grow marijuana using a passive hydroponic system? Sure, you can (if the law allows it!) But, you can grow so much more. And you can't grow everything.

When it comes to indoor passive hydroponics, the biggest hurdle you may face is space. The general consensus is that passive indoor hydroponic systems are great for small plants – like lettuce, leafy greens and herbs – but not for nutrient hungry and space demanding plants such as tomatoes, pumpkins, watermelons, etc. The fact is that these entirely passive non-recirculating systems work for <u>all</u> these plants, provided you have adequate growing conditions and the space (vertical or horizontal) necessary for them to grow.

The questions now become, how is this possible and how can you do it? The answers are simple. Passive hydroponics without any pumps or motors can be done for large or small plants given that the following conditions are met:

- Enough space for roots
- Enough space for the plant to grow above the water (such as the vines of a cucumber plant)
- Enough nutrient solution for the duration of the growing period (or until replenished)

- Enough oxygen and carbon dioxide for the plant's roots
- Electricity to power the highly efficient LED grow lights!

If these five conditions are met, you will be able to build a passive hydroponic growing system that needs no water pumps to give a good yield. Once you learn the basics of growing in this manner, part of the fun of this practice is experimenting to see what you can grow!

How can you make such a system? The systems that have given the best results up until now are those that follow a very simple design plan. The plant is put in an absorbent nutrient media and placed to float or stand just above the initial nutrient solution level. The nutrient level slowly decreases in the beginning (due to evaporation) and then quickly as the plants start to absorb water and nutrients. As the level of nutrient solution lowers, the plant roots become exposed to layers of air from which they can absorb oxygen and carbon dioxide, allowing them to effectively absorb nutrients from the solution below.

Most people believe that if roots are submerged in an unaerated solution they will die, but this is only true if the whole root system is submerged. This is something that Bernard Kratky (remember him?) discovered in the 1980s. If a good part of the system is given an "air buffer" from which to absorb oxygen and this space remains humid, the result is a system that can absorb nutrients from the unaerated solution and oxygen from the air buffer zone.

We'll get into the specifics of the how and what of growing later in this book, but by way of introduction, we should point out that one of the only limitations to what you can grow is space for that redwood tree to grow to its full potential!

A word of advice to those of you who are new to hydroponic gardening is to start small, learn the process and build a little at a time. Let your desire to expand and learn more be fueled by your successes, failures and inspirations.

What you might take away from the list of pros and cons is that passive hydroponic gardening is perfect for the home grower who wants an easy way to have a variety of edibles year-round that are affordable and fun to grow.

Types of Hydroponics Systems and Their Variations

Before we leave this first introductory chapter overview, we thought it might be good to quickly review other types of hydroponic systems. Sure, we're true believers in the system of passive hydroponics for all the reasons listed already, but there are other ways to put together a hydroponic system.

Hydroponic gardening systems range from a jar of water with a few seeds tossed in to elaborate systems with multiple levels of grow trays, pumps, lights that raise and lower depending on plant growth, conveyer belts to move plants indoor and out…. etc., etc., etc.…! The following review of basic hydroponic gardening systems is meant to show that the basic premise of growing plants without soil is a very real and very doable option for home gardeners.

There are basically two types of hydroponic gardening systems: passive and dynamic/active. There are several varieties of each. The difference between the two types is somewhat suggested in their names. Passive systems do not require water circulation. Dynamic systems do. The sprouting jar and our Anywhere Anytime Garden system are passive hydroponic systems.

The Simple Jar

This is even simpler than the passive hydroponic system that this book will describe. Sprouts grown in a jar of water are the most basic form of plants grown hydroponically. You do not need to build any systems, invest in any equipment (outside of a jar with a lid) or spend a lot of time to grow seeds that will provide you with a basic education and a great deal of nutrition.

You can grow many types of sprouts in a simple jar of water, from beans to grains and vegetables. Sprouted seeds, beans and nuts can be eaten raw or used for cooking.

All you need to get started growing sprouts is a jar, some seeds and water. You can happily and easily grow large quantities of sprouts for many years with only those three items. You don't need a specially designed jar; any glass jar will do. The best jars are quart-sized, wide-mouth canning jars (the same jars that are best for our Anywhere Anytime Garden).

Sprouting seeds in a jar is simply a matter of soaking the seeds and making sure that you change the water regularly. Start the seeds in a dark place and as they begin to form sprouts, move the jar into indirect sunlight to allow them to turn green. It's that easy.

The idea behind our Anywhere Anytime Garden system is only slightly more complex. Systems we will review here, such as the bubbler system and the bucket system, are fundamentally based on the same concept as the sprout jar. You will see that what begins as a simple jar of water can get progressively more complicated. What we hope to explain is that complicated does not always mean better when it comes to home gardening.

Passive Hydroponics Systems

Passive hydroponic systems are easily started and are the first choice for the beginning small-scale hydroponic gardener. Because they are simple, you can create them in several different ways. Basically, though, most systems derive from either the raft system or the bucket system. Raft systems have plants floating on the surface of the aerated water solution, and bucket systems have the plants held in place. Bucket systems tend to be smaller and are used for individual plants or small groupings. The water does not flow, which makes this simpler to use and set up because it needs less equipment. The Anywhere Anytime Garden system is a variation on the Bucket System. We'll refer to it as the Jar System.

TYPES OF PASSIVE HYDROPONIC SYSTEMS

- Raft system
- Bucket/Jar system
- Top-drip system
- Wick system
- Ebb-and-flow system (note: the ebb-and-flow system can be either a passive or dynamic/active system, depending on how you treat the nutrient solution after it flows away from the plants. If the solution is not recirculated through the system, the system would be considered a passive system. If the nutrient solution is recirculated through the system by using a pump, the system is a dynamic hydroponic gardening system.)

Raft System

This is most commonly used with lettuce, herbs and other small leafy plants. This is practical only for smaller plants because the plants must float on the surface of the solution, and larger plants make this impractical. The main pieces of equipment are floating components (rafts) to hold your plants on the surface of the solution and a large container to use as a reservoir. Because the plants float on the surface of the water/solution, the roots really are not in the open oxygenated area as they are in the bucket or jar system. Because of this, you also need an aerator because the water is not moving, and the roots are usually submerged.

Bucket/Jar System

This is sometimes called a deep-water culture as it has a much deeper water reservoir than some of the other systems. Each bucket/jar needs a support for the plant, which is usually a net basket for growing medium that's attached to the underside lid, or in the place of the lid of the reservoir. A bucket system can be very basic, often using off-the-shelf Rubbermaid storage totes, 5-gallon buckets, or Mason jars as the main reservoir. This is another good place to start if you plan on going the DIY route, much like the raft system.

The roots grow through the medium and mesh basket directly into the pool of liquid below in the reservoir. As the plant matures and the roots begin to develop, the liquid nutrient is absorbed by the roots and some of it evaporates with the water, leaving a gap between the bottom of the net pot where the plant is and the surface of the liquid nutrient. This humid gap is what provides the oxygen the plant needs to grow, so an aerator is not necessary. Again, this method of passive hydroponics is what Bernard Kratky developed in the 1980s.

Top Drip System

This is not strictly a static system, since the water is moving, but it is still considered a passive system as it is relatively self-contained. With a top drip system, water is pumped from the bottom of the reservoir to above the plant support and growing medium. It then trickles down through the roots back to the reservoir in a continual loop. Aerators are not needed because the constant motion of the water allows for natural aeration to take place and the water will not stagnate.

Aside from the top/bottom bucket arrangement, you also will need a pump with hosing to move the water from the bottom to the top. This is a very common type of hydroponic system, and it can be expanded to work with large trays of plants and multiple buckets or jars rather than just a single bucket or jar. Hoses also can connect several buckets/jars and a central reservoir with a single large pump.

Wick System

Wick systems are extremely simple, only slightly more involved than the Kratky system, as they have no pumps or moving parts. Nutrient solution is drawn up from a small reservoir under the plants into the main pot with the growing medium. Cloth strips or even short lengths of cotton rope are used as the wicks to draw the nutrient solution up into the plant. Alternatively, the medium itself can be in contact with the water, and it will absorb naturally on its own. This approach will lead to a wetter medium compared to the use of actual wicks, though the solution or roots still need to be aerated or to have oxygen delivered in some way.

The wick system is more like conventional soil-based gardening because the plants roots are usually held completely within the mass of growing medium rather than being exposed directly to the nutrient solution. The medium that you use for these arrangements must be absorbent (vermiculite, coco fiber, or moss) but will need to have enough drainage to allow for some air. The media used in the root zone should have enough air space to avoid rotting the roots. You should aim for 10-20% air space in your media.

The primary benefit of using a wick system is its simplicity and independence from a power source, though, again, it is not quite as simple as the Kratky method. Unlike the other options, this one will continue working just fine even if there is a prolonged power outage. The nutrient solution is not reclaimed or recycled through the system. You just must refill the reservoir when the volume gets low.

Dynamic Hydroponic Systems

Dynamic hydroponic systems are those that recirculate the liquid nutrient solution through the system if the system is viable. This recirculation is done using pumps and hoses, for the most part.

Ebb and Flow

This system creates a tidal effect, periodically flooding the root chambers with nutrient solution and then allowing it to drain away. The drained nutrient solution is collected and recirculated if the nutrient solution is viable. This system is also sometimes called a flood-and-drain system. These are the most common systems for larger hydroponic gardens.

Nutrient Film Technique

This type of hydroponic system is more commonly known as just NFT. It is somewhat more advanced and not usually attempted by beginners until they have a little more knowledge about the equipment.

In this technique a thin stream of water is pumped continually past the ends of the roots giving the plants a regular supply of nutrients while also leaving most of the root mass exposed to the air. This prevents the roots from rotting, which can happen in too much water. Actually, this system is quite similar in concept to the Kratky method, which allows the roots to be exposed to oxygen and carbon dioxide, but this one is designed to be dynamic in that the nutrient-filled water is pumped and recirculated through the system.

Aeroponics

In an aeroponic system, the liquid nutrient solution is handled much differently. Plants are suspended in their mesh pots, but the roots hang loose in a large open chamber. During the day, solution is frequently misted or sprayed into the chamber to nourish and moisten the roots. In this way, the plant receives both nutrients and oxygen.

A Closer Look at Passive Hydroponics Systems

In the previous chapter we explored several types of passive hydroponic systems: the raft system, the bucket/jar system, the top drip system and the wick system. All are relatively easy to construct and maintain. Each has its pros and cons, and each is a relatively good place to start for those of you who are new to hydroponics.

Our preference for indoor passive hydroponic systems, however, and what we like to call the Anywhere Anytime Garden, is the Kratky Method combined with a state-of-the-art grow light. We believe that this method offers the indoor home gardener the most flexibility, the most affordable way of growing, the best options for expansion and truly the best opportunity to have a successful Anywhere Anytime Garden!

The Kratky Method

Bernard Kratky is a researcher emeritus in the Department of Tropical Plant and Soil Sciences at the University of Hawaii at Manoa. Dr. Kratky's research interests are non-circulating hydroponic culture, agricultural plastics, drip irrigation and the culture and management of vegetable crops.

In the mid-1980s, Dr. Kratky spent a one-year sabbatical at the Asian Vegetable Research and Development Center in Taiwan. There, along with Dr. Hideo Imai, a Japanese scientist, he made an interesting observation related to Taiwanese farmers who can grow vegetable crops on swampy lowland fields. The two researchers noted that the farmers' crops grew very well in what was, essentially, stagnant water. They further noted that the lower portions of the plants' root systems were in the water, but the upper portion of the roots were in soil which allowed the plants to get air. This observation was the basis for Dr. Kratky's research into non-circulating or passive hydroponic systems.

In 2009 Dr. Kratky presented a paper titled "Three Non-circulating Hydroponic Methods for Growing Lettuce*"* at the Proceedings of the International Symposium on Soilless Culture and Hydroponics. The abstract of his paper reads:

"Three non-circulating hydroponic methods for growing lettuce are described, which do not require electricity, pumps or wicks. All the nutrient solution is added prior to planting or transplanting. In the simplest system, lettuce is seeded in a tapered plastic net pot filled with growing medium and placed in a darkened, 4-liter plastic bottle filled with nutrient solution with the lower 3 cm. portion of the pot immersed in nutrient solution. Plants are automatically watered because the entire growing medium in the net pot becomes moistened by capillary action. Plant growth reduces the nutrient solution level, creating an enlarging moist air space. Meanwhile, the root system expands and continues to absorb water and nutrients. Leaf and semi-head lettuce cultivars are usually harvested at about 4 to 7 weeks after seeding. A typical expansion of this concept to a commercial scale employs a 14 cm. high tank lined with polyethylene sheeting which is filled with nutrient solution and covered with an expanded or extruded polystyrene sheet resting on the tank frame. Lettuce is planted or transplanted into net pots filled with growing medium and placed in holes in the cover. Lettuce seedlings are initially watered by capillary action, and later, by direct root uptake. The crop is harvested before the nutrient solution becomes exhausted. Another modification of this method is a float-support system in long rectangular raceway tanks. Lettuce is planted or transplanted into net pots placed in a sheet of extruded polystyrene. The cover initially floats on the nutrient solution, and then, comes to rest on two parallel plastic pipes (10 cm. diam.) resting on the tank floor as the nutrient solution level recedes due to plant growth. The tank is filled with water immediately prior to harvesting and floating rafts may be easily moved to a harvesting station."

Kratky's paper begins by explaining the basic idea behind passive hydroponic gardening. Essentially, seeds are planted in growing medium such as small clay pellets, which are in a small net pot. The net pot is first suspended in a liquid nutrient solution to moisten the medium and the seeds. The seeds sprout and begin to grow roots that grow down into the solution. The sprouts also grow up toward the light. Plant growth and time cause the liquid nutrient solution to decrease. As it decreases, some roots are left open in air and some continue to grow down into the solution. The roots that are not in the solution gather oxygen and carbon dioxide, and the roots that are in the solution gather nutrients. Thus, the plant develops "oxygen roots" and "water and nutrient roots." Through the growing cycle the liquid nutrient solution level may be kept at the same level or it may be lowered, but it should not be raised to cover all the roots. Submerging the oxygen roots in the liquid will drown the plant. The roots need oxygen and carbon dioxide. Plants are carbon based. They get their carbon from the carbon dioxide in the air.

In his paper, Dr. Kratky describes three basic passive hydroponic systems. The first system, the simplest, uses a 4-liter bottle method, we will discuss this system later as it is nearly identical to the bucket/jar system. The second system is an expanded version of the bottle method as it employs a commercial-sized tank with a top cover. Holes are placed in the top cover to accommodate the net pots that the plants grow in. The third system is a float-support system. It is a little more complicated to construct. It employs a tank, some plastic piping and a cover with holes that the net pots are placed in. The cover floats initially, but as the liquid nutrient evaporates, the board comes to rest on the pipes, which allows the oxygen level to increase.

The advantages of this passive hydroponic system are many. It is easy to construct, easy to maintain, cost-efficient, can be constructed and maintained virtually anywhere and can grow plants year-round indoors with the use of high-efficiency LED grow lights.

The conclusion of Dr. Kratky's paper makes a great case for passive hydroponics:

"A non-circulating hydroponic concept for growing lettuce is described where electricity and pumps are not needed, and the entire crop can be grown with only an initial application of water and nutrients."

This says simplicity.

Commercial Systems vs DIY

When you decide that creating a passive indoor hydroponic system is something that you'd like to pursue, you will have several choices to make when it comes to determining specific system types. Will you purchase a prepackaged system? Will you make your own system? Or will the system you build be a little bit of both?

Our advice at this point is to start small and keep it simple. We also advise that you make as much of the system as you can with materials that you already have. A basic passive hydroponic system is, as we already discovered in Dr. Kratky's paper, a simple operation. You can get started on your own do-it-yourself system with a large-mouth quart canning jar. You will probably have to spend a couple of dollars on a 3-inch diameter net pot and some growing medium, a few dollars on nutrient and seeds, but that's about the extent of it… especially if you have a sunny window place in your home.

To make the concept of our Anywhere Anytime Garden a reality, you will also require a grow light. The grow light will give you the ability to truly grow anywhere and anytime.

By starting simple and doing it yourself, you can grow how you want, what you want, where you want and control how much you spend. What could be better than that?

In the next chapter we will offer a detailed description of all the equipment and supplies that you may need to construct and start your own system. The chapter after that will offer detailed instructions for putting it all together. We must state at this time, however, that the building, growing, and maintaining of these systems is extremely simple and can be done by anyone.

The Makings of a Passive Hydroponics System

As we have mentioned on numerous occasions, the primary selling point of indoor passive hydroponic systems is their simplicity. When we say, "the makings," we really are only talking about six or seven items.

Water

Nutrients

Container(s)

Net pot(s)

Growing medium

Light(s)

Seeds

Additional items include trays to hold your containers some kind of shelving unit if you expand, a container for pre-mixed nutrient solution and a support of some kind for your light(s).

But even with these additions, you're still looking at a very simple system with very few moving parts that requires very low maintenance.

The goal of this chapter is to take a closer look at the main elements that comprise your indoor passive hydroponic system and to explore the options as you begin to put it together.

Water

We explained earlier that the word "hydroponics" is derived from two Greek words: "hydro" meaning water and "ponos" meaning labor or work. In other words: We let the water do the work. Water is what delivers the nutrients to the plants and is the key component in any hydroponic gardening system. Also, know that most plants are about 75 percent water.

You should be aware of several different facts about water when you decide whether to use your home tap water for gardening purposes and, if you choose to do so, what you might do to make it better for your plants. You should know how hard or soft your water is, and you should understand its general chemical composition.

That said, you might also choose just to go with home tap water and not really worry too much about its chemical makeup. After all, if you drink and cook with it with no negative effects, it's probably all right. On the other hand, water quality in some areas of the country has been found to be problematic. So, you might want to find out exactly what is in your local water.

A good place to start learning about your water quality is a pH test. According to the Environmental Protection Agency, "The pH scale measures how acidic or basic a substance is. It ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. Each whole pH value below 7 is ten times more acidic than the next higher value. For example, a pH of 4 is ten times more acidic than a pH of 5 and 100 times (ten times ten) more acidic than a pH of 6. The same holds true for pH values above 7, each of which is ten times more alkaline — another way to say basic — than the next lower whole value. For example, a pH of 10 is ten times more alkaline than a pH of 9.

"Pure water is neutral with a pH of 7.0. When chemicals are mixed with water, the mixture can become either acidic or basic. Vinegar and lemon juice are acidic substances, while laundry detergents and ammonia are basic." You can purchase pH test kits at many large hardware stores.

You also might want to know how hard or soft your water is. Hard water is measured by the amount of mineral salts that it contains. You can get a report on your water's hardness from your municipal water service. You can get kits at your local hardware store that will test your water. You will see on the table below numbers that correspond to the water's alkalinity and hardness.

You probably want to start with water that is as close to neutral as possible. If you are curious to find out about the water you are using from your tap, you can probably go to your city's municipal website and search for a water quality report. Do an internet search of "annual water quality report" for your community.

Example: The following information was included in an annual water report submitted by the city of Lincoln, Nebraska.

WATER QUALITY PARAMETERS

pH 7.71

Total Alkalinity (CaCO) 3160 ppm

Total Hardness (CaCO) 3200 ppm

(12 grains per gallon)

Total Dissolved Solids 336 ppm

Calcium 54.4 ppm

Chloride 20.5 ppm

Iron <0.05 ppm

Manganese 1.04 ppb

Sodium 30.6 ppm

Sulfate 77 ppm

(12/10/09)

Lincoln's water is moderately hard.

Alkalinity, pH and hardness are important

if considering a water softener.

Of the items listed in the water report above, six will have the greatest impact on gardening: carbonate (noted on the above table as Total Alkalinity), chloride, sodium, calcium, sulfate, and magnesium.

It's good to know that plants have developed a variety of strategies for their growth and survival determined by their native environment. They have developed a variety of "tastes" and "preferences" for different chemical compositions that aid in their nutrition. A good example is the blueberry bush that requires a highly acidic environment to grow and produce fruit. The fruit of the blueberry, at the same time, contains a skin that is also highly acidic.

On a water report, you will often see these items listed in parts per million (ppm), which is equivalent to 1 milligram per liter (mg/L). To convert the ppm listed on your local water report to mg/L, you can go to **www.unitconversion.org/concentration-solution/part-per-million-ppm-conversion.html**. This website, UnitConversion.org, provides many online conversion tools and resources.

Local tap water can be diluted with purified or distilled water to adjust your target water profile. Also, you can use additives to increase the level of key minerals. Additives of choice are baking soda ($NaHCO_3$), table salt ($NaCl$), gypsum ($CaSO_4$), calcium chloride ($CaCl$), epsom salts ($MgSO_4$), and chalk ($CaCO_3$). Also, there are commercial solutions that adjust the water's pH level.

Hard and Soft Water

Adjusting the hardness and pH of your water for the purpose of hydroponic gardening is a complicated matter, but it is useful to know its status. For beginners, if you have water that lies way outside the neutral range in pH, hardness, and/or taste, you might consider using purified water, spring water, deionized water or reverse osmosis water. The cost for five gallons is not prohibitive, and you will be much more pleased with the results. If you have a large-scale growing operation, this cost may be prohibitive.

You might just want to know if you are feeding your plants hard water (water with a high number of minerals) or soft water (water that has had the minerals removed). Generally, you can taste this. It is probably not necessary to test your water to get started, but it is something that some may want to be aware of.

When you think about altering the chemical composition of your local water supply, you also will need to keep in mind the nutrient solution to be added to the water that will be supplied to the plants. Nutrient solutions will be explored in greater detail later in this chapter.

Chlorine and Chlorimines

If you use tap water, the most common issue you will face with your hydroponic garden water is chlorine. Chlorine is a micronutrient required by plants, though the quantity needed is extremely minimal. The amount of chlorine present in unfiltered tap water is more than your plants require. The result of over chlorination is diminished growth. Root health is upset by chlorine and beneficial bacteria and fungi are quickly killed off. The microflora and microfauna living in the root zone are key to high yields and healthy plants.

Chloramines are chemical compounds of ammonia and chlorine that are also often used as municipal water supply sanitizers as they react differently than chlorine and provide water that tastes and smells better. Chloramines do not evaporate from water the way chlorine does, and many water filters that remove chlorine cannot remove chloramine. The effects of chloramine on your garden are even more detrimental than chlorine.

To avoid the problems caused by these chemicals, invest in a water filter that removes both chlorine and chloramine. The improvement you'll observe in plant health will be considerable and translate to a substantial increase in your harvest as well.

You will recall in the earlier review of the history of hydroponic gardening that John Woodward determined in 1699 that pure water was not as good for soil-less plants as water that had once had soil soaked in it. This led to the important understanding of how water holds minerals once it has been in contact with soil. This discovery does not mean that plants are better off grown in soil, only that the minerals contained in the soil may be of use to the plants. Of course, minerals found in your backyard soil may also be bad for your plants or they may have no effect at all.

As we have mentioned on several occasions, one of the best things about indoor hydroponic gardening is that you have the power to be in complete control of the plants' nutrition and environment. If you start with water that is completely neutral, you can give the plant only the nutrients that will help it grow while omitting any negative minerals and or chemicals that may be found in soil. Your task is to learn what the best diet is for your garden.

Nutrients

Back in the earlier section of this book that looked at the history of hydroponics, you read about experiments carried out by the Belgian scientist, Jan van Helmont in the 17^{th} century. He was one of the earliest researchers to observe that plants obtain substances such as nutrients from water. Van Helmont planted a 5-pound willow shoot in a vessel that contained 200 pounds of dried soil. The vessel was then covered to keep out any possible contaminants. Van Helmont regularly watered the contents of the vessel with rainwater for five years. After this period, he noted that the willow shoot had increased in weight by 160 pounds, but the soil lost less than two ounces. From this observation Van Helmont concluded that plants grown in soil receive their nutrients, not from the dirt, but from the water. It was subsequently realized that plants also benefit from the oxygen and carbon dioxide in the air around them.

Then in 1699 John Woodward determined that pure water was not as good for soil-less plants as water that had once contained soil. This led to the important understanding of how water retains minerals once it has been in contact with soil. Subsequent research led to the first man-made nutrient solution for hydroponic gardening.

Now that you have learned that the primary goal of a hydroponic system is to deliver nutrients to the plant, we will examine the nature of those nutrients. The liquid nutrient solutions used in hydroponics are the key to having healthy productive plants. It does not matter how expensive or sophisticated your equipment is. If your nutrients are not chosen properly, your garden will fail.

The aim of this section is to detail the chemistry of plant nutrition to give you a good understanding of your crops' nutritional needs. Because of the wide variety of available nutrients, you really do not need to dive deeply into nutrient chemistry, but we think it is important to offer this information as a resource to those who are interested. Also, in some cases, it is important to have this resource available to answer any questions that are connected to growth issues. Do whatever works best for you.

As you read through the following information, recall the information about water described earlier. If you plan to use your local tap water, you would be well served to understand its chemical make-up. Knowing what you are starting with is especially useful if you plan on making your own nutrient solution.

If you are using water from a well or of an unknown source, you can always take it to be tested. Contact the local health department in your city or county, and they should be able to direct you to a certified laboratory that will test it and tell you its exact chemical composition.

You can also test a variety of water options yourself. Plant seeds in your hydroponic set-up using tap water, neutral purified water, spring water, deionized water and/or reverse osmosis water in separate containers. Make sure you plant the same types of seeds in each test jar. In which water do the plants respond best?

Electrical Conductivity Measuring

Electrical conductivity measuring is how you identify your solution's mineral content. Pure water will not conduct electricity. Only dissolved minerals in the water can allow that to happen, so you can measure how many minerals are in the solution based on how well (or how poorly) it conducts electricity.

This measurement will not be able to give you a chemical-by-chemical breakdown of exactly what the water is composed of, but it does provide a very convenient and easy way of quickly determining how nutritionally depleted your reservoir water is. Basically, the more materials that are dissolved in the water, the more electricity it will carry.

You can test the conductivity of a liquid solution with an electrical conductivity (EC) meter. You can get a small inexpensive EC meter from an online retailer for about $30. This is not essential equipment, but if you are interested, it is available and relatively affordable.

Electrical conductivity (EC) is directly measured in milliSeimens per centimeter (mS/cm), or also as millimhos per centimeter (mMhos/cm). You will get this reading directly from your meter. Unfortunately, most people are more familiar and more comfortable with parts per million (ppm) as a way of measuring materials in solution. To add to the confusion, other ways of measuring dissolved materials include total dissolved solids (TDS). Because the meter will measure in EC to begin with, that is the most accurate way to describe the nutrient content for hydroponic purposes.

You can make some rough conversions between EC and PPM. A reading of 1 mS/cm can equal anywhere between 500 and 700 ppm depending on whose tables you are checking. The reason why there is no official conversion is because the two units are not really measuring the same thing. Not all materials in solution will have the same EC readings, so there is no way to determine how many parts of anything are in a liquid based solely on the EC readings. These are only approximations. Unfortunately, American gardeners have not adjusted to the use of EC, and most publications still will use ppm references to discuss nutrient concentrations.

With that in mind, most plants do very well with nutrients at an 800 to 1200 ppm level. As you might expect, this will be determined somewhat by the specific nutrient mixture you are using in the first place. Taking EC readings with a fresh batch of solution will give you a baseline against which to measure subsequent readings to judge how depleted your mix is becoming over time.

Meters for measuring EC vary, and you can adjust your purchase to suit your budget. They fundamentally all work the same way by sensing a small electrical current between two electrodes in the probe. Some meters are meant to be left in the solution at all times and will give you an ongoing reading, and others are just dipped into the water when you want to take a reading.

When measuring EC, you should regularly take two readings each time. One should be from the solution in your main reservoir, and the other should be taken from within the plants' growing medium. You do not necessarily have to measure each plant separately, but alternate which ones are being tested with each day's routine. The reason for doing this is to see that the growing medium is not forming a build-up of salts, which would possibly have a negative impact on your plants.

That said, because the hydroponic system we are describing is a small passive one for the home, the level of examination your nutrient solution will require is negligible. Again, we only offer this information as resource material.

There are dozens of solution mixes you can use, all with their own instructions, ratios, and programs. Some are designed to promote flowering, while others are mixed to promote more root growth. Solutions are mixed with water to the proper amounts based on the brand's instructions and then used in your hydroponics system. Some nutrients are one-part, meaning there is just one liquid or powder to mix with water. More in-depth products that allow for more tailoring are two-part or even three-part.

You also will find some basic formulas are purchased as a two-part solution because of potential chemical reactions between ingredients, not because you can (or should) tailor your final solution by "adjusting your use of each portion." When in concentrated form, certain compounds will react with each other, causing crystals to form. By diluting each portion first, and then combining, you can avoid these reactions. Again, reading the instructions should guide you on how to do this.

Premixed or Do-It-Yourself Formulas

You can either stick to a premixed or one-part formula to keep things simple or get more creative and start mixing up the individual nutrients yourself to make a custom blend for your growing media. To maintain the simplicity of your Anywhere Anytime Garden, we recommend finding a premixed nutrient solution that works for you and sticking with it. But, for those of you DIYers, we offer this resource to get you started. In any case, just like food for humans, remember that more is not better.

The term "do-it-yourself" is a bit of a misnomer, as you will be using commercially made products even if you decide to create your own homemade blend of nutrients. The specific chemicals that go into a typical nutrient solution are outlined later in this chapter but suffice it to say that it is not something you can put together properly with standard household ingredients.

The question is often asked as to whether or not animal droppings can be used as nutrient. The answer to that question is "yes and no". If you are exploring the practice of aquaponics, you will, of course, count on fish droppings to provide some of the nutrient to the plants that share the environment with them. On the other hand, to use animal waste in hydroponics takes a bit more study and preparation than we are prepared to deliver here. The short answer to the question is then…., "Yes, but…". For the beginner, though, we advise against it.

Breakdown of Essential Elements

There are dozens of components in any good nutrient solution. Although you do not need a degree in chemistry to manage your garden, it is a very good idea to understand the basic principles behind these ingredients. Plants require about 14 elements for their growth. Each chemical has a very specific effect on your plants and can be adjusted to create a solution that perfectly suits your gardening needs. You will find all these elements in any of the premixed nutrient solution that you purchase commercially.

These compounds are typically broken down into two categories: macronutrients and micronutrients. Macronutrients make up most of any solution, and they are required in the highest volumes. The micronutrients are necessary but only in smaller trace amounts. Six macronutrients are used in hydroponic solutions: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Each one of these is described in more detail in this section. Micronutrients will be explained following the description of macronutrients. Symptoms for both deficiencies and excessive amounts are provided since either one can become a problem in a hydroponic system.

Macronutrients

NITROGEN (N)

Nitrogen might be considered the most important of all the nutrients, and it influences the vegetative growth of the plant, which means all the leaves and stems. It also is used by the plant in the creation of chlorophyll as well as the proteins used in new cell walls. Because nitrogen is used so much with new growth, you want it to be higher during growth periods before the plant needs to start setting fruit or flowering.

Because nitrogen is so vital and is used so quickly, it is often part of additional fertilizers as well as standard nutrient solutions. It is provided in two forms in most solutions: as ammonium (NH_4) and nitrate (NO_3). Ammonium can be too potent for some plants and “burns” them while nitrate takes longer to be assimilated by the plant’s cells. A mix of the two can provide a good overall supply of nitrogen.

NITROGEN DEFICIENCY

Because your plants consume it so quickly, nitrogen easily can become deficient in your solution. When the concentrations get too low, the leaves will start to turn yellow in the spaces between the veins. This is called interveinal chlorosis. Lower or older leaves will show symptoms first because nitrogen is a “mobile” nutrient, and plants will move it to newer leaves that need it more. As more leaves turn yellow, they will drop off quickly.

With an interruption in green chlorophyll production, stems and smaller leaves may develop a red or purple cast (usually the underside of the leaf rather than the top surface).

EXCESSIVE NITROGEN

At first, it will seem as though your plants are vigorous and thriving by producing many new leaves. But you soon will notice that the stems are weak, and the leaves will be bent over as they grow. Any flowers that bloom will be small with overly fine petals. After a short time, leaves will start to turn brown, dry out, and fall off. If you check the roots, they will be very slow to grow as the plant is putting all its energy into developing excessive foliage.

PHOSPHORUS (P)

While nitrogen is used in leaf production, phosphorus is most notably involved in flowering, fruiting and seed production. It also is used heavily by plants at the early stages of germination and seedling growth. Most nutrient solutions geared toward improved blooms or fruit production are high in phosphorus. Chemically, it is used in many plant enzymes, and it is a compound in DNA.

PHOSPHORUS DEFICIENCY

With phosphorus deficiency, overall plant growth will be stunted, particularly any flowering that should be taking place. Blooms that do open will be smaller than usual. Some of the first signs of low phosphorus will be in the leaves. Veins will start to darken, turning purplish or black. The parts of the leaves between the veins also will start to turn black, starting at the tip of the leaf and slowly taking over the whole leaf, at which point it usually drops off.

You also can get phosphorus deficiency symptoms if your plants are lacking in zinc (a micronutrient) because zinc is necessary for the plant to properly use its phosphorus supply. Phosphorus uptake also can be interrupted if your solution has a pH over 7. These are two other areas you should always check when you see plants with deficiency symptoms that are not improved with added phosphorus.

EXCESSIVE PHOSPHORUS

Having too much phosphorus in your system usually will not create too many negative symptoms because the plants can handle this element, even in high concentrations. However, it can start to interfere with the use uptake of other nutrients, so having too much phosphorus can manifest as a deficiency in other minerals (such as calcium, zinc, magnesium, and copper).

POTASSIUM (K)

Potassium is used in all forms of plant growth, and it helps the plant handle sugar and starch production. Potassium levels also encourage sturdy root growth and can help plants resist fungal attacks.

POTASSIUM DEFICIENCY

When your solution starts to run low in potassium, your plants will start to turn yellow (older leaves will show symptoms first). The yellowing tends to take place across the entire leaf surface. The leaves will then get dry around the edges, showing crisp brown tips. Larger rust brown patches can show up on the rest of the leaves before they drop off. If you are growing flowering plants, they likely will fail to bloom. Most leaves will look dull on the surface and lose their natural shine.

EXCESSIVE POTASSIUM

Having excessive potassium levels in itself is not toxic to plants but can reduce the uptake (absorption) of other nutrients. The most notable of these is nitrogen, although it can affect magnesium.

The previous three macronutrients are considered primary nutrients because they are so fundamental in a plant's growth and development. The next three are considered secondary because they are required in smaller quantities, though they are just as vital to overall plant health.

CALCIUM (Ca)

Calcium is used by the plant in creating new cell walls; particularly in the fast-growing root tip zones.

CALCIUM DEFICIENCY

Stems can start to weaken, creating a droopy look as the stems are unable to hold up the leaves completely. Unlike the typical yellowing that occurs with many other nutrient deficiencies, a lack of calcium will create very dark leaves. Younger leaves will show symptoms before the older ones because calcium does not transport well through the plant.

Very new leaves will start to turn yellow as the problem persists and can even turn dark purple. Overall growth of the plant will be reduced or stopped altogether.

EXCESSIVE CALCIUM

Too much calcium in your nutrient solution is not going to cause many symptoms though your plants can start to wilt if it gets too high. It also can be evident in your solution reservoir as it can cloud the water.

MAGNESIUM (Mg)

Magnesium is one of the chemical components of chlorophyll, and it will be used in large amounts in fast-growing plants (annuals). You should not confuse this with manganese, which is still important, but as a micronutrient only.

MAGNESIUM DEFICIENCY

This is one of the more common problems you will find with nutrient deficiencies in hydroponics plants. Unfortunately, it also can take a few weeks before symptoms start to develop. Lower leaves will start to yellow, which quickly spreads across the entire leaf. The leaves will turn extremely yellow or even off-white before they finally die and drop off the plant. As it progresses, the edges of the leaves will start to turn dry and brown, and rusty spots can start to form on the leaf.

Even if your solution has the proper levels of magnesium, it may not be taken up by the plants if the roots are being kept too cool. Raise the temperature and see if that improves the situation.

EXCESSIVE MAGNESIUM

Having an excess of magnesium is not going to cause any particular problems, and you will not see any adverse symptoms in your plants if this happens.

SULFUR (S)

Sulfur is involved in many plant processes, particularly the creation of vitamins and hormones necessary for plant development. Calcium will bond with sulfur to create calcium sulfate (also known as gypsum), and it can cloud the water or even settle out as a solid. This can lead to a lack of sulfur in solution, creating a deficiency.

SULFUR DEFICIENCY

As usual, you will be looking for yellow leaves though the progression is a little different than with the other elements. The newer leaves will start to show their symptoms first, usually at their base rather than the tips. The veins usually stay deep green with the rest of the leaf getting paler as the problem persists. Eventually the leaf tips will curl downward and may show some signs of burning or drying at the edges. There will not be any brown spots across the leaf, but some stems can start to look dark and purplish.

EXCESSIVE SULFUR

Your plants will not suffer dramatically if there is a high level of sulfur in their solution though overall growth will be slow and leaves will be darker green than usual.

Micronutrients

ZINC (Zn)

Zinc is crucial for the creation of chlorophyll and other enzymes. It is often found to be deficient in soil-grown plants though most nutrient solutions have an adequate supply. A lack of zinc will lead to leaf yellowing with some browning along the edges. It resembles magnesium deficiency, but without the brown spots on the leaf surface. New leaves will have a crinkled appearance or look otherwise deformed. The same goes for flowers. Overall plant growth is very slow when there is a low level of zinc.

IRON (Fe)

Iron is not easily absorbed, so you need to have a good concentration of it available in your solution to ward off deficiencies. Acid solutions will also inhibit iron uptake, so check on your pH if you detect a problem. Younger leaves show symptoms first because iron is not easily moved around the plant and cannot be drawn from older leaves for use. The spaces between the veins will start to yellow, starting at the base of the leaf. The veins usually remain green.

MANGANESE (Mn)

Do not confuse Manganese with the macronutrient magnesium although their deficiency symptoms are actually very similar. The veins remain green while the rest of the leaf slowly turns yellow, starting around the base. Dead patches can start to form, which are not the same as the discolored brown or rust patches found with some other deficiency issues. Overall plant growth is stunted, and the plant will take a long time to mature.

The following micronutrients are important but required in such small quantities that it is seldom a problem. You only likely will find deficiencies in these if you are experimenting with your own personal nutrient solutions rather than using a commercial blend. Even so, a good gardener is always familiar with all potential problems.

CHLORINE (Ci)

Chlorine is added to almost all municipal water supplies, so it is highly unlikely that you will find a deficiency even if you are filtering your water. If there does happen to be a deficiency, roots will develop improperly, leaving them very short and leaves will take on an unusual bronze color. If the amount of chlorine in the water is excessive, young leaves will quickly develop dead or burned edges that will spread through the plant if the problem is not corrected.

COPPER (Cu)

Younger leaves will wilt and turn a brownish-gray if there is not enough copper in your solution. The wilting will spread to the whole plant, and you can use a copper-based fungicide to add some additional copper as a quick treatment. Excessive copper will lead to a darkening of the roots and slow growing plants. If your solution is acidic, it can make a copper overdose worse. Copper is required in very small amounts, so you do need to be careful not to overdo your treatment.

NICKEL (Ni)

It is very unlikely you ever will come across a nickel deficiency, and there are no unique symptoms you will be able to identify.

BORON (B)

A lack of boron will give your plants stubby roots, and new leaves will quickly start looking burned right after they emerge. As the deficiency continues, the darkening or burning will move down the plant to impact older leaves. There can be wilting and the formation of dead or rotting spots in your leaves.

SILICON (Si)

It is believed that a silicon deficiency can cause plants to stop producing new leaves or simply be less productive. It is a very common element in water, and specific studies into its purpose have not been done.

SODIUM (Na)

This refers to the pure element sodium not the sodium chloride we use as table salt. Sodium is one element you do not want to have if you can avoid it, and the water used to mix up your nutrient solution should have no more than 50 ppm in concentration. For leafy greens, sodium levels above 20 ppm can start affect the roots. If you look at the water report from Lincoln, Nebraska displayed earlier, you will note that the city water has 30 ppm. If water levels are above 12 ppm there are three satisfactory methods to avoid excess sodium in nutrient solutions. One is to use a reverse osmosis water purifier. Secondly, if you use a water softener in your house, you might be able to get water with a lower sodium level by drawing water from an outside spigot/garden hose. Finally, you can save and use rain water.

Nutrient Composition Values

Though you cannot use an EC meter to measure each component in your solution, it can be helpful to have a reference table of concentrations for each element. When working with separate products or blending your own fertilizers, you will need to have a rough awareness of how much each nutrient should be.

The following list provides the average amounts you will want in parts per million (ppm) for each major nutrient in a solution. These are just estimates, and your plants can tolerate wider ranges.

Nitrogen	250 ppm
Phosphorus	80 ppm

Potassium	300 ppm
Calcium	200 ppm
Magnesium	75 ppm
Sulfur	400 ppm
Iron	5 ppm
Copper	0.05 ppm
Zinc	0.5 ppm
Boron	1 ppm
Manganese	2 ppm

As mentioned, your standard EC measurements will not provide this detail to you. But other chemical test kits can provide a better look at the concentrations of each element in a solution. Garden stores offer great kits you can use to test for specific elements.

Handling Imbalances

As you can see from the above section, there can be many potential problems if you have the wrong amount of any of these nutrients. Deficiencies are more common than excesses since plants simply cease drawing in certain chemicals once they no longer need them. Of course, this is not a perfect system, and you can have some toxic symptoms if the concentrations of certain chemicals are too high.

But the fact is that you do not manage your nutrient solution just one chemical at a time. The fact that you are low in sulfur or potassium does not simply mean you add more of them to the batch. This is especially true if you are using a premixed liquid or powder formulation for your garden.

If you start to notice deficiencies in your plants, you may want to consider another type of nutrient solution. You may want to experiment with solutions depending on what you are growing. We will recommend some brands of solutions later in this chapter

If you continue to have plant growth problems, you need to change solutions completely. With so many brands and mixtures on the market, there is no reason to assume that they are all the same. Each one will vary its formula a little, so look around to find one that is higher in whatever element you are frequently lacking. Or use other additives to boost that one element.

Commercial Nutrients

Though there are too many specific types of nutrient products to list completely, here are some of the companies that sell nutrient solutions that are good for passive hydroponics and beginner setups. Many of these are complete solutions that would be used on their own in your system. Some solutions are additions that you would use at certain times in the season or to counteract temporary nutritional problems. Some of these companies also sell fertilizer for soil-based gardens.

For the most part, hydroponic solutions are very complex, and products are not simply offered with one or two minerals as ingredients. Most blends will include standard nutrients (in a mix of amounts and ratios) as well as other compounds. They often have their own proprietary mix of amino acids, vitamins, hormones and more that are not explicitly listed. Prepare for some trial and error once you go beyond the very basic mixes.

One further note on nutrients is the notation of three numbers included with most products that have a broad nutrient composition (as opposed to those that are just fertilizers or additives). These figures represent the nitrogen-phosphorus-potassium (N-P-K) content and will make your label reading a little easier if you are focusing on these main nutrients. For example, the popular MaxiGro solution by General Hydroponics® reads 10-5-14, meaning that it contains 10 percent nitrogen, 5 percent phosphorus and 14 percent potassium.

GENERAL HYDROPONICS

This is a popular line of hydroponics solutions, and their MaxiGro series is one of the most popular solutions that work as a general standard formula. This is a very good place to start if you are looking for your first solution. There are two blends: MaxiGro for general plant growth, MaxiBloom for flowering or fruiting periods. They also have another line called General Organics that focuses on organic and vegan ingredients but offers the same concept of growth, flowering, and micronutrients. They also carry other fertilizers and supplements.

BOTANICARE

You also can get very good basic solutions from Botanicare, and their Pure Blend® line is similar to the products just mentioned above. Each is a one-part liquid solution, and there is one formula for general plant growth and one for blooms and fruit. There is also an additional one specific to soil growing or coco fiber. If you are looking for base solutions, their Triflex and CNS17 lines offer some other NPK blends to choose from. Each one has a simple growth formula as well as one for flowers and fruit production. Botanicare also has a selection of more specialized fertilizers and amendments for fine-tuning your overall system.

FOX FARM

Fox Farm sells many kinds of fertilizers, including some for soil growing as well as hydroponics. Make sure you know which you are buying. They have two very good products for hydroponics use. Their Grow Big® mixture makes a good all-around nutrient solution, and the Big Bloom mix is unusually mild and makes a good choice when you need to flush out your system when nutrient imbalances have built up.

EARTH JUICE

You can get good base solutions from Earth Juice, focusing on standard growth or flowering stages, and they also have a nutrient booster called Catalyst that has a mixture of molasses and kelp emulsions for a little extra help. They also carry pH adjusters and a potassium-based fertilizer called Earth Juice Meta to improve harvesting production. Earth Juice also offers root stimulators and cloning products for when you are propagating new plants.

ADVANCED NUTRIENTS

Most of their products are more expensive than the others, but you will find a huge selection of formulas and mixes for your plants with Advanced Nutrients. Their basic line comes in three formulas: Grow, Bloom and Micro, which are similar to other products already mentioned. They also have more sophisticated products that come in two parts to be mixed *after* you dilute them. Their Connoisseur and Sensei Grow solutions are both two-part mixtures. Some of their products are fancifully named, such as Voodoo Juice, Hammerhead, and Wet Betty. But if you take the time to read the ingredients, you will probably find just about any type of formula you could want. They also have several pH adjusters for when your levels are out of line.

ROOTS ORGANICS

Roots Organics has a mix of products, but their Soul Synthetics makes a great base for your nutrient needs. They use synthetic compounds rather than natural ones. You can get the typical grow and flower blends, as well as mixes with micronutrients, extra amino acids, or other custom combinations to suit any situation. They lean towards flowering boosters, though you can get some benefits for fruiting plants, too.

CANNA Coco A & B

Coco is a complete professional nutrient for plants containing all the essential elements for optimal growing and flowering. Due to the special characteristics of coco substrate CANNA COCO nutrients don't have a Vega and Flores version, there is one unique formulation for both the growth and blooming phase.

Containers

Now that you have your water and nutrient solution figured out, you will need something to put it in that will act as a reservoir in which your plants will grow. For starting your Anywhere Anytime Garden you will have three basic options to choose from. Each is relatively easy to acquire and put together.

Jars

Buckets

Totes

Jars

Jars are the easiest option… and maybe even the easiest all-around way to garden using the passive hydroponic system. Wide-mouth quart jars are ideal as you can grow a wide variety of lettuces, herbs and other plants. The wide-mouth quart Ball Mason jar has a 3-inch mouth opening at the top of the jar. That is the perfect size to accommodate 3-inch net pots (which we will describe a little later in this chapter).

Wide-mouth quart Mason jars are very affordable and easily found in many grocery stores or through online retailers. A dozen jars cost about $15.00 new and can often be found for pennies at thrift stores.

It is important that the containers you use as reservoirs be somewhat dark or opaque. Cover the jars with sleeves of any kind, whether simple pieces of paper, old (or new) socks or tape. We'll discuss this more in the next chapter.

Buckets

5-gallon buckets are another option you might choose. Again, you will want to use an opaque bucket that is made of food-grade plastic. Make sure that you choose a bucket that has a lid. You will need to cut a hole or holes in the lid to accommodate your 3-inch net pots. Standard 5-gallon pails made by United States Plastic Corporation are 14.5 inches high, 11.91 inches in diameter at the top and 10.33 inches in diameter at the bottom. You will be able to accommodate 4 to 5 net pots in a standard 5-gallon bucket for smaller plants. You can also use larger net pots which may range 4 to 6 inches in diameter.

Buckets are a little more difficult to deal with (as opposed to jars) as you will have to cut holes in the lid, but buckets can also be used to grow larger plants as they can accommodate larger net pots. Or, you can purchase a "net pot lid." These are available from 4 inches all the way up to 10-inch diameter net pots. These simply replace the lid on the bucket and can be ordered for about $6.00 online.

Totes

Totes come in many sizes. Totes are also called bins or tubs. Make sure that the totes you use are food grade. An example of a bin that might be used for an indoor passive hydroponic system is a food-grade bin that is 16 x 11 x 5 inches with a fitting lid. Holes are cut in the lid to accommodate net pots. Nutrient solution is poured into the bin and the lid with the net pots are fitted on top.

Totes are somewhat more expensive than jars or buckets and are not as flexible.

Jars, buckets and totes are the three standard choices for putting together your Anywhere Anytime Garden, but you do not have to stick with one of these options. You can use any kind of container that will accommodate your nutrient solution and has a place to contain your growing medium. You may remember reading earlier about Dr. Bernard Kratky who used a 4-litre plastic bottle with a tapered net pot to grow lettuce.

As our goal is to make it as simple and accessible as possible for you to have an Anywhere Anytime Garden, our recommendation is to go with the simple quart Mason jar… at least to start with.

Net Pots and Growing Medium

A net pot, or net cup, is a reusable plastic cup with holes in the sides and bottom and a lip around the edge. The holes allow liquid nutrient to get into your growing medium and then for the plant roots to grow down into the nutrient solution in the reservoir. The basic idea is that you put your growing medium in the net pot and the seeds into the medium. The net pot is then fitted into the top of the liquid nutrient-filled container (jar, bucket, etc.…).

Net pots are very inexpensive (3-inch net pots are about $ .25) and can be found at your local garden/hydroponic store or through an online retailer.

Once you have your container, liquid nutrients and net pots, you will need a growing medium in which to plant your seeds. You have many options. Experiment with several types to determine what works best for you.

The main task of a growing medium is to offer support for your plants and their roots as they grow. Without the support, your seeds would sprout in the nutrient solution but not develop as they would drown. There are different options when it comes to growing medium. Some are organic, and some are man-made. In many cases, there is minimal difference between one type and the next, even though many hydroponics gardeners may swear by one medium over another.

Support of the plant is the main function of growing medium. But, what does that mean? It means that the growing medium must allow the nutrient solution to come up to a new seed and then allow the seed to send its root down into the liquid while providing an anchor for the plant to grow up. All materials should be light and porous so that they can hold a mix of air and water within them and still allow roots to grow freely between the particles. They also should be chemically inert so that they do not contribute to the nutrient mix that your solution is providing. That would defeat the main purpose of hydroponics.

EXPANDED CLAY PELLETS

This is a very popular growing medium for many gardeners, and it goes by brand names such as Hydroton®, Geolite and Grow Rocks. It is also sometimes just known as LECA, for lightweight expanded clay aggregate. The pellets are available in different widths.

One of the great benefits of expanded clay is that the pieces are reusable. You can just wash them off between growing projects and use them again with a new set of plants. It is a good idea to sterilize them gently with a dilute solution of bleach to make sure you are not transferring any mold spores from one growing batch to the next. You can sterilize the clay pellets by placing them in a dishwasher mesh bag and running them through a dishwasher cycle. Being reusable does help to offset the fact that they are more expensive to purchase in the first place. They also should be rinsed off well before their first use to remove any clay dust.

COCONUT FIBER

Coconut fiber is becoming one of the more popular types of hydroponic media in use right now. It is inexpensive, and it holds water well without smothering roots. It is a natural and biodegradable material collected from the outside of coconut shells. It also goes by the name coir, coco coir or coco peat. The fiber is sold in pressed blocks for easier handling. You must break it apart before use. It works even better if you add some perlite to the mix for a little extra aeration and drainage. We recommend a 50/50 mix of coco coir and perlite. This is an ideal mix for growing root plants such as beets, carrots, radishes, etc.…

ROCK WOOL

Rock wool is a light and very fibrous inorganic material. It is made from heated rock spun into fibers when it is molten. It is pressed into various shapes and sizes to accommodate your hydroponics needs, with small plugs working well for seeds and larger bricks for more mature plants. Though it is primarily made from natural sources, this inorganic material is not biodegradable.

It’s All About the Light

“Mary, Mary, quite contrary, how does your garden grow?”

So far, we’ve seen that it is not so much the soil that helps Mary’s garden to grow, but rather the water and its ability to deliver nutrients to roots. But plants also get energy from above…. That is, from light.

When you put your seeds in the soil outdoors, they get sunlight. The amount of light they receive depends on where they are planted and how many hours they receive sunshine.

Lighting Options

Even something as simple as a light bulb is going to come in several varieties. There are many different kinds, and they all may or may not have a place in a hydroponic system.

Household incandescent bulbs are not very good for growing for several reasons. They do not provide the proper spectrum of light, and they are extremely hot compared to fluorescent bulbs and LEDs. In an enclosed area, heat buildup could be a detriment to your gardening, not to mention the short life span of an incandescent bulb. Considering your lights will be on for between 10 and 18 hours a day, you will spend a lot of time replacing bulbs if you use incandescent bulbs.

There are several lighting options available to home hydroponic gardeners, though lighting is currently going through a great deal of change. High Pressure Sodium (HPS) and Metal Halide (MH) have been the lights of choice for serious gardeners in the recent past. Both are considered High Intensity Discharge (HID) lighting. While these are the better-quality lights intended to be used as grow lights, they use a considerable amount of energy, and bulbs can be very expensive to replace.

Here are the basic points about each type of HID lamp, without going into the chemistry that makes one different from the other.

HPS bulbs have more light in the red end of the spectrum, with MH bulbs leaning the other way to the blue end. Overall though, MH lights offer a wider spectrum of light and are closer to natural sunlight in terms of the color content. Large hydroponic operations often combine the two in order to create the most complete possible spectrum.

Both types of bulbs are offered on the market in a range of wattages, running from 150-watt to more than 1000-watt. Costs are comparable, though MH lights can be costlier at the higher wattages. That will also depend on the manufacturer, as some are more expensive than others.

LED lights (Light Emitting Diode) are the wave of the future of lighting. LEDs last much longer than anything currently on the market and will give the gardener the ease and ability to offer plants the specific spectrum of light necessary for each stage of growth. While LEDs can cost more for the initial purchase than other forms of lighting options, the hydroponic gardener will find that, in the long run, they are less expensive to maintain, are cheaper to operate than other options on the market and can quickly pay for themselves in energy savings. Determining precisely what your most cost-effective lighting option is can be a bit of a complicated science, as you need to go beyond the cost of the lighting equipment and the cost of powering the lights. You also need to consider the results generated by the lights. Compared to other types of grow lights, LEDs for indoor plants are attractive because they do not require ballasts and produce considerably less heat than fluorescent, sodium vapor, or metal halide lighting. This allows LEDs to be placed closer to the plant canopy than other lights. Also, plants under LEDs give off less water vapor, as a result of the reduction in heat, and thus the time between watering cycles is longer. Due to their high efficiency and effectiveness, LEDs are well worth your further exploration. However, looking at the entire market of LED grow lights, there are still big differences in the efficiency and performance they deliver, so be sure that you have reviewed the specifications carefully.

We are aware how important the sun is to our gardens. It provides the energy that plants need for photosynthesis to convert carbon dioxide and water into sugars. This is, quite simply, the bottom line on light and the importance of light to your plants. From here on in this section, we're going to throw some science at you to explain the specifics of photosynthesis and how plants use light energy. Hang with us… it's pretty interesting!

Our eyes and plants absorb energy within a relatively narrow range of the electromagnetic spectrum. Humans and plants both "see" light with wavelengths between 400 nm (violet) and 700 nm (red). For us this range of wavelengths is called the visible light spectrum and the unit of measure for the light we see is lumens. For plants this region of light is called Photosynthetically Active Radiation (PAR) and the unit of measure is micromoles of photons per second. (For scientific types, a mol is 6.022 x 10 ^23.) Measuring in micromoles allows us to read density of light rather than brightness.

It is important for us to understand that lumens are a measure of how humans perceive light and are not related to how plants absorb light. Conversely, PAR energy is not particularly important to how humans see light. For this reason, we should not be determining which lights we use for growing our plants based on either lumens, lux, ft-candles, or watts. These are all units of measure for how we perceive light and how much power the light source “consumes” to make the light we see.

Some units for how we (humans) perceive light are provided below.

Luminous Flux is measured in lumens (lm) and is the total quantity of visible light as perceived by humans emitted by a source.

Lux is the number of lumens per square meter of surface area. A foot-candle is 10.764 Lux.

Some units for how plants perceive light are provided below.

Photosynthetically Active Radiation (PAR) is the light between 400 and 700 nanometers that plants use for photosynthesis to convert CO2 and water into sugars. The measure of PAR energy is called the Photosynthetic Photon Flux (PPF) and the units are in micromoles of photons per second. Like total Luminous Flux, PPF output from a “grow light” can be measured in an integrating sphere like the one shown below.

Photosynthetic Photon Flux Density (PPFD) is a measure of PAR energy that is striking a surface. The units often used for PPFD are micromoles of photons per square meter per second (umoles/m squared-second). In the horticultural industry, PPFD is measured using a PAR meter similar to the one shown on the left below. Although professional grade meters similar to the Licor meter shown below, can be very expensive (i.e. $1000+), hobby meters have recently become available that can be purchased for less than $200. Although they may not be as accurate in measuring PAR energy, we have found that they are often within 10 percent of the same reading on the more expensive meters.

Licor PAR Meter Hydrofarm PAR Meter

A second measurement for PPFD is the Daily Light Integral (DLI). This is the total amount of PAR energy that strikes a surface (i.e. plant leaves) over a day. This is calculated by adding together all of energy over the entire day. The units for DLI are moles of photons per square meter per day. This is done by multiplying the average PPFD as measured by a PAR meter by 3600 seconds per hour then multiplying the value by the number of hours the light source (sun or artificial light) is on and then dividing by 1,000,000 to convert micromoles into moles.

Example:

(300 umoles/square meter-second) x (3600 seconds/hour) x (16 hours/day) x (1 mole/1,000,000 micromoles)= 17.28 moles/square meter-day

Watts are a measure of the amount of energy a light source consumes and is not a measure of either Luminous Flux (Lumens) nor PAR energy. This is a measure of what we are consuming to create the light and what our electric bill says we used (KWhr) per month. In effect, we want the Watts we use to be as low as possible and the PAR we create with our lights to be as high as possible.

PAR Efficacy is the amount of PAR energy created by a light source divided by the power it takes to create that PAR energy. As an example, if a light source has an output of 100 micromoles per second and it consumes 50 Watts (Joule/second) of power, its PAR Efficacy would be 2 micromoles/J.

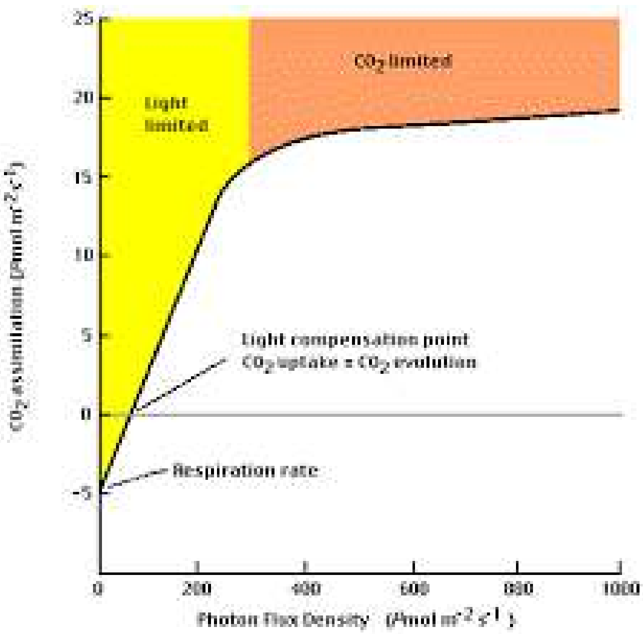
Spectral Power Distribution (SPD) is shown in charts published by the suppliers of light sources. These charts depict the intensity of the light at various wavelengths. Because plants absorb energy between 400 and 700 nm wavelengths, we would want as much of the energy from the grow light sources to be between these two wavelengths. As we will see from the SPD charts in the next few pages, LED lights have much higher efficacies (micromoles /Joule) than any other type of grow light, due to their relatively narrow region of transmission.

Target Efficiency is a measurement that provides the relative amount of light that is "hitting your plants" relative to the amount of PAR energy that the fixture emits. Even though a 1000 Watt HPS (High Pressure Sodium) fixture may be generating 1500 micromoles per second of Photosynthetically Active Radiation, if that light is not efficiently directed at your plants, much of the PAR would be wasted light, but the HPS may be doing a great job of lighting the walls, floor, or ceiling. Because HPS lights use relatively inefficient reflectors to help direct the round light source toward your plants and they need to be placed two to four feet above the plants so they do not burn the plant, their "Target Efficiency" could be as low as 60%. With LED light sources where the light can be evenly distributed above the canopy and the distance above the canopy can be a little as 6 inches without burning the plants, target efficiencies can be above 85%. This is a very important factor to be considered when selecting the appropriate grow lights for your application.

The Saturation Curve shown below provides some insights into what the limiting factors to photosynthesis include. Up to a specific level of Photosynthetic Photon Flux Density (PPFD), the limitation is the level of lighting that the plants receive. Beyond the PPFD saturation point, the level of CO2 in the environment becomes the limiting factor as shown below. For the plant to continue to grow faster, additional CO2 may need to be added.

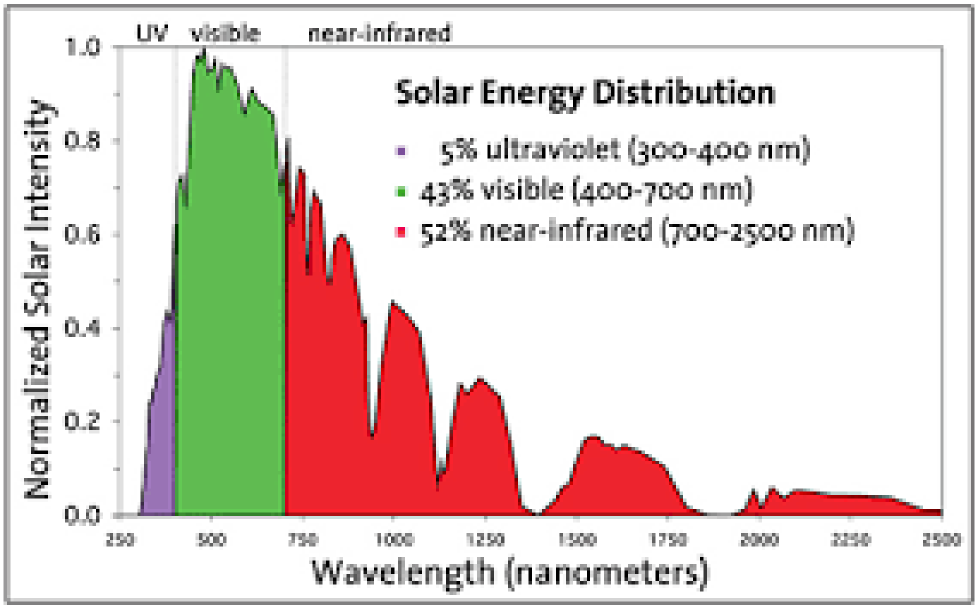
The Respiration Rate shown in the chart below is the rate at which plants consume glucose and oxygen and give off carbon dioxide and water. During this period, the plants are losing mass but respiration is critical to their survival.

The Light Compensation Point shown below is the level of light at which plant is neither gaining mass nor losing mass but is staying "steady." For many plants, this level of PPFD is roughly 100 micromoles per square meter per second. In effect, this is the level of light needed to start growing a plant but you cannot grow most plants to maturity with PPFD levels of 100 umoles/square meter per second or less. It is important to note that this is why most florescent light sources and low quality LED light sources do not provide satisfactory results in growing plants to full maturity. In effect, they produce too little light.



What is the Sun's Output of Photosynthetically Active Radiation?

By the time the sun's energy reaches the surface of the earth, about 43 percent of its total energy is within the visible or PAR region, while 52 percent is in the Infrared (IR) or heat region and 5 percent is in the Ultraviolet (UV) region. Although plants may be both negatively and positively affected by energy in the IR or UV wavelengths, they do not directly use "light" in these wavelengths for photosynthesis. In effect, we can say that the sun is 43 percent efficient at producing PAR energy.



The sun’s electromagnetic spectrum with the UV, Visible/PAR region, and IR regions

Because we do not have access to the sun’s energy everywhere and all the time, our Anywhere/Anytime Garden needs to rely on another source of PAR.

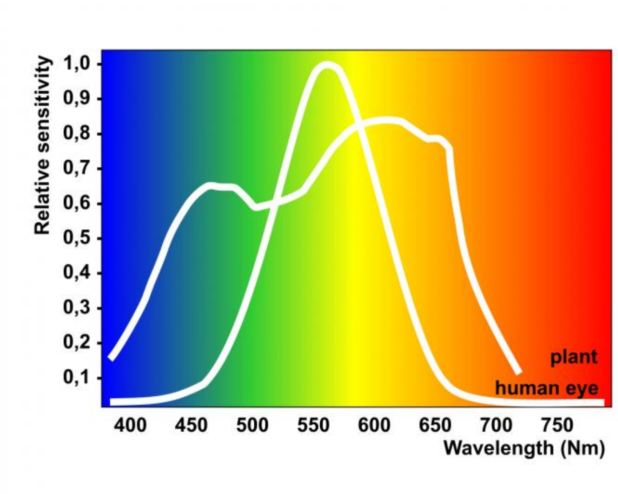
Until roughly 2010, the only practical alternatives that were available for indoor growing were incandescent, florescent, MH, and HPS lights. All of these were originally designed as light sources for us to be able to light our homes, businesses, and streets. They were not originally intended to be lights used to grow our plants indoors, but they were the only options that we had available to us.

After the blue LED was invented by Dr. Shuji Nakamura in Japan in 1991, the potential of having an Anywhere/Anytime Garden was born. The blue LED enabled us to create light that was not only blue but also allowed us to create white (full spectrum) light using a method by which a “yellow phosphor” is placed onto the blue LED in order to make the light cover the entire range of visible light between 400 and 700 nm wavelengths. Until then, the red LEDs that were available since the 1960s could not be used to create full spectrum light due to their longer wavelength.

In 1997, Dr. Cary Mitchell of Purdue University began his research for NASA to find a better way to grow food in outer space. His research concluded that a mix of blue and red LEDs could be used to reduce the amount of electrical power per growing area by 90 percent when compared to grow lights available at that time, and by 50 percent over full spectrum (white) LEDs.

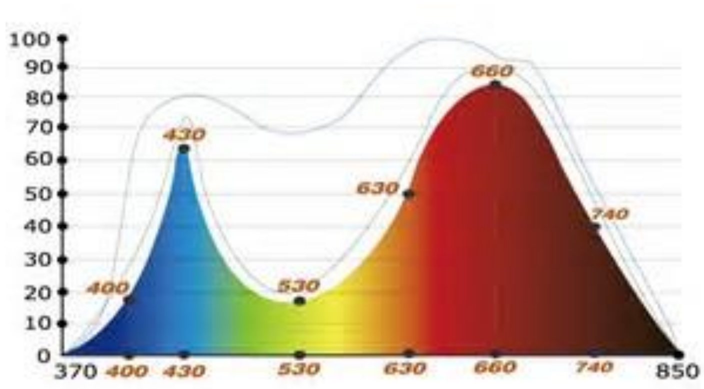
His comment regarding the results of his research was:

“Everything on Earth is ultimately driven by sunlight and photosynthesis. The question is how we can replicate that in space. If you have to generate your own light with limited energy resources, targeted LED lighting is your best option. We’re no longer stuck in the era of high-power lighting and large, hot, fragile lamps.”

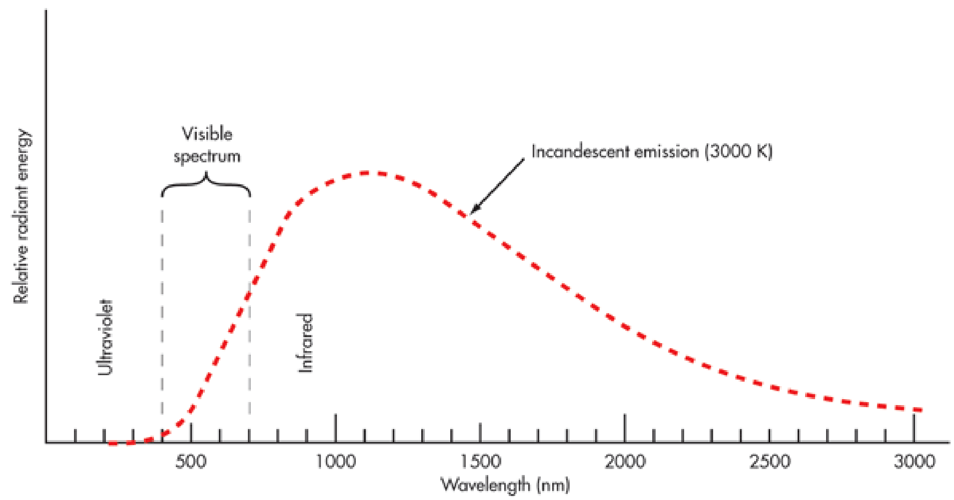


The human eye’s and plant’s sensitivity to specific wavelengths of light.

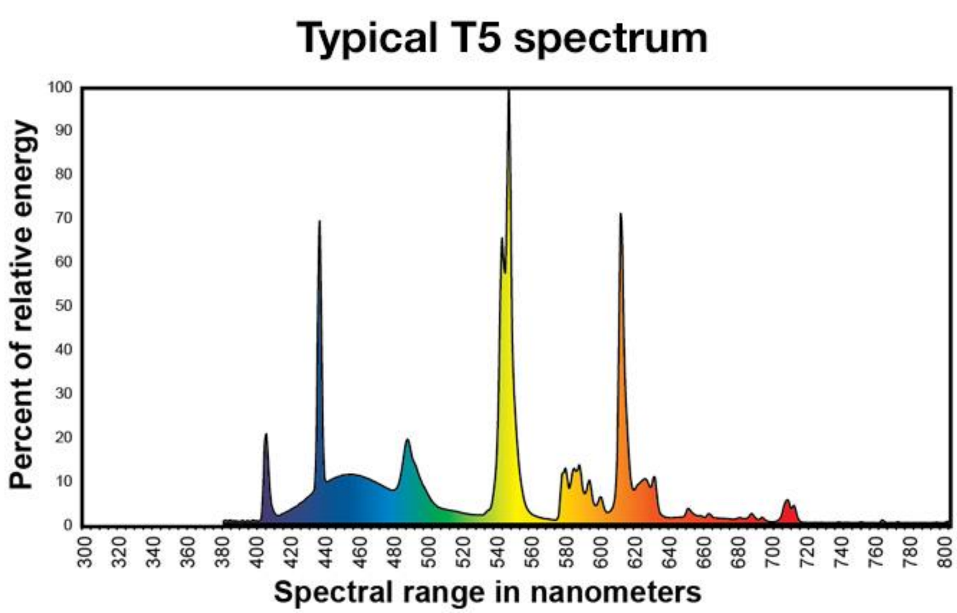
To better understand why LEDs are able to so significantly reduce the energy requirements for photosynthethsis, we need to review the Spectral Power Distribution (SPD) of the lights that we have used in the past and compare them to the SPD of LEDs tuned to the plants response to light.



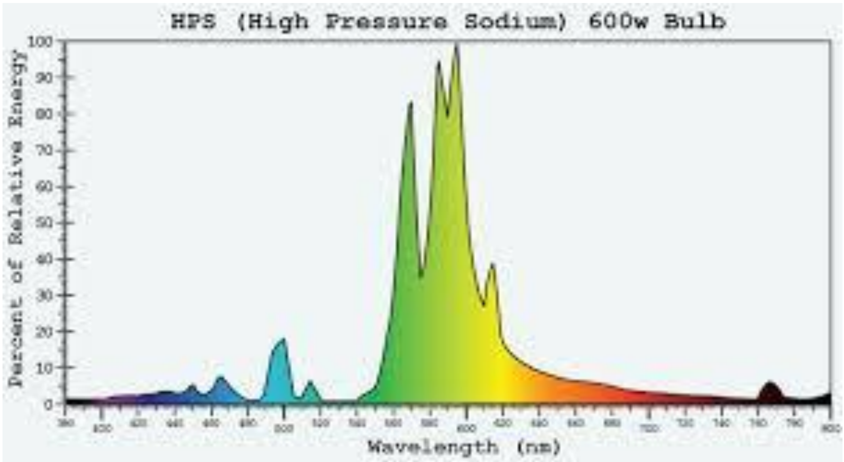
As can be seen from the graph above, the LED output curve is very close to that of a plant’s sensitivity to light. This is the basis of the LED’s efficacy in promoting photosyethesis. When comparing the spectrums of other light sources used for indoor gardening here is what we see.



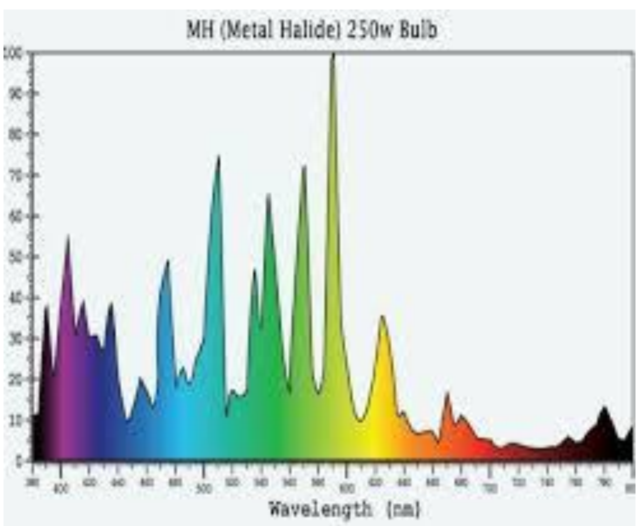
As you can see from this graph from a 3000 K incandescent bulb, only a very small portion of the bulb's energy is in the visible or PAR region. Roughly 95 percent of the bulbs energy is in the IR or heat region. An incandescent bulb is not a very good source of PAR energy and can be very damaging to plants because of its very high temperatures.



The SPD of a typical flourescent T5 shows that the bulk of the lamps energy is in the yellow/green region whereas photosynthesis occurs most efficiently with light in the blue and red regions. T5 lamps are successfully used for seed and seedling starting but if they are to be used for full plant growth, they would need to be placed very close to the plant and would consume between 3 to 5 times more energy to achieve equivelent plant production to high quality LED lighting.



The SPD of the High Pressure Sodium light is the closest of the conventional light sources to providing much of its energy within the PAR region as can be seen from the graph above. HPS lamps have a very distinct "yellow-orange" look to them and do not contain much energy in the blue region unlike other forms of HID lights called Metal Halide. HPS are often used during the flowering stages of plant growth.



The SPD for Metal Halide lights is shifted toward the blue region which is why they are more commonly used for the early stages of plant growth when plants are not blooming.

One factor that is related to lighting that will help you to optimize your Anywhere/Anytime Garden is an understanding of photoperiod. It is important to understand because photoperiod determines when the plant will bloom. It is defined as the period of time that a plant is exposed to light and dark over the course of a day. Although it is also widely referred to in grower speak as "daylength", that is misleading because the plant is actually having a response to the hours of darkness required to trigger flowering as opposed to having a requirement for a certain number of hours of light.

Flowering plants fall into three categories of photoperiodism. They can be short-day plants, long-day plants, or day-neutral plants. Knowing which category the plant(s) you are growing are in is important so that you can deliver the right number of hours of light (dark) to either promote flowering or, in some cases, delay flowering. Professional growers regularly use photoperiod to manipulate the flowering response of their crops.

Short-day plants will only form flowers when the days are short and the nights are long. In nature, short-day plants typically bloom in the spring and the fall when the nights are longer. Some examples of short-day plants are rosemary, green onions, cannabis, and some varieties of strawberries.

Conversely, long-day plants will bloom only when the days are long and the nights are short. In nature, these plants typically flower from late spring to late summer when the night is shortest. Some plants in this category are spinach, basil, radish, Swiss Chard, and lettuce varieties. Although it feels counterintuitive, the reason lettuce is considered a long day plant even though it is favorable to plant and consume in the cooler parts of spring is because it flowers when the nights get shorter. This is undesirable for many crops that aren't grown for their flowers and is called bolting. Other plants that bolt are spinach and many herbs varieties. In the outdoor garden, we work hard to pinch off the flowers to prevent bolting. Indoors we can prevent bolting altogether by maintaining short-day lighting with longer periods of dark.

Another group of plants are considered day-neutral plants will flower regardless of number of hours of light or dark the plant receives. Examples of day-neutral plants are tomatoes, sunflowers, beans, peas, corn, cucumbers, roses, and peppers.

Another factor that affects the size, shape, appearance, and rate of growth of your Anywhere/Anytime Garden plants is the SPD of your lights. We discussed how the SPD of each of the grow light options varies earlier in this chapter but we did not discuss how it affects your plants and how the light makes your plants look.

With most of the light sources that we discussed, the SPD for the light source is fixed and it is not possible to significantly modify it. But for LEDs, this is not the case. Because LED light sources are made up of mutliple small light sources, it is possible to tune the light in a way that it optimizes the growth rate, size, taste, and appearance of the plants. Although the ratio of desirable wavelengths for ideal growth conditions may vary some, based on the plants being grown, a ratio between red, blue, and green or white light can be selected to provide the necessary light for your Anywhere/Anytime Garden to give you great results. It turns out that roughly, a ratio of 70 red, 10 green or white, and 20 blue is good ratio for how broad the leaves become, how tall the plants grow, and how the plants look to us. There is significant research being done in this area of horticulture but real world studies have shown that these ranges of wavelength ratios produce very good results.

In Summary: The top 10 reasons that LEDs are the best lighting option for your Anywhere/Anytime Garden!

1. They are tuned to the wavelengths that your plants need to grow quickly.
2. They do not get hot so that they can be placed closer to your plants without burning them.
3. They have the highest efficacy of any light source for producing PAR energy for your plants.
4. If you use them every day for 18 hours per day, they will last at least 8 years, and you will never have to replace expensive bulbs.
5. Their energy use is very low, which makes it very inexpensive to operate them.
6. They are directional light sources so that almost all of their PAR energy can be directed into your plants.
7. They can be very lightweight so that the LED light sources can be placed horizontally, vertically or in the middle of your plants.
8. The best LED light sources are often manufactured in the USA and come with 5 year warranties.
9. They have become cost effective in the last several years, having a Return on Investment of less than one year.
10. They are the future of how we are/will be growing our food on a commercial scale.

Directions for Assembling a Passive Hydroponic System

Up to this point we have explored all the components of several passive hydroponic systems… except for the seeds and plants. Before you sow the seeds to grow those plants in your Anywhere Anytime Garden, you must obviously put all these components together. This chapter is dedicated to helping you decide where and how to start.

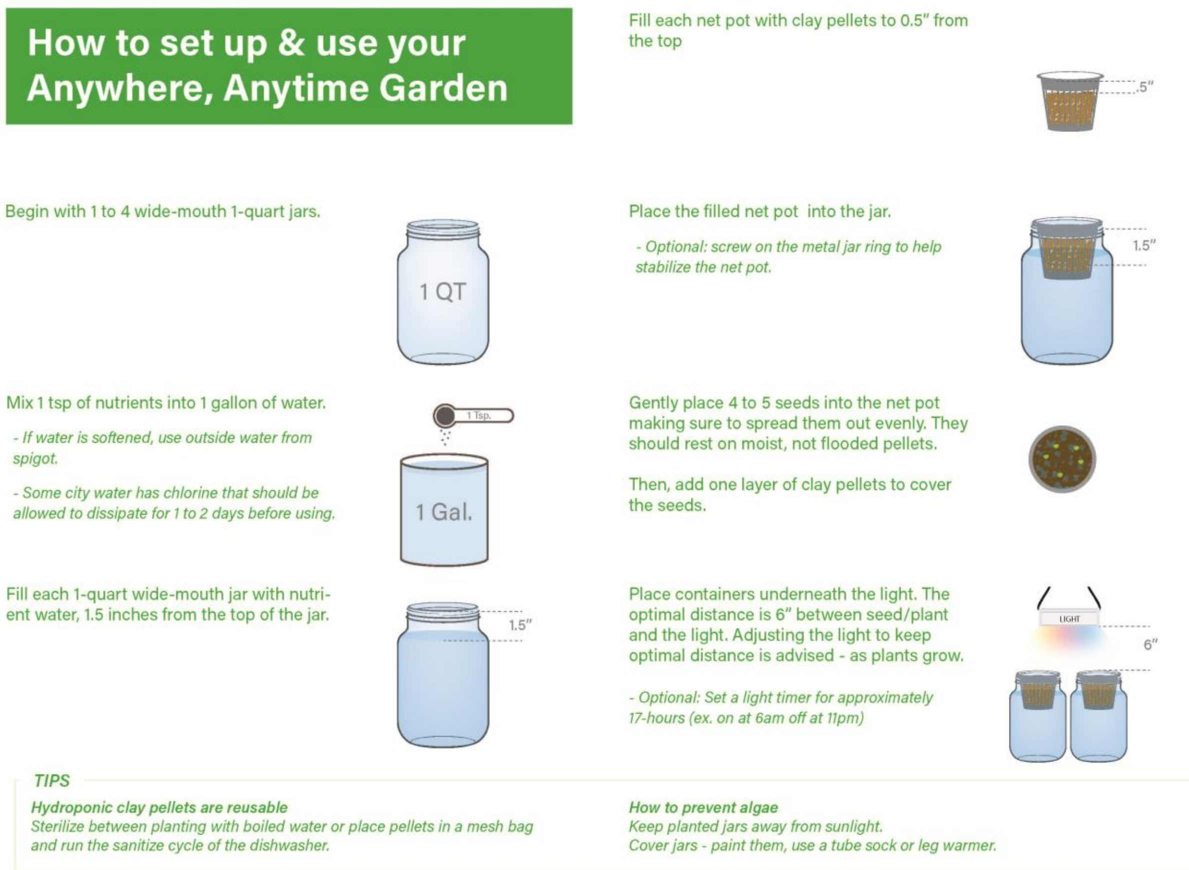
The basic components are the containers, net pots, growing medium, water, nutrients and light. With that, the only things missing are the seeds, which we will address in the next chapter.

Passive hydroponics is by far the simplest of all possible systems because it has no pumps, tubes or moving water to worry about. There are, however, levels of difficulty that range from the single jar to the multi-plant raft. Here we will start with the simplest system and work our way up to one that's just slightly less simple.

The Jar Growing System

Materials:

- One glass jar such as a Ball Mason Wide Mouth Quart Jar
- 3-inch net pot
- Growing medium such as clay pellets or rock wool
- Nutrients
- Water
- Light, such as a LED grow light
- Seeds



Maintaining Your Jar Growing System

Maintaining your hydroponic gardening system is important to protect your plant's health (guard against disease) and to keep the system free of precipitates such as calcium and other minerals that may collect on your equipment.

How often you clean your entire system is entirely up to you. It is vital that you keep a sharp eye on your system and the plants to determine if there is a problem related to cleanliness, bacteria or algae. If so, it will be necessary to clean the system.

After you have determined that it is time to clean your system, dismantle it by removing the plants, the mesh pots and the grow medium from the jar.

Discard the water/nutrient solution.

Clean all components with hot water and a good sanitizer such as Star San®.

Fill the jar with water and add household bleach at a level of one teaspoon per quart.

Mix the bleach into the water and allow it to soak for 24 to 72 hours.

After the jar has soaked, discard the bleach solution, and flush the whole system several times with fresh water to rid it of the bleach and any other materials dislodged by the cleaning.

If you are using expanded clay pellets as a growing medium, you can boil them in water for about 10 minutes to clean them before reusing them.

Note: if you have a good stock of jars and net pots, you will not have to wait while the jars are soaking to begin new seeds/plants.

The Bucket System

Only slightly less simple than the Jar System described above, this system can be put together in two ways, both of which are described here. The first variation uses the fewest materials of any system described in this book and is very easy to construct, use and maintain.

Bucket System Variation #1

Materials:

- Five-gallon plastic bucket made of food-grade plastic, which is plastic deemed safe for use by the Food and Drug Administration. The bucket should be opaque. If the bucket is a light color or clear, you should paint it a dark color or put a sleeve around it.

- One-half inch diameter PVC pipe that is as long as the bucket is tall

- Enough growing medium to fill the bucket to within 1 inch of the rim. The preferred growing medium for this system is perlite, a lightweight volcanic glass that has high water content. It is a common medium for hydroponic gardening systems. The perlite to fill a 5-gallon bucket will cost about $10. It is available at many large hardware stores or garden centers.

- A wooden dowel rod slightly longer than the PVC pipe.

- Nutrients

- Water
- Light, such as a LED grow light
- Seeds

Tools:

- Saw
- Drill

Instructions:

- Clean the bucket with household bleach or some other sanitizing agent.
- Measure and cut the PVC pipe so it is as long as the bucket is tall.
- Drill one or two small holes near what will be the bottom of the PVC pipe.
- Measure and cut the wooden dowel rod so it is about 3 inches longer than the PVC pipe.
- Stand the PVC pipe in the bucket (anywhere away from the very edge of the bucket is good).
- Hold the PVC pipe upright as you fill the bucket with the perlite to within one inch of the top of the bucket.
- Pour a water/nutrient solution into the perlite filled bucket to within 2 to 3 inches of the top fill of perlite.
- Use the dowel rod to check the level of water/nutrient solution by inserting the dowel rod into the PVC pipe. The dowel rod and PVC pipe with act like the dipstick that checks the oil in your car. The level of the water/nutrient solution will be seen on the dowel rod.

The Bucket System is now ready to be used. You can plant seeds directly into the perlite, or you can transplant seeds that have germinated elsewhere.

As the plant's roots grow, you can decrease the level of water/nutrient solution from 2 inches to as much as 10 inches. Continue to use the dowel rod to check the level of the water/nutrient solution.

The upper level of perlite not submersed in the water/nutrient solution will provide the plant roots with the necessary oxygen.

Bucket System Variation #2

This system is like the Jar System described earlier, but larger and able to accommodate four net pots or one large (10-inch) net pot

Materials:

• Five-gallon plastic bucket with a lid made of food-grade plastic. Food-grade plastic is plastic deemed safe for use by the Food and Drug Administration. The bucket should be opaque. If the bucket is a light color or clear, you should paint the bucket a dark color or put a sleeve around it.

• Four 3-inch net pots

• Growing medium such as clay pellets or rock wool

• Nutrients

• Water

• Light such as a LED grow light

• Seeds

. Tools:

• Saw

Instructions:

- Clean the bucket with household bleach or some other sanitizing agent.
- (If you use the 10-inch net pot, you can skip this step.) Use a saw to cut four holes in the lid of the bucket that will accommodate the 3-inch net pots. You can use the top opening of a wide-mouth Mason jar to trace the circular openings for the net pots.

- Fill the bucket with water to within one inch of the rim.
- Add the necessary nutrients to the water. (Follow the directions on the packaging.)
- Place the lid on the bucket or place the 10-inch net pot in the top of the bucket.
- Fill the 3-inch net pots with your chosen medium (clay pellets, rock wool, etc.…) and place the net pots in the openings you cut into the lid.
- If you are using clay pellets, wet them or soak them for a few minutes before use.
- Fill the net pot with wet clay pellets to about one-half inch of the top of the net pot.
- Place four to five seeds into the net pot and spread them around.
- Add enough clay pellets to just cover the seeds.
- If you are using rock wool, use a toothpick to poke four to five small holes in the rock wool and place seeds in the holes.
- Set a timer for the LED grow light to be on for 17 hours a day. (we usually turn them on at 6 a.m. and off at 11 p.m.). Timers are not necessary, but timers, once set, take the guesswork out of the equation and make your system more "no fuss."

Maintaining Your Bucket Hydroponic System

Maintaining your hydroponic gardening system is important to protect your plant's health (guarding against disease) and to clear the system of precipitates such as calcium and other minerals that may be in your water/nutrient solution.

How often you clean your entire system is up to you. Some will maintain that you should cleanse your system after each harvest. This is time-consuming but helps to avoid issues such as root rot.

It is vital that you keep a sharp eye on your system and the plants to determine if there is a problem related to the cleanliness, bacteria or algae. If so, it will be necessary to clean the system.

After you have determined that it is time to clean your system, dismantle it by removing the plants, the plant cups and the perlite from the bucket.

Discard the water/nutrient solution.

It is possible to clean and reuse the perlite by soaking it in a weak bleach/water solution and then allowing it to dry. You can spread it out in a thin layer on a large drop cloth. That said, perlite is very inexpensive, and you may just choose to dispose of it and use a new bag.

Clean all components with hot water and a good sanitizer such as Star San.

Fill the bucket with water and add household bleach at a level of 4 teaspoons per gallon of water.

Mix the bleach into the water and allow to soak for 24 to 72 hours.

After the bucket has soaked, discard the bleach solution and rinse the bucket several times with fresh water to get rid of the bleach and any other materials dislodged by the cleaning.

If you choose to use tap water to rinse your bucket, be sure that you have allowed the water to sit for 24 hours before using it in order to allow any chlorine in the water to dissipate.

Green Thumb Gardening Tip from Bob Klemmer

"I have a small hydroponic starter system. It's a small HDX roller basket cart purchased at Home Depot. It has two baskets and a top shelf. The middle basket has 12 Ball jars and a light attached to the top shelf. The lower shelf has a light attached to the middle basket. This is where

I do experiments like using a colander to grow spinach. The top shelf is for supplies right now, but it could be a third growing area.

The only things I had to purchase to build this system were the HDX cart and some Happy Leaf LED lights.

I've experimented with growing spinach in a colander in a plastic container and have been experimenting with various fertilizers such as Homegrown mix, MaxiGrow, BioThrive Grow 4-3-3.

The advantages of this type of arrangement are fresh, organic, on-demand vegetables and herbs. The disadvantage is cost vs. yield vs. time to get yield. So far, it's okay for a single individual, but not for a family.

I am currently growing lettuce, kale, spinach and herbs.

Some common mistakes made by those new to this type of gardening are letting the water in the jars go dry. Since the jars go fairly long before a refill, it is easy for a fast-growing plant to suck the water dry. Almost instantly the plants droop. It happened twice in the first month. Once the plant recovered, and once it did not. Care must be taken in keeping the jars always filled since you could also drown the plant.

Hydroponics is a good hobby. Don't expect too much return on investment until you figure out what you can grow and what you will consume compared to what you can just buy in the store. You most likely will need to expand past the Ball jar stage to make it worthwhile. If you want to become a hydroponics gardener and have a steady supply of good vegetables, you'll need to allow yourself the time to see what has value and what does not."

What and How Can You Grow with Your Anywhere Anytime Garden?

In all likelihood, most hydroponic gardeners will enter this endeavor with a wish list of plants they want to grow. Some will want to grow herbs, while others will want to grow flowers. Some gardeners will want to grow a variety ranging from fruits and vegetables to herbs and flowers. Later chapters will discuss the plants best grown in hydroponic gardens and teach you, the reader, the fundamentals on how to get started growing a variety of plant types. Like any other endeavor as complex as gardening, some activities are easier to manage than others. A good example in this regard is that it is easier to grow lettuce in your hydroponic garden than it is to grow blueberries. Basil is easier to grow than potatoes. It is possible, however, to grow any of these items in your hydroponic garden with a little know-how and experience.

Experience is a vital tool in learning and being successful. The old adage, "You must learn to walk before you can run," applies here. As you plan and take your first steps along this path, learn to grow the easy plants first. There is a difference between growing lettuce and growing carrots, but you will gain vital experience in working with the essential tools and the various components of your garden while enjoying the relatively easy success of growing a delicious variety of lettuce, a plant that is much easier to grow hydroponically than carrots.

Starting Your Plants

You have several options when you start planting. You can start your plants from seed, sprouts (seedlings), or from shoots (cuttings). Depending on what stage you choose will determine precisely how you start. Some plants are better started from seeds while others are better started from transplants. Some hydroponic gardening systems are better to start your plants at a particular stage, though with some experience, you can start just about anywhere.

You will find that the most rewarding way to start your plants is from seeds. This will give you a much bigger variety of plants to grow, and it will allow you experience the entire cycle of a plant's life. Learning how to grow from seed and then to collect the seeds that the mature plant produces in order to start the cycle anew is also more affordable than buying seeds.

A seed is a beginning, as well as an ending. A seed is part of an ongoing life cycle: the seed grows into the plant that produces the seed and on and on. What power that little seed must hold! We all know the proverb, “From little acorns, mighty oaks do grow.” This sentiment is just as true of sunflower seeds, wheat berries and lentils, all of which hold the power of transformation.

Seeds

“To see things in the seed, that is genius.” — Lao Tzu, Chinese philosopher

The sprout is the first stage of life beyond the seed. Seeds are dormant packets of energy. That is, they are asleep. Seeds can remain dormant for very long periods of time. In fact, scientists are still trying to answer the question of just how long. Scientists have germinated seeds that they know are 140 years old. UCLA research biologist Jane Shen-Miller has a living seed from a dry lakebed in China that carbon testing has shown to be more than 1,200 years old. A living seed is a seed that, while still dormant, is capable of germination.

All this points to a life force within a seed that is powerful and resilient. A sprout is what occurs the moment that dormant life force has been awakened. Sprouts of seeds require the life-giving power of water for this awakening. Hungarian biochemist Albert Szent-György, who won the 1937 Nobel Prize for Medicine, once said, “Water is life's matter and matrix, mother and medium. There is no life without water.” That is as true for humans as it is for seeds, grains, legumes and nuts.

To sprout a seed, you need to just add water. To test this, do a little experiment. Take one seed, any kind of seed will do, and drop it in a glass of water. Place the glass in a dark place, and after a few days (depending on the kind of seed you choose), a sprout will appear. Some seeds transform overnight. Red lentils will show sprouts in as few as 12 hours.

How a seed transforms into a sprout is a complex tale that begins before the seed itself is produced. As the seed is a part of a cycle of life, saying that the seed comes before the plant is akin to saying that the egg came before the chicken. The seed was born by a plant that put all its life energy into making seeds. Making seeds ensures the plant will continue to thrive from generation to generation. In creating the seed, the plant provided all the vitamins, minerals, proteins, fats and carbohydrates necessary to for the seed to thrive. The plant uses various mechanisms to cast the seed off to wait for the conditions needed to germinate and begin the life cycle anew.

Your task as the gardener is to provide the environment suitable for germination. By providing that seed with life's matter and matrix -- that is, water and air at a proper temperature -- you allow that seed to begin to transform that stored energy into a growing life force.

Transforming from Seed to Sprout

How to set the life cycle in motion for seeds varies from seed to seed. The process is governed by how the plant developed over its long history as a living organism. Some seeds have thin outer coats and will germinate quickly with a little water and a relatively warm temperature. However, some seeds require a longer germination time because they were developed to be ingested by animals, carried away from the plant that produced it, and dispersed far away after a long winter. Some seeds have developed a deep dormancy that protects the seed from sprouting in the late fall or winter, which would certainly not be beneficial to its continued survival. Some nuts, such as almonds, have very thin seed coats and require a very short germination time (one to two days). The other end of the spectrum is the coconut, with a very thick coat, that takes about four months to germinate. Sprouted coconuts are considered a delicacy and quite delicious.

As the seed sprouts, some significant chemical changes begin to take place. The seed, with the help of water and air, begins to produce enzymes that are vital in converting the stored and concentrated nutrients into everything it will need to carry on its life cycle. Enzymes are proteins produced in living cells that speed up or increase the rate of a chemical reaction such as the metabolic processes of an organism. Enzymes can increase the speed of a chemical reaction by up to a million times more than normal. By introducing that little seed to water, you have set a miraculous force into motion.

Anatomy of a Seed

The true blessing of the seed is the miracle of what it holds. We stated previously that plants live to create those seeds that will ensure their survival as a species. While it is true that not all plants produce seeds for reproduction, this section will examine how plants produce seeds, disperse them, and how they germinate to begin the life cycle anew. Most vascular plants produce seeds. Some plants reproduce through sporulation (ferns) or asexual propagation such as developing specialized roots and stems (such as tubers or stolons) that produce offspring identical to the parent plant without the development of seed.

In examining the entirety of the plant kingdom that produces seeds, you can separate them into two categories: those that produce flowers and those that do not. There is a category of plant that does not produce flowers or seeds (ferns, for example) and these plants reproduce via spores. There is a wide variety of plants that produce flowers, ranging from apple trees and cacti to pumpkins. Seed-bearing plants that do not produce flowers include coniferous trees like spruce trees and pine trees.

Pollination

Both flowering and non-flowering seed-producing plants follow a similar growth process, and both kinds of plants have male and female parts. Plants produce pollen (the male part) and a way to collect the pollen, such as a flower or, in the case of coniferous trees, cones (the female part). Wind, insects and animals transfer pollen from plant to plant to fertilize the female part of the plant. After fertilization, seeds are produced.

Coniferous trees rely solely on the wind for pollination. The pollen is very light, and breezes can easily transport it. Pinecones are sticky and easily catch the pollen that blows in the wind.

Flowering plants may be pollinated by pollen in the wind, but they also rely on bees, other insects and animals. As bees gather nectar from flowers, they also gather pollen on their bodies and this pollen travels with them from plant to plant. Pollen fertilizes the plant and after the plant is fertilized it creates seeds. Fertilized flowering plants create seeds in fruit, and coniferous plants create the seed in their cones. The fruit and the cone protects the seed. That seed contains all the genetic information and plant energy required to make a new plant. When the seed matures to the point that it has collected all the information and energy required to grow a new plant, the mother plant casts the seed off to do its job of sprouting, growing, and keeping the cycle of life moving forward.

Because most plants are stationary and cannot travel from place to place, they count on animals and the wind to scatter their seeds. Sometimes the seed falls close to the mother plant, but sometimes a bird may eat the fruit containing the seed and fly a great distance to drop the seed many miles away. Sometimes the seed is harvested for you to use in your kitchen, sprouting jar or garden.

Seeds for sprouting come from flowering plants and coniferous plants. Some seeds sprout better than others, not all seeds are germinated in the same way, but all seeds have a similar design and each viable seed has the ability to become a new plant, given the right conditions.

Germination

The best kind of seed to examine in order to understand how a seed germinates is a bean. Beans are large compared to other seeds and it is relatively easy to open them and see what is going on inside. Also, beans have relatively thin coats, making them easy to open.

To see just how a bean germinates, fold and roll a thick paper towel so it conforms to the inside of a clear glass. Put some sand in the middle of the paper towel in the glass to hold the paper towel in its cylindrical shape as you will be wetting the towel. Place a bean (kidney or lima beans work well for this experiment) between the paper towel and the glass, so you can see the bean. Moisten the paper towel with water. Place the glass in a dark cabinet and observe it over several days. You will see the bean sprout develop a root and begin to develop leaves.

To illustrate this more clearly, take a second bean and slice it open. See what it looks like inside before it germinates. To make it easier to open, soak the bean overnight, which will cause it to soften and swell a little. Make a cut around the outer edge of the bean, avoiding the blemish where the bean was connected by the seed stalk to the inside of the pod. If you are using a larger bean like a lima bean, you should be able to identify this blemish. After you make the cut, you can easily remove the seed coat, which is called the testa. As you remove the testa, you will see a young root (called a radicle) that fits into the area where that small blemish was. This is where the seed was attached to the pod. You might liken this to an umbilical cord because this is how the seed received nutrients from the mother plant.

You will find that you can split the inside of the bean into two halves, which are called the cotyledons. The cotyledons are the seed leaves and contain the stored energy the seed will need to grow into a plant. In other words, the cotyledon is the plant’s food. Between the cotyledons is the tiny plant that will develop into a new bean plant. This is the tiny plant that you will see emerge from the bean in your glass experiment. This tiny plant is made up of a root and a plumule (shoot) that has small leaves.

After the mother plant has cast off the seed, its germination depends on the temperature and moisture of the environment in which it eventually lands. Warmer temperatures are generally more conducive to germination and seed growth than cooler ones. The germination process consists of the seed taking on water, which triggers the production of enzymes that convert the stored and concentrated nutrients into all the things the seed will need to carry on the life cycle. In any case, once a seed begins to imbibe water and begins the germination process, it is crucial that the seed have consistent moisture, or it will halt development and render your seed unviable.

Sprouts vs. Shoots

As the seed feeds itself and that feeding increases, a root pushes through the testa. The root is the part of the plant that travels down into the growing medium to anchor the plant and collect nutrients. This is a sprout. The water causes new growth to occur in the seed, which forms the sprout.

The part of the seed that will travel upward to collect nutrients from the light and the air is the plumule. The plumule, if allowed to develop, will become a shoot. Thus, the new growth that will become the root is the sprout and the aerial part of the plant that will become a leaf is the shoot. This is the difference between sprouts and shoots.

Starting Your Seeds

Depending on what you choose to grow, starting your seeds in your hydroponic system is an easy and practical choice for many types of plants. Earlier, we described how to put your hydroponic system together. Many plants, such as microgreens and herbs can be started by just placing the seeds directly in or on? the growing medium that is placed in the net pot. Other plants will benefit from starting the seeds in starter pots or flats before moving seedlings to the hydroponic system. You have seen references to seed plugs in earlier chapters. These plugs are soilless planting media with a sprouted plant seedling ready to grow. The reason that you are advised to start your plants in starter pots or flats before placing them in the hydroponic system is that most seeds are very small, and it is easy to lose them or for them to be washed away. Another advantage to starting the seeds in plant pots or in flats is that it allows you to better control the amount of moisture the seed receives.

Because you are growing your plants without soil, you should choose to start your seeds in materials that are inorganic. Whether you choose individual starter pots or flats that can accommodate multiple plants, you will fill the given space with the inorganic medium and start the seed in that medium. This seed-planted medium will become the plug that will be placed into your hydroponic gardening system.

We recommend that you do not use organic matter such as peat or potting soil for your seed plugs as these materials break down relatively quickly. Materials such as peat and potting soil may be great for soil gardening, but materials that break down can cause problems with any pumps that you may be using. If you are employing a passive system, using inorganic materials such as LECA (clay pellets) is preferable because you can use them again and again.

Several commercial products that are good choices for starter plugs are available. A few commercially produced starter media include:

- Rapid Root Starter Plugs
- Grodan Rock Wool Starter Cubes
- Perfect Starts
- Oasis Horticubes®

If you review the growing media described earlier, you will come across several of the media listed above. You also will see that there is a selection of media that may work well for more mature plants but will not be suitable for seeds. The medium that is ideal for seeds is a medium that absorbs liquid nutrients well but is not loose. The products listed above are ideal as they are absorbent, solid pieces of material rather than loose-like sand or pebbles.

If you do not choose any of the commercial products listed above, you can purchase sheets of rock wool that you can divided and cut to suit your needs.

Whether you choose to start a single seed or multiple seeds in a tray, you will want to find a dark, warm spot to start them and a well-lighted location to move them to after germination. For some seeds, such as peppers, temperature plays a crucial role in germination. We'll review this in a later chapter. If you do not have that well-lit spot, be sure to have a grow light ready to go. Direct sunlight is not advised, but it should be well-lit indirect light. A general temp range for most seeds is between 68-72 degrees. Some seeds, such as peppers, require a slightly warmer stat up to 80 degrees.

The pots or trays you employ will allow for one or two seeds in a small amount of medium. The pots or trays will allow nutrient solution to be absorbed by the medium and will have holes in the bottom for drainage. Because the pots or tray will drain, you also should have the pots or trays resting in or on an irrigation tray. A simple boot tray from the local hardware store is inexpensive and works wonders.

Newly planted seeds should be kept in the dark until germination. Cover your pots or trays with an opaque lid. After they germinate, they need to be in a well-lit place.

If you find that you need to have more control over the temperature, you can purchase and employ a heat mat to place beneath the drainage tray. The heat mat can help keep the temperature of the germination pots or trays at a constant ideal temperature.

Another addition to your you might choose is a humidity dome. Once the seeds have germinated, a clear dome or cover can be used to increase the relative humidity in your new seedlings' environment. You can purchase something like a hard-clear plastic shell, or you can simply use a piece of plexiglass or glass that fits snugly over your plants, like a window box. This shell should have small holes in it to allow some amount of airflow.

Once you have all your component parts, including your chosen seeds, you will take the following steps to get your seeds started:

- Add your chosen medium (rock wool, Oasis plugs, or whatever medium you have chosen) to the pots or tray cells.
- Soak the medium in the pots or tray cells with water and allow them to drain before you add your seeds to the medium. Check that the medium is wet to the touch but not thoroughly saturated.
- For most fruits and vegetables, you should place two seeds at the center of each plug located on the pots or tray cells. For herbs, you should place six to eight seeds at the center of each plug. If you are working with very small seeds, you can use a wet toothpick to center the seeds.

- After the seeds have been placed in the medium, cover the pots or tray with an opaque lid until germination.
- Keep a close eye on the medium with the seeds, and be sure that it, plus the pots and tray cells, are evenly moist to the touch.
- When germination occurs, you can remove the opaque cover and move the pots or tray to a well-lit place, but not direct sunlight. You also can start using grow lights at this time.
- After germination occurs, start moistening the medium with a mixture of 50 percent water and 50 percent nutrient solution, or a diluted nutrient solution.
- The seedlings at this point will benefit from high humidity. If you have a clear cover that can be placed over them that will allow light to get in, use it. Again, this cover should have holes that allow airflow.
- When you start to see leaves form on your plants, you should thin them by removing the seedlings that appear less healthy from each pot or tray cell. It is always difficult to pull out what seem to be good seedlings, but your remaining plants will be much happier without the competition for nutrients and water from other plants which can result in weaker plants and/or a smaller harvest.
- You are ready to transplant your plants from germination pots or trays to your hydroponic system once you begin to see roots on the bottoms and sides of the plugs.

Transplanting Your Seedlings

Transplanting your new plants from the starter pots and/or trays to your chosen hydroponic system is straightforward and simple, but you do have to keep several things in mind. The plants are hardy and can put up with some amount of mistreatment, but you do need to guard against drying them out and blasting them with light. You also need to take care to place the new seedlings into pots that will be the appropriate size for the plants when they are fully grown.

If you depend on natural sunlight for your plants' growth, do not place them in direct sunlight right away. Light is important, but the heat of direct sunlight will dry the small plants out quickly. Keep in a well-lit place, though not in direct sunlight.

If you will be using grow lights, be sure that the lights are 12 – 18" above the new plants to start. If you are using LED lights, you can move them to 6 inches above the plants as LEDs don't generate the kind of heat that incandescent and fluorescent bulbs do.

Choose grow pots that are appropriate for the size of the fully-grown plant. Smaller plants such as herbs might do well in 1-quart jars or pots. Plants that will grow larger, such as tomatoes, will demand larger pots such as a 5-gallon bucket.

To move your seedlings from the starter pots/trays to your chosen hydroponic system, take the following steps:

- Fill the pot(s) that will be used in the hydroponic system with the medium you will be using. You might choose rock wool, expanded clay, perlite, or any one of a combination of growing media as described earlier.
- Dig a hole in the medium large enough to accommodate the plug that contains the seedling.
- Gently remove the plugs from the starter pot(s)/tray. Do not tug on the plant – they are quite tender at this stage and susceptible to root or shoot damage. Instead try pushing them up from the bottom.
- Place the plug directly into the hole you dug in the medium. There is no need to remove the plant from the plug.
- Fill the space around the plug with medium. You never want to pot them deeper than the soil level they were germinated in or you put the plants in jeopardy of crown rot.
- Add water/nutrient solution from above. Keep the level relatively high so that you don't dry out the media until the roots of the plant extend into the nutrients of your hydroponic system.

  Doing an Internet search for seed companies will get you hundreds, if not thousands, of results. The following is a list of some of the more popular seed purveyors. Wherever you purchase seeds from, it is important to do so from a reputable source.

- Burpee®

- De Ruiter™ Seeds
- Fruition Seeds
- High Mowing Organic Seeds
- Johnny's Selected Seeds
- Ornamental Edibles
- Richters
- Rijk Zwaan
- Stokes® Seeds

Store-Bought Seedlings

There are many advantages to starting your plants from seed in the manner described above:

- Starting from seed is more cost effective than buying transplants from a garden store, especially if you start from seeds that have been saved from plants that you grew.
- You will find that you have will have a greater selection of plants and plant varieties if you decide to start from seed. Your options for seedling purchases will be somewhat limited.
- When you purchase transplants, you cannot be sure that you are purchasing a healthy plant that is free of pest infestation. It is easier to protect against these threats if you start from seed from a reliable source. If you bring diseased and/or pest infested plants into your home or greenhouse, there is great danger that they will spread to other plants. Some diseases and pests are very difficult to eliminate once present.
- Plants that you start from seed will be in the type of medium that you choose. Plants that you purchase as seedlings will most likely, be in an organic medium such as peat or soil that you will need to carefully remove from the plant roots before you place them in your hydroponic system. Often young plants have a difficult time withstanding this rough transplant. Melons, squash, herbs, lettuce, and legumes will all have a difficult time after having their roots disturbed.

If you do choose to purchase seedlings from a store, you should take the following precautions:

- Purchase an insecticidal soap and a houseplant/garden spray to rid your plants of any insects that may be present. Some, such as mites, are very difficult to see with the naked eye.
- Spray the plants inside your home, but not in your grow room. Do not bring the plants into the grow room until you have treated them by saturating them to eradicate the pest threat.
- When you are ready to transplant your seedlings, carefully break off the peat pots they have been started in. Do this to each plant one at a time so that the roots of the young plant will not have time to dry out before you get them safely into its new grow pot.
- Be very careful as you remove as much soil as possible from the newly formed root system. As you remove the soil, you can do so under a gentle wash of warm or room temperature water.
- After you have removed most of the soil, place the seedling into the medium you have already prepared in your system. Gently fill the medium in around the roots of the newly replanted plant.

Green Thumb Garden Tip from Petra Page-Mann

Nine Questions to Consider When Sourcing Seeds (and what to really ask about GMOs)

But First: Seeds are magic. They are living, breathing, infinitely replicating beings.

And: We reap what we sow.

Here are nine key questions to increase your garden's success from the start.

1. Are you growing indoors or outdoors?

If you're growing outdoors, regional adaptation and timing matters. Indoors, with the right equipment, you can start virtually any seed at any time.

2. Where are you growing? Is plant size a consideration?

Some varieties are more compact than others, which makes them more suitable for containers, raised beds and other gardens with limited space. If you have a large garden, you can accommodate any size plant.

3. Where are you growing? Is climate a consideration?

Sowing regionally adapted seeds is one of the easiest ways to be a more successful gardener.

For example:
-heat-tolerant lettuce is critical in Texas
-Late blight-tolerant tomatoes are important in New York
-early maturing melons are vital in Maine

4. A “local" may or may not offer “local” seed

Your local supermarket sells food from all over the country and all over the world. Most seed companies are the same. To find out, give them a call. Ask where their seed is coming from, who grows it and where and what they’re selecting each generation for.

5. Do you want organic or conventional seed?

Our health is related to the health of our parents. The same is true for plants.

Conventional seed is grown with the industrial inputs of pesticides, herbicides and petro-chemical fertility. If you don’t want those things in your body, in your garden or in your world, buy organic.

Organic seeds grow more abundant with fewer inputs. They compete with weeds. They have stronger immune systems, which help them resist disease and insect pressure better than their conventional equivalents. Their root systems are extensive and don’t have to wait for chemical nutrients to feed them. Organic seeds are one of the easiest ways to make your garden more abundant.

6. What season are you planting for?

Most varieties are best grown in specific seasons. Lettuce, for example, has thousands of unique varieties. Optima, a lime-green butterhead that melts in your mouth, is only worth growing in summer. Winter Density is an ideal spring/fall lettuce (as the name suggests), though ironically it is an exceptionally bolt-tolerant lettuce that’s perfect for summer, as well. Don't always trust a book by its cover! See #9.

Such subtle things can make all the difference.

7. Consider your light and fertility

Each variety has unique light and fertility requirements. For example, lettuce grow marvelously in partial shade while tomatoes will struggle. Sunflowers thrive in poor soil while melons suffer.

Generally, leaves (kale, parsley, lettuce) need less light and fertility than plants that wish to fruit (tomatoes, cucumbers, melons).

8. All seeds are not equal.

‘Cherokee Purple’ tomato can be found in 100+ seed catalogs. Are they all the same? With some varieties, yes and others no. How can you tell? You can always call the company and ask where they source their seed. We also recommend:

9. Experiment! Trial! Explore! Have fun!

Take notes. Stick with varieties and companies that serve your needs. Always be open to trying new varieties and new companies. Most of all, stay curious.

One question you are wanting to ask a seed company and the two questions to ask:

Is this seed GMO-free?

It's an important question! No seed company sells packets of GMO seed to home gardeners. Growing GMOs requires a stack of paperwork and licensing. Every seed company can hand you a packet and say, “these seeds are GMO-free.” Here are the two questions that truly get to the heart of your question:

“Do you source seeds from companies that sell GMOs (like Syngenta)?” and

“Is this seed company owned by a larger seed company that does sell GMOs?”

See what you learn!

Storing Seed

If you have leftover seed, most will last 3 years without losing significant germination. Your seed may even store longer when stored in a dry place in a stable temperature, the lower the better. Some exceptions are alliums (including onions, scallions, leeks) as well as parsnips and peppers, which are best purchased every season. A water tight container in your refrigerator is ideal.

If you're serious about storing seed long-term, here are two things to consider:

1. The 100 Rule. Seeds stored in environments where the combined temperature and humidity are less than 100 F. have higher germination rates than those totaling more than 100. Keep the temperature as low as possible. Stable humidity around 20 percent is ideal.
2. Freezing seeds is always an option. Dry seeds fully and then put them in a sealed container for three days with desiccant. (The packets you find in shoes and vitamins are perfect.) Label them well in your freezer and they'll germinate well for decades.

The Basics of Plant Growth

Like all living things, plants need both water and nutrients to survive and grow. Most plants use water to carry nutrients back and forth between the roots and leaves. In most plants, nutrient-filled water is taken up through the roots. As we saw in an earlier chapter, the most important nutrients for plants growing needs are nitrogen (N), phosphorus (P), and potassium (K). Nitrogen is necessary for making green leaves, phosphorus is needed for making big flowers and strong roots, and potassium is good for the overall health of the plant and helps the plants fight off disease. Too little or too much water or nutrients can also be harmful. Fresh clean air is also a great benefit to plant growth. Dirty air caused by smoke, gases, and other pollutants can be harmful to plants, limiting their ability to take in carbon dioxide from the air for making food (photosynthesis). It can also block out the light which is necessary for healthy plant growth. Light is used as energy for making food, a process called photosynthesis.

The word "photosynthesis" is derived from the Greek: photo or "light" and synthesis, "putting together."

Photosynthesis is the process by which green plants, algae and some forms of bacteria use energy from light to convert carbon dioxide and water into glucose.

carbon dioxide + water + light energy = glucose + oxygen + water

Glucose is made up of carbon, hydrogen and oxygen atoms. Glucose made by the process of photosynthesis may be used in three ways:

- It can be converted into chemicals required for growth of plant cells such as cellulose.
- It can be converted into starch, a storage molecule, that can be converted back to glucose when the plant requires it.
- It can be broken down during the process of respiration, releasing energy stored in the glucose molecules.

Too little light can make plants weak and leggy looking because they stretch to find a source of light. They will also have fewer flowers and fruits.

Temperature is important too. Most plants prefer cooler nighttime temperatures and warmer daytime temperatures. Too hot and they may burn; too cold and they will freeze. Many plants thrive in a relatively unfluctuating temperature.

Space is yet another factor to consider when growing plants. Both the roots and foliage (leaves) need room to grow. Without enough room, plants can become stunted or too small. Overcrowded plants are also more likely to suffer from diseases since airflow may be limited. Finally, plants require time. They do not grow overnight. It takes time and patience to grow plants, some more so than others. Most plants require a particular number of days, months, or even years to produce.

Your Passive Hydroponic Crops

What to grow?

The answer to this question of "what to grow?" is, of course, "Anything I want to!" There are, however, plants that are easier to grow in hydroponic systems and plants that are recommended for the hydroponic novice.

Plants recommended for those new to hydroponic gardening are plants that can be grown in a wide variety of hydroponic system types, are easy to start by seed, are easy to maintain, have a relatively quick grow time, take little space, and are forgiving of grower errors. This might seem like a hefty list of requirements for the novice looking for a straightforward way into learning more about hydroponic gardening, but the list of plants that fit these requirements is quite lengthy.

Generally, the beginning hydroponic gardener can start by growing herbs, lettuces, and/or small ornamental plants. The list of specific plants might include:

- Parsley
- Basil
- Dill
- Cilantro
- Bibb lettuce
- Iceberg lettuce
- Romaine
- African violets
- Begonias
- Zinnias
- Bamboo

This is, of course, a very short list that could be much longer. The plants mentioned above are just a small example of the herbs, lettuce varieties and ornamental plants that you might consider starting as a novice hydroponic grower.

As you gain a firmer understanding of how hydroponics works and how different systems work for you and your plants, you can consider growing your operations to include a larger variety of fruits, vegetables, herbs, and ornamental plants.

You will find that most plants that you would normally grow outdoors in a garden can be grown successfully hydroponically. Even so, here is a list of most common plants that will thrive in a water-based gardening system:

Artichokes

Beans, green

Beans, dry

Beets

Blueberries

Broccoli

Brussels sprouts

Cabbage

Carrots

Cauliflower

Celery

Cucumber

Eggplant

Endive

Garlic

Kale

Leeks

Lettuce

Okra

Onion

Parsnip

Peas

Peppers, sweet

Peppers, hot

Potatoes

Radishes

Raspberries

Spinach

Squashes

Strawberries

Sweet potatoes

Tomatoes

Fruit trees can be started with hydroponics to create strong seedlings, but standard size trees will need outdoor planting. Small dwarf trees may be able to grow to a harvestable age within a hydroponics system as long as you address their size and keep them pruned. Herbs of any type, as well as most flowering plants, can be grown without much restriction.

Certain vegetables such as corn, zucchini, pumpkins and most melons are not that practical because they take up too much space although many vining plants can be trained vertically if you are willing to provide support for the plant as it grows. That is not to say they cannot be grown. If you have the room and can be a little creative with plant supports, you may be successful even with these plants. Once you learn more about hydroponics, you could try taking them on as a personal challenge.

As a novice reading about the potential cornucopia of harvests to come, you either will feel overwhelmed by the possibilities of what to grow, or you will be inspired to dive in and plant as wide a variety of plants as you have the space to accommodate. However, you choose to proceed, a good rule of green thumb is to begin by planting things your family appreciates. If you enjoy cooking, start by preparing a small hydroponic system in your kitchen (if there is space) and planting a small herb garden. Growing items such as chives, parsley, oregano and basil right in your kitchen will allow you to snip and use them in your recipes for the freshest, best-tasting herbs to be added to your family meals.

Another upside of starting a small hydroponic herb garden in your kitchen is that kitchens are frequently the busiest room of the house. It is easy to keep a close eye on the progress (or lack of progress) of your plants. Also, it gets everyone in the household interested in the growth of the plants.

Once you get the hang of hydroponics through your kitchen herb garden and you become accustomed to tending to your plants, you can consider expanding your hydroponic operations to other plants in other areas of your house, porch, patio, and/or yard. If you do expand your garden to include both indoor and outdoor plants, be very careful about how you handle the plants you grow outside. You do not want to introduce the pests that will enjoy your outdoor plants to the relatively clean indoor plants. Be sure to wash any harvested plants outdoors before you bring them indoors.

As the list of your potential crops is long, we'll break down this following section into categories:

- Microgreens, leafy greens, herbs
- Larger vegetables
- Root vegetables
- Fruit
- Flowering houseplants

Microgreens/Leafy Greens/Herbs

This is the best place for new growers to start. Growing these types of plants in your Anywhere Anytime Garden is so easy, we're convinced that you will be totally sold on the concept of passive hydroponics, if you aren't already. The results are amazing.

Let's start with a brief definition of each of these categories.

MICROGREENS

Also known as "vegetable confetti," microgreens are sometimes confused with sprouts. Sprouts are germinated seeds that are eaten root, seed and shoot. Microgreens, however, include a variety of edible immature greens, harvested with scissors less than a month after germination, when the plants are up to 2 inches tall. The stems, cotyledons (or seed leaves) and first set of true leaves are all edible. Microgreens are larger than a sprout but smaller than a baby salad leaf and will usually have produced at least two true leaves after expansion of the seedling leaves or cotyledons. Because they are harvested at such an immature stage, seed is sown at a high density to maximize yields from each crop.

Which seeds work best? Microgreens fall into four main categories:

- **Shoots and tendrils** such as pea, sunflower and corn shoots, are often used as garnishes, although they all have their own mild and somewhat surprising flavor.
- **Spicy greens** include arugula, radish, cress and mustards.

- **Micro herbs** include those used not only as garnishes, but also for their characteristic flavor such as parsley, fennel, edible chrysanthemums, cilantro, basil, French sorrel, mint, dill, chives, onion.
- **Tender greens** are highly diverse in flavor, leaf size, shape and color. They include red cabbage, broccoli, spinach, beet (red), tatsoi, mizuna, amaranth, chard, kale, endive, chicory, celery, carrot and lettuce.

Salad greens, leafy vegetables, herbs and even edible flowers can be grown as microgreens, though some varieties are better suited than others. Beginners often start by growing one type of seed, such as broccoli, cauliflower, cabbage, mustard, chia, sunflower or buckwheat — among the easiest-to-grow varieties of microgreens — in a single container. (You can easily grow different seeds in several containers and mix your microgreens after harvesting.)

LEAFY GREENS

Leafy greens are plants that cover a wide territory, as well. Leafy greens can be subdivided into four categories:

- Lettuces
- Cruciferous leafy greens
- Spinach and Swiss chard
- Edible leafy greens

LETTUCES

There are many varieties of lettuce, both light and dark leaf, but you can break this category down to five basic types. Dark green lettuces include romaine, green leaf and butterhead. These nutrient-dense leaves are crisp and slightly bitter, and most people use them to make raw salads.

CRISPHEAD OR ICEBERG

Crisphead lettuce, more commonly known as iceberg, has a tight head of crisp leaves, but if you are growing it in a small passive hydroponic set-up, you may not want to grow it to maturity. Some iceberg lettuce varieties include: Ballade, Crispino, Ithaca, Legacy, Mission, Salinas, Summertime and Sun Devil.

SUMMER CRISP, FRENCH CRISP OR BATAVIAN

Summer Crisp is a large lettuce variety with great flavor. It has thick, crisp outer leaves which can be harvested as a loose-leaf until the head forms while the heart is sweet, juicy and a bit nutty. Different types of lettuce for this variety are: Jack Ice, Oscarde, Reine Des glaces, Anuenue, Loma, Magenta, Nevada and Roger.

BUTTERHEAD, BOSTON OR BIBB

One of the more delicate varieties of lettuce, Butterhead is creamy to light green on the inside and loose, soft and ruffled green on the exterior. These different types of lettuce may be harvested by removing the entire head or just the outside leaves. They are easier to grow than the Crispheads. These varieties of lettuce include: Blushed Butter Oak, Buttercrunch, Carmona, Divina, Emerald Oak, Flashy Butter Oak, Kweik, Pirat, Sanguine Ameliore, Summer Bib, Tom Thumb, Victoria, and Yugoslavian red.

ROMAINE OR COS

Romaine varieties are typically 8-10 inches tall and upright growing with spoon-shaped, tightly folded leaves and thick ribs. Coloration is medium green on the exterior to greenish white inside. The outer leaves are sometimes tough while the interior foliage is tender with wonderful crunch and sweetness. 'Romaine' comes from the word Roman while 'Cos' is derived from the Greek island of Kos. Some different types of this lettuce are: Brown Golding, Chaos Mix II black, Chaos Mix II white, Devil's Tongue, Dark Green Romaine, De Morges Braun, Hyper Red Rumple, Little Leprechaun, Mixed Chaos black, Mixed Chaos white, Nova F3, Nova F4 black, Nova F4 white, Paris Island Cos, Valmaine, and Winter Density.

LOOSELEAF, LEAF, CUTTING OR BUNCHING

The easiest types of lettuce to grow are the loose-leaf varieties, which form no head or heart. Harvest these varieties either whole or by the leaf as they mature. A wide variety of colors and shapes are available in the following lettuce varieties: Austrian Greenleaf, Bijou, Black Seeded Simpson, Bronze Leaf, Brunia, Cracoviensis, Fine Frilled, Gold Rush, Green Ice, New Red Fire, Oakleaf, Perilla Green, Perilla Red, Merlot, Merveille De Mai, Red Sails, Ruby, Salad Bowl, and

Simpson Elite.

CRUCIFEROUS LEAFY GREENS

Kale, mustard greens, collard greens, cabbage and broccoli are cruciferous leafy greens. Cruciferous vegetables are high in nutrients and contain glucosinolates, which inhibit the growth of certain cancers. Magnesium and tryptophan are also abundant in these greens; these minerals enhance heart health and brain function. Cruciferous vegetables are low-calorie, and rich in folate, vitamins C, E, and K, and fiber. Fiber is an important nutrient to incorporate if weight loss is the goal, as it helps keep you fuller longer.

Cruciferous vegetables are also good sources of phytonutrients, which are plant-based compounds that may help lower inflammation and reduce the risk of developing cancer.

An abbreviated list of cruciferous vegetables includes:

- Arugula
- Bok choy
- Broccoli
- Brussel sprouts
- Cabbage
- Cauliflower
- Collard greens
- Kale
- Mustard greens
- Radish
- Turnip
- Watercress

SPINACH AND SWISS CHARD

Spinach varieties come in savoy, semi-savoy, and flat-leafed types, with many cultivars of each.

- 'Savoy' has dark green, crinkly and curly leaves. It is the type sold in fresh bunches in most supermarkets in the United States. One heirloom variety of savoy is 'Bloomsdale', which is somewhat resistant to bolting (When a plant "bolts" it produces seeds immaturely. This affects the plant as much of its energy goes into producing seeds). Other common heirloom varieties are 'Merlo Nero' (a mild variety from Italy) and 'Viroflay' (a very large spinach with great yields).
- Semi-savoy is a hybrid variety with slightly crinkled leaves. It has the same texture as 'Savoy', but it is not as difficult to clean. It is grown for both fresh market and processing. 'Tyee Hybrid' is a common semi-savoy.
- Flat- or smooth-leaf spinach has broad, smooth leaves that are easier to clean than 'Savoy'. This type is often grown for canned and frozen spinach, as well as soups, baby foods, and processed foods. 'Giant Noble' is an example variety.

There are also several spinach alternatives that you might consider. New Zealand spinach (*Tetragonia tetragonioides*) and Malabar Spinach (*Basella alba*) are botanically unrelated to true spinach, but good substitutes.

New Zealand spinach has crisp, succulent leaves that melt in your mouth as you bite down on them. It's good raw, but dissolves into mush when cooked.

Malabar spinach needs a trellis to climb on to reach its true potential—a 10-foot (3 meter) vine! If you plan to grow Malabar spinach in your passive hydroponic garden, you might consider a tomato cage as a makeshift trellis.

Swiss chard and spinach have vibrant leaves with bold colors. They belong to a family of leaves called *Amaranthaceae* and are similar in taste and nutritional value. Spinach and chard are available throughout the year, and both are rich in iron, which carries oxygen to the blood. Include these leaves in your raw salads, or chop, steam and season them lightly to create a delicious side dish.

Swiss chard is also one of the most nutritious vegetables around today. It has distinctly large, dark green leaves, which are harvested at various stages of maturity. The whole young plant stalks and leaves can be used for salads. The entirety of the mature plant can be harvested for sautéing and cooking dishes.

Swiss chard is known by many other names, including silverbeet, spinach beet, perpetual spinach, bright lights, crab beet, and seakale beets. It has been around for centuries but has been confused with beets and other vegetables like cardoon because of their physical similarities.

Swiss chard comes in various types depending on shine, crunchy stalks, and petiole. There's the green stalk (Lucullus), Red stalk (Charlotte, rhubarb chard), and multicolor stalks (Bright Lights).

EDIBLE LEAFY GREENS

Most common edible plants in this initial category that you might grow in your Anywhere Anytime Garden will have been covered in over the last couple of pages. There is this final category, **Edible Leafy Greens,** that will serve as a catch-all for some of the crops that don't really fit neatly into any of the above categories of Lettuce/Spinach/Chard/Cruciferous Leafy Greens.

The items in this category could arguably fit into one of the above categories, but we're listing them here as an example of the wide variety of easy options you might consider as you get started with your indoor passive hydroponic garden.

Wheat grass

Alfalfa

Clover

Dandelion greens

Amaranth

Borage

This list could be much, much longer, but it serves as an example of the wide variety of leafy greens that you can grow in your Anywhere Anytime Garden.

HERBS

Just as popular and as easy to grow as the leafy greens covered above are herbs. Having a variety of freshly grown herbs in your kitchen that you can snip or harvest moments before a meal can mean an incredible edible tasty treat. Imagine having the ability to harvest a fresh basil plant for use as pesto as the water for pasta is boiling. It is guaranteed that the flavor of a freshly made pesto will beat anything you buy in the supermarket.

Like the lists of lettuces, spinach and leafy greens offered earlier, the list of herbs you can grow in your passive hydroponic garden is lengthy. We offer a few for your consideration:

Basil

Parsley

Oregano

Cilantro

Chives

Dill

Lemon grass

Mint

Tarragon

And on and on….

…And How to Grow Them

You can start by planting a single plant in one jar or, depending on your light source, you may want to start multiple jars with a variety of these simple crops.

Example:

If you are using the Happy Leaf PROCYON MINI 4-inch light that has a vegetative grow area of 1 by 1 foot, you can easily grow microgreens, leafy greens, herbs in four different quart jars. Most of the items listed in the **Microgreens/Leafy Greens/Herbs** categories will grow indoors in your Anywhere Anytime Garden with minimal time and effort on your part.

Some of the items, such as head lettuce or wasabi, can be used early in its growth cycle as you harvest young leaves and stems. They can also be allowed to mature with a little added effort and time. Wasabi, for instance, takes about 8 – 12 months to develop the rhizome, or stem, that we're used to consuming ground up on our sushi. But the leaves are flavorful, with much or the same peppery flavor as the rhizome and can be consumed as the plant grows. NOTE: Wasabi is a difficult plant to grow, but if you're up for a long-term challenge, go for it!

Back to growing! Try this:

You'll need:

- Largemouth quart jar(s)
- Net pot(s)
- Hydroponic clay pellets
- Nutrients
- Water
- Seeds
- LED grow light
- Timer

What you'll do

- Premix the nutrients in the water as per the directions on the nutrient package (If you're going to start 4-quart jars, you can premix one gallon of nutrient solution)
- Fill 3-inch net pot(s) with wet clay pellets to be within ½ inch of the top of the pot

- Set the net pot(s) into the mouth of the jars
- Pour the premixed nutrient-filled water into the jar(s) to be within 1 inch of the top of the jar (the solution should be about half-way up the side of the net pot
- Place 4 – 5 seeds into the clay pellets (spread around)
- Add enough clay pellets just to cover the seeds
- Set timer on LED grow lights to about 17 hours a day (say, 6:00 am – 11:00 pm)
- Place containers under light so that they are about 6 inches below the light, adjusting periodically as the plant grows.
- Keep an eye on your plants as they grow. As nutrient solution is taken up by the plants and/or evaporates, add solution to the jar. Be sure that you leave some of the plant roots exposed to oxygen. You should be able to harvest in 4 – 6 weeks!

Plants that Demand More Space

The plants described above can easily be grown in your passive hydroponic system using quart jars and 3-inch net pots. We find, however, that many people that are interested in growing plants indoors want to grow things such as peppers, tomatoes, potatoes and a whole host of things that just take a little more space. No problem! …. If you have the space!

We'll divide these larger plants into two categories: Above surface and below surface… that is, plants such as tomatoes and peppers that produce their fruit in the light, and potatoes and carrots and other plants that produce below the surface (root vegetables). What's not included here that we will address a little later are those plants that are perennials such as strawberries, rhubarb, and asparagus.

Above Surface

A partial list of these larger Above Surface plants includes:

Tomatoes

Tomatillos

Peppers

Peas

Collards

Chard

Brussel Sprouts

Again, this list can go on and on…

The basic concept for growing these larger plants is the same as growing the smaller ones described earlier. The only difference here is that you will require more space and larger containers and net pots. Also, in some cases, you will require tomato cages or similar structures to support your plants.

You'll need:

- 3.5 – 5-gallon bucket(s)
- Net pot(s) to accommodate the mouth of the bucket (10")
- Hydroponic clay pellets or other growing medium such as coconut fiber
- Tomato cage (for some plants)
- Nutrients
- Water
- Seeds
- LED grow light
- Timer

What you'll do:

- Premix the nutrients in the water as per the directions on the nutrient package (If you're going to start a single 5-gallon bucket, you can premix 5 gallons of nutrient solution in the bucket.)
- Fill net pot(s) with clay pellets to be within ½ inch of the top of the pot
- Remove about a cup of nutrient solution from the bucket and pour it over the medium to dampen it
- Set the net pot(s) into the mouth of the bucket
- Place 4 – 5 seeds into the clay pellets (spread around)

- Add enough clay pellets just to cover the seeds
- Set timer on LED grow lights to about 16-17 hours a day (say, 6:00 am – 10 or 11:00 pm)
- Place containers under light so that they are about 6 inches below the light, adjusting periodically as the plant grows.
- Plant maturation will be determined by the type of plant you decide to grow.
- Plants such as tomatoes, peas, and beans will need support as they grow. Inexpensive freestanding plastic tomato cages are the perfect solution for this!

Root Vegetables

These are the plants where, for the most part, the business end of the plant happens below the surface. Some plants here, such as beets, have delicious greens. We're putting all the plants in this category because we tend to associate them with the parts that we consume that develop beneath the medium surface.

Some of the plants that fit into this category are:

Carrots

Beets

Parsnips

Radish

Turnip

You'll need:

- 8-gallon plastic storage bin with a lid
- Drill with 1/4-inch drill bit
- Perlite
- Pre-mixed hydroponic nutrient solution (mixed according to package directions)
- Watering can

What you'll do:

- Drill three or four one-quarter-inch drainage holes on each side of the 8-gallon plastic storage bin, 3 inches up from the bottom. Space the holes equally along each side.
- Place the storage bin in the lid so that the lid acts as a drainage tray.
- Fill the bin with perlite to a depth of at least 12 inches. Depending on the type of root vegetable you've selected, you may need to make the perlite even deeper, but for most root vegetables that are suitable for container growing, 12 inches is enough.
- Dampen the upper layer of perlite with the pre-mixed nutrient solution.
- Sprinkle seeds over the perlite, spacing them about half an inch apart.
- Cover the seeds with a one-half-inch layer of perlite and keep them damp until they sprout. Once they are 2 inches tall, thin them so that they are 3 inches apart, leaving the strongest plants to grow.
- Fill the bottom of the bin with nutrient solution once the plants are established. The holes will keep the solution from getting too deep, since the extra will pour out through them, but make sure your bin lid is in place to catch the runoff. The runoff can be recirculated.
- Suspend your Happy Leaf LED grow lights 6 inches above your plants.
- Set timer on LED grow lights to about 17 hours a day (say, 6 a.m.– 11 p.m.)
- Sprinkle or mist the plants lightly with nutrient solution two or three times each day. Use just enough to make sure the upper layer of perlite gets damp. The plants will draw most of what they need from the reservoir below them, but sprinkling will insure that your plants get adequate moisture. Continue watering your carrots until they are ready to harvest.

Caring for Your Anywhere Anytime Garden

As you review the chapters of this book carefully, you will note that one of biggest differences between an outdoor soil-based garden and an indoor hydroponic garden is the level of control the gardener has over the environment and life of the garden. With such a high level of environmental control, you should be able to guard against many of the issues that could cause your plants to suffer. These issues include nutrient deficiencies, pests and plant diseases.

As you learn and become an experienced hydroponic gardener, your knowledge of the nutrients you feed your plants will grow, and you will grow to understand how, when, and how much best suits the plants you choose in the hydroponic system of your choosing. An earlier chapter has a very comprehensive review of plant nutrients and explains the issues that might arise if your plants get too much or too little of a specific nutrient. If your plants start to develop signs of ill-health and there are not any signs of pests present, review the chapter on plant nutrients to determine if your plants are suffering a problem caused by a nutrient deficiency or a nutrient overdose.

PRUNING

If you want your plants, especially your herbs, to grow into their most luscious, abundant selves, then you need to know how to prune. Pruning is essentially snipping off leaves and some stems parts of stems, which will prompt them to continue to grow. In doing so, you can control the shape of your plants, as well as their size! Here are some top tips on pruning your herbs.

Pruning is good for your plants. For most plants, you want to prune early and often. By pruning early, this means when your plants are established but still young and small.

Not only will you be able to ensure optimal growth and a fuller, nicer shape when you prune regularly, but in spending more time on your plants, you'll be able to identify any disease or insect problems they may have from the outset.

Never prune away more than one-third of the plant.

You can use your fingers and pinch off leaves and stems for most plants, and scissors for others. Use your fingers for delicate plants, and make sure to pinch tightly and cleanly, right through the stem of the leaf. Small scissors, such as nail scissors, work well for this, too.

The most important thing is to *not tear or rip* off stems.
Identify what type of attention your herbs need.

Leafier plants like basil can die quickly after blossoming, so pruning is particularly important for such plants. When pruning these types of plants, cut them right where the leaf meets the stem. For most greens and herbs, you will want to remove any flowers as soon as they form to keep the plant in a vegetative state. Once they form flowers, much of the plant's energy is being redirected into reproduction instead of producing more of the shoots that we eat.

Woodier herbs, like rosemary and thyme, should be trimmed so that they don't become too woody (as they generally do with age), as no new leaves will grow. As soon as you start to see new growth, pinch some of the leaves back.

It is best to prune the leaves at the top, not the bottom. Take basil, for example. When plants are only a few inches tall, you want to prune or "pinch" off the newest leaves at the top. It may seem counterintuitive, leaving the big, full leaves to grow at the bottom. But you need them to act as the basis of your plants, your big solar panels for your plants to absorb light. When you remove the tips of branches, it promotes lateral shoots creating a tighter, less leggy and more well-branched plant.

Pests and Diseases

Plants are susceptible to pests and diseases and anyone who has gardened outdoors long enough has certainly had the unfortunate experience of a favorite plant or even a whole crop perish at the hands of these grower banes. The good news is that, like humans, one that is healthy is far less likely to succumb to the damaging effects of these critters. Using the method of growing that we have just described, you are growing your plants in optimal conditions. This results in spectacularly healthy plants that rarely need you to take action against detrimental invaders.

However, it is possible that you will have to deal with an unwanted pest or disease although it is FAR less likely to be affected than the same plant being grown outdoors which is more vulnerable the whims of nature.

This is true for several reasons.

1. You don't have the wind blowing in insects or diseases from plant to plant.

2. You don't have soil to harbor diseases and provide a perfect breeding ground for insects to lay eggs or provide protection.

3. Temperature is more stable, providing the plant with less swings in day and night temperatures.

4. You are providing the plant with exactly the spectrum of light it needs to get off to a better, faster start, outgrowing many potential problems from the start.

Pests

The most common reasons that pests can be introduced to an Anywhere, Anytime garden are:

1. You have other houseplants that harbor pests that find their way to your Kratke crops.

2. You are growing them near an open window and pests get in through the screen and onto your plants.

3. You buy houseplants or use cuttings that have eggs on them that are too small for the eye to see so you unknowingly plant them up and don't see a problem until they hatch, or the disease shows symptoms.

4. The very best way to introduce pests into your home is when you bring outdoor plants inside. For this reason, it is very important to make sure they are disease and insect free before they get a free ticket to thrive in your home.

If one of the aforementioned situations begins to affect your plants, don't lose hope! The most important tool you have in preventing irreversible damage is to monitor your plants regularly. The earlier you can catch a problem, the easier it is to control them. A small, inexpensive hand lens will go a long way in spotting and identifying any problems before they have a chance to take over your crops.

At the first sign of plant damage, there are several steps you can take to prevent further spread of the problem.

1. Remove the infected part of the plant if practical.

2. Isolate the plant to make sure it doesn't begin to affect nearby plants.

3. Following instructions on the label, use an organic or natural pesticide to spray the affected plant at suggested intervals. Be sure to note that spraying on edibles is an accepted use.

4. If the pests have spread to a larger extent, or if you have several of the same plants (with the same susceptibility) in one area, sometimes is it better to cut your losses and eliminate the plant altogether before it infects your nearby healthy plants.

Common Intruders of Indoor Plants

Fungus Gnats

These little flying insects are common in houseplants and other plants growing indoors. The entire life cycle of a fungus gnat is less than a month. Like many insects, the adult's sole job is to reproduce. They lay up to 200 eggs in the soil which then hatch into larvae. It is in the larval stage that they cause plant damage by feeding on the roots.

The good news is that they are more of a nuisance pest and it takes a continuous population repeatedly feeding on your plants to do any irreversible damage. The great news is that the adult needs moist organic matter to lay her eggs in and that is absent in the passive hydroponic Kratky method. For this reason, it would be unusual to see any issues in your passive hydroponic containers. So, plant away in gnat-free bliss! Unless you have plants growing in soil near your plants, you are unlikely to ever have any fungus gnat frustration. If you do have soil grown plants around, there are many natural ways to control them. Using yellow sticky cards are a great way to monitor the presence of these pests but if you have them, it will be obvious as they fly around when disturbed.

Spider Mites

These tiny little creatures are extremely difficult to detect with the naked eye until there is enough of a population that they are already causing problems for your plants. If you monitor vigilantly, you can often detect them early by looking sign of a problem is speckling on the upper side of the leaves or webbing on the underside of the leaves. They are very difficult to control once established because we often don't see them until they are a problem population, are present from the egg to adult stage simultaneously, and are quite protected against sprays under their webbing. A decent magnifying hand lens is essential in detecting them early because they usually go unnoticed until they have proliferated to the point when action is necessary. Organic sprays, such as pyrethrin, can be used to suffocate them but again, it is very hard to completely reverse an infestation without repetitive action. It is usually best to try to cut out the affected stem(s) first to eliminate as many as possible before spraying. Be sure not to handle other healthy plants and keep the plant itself from touching other nearby plants as these are great ways to spread an outbreak.

Thrip

Adult thrip are very small, flying insects that love to live in the flower buds of plants. With leafy greens, this usually isn't a concern but can be common on houseplants and other flowering plants. They have scraping-sucking mouth parts and damage looks like small, silvery spots on the surface of the leaf. An infested plant will start to shrivel and curl and become quite unsightly. In nature, they overwinter in soil which is good news for us Kratke growers – there is no soil for them to harbor. Once established, they can thrive in our cozy homes so vigilant monitoring to catch the problem early is essential. Good sanitation practices are also important because they can live in fallen debris. They are attracted to blue sticky traps so having some hung around your plants can help you immensely with early detection.

Diseases

Foliar Diseases

Although there are a multitude of foliar diseases that affect plants, the good news is that many of them spread by wind and rain which are both absent in this indoor growing method. Many diseases continue to proliferate readily in the presence of wet foliage or splashing water. Because we water from underneath the plant, we eliminate the ability of many foliar diseases to spread uncontrolled. If you are using cuttings, make sure they are from a reputable, disease-free source.

Root Rot Diseases

The most common diseases that can occur in the Kratky method are ones that cause root rot, such as phytophthora or Pythium. They work by rotting the roots and cutting off the plant's ability to draw up nutrients to thrive. These can be largely eliminated by making sure that your media and jars are thoroughly sterilized before planting and again between crops. Spores of these diseases can live dormant on the surface of unsterilized materials for a surprisingly long time. Also, it is also crucial that you do not fill the jars with your nutrient solution above the level of the net pot so that the roots have space to breathe. It is the oxygen available in this space that makes it possible to grow healthy plants using the Kratke method.

Crown Rot Diseases

These types of diseases often occur when there is too much substrate around the "crown" or base of the plant where it meets the media. This rarely, if ever, occurs when using hydroponic clay pellets because they are very light weight and porous which allows ample air flow to the stem. When using cuttings in other types of media, it is important to never bury the crown below the surface so that it has ample oxygen and doesn't choke the plant.

For all the aforementioned insects and diseases, it is important that you practice good sanitation around your plants by cleaning up any fallen debris and remove any damaged leaves.

Harvesting and Eating Your Anywhere Anytime Garden

All through this book you have read how easy and wonderous growing a whole host of plants in your Anywhere Anytime Garden can be. But we saved the best for last! The best part of having your garden indoors year-round at your fingertips is that once your system is up and running, you can harvest ANYTIME and enjoy fresh grown food.

As for how to "harvest", you can refer to the earlier section on pruning for many of your plants such as basil and lettuce. For plants such as tomatoes, carrots and the like… let them grow and pick them when they're ready.

As you harvest and enjoy your leafy greens and herbs, you will notice that the plants have a definite life cycle. You can prune and use these greens for salads for a number on months and the leaves will continue to grow. There will come a time, however, after several months, that the plants will start to look a little tired. At this point, you can harvest and enjoy what the plant has left to offer and start anew.

Enjoying (A Few Recipes for you)

The best of all conclusions for this book about your Anywhere Anytime Garden is this short collection of recipe ideas that use a sampling of the endless number of herbs, greens, and roots you can grow anywhere at any time. Enjoy your bounty and please feel free to share with us your garden pictures and delicious recipes!

Tomato Basil Dip

Ingredients:

3 cups diced fresh tomatoes (any type will do.. sweet cherry tomatoes are fabulous!)

1 tablespoon smashed garlic (more is even better)

½ cup chopped fresh basil

1 tablespoon olive oil

Dash of balsamic vinegar

Salt and pepper to taste

Toss all ingredients together. Best served on sliced fresh baguette. This dip is the definition of summer!

Pesto

Traditional pesto is made with basil, but you can also consider other greens such as spinach or arugula(!)

Ingredients:

4 cups tightly packed fresh greens (basil, spinach, or arugula)

1/3 cup olive oil (maybe as much as ½ cup)

2 – 4 crushed garlic cloves

¼ - ½ cups pine nuts, walnuts, or black walnuts

½ cup fresh grated Parmesan or Romano cheese

Place basil, nuts, garlic, olive oil in a food processor. Pulse until the mixture is chopped very fine but not smooth. Remove from processor bowl and add cheese.

Serve on pasta, pizza, bread, or in soups.

You may freeze pesto, but don’t add the cheese until you are ready to use it.

Sautéed Greens with Pasta

Ingredients

8 - 16 cloves garlic, thinly sliced

1/4 cup extra-virgin olive oil

2 medium onions, halved and sliced

1/8 teaspoon red pepper flakes, or more to taste

Kosher salt to taste

12 cups torn winter greens, such as kale, chard, escarole or mustard greens (about 2 1/2 pounds)

1/3 cup dry white wine

12 ounces spaghetti

1/4 cup grated pecorino Romano cheese

Bring a large pot of salted water to a boil. Meanwhile, cook the garlic in the olive oil in a large skillet over medium-high heat, stirring occasionally, until golden brown and crisp, about 3 minutes. Add the onions and red pepper flakes; cook, stirring, until the onions are translucent, about 3 minutes. Add the spaghetti to the boiling water and cook until al dente, 8 to 10 minutes. Drain the pasta and transfer to a serving bowl.

When the onions are almost done, add the greens and white wine to the pan and cook, uncovered, until just tender, about 3 minutes. Cover and allow to cook for another 2 – 3 minutes.

Transfer pasta to plates for serving and top with sautéed greens and grated Parmesan cheese.