

William Texier's Related Books

*Hydroponics for Everybody,  
All about Home Horticulture*  
(English Edition, Mama Publishing, 2013, 2014, 2015)

*L'Hydroponie pour tous,  
Tout sur l'horticulture à la maison*  
(French Edition, Mama Éditions, 2013, 2014, 2015)

*Hydroponik leicht gemacht,  
Alles über Pflanzenanbau im Haus*  
(German Edition, Mama Publishing, 2013, 2014, 2015)

*Hidroponía para todos,  
Todo sobre la horticultura en casa*  
(Spanish Edition, Mama Publishing, 2013, 2015)

*Гидропоника для всех,  
Всё о Садоводство на дому*  
(Russian Edition, Mama Publishing, 2013, 2015)

*Hydroponie pro každého,  
Vše o domácím zahradnictví*  
(Czech Edition, Mama Publishing, 2013, 2015)

*Idroponica per tutti,  
Tutto sull'orticoltura domestica*  
(Italian Edition, Mama Publishing, 2015)

*Hydrocultuur voor iedereen,  
Alles over thuiskweken*  
(Dutch Edition, Mama Publishing, 2016)

# Hydroponics for Everybody



WILLIAM TEXIER

# Hydroponics for Everybody

ALL ABOUT HOME HORTICULTURE

Illustrations : Lorie Verlomme

Copyright © Mama Publishing (2015)  
All rights reserved for all countries

ISBN 978-2-84594-120-5  
*HydroScope* : Designed and produced by Tigrane Hadengue

Mama Publishing, 7 rue Pétion, 75011 Paris (France)

MAMA PUBLISHING

*Hydroponics is an artificial but not unnatural crop production method, based upon those same principles which nature has set up as the pattern of life.*

William F. Gericke  
*Founder of modern hydroponics*

## Acknowledgements

I would like to thank the people who helped me with this book,  
from proofreading to editing my strange English,  
Hilaria, Lani and Cal, Fred and Alix.

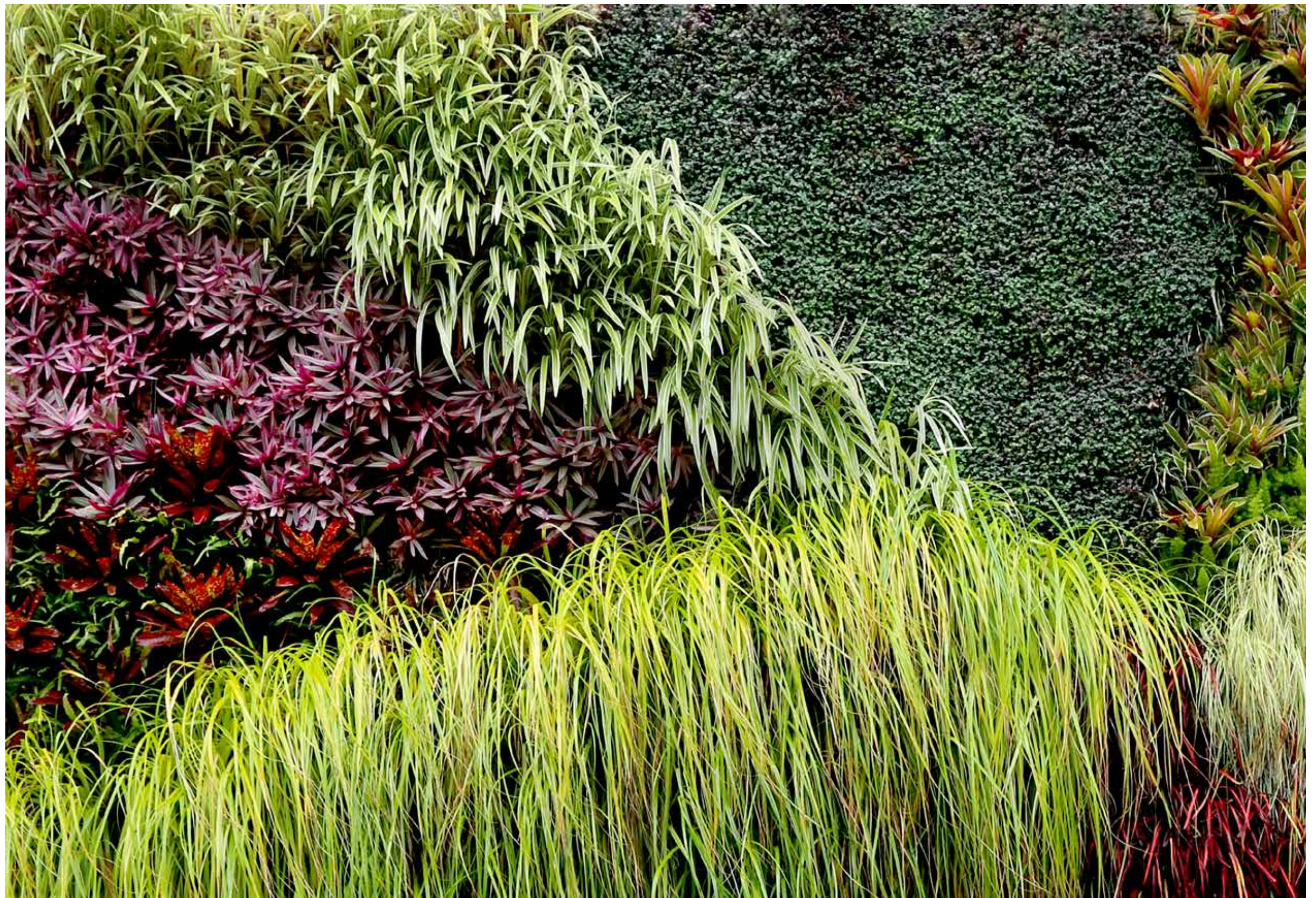
Special thanks for my wife, friend, and longtime accomplice  
Noucetta. And of course, I cannot forget my dear friends  
Lawrence Brooke, with whom that adventure started...  
and continues, and Cal Herrmann who taught me  
the little chemistry that I know.

I also would like to dedicate this book to all of you  
growers and plant lovers.

# Table of Contents

<b>FOREWORD</b>	<b>15</b>
<b>INTRODUCTION</b>	<b>17</b>
<i>A Brief History</i>	19
<i>Advantages: Why Hydro?</i>	24
<i>Limitations</i>	29
<b>CHAPTER 1 THE DIFFERENT HYDROPONICS SYSTEMS</b>	<b>33</b>
<i>Passive Systems</i>	33
<i>Flood and Drain</i>	34
<i>NFT</i>	38
<i>DFT: Deep Flow Technique</i>	42
<i>Drip Systems</i>	42
<i>Aero-hydroponics</i>	46
Air pumps	46
Water pumps	50
Vortex	52
<i>Aeroponics</i>	54
<i>Vertical Cultivation</i>	56
<i>DWC: Deep Water Cultivation</i>	59
<i>Hydroponics of the Future</i>	61
<i>Which One to Choose?</i>	61
<b>CHAPTER 2 HYDROPONIC SUBSTRATES</b>	<b>65</b>
<i>Common Features</i>	65
<i>Inorganic Substrates</i>	67
Rockwool – Glasswool	67
Lava rocks	69
Pumice	69
Perlite	69
Vermiculite	71
Gravel	71
Sand	71
Expanded clay pebbles	73
<i>Organic Substrates</i>	73
Peat moss	73
Coco coir	75
Sawdust	76
<i>Others</i>	76
Soilless mixes	76
Water	76
<b>CHAPTER 3 THE NUTRIENT SOLUTION: WATER, NUTRIENTS, AND FILTRATION</b>	<b>83</b>
<i>Water</i>	83
pH	84
Table: pH scale, some examples	84
Alkalinity	86
Hardness	87
Salinity	87
<i>Filtration and Treatments</i>	89
Reverse osmosis	89
UV Filter	90
Sand filter	92
Biofilter	92
Activated carbon filter	92
Ceramic filters	92
<i>The Nutrients</i>	94
Table: The role of each element	95
<b>CHAPTER 4 MANAGEMENT OF NUTRIENT SOLUTION</b>	<b>101</b>
<i>Temperature</i>	102
<i>pH</i>	104
Table of absorption	104
<i>Conductivity</i>	105
Table of conductivity in mS/cm	105
<i>Changing the Solution</i>	106
<i>Some Basic Advice</i>	108
<b>CHAPTER 5 HYDROPONICS PLANTATION STAGE BY STAGE</b>	<b>113</b>
<i>Sowing</i>	113
<i>Mother Plant</i>	114
<i>Cuttings</i>	116
<i>Vegetative Stage</i>	118
<i>Flowering and Fruiting</i>	120
<i>Harvest</i>	122
<i>Growing for Seeds</i>	122
<i>Hydroponics for Outdoors</i>	122

<b>CHAPTER 6 THE HYDROPONICS GROW ROOM</b>	<b>123</b>
<i>Space</i>	123
<i>Humidity</i>	126
<i>Ventilation</i>	128
<i>CO<sub>2</sub></i>	129
<i>Light</i>	132
Metal Halide (MH)	
– High Pressure Sodium (HPS)	136
LED (Light emitting diodes)	136
Plasma light	136
<i>Odor</i>	138
<b>CHAPTER 7 DEFICIENCIES, PESTS, AND OTHERS</b>	<b>143</b>
<i>Deficiencies</i>	143
Table of mobile, semi, and fixed elements	144
Table of deficiencies/excesses	144
<i>Pests in Indoor Cultivation</i>	146
Above ground	149
• Spider mites	149
• Aphids	151
• Thrips	151
• Whiteflies	151
• Molds – Fungi	151
Below the ground	153
• Root aphids	153
• Nematodes	153
• Fungus gnat	153
• Molds – Fungi	153
<b>CHAPTER 8 ADDITIVES: BRINGING LIFE TO HYDROPONICS</b>	<b>159</b>
<i>Silica</i>	160
<i>Humates</i>	161
<i>Plant Extracts (Boosters)</i>	162
<i>Hormones</i>	164
<i>Algae Extracts</i>	165
<i>Fungi and Bacteria</i>	165
<i>Worm Casting Extract</i>	166
<i>Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>)</i>	168
<i>CO<sub>2</sub> Tabs</i>	169
<i>Enzymes</i>	170
<i>Mycorrhiza</i>	170
<b>CHAPTER 9 CAN HYDROPONICS BE ORGANIC? BIOPONICS</b>	<b>175</b>
<i>Conductivity</i>	177
<i>pH Level</i>	178
<i>Filtration</i>	179
<b>CHAPTER 10 URBAN GARDENING (OUTDOOR AND INDOOR)</b>	<b>181</b>
<i>General Principles</i>	182
Impermeability	182
Heat	182
Rain	183
Frost	183
Wind	183
Insects	185
Kitchen, Living Room	185
Terraces, Balconies	186
Vegetal Walls	186
Roofs	193
City Farms	194
<b>CONCLUSION</b>	<b>199</b>
<b>APPENDIX 1 GALLERY</b>	<b>203</b>
<b>APPENDIX 2 THE LAW AND THE LABEL</b>	<b>217</b>
<i>What Does the Law Say?</i>	217
Minerals	217
Mixes of mineral and organic	218
Organic	218
Eco labels	218
<i>Consumer's Information</i>	218
What does the label tell you?	219
What the label does not say	219
What do we find on the labels in real life?	220
<i>In Brief</i>	220
<b>APPENDIX 3 CONVERSION CHART</b>	<b>221</b>
<b>APPENDIX 4 BIBLIOGRAPHY</b>	<b>223</b>
<b>INDEX</b>	<b>227</b>



# Foreword

Over the many years that I have worked in the field of hydroponics, the most difficult thing to obtain has been good information about how to grow crops hydroponically at home. Huge leaps in hydroponic technologies have led to better cultivation systems, nutrients, and plant growth supplements. However, useful information has been much slower in becoming available.

When I started General Hydroponics Inc. in the early 1970s, the human population on Earth was approximately 4 billion; today, it is more than 7 billion. The consequences of rapid population growth on Earth have strained ecological systems to the point that in addition to climate change we are also seeing a rapid decline in the quality of soil and water resources. This process has made hydroponic crop production even more important. For a grower to be successful, it is as important to have knowledge as it is to have good equipment and water.

*Hydroponics For Everybody* is the book we have all been waiting for. It was written by William Texier, who has distinguished himself as a proven innovator in hydroponics. Together, William and I created General Hydroponics Inc. over the past decades to meet the needs of people everywhere who wish to have control over their food supply. We worked on improved hydroponic systems to simplify crop production at home. We fine-tuned the nutrient profiles necessary to enable better plant growth, resistance to pests and diseases, and improve crop quality and yield.

*Hydroponics For Everybody* is your guide to achieving success in growing for yourself, your family, and your friends. It provides information at every level, from beginner through professional growers. It covers every aspect of hydroponics, from starting plants and growing them hydroponically, through the phases of life, and finally to harvest. Critical issues are discussed, including water quality, temperature, humidity, ventilation, pest avoidance and management, lighting, and numerous other topics that can mean the difference between crop success and failure. The information in this book is as important as the quality of the equipment and methods you use in growing hydroponically. It will help you achieve your best crops.

Read this book and grow. Then read it again and your skills will grow, too.

Lawrence Brooke  
Founder – General Hydroponics Inc.  
BS University of California – Berkeley

# Introduction



Webster's Dictionary gives the following wonderfully succinct definition of the word "hydroponics":

"A technique of growing plants without soil, in water containing dissolved nutrients."

Well, that's it in a nutshell. When done right, hydroponics can produce better tasting, more nutritious fruits, vegetables, and herbs with lower ecological impact than traditional soil-based cultivation. In this book I would like to help you "do it right." I will share with you all of the practical information I've garnered through my lifetime of growing with hydroponics. The more you understand, the more successful you'll be; as we go along, I'll do my best to explain each new term and concept, and show you how to apply them.

There are two ways to grow plants in water: with the bare-roots growing in a nutrient solution, or with a non-soil, inert substrate. In some languages, the term "hydroponics" is reserved for water-based cultivation, while the term "soilless" is used for substrate-based culture. We will discuss both in this book.

The basic principles of hydroponics are very simple, almost childish: a nutrient solution must be kept at a tolerable temperature, oxygenated, and provide the plants with the nutrients they need. Oxygenation is really the heart of it. To make a good hydroponics system, the water has to be saturated with oxygen at all times. Once you know this, you can almost throw away the book, because you've learned the most important factor, which is so important that I will come back to the subject often.

The word "hydroponics" comes from two Greek roots: "Hydro" meaning water and "ponos" meaning work. You can translate it in several ways: "water at work" or "working with water," and also "the work of water." Whichever you prefer, the meaning it conveys is clear. The word hydroponics, by and large, does not describe a single technology, but rather it covers many different techniques that we will examine further on. Sadly and confusingly, this means that the term "hydro"<sup>(1)</sup> also encompasses poor practices that can be extremely damaging for the environment, wasteful of water, and produce low quality food totally devoid of interest both in terms of taste and nutritional value. If you've only encountered hydroponics products in the form of tasteless tomatoes and odorless roses at your local supermarket, I can't blame you for having concluded that hydroponics is an unnatural and environmentally polluting way to produce industrial quantities of something that only looks like food. Unfortunately, you are not wrong. The processes to grow these products generate ugly mountains of waste, old plastic mulching, used slabs of rock wool, and many other unwanted materials, none of them biodegradable.

---

1. I often use "hydro" as shorthand for "hydroponics."



Fortunately, hydroponics has much, much more to offer. I will do my best to enlighten you and steer you away from such benighted practices.

Let us start by learning to distinguish between open and closed systems. Most commercial operations are purely open systems (and pretty basic ones). The plants are grown on a rock wool slab; a nutrient solution is circulated various times a day, according to ambient temperature, subsequently releasing 25 to 30% of this nutrient solution into the ground with each watering. This is done to avoid a salt buildup in the substrate. This technique is very damaging for the ecosystem, and it gives a bad name to hydroponics. It is still largely in use today because it is extremely cheap to put in place. To achieve a competitive market price, most commercial growers use this open system to maintain low production level cost. However, many recent new regulations mandate recovering this wastewater from the drain and disposing of it safely. Wastewater is now often treated and recirculated.

Then there are closed systems in which the nutrient solution circulates from a tank to a crop and then back into the tank. In this case, all the water used is absorbed by the plant and transpired, resulting in high water use efficiency. There is also no contact between the nutrient solution and the ground, and therefore no risk of polluting the soil or having unwanted nutrients leaching into the groundwater.

These are the systems most likely to be encountered in your local grow shop. Because they are the easiest to adapt to various sizes of grow rooms, they represent the vast majority offered to the hobby market. Closing the system resolves the waste of water, but multiple problems remain.

You can still produce very poor quality crops in a closed hydro system. The other issue to address is nutrition. Most commercial hydroponics growers do not give their plants proper nutrition. They simply cannot afford to do it. Yet, in order to produce tasty food, you must provide your plants with all the elements they need, in a form they can absorb. We will discuss this subject in detail in a later chapter.

The other key reason why commercial hydro produces poor results is simply because the plant varieties chosen for large-scale cultivation are selected primarily for appearance and handling properties. For example, tomato cultivars are selected so that all the fruits will be the same size and color, and that hundreds of people can handle them in the store without blemish. None of this has to do with taste or nutritional value. And yet, if you take a good variety, say your favorite tomato plant from your garden, and place it in a hydroponics system and give it the proper nutrition, you will obtain something that may surprise you: delicious tomatoes, faster and with a much higher yield than in soil. My years of experience have taught me that this will work pretty much with any plant.

What is called “hydroponics” and what is not? The line sometimes is fine. There are two prerequisites for a growing operation to qualify as hydroponics: the nutrients must be brought to the roots via irrigation water, and the substrate, if any, must be inert and provide only a physical support. At the most, the substrate might have a cation exchange capacity (like coco fiber does, for instance), but in no case should it deliver any kind of nutrient to the plant. Imagine that you have plants growing in pots on a table and that you irrigate and feed each pot via an individual dripper. If the pots are filled with an inert substrate, this is hydroponics. If the same pot is filled with potting soil, it is not. The practice of adding nutrients to the irrigation water through feed lines and emitters, when in soil, is called fertigation, not hydroponics.

## A Brief History

**+/- 2000 BC:** First recorded potted plant. This happened in Egypt. It has nothing to do with hydro, but I like that date. In some ways, this is the beginning of the story: for the first time, man took plants out of the ground, put them in potted soil, and brought them home.

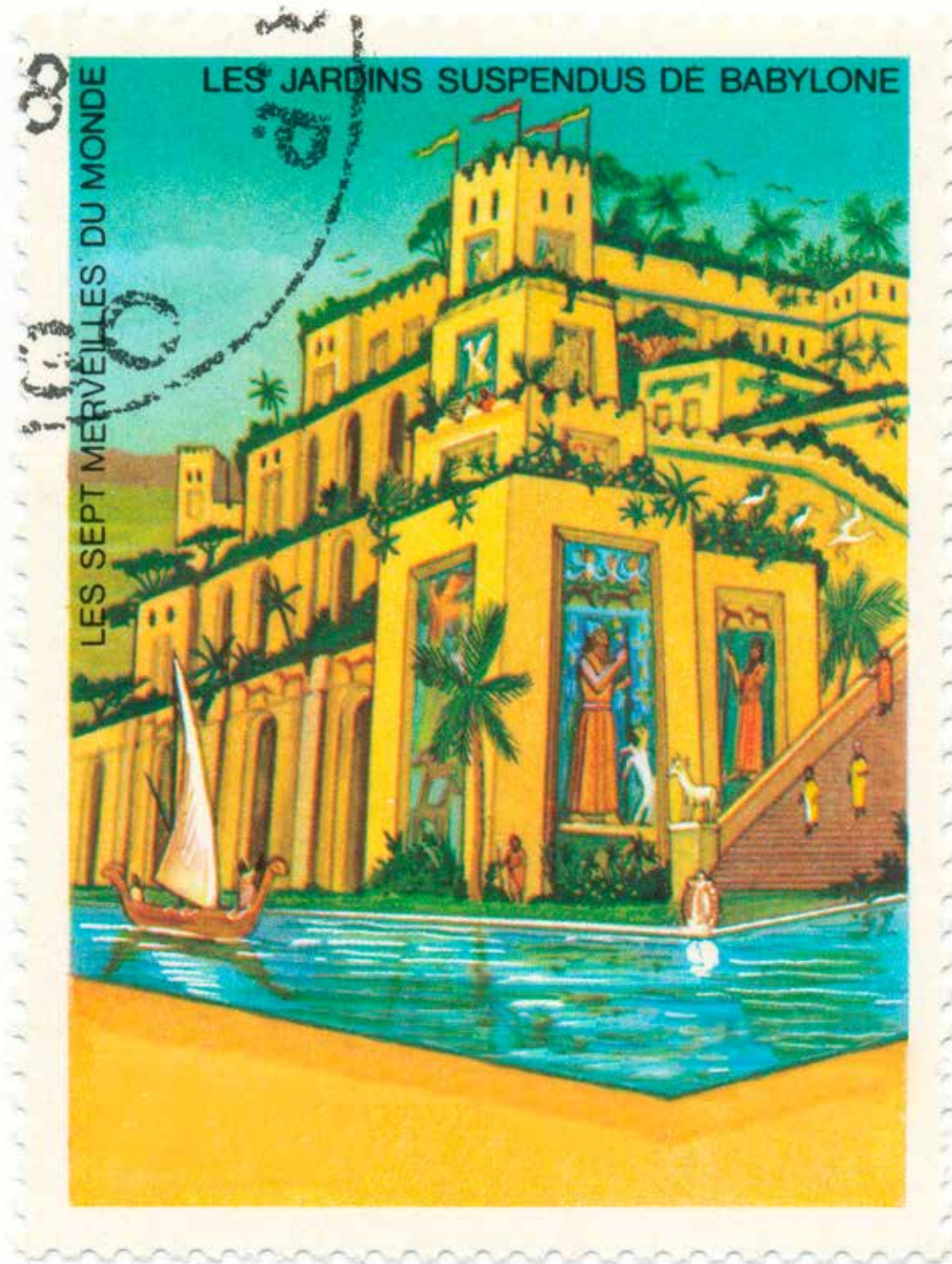
**-600 BC:** The famous hanging gardens of Babylon are often cited as being the first recorded use of hydroponics. **1** Sadly, the ancient fabled plantings do not strictly meet our definition of hydro, because although the plants were grown in channels with a constant stream of water bathing their roots, the channels were filled with earth. Incidentally, the gardens didn't really “hang” either; that idea stems from a mistranslation of a Greek word meaning “overhanging.” Nevertheless, this is the oldest recorded use of a large irrigation system integrated into a building.

**1100:** Indian tribes in South America and Mexico (Aztecs and others as well) used floating rafts, called “chinampas,” to increase their arable land. Made of interwoven stems of rushes, reeds, and corn, these man-made “islands” floated on the lakes. On these frames they would place the rich mud from volcanic soil. These floating islands were then used to grow food crops. The plants would get their nutrition both from the mud and by sending roots down in the water. The lake waters, very rich in dissolved salts, were cool and well oxygenated. This technique was also used in other parts of the world. For example, in 1275, Marco Polo encountered floating gardens in China. Although we cannot be certain where and when floating gardens were first used, they were the first true hydroponics technology.

**1699:** John Woodward, a naturalist historian interested in botany, also a fellow of the Royal Society of England, made the first experiment demonstrating that plants get their nutrition from the soil and by means of water. We do not know what the rest of the people on the planet knew on the subject, but until 1699, the occidental man had very little knowledge how and why a plant would grow. In what was the first hydroponics experiment, Woodward showed that plants grew better in river water than in the purer distilled water, *i.e.* that plants must extract something from the water that helps them grow. By growing plants in water to which he added various amounts of soil, he demonstrated that the greater the amount of soil, the better the growth, and therefore plants must benefit from something within the soil.

After that, knowledge of plant physiology was gained slowly. It took another hundred years for another British scientist, Joseph Priestley, to demonstrate that plants change the composition of the air around them. Later he “discovered” oxygen, and proved that plants absorb it and release carbon dioxide. Then in 1779, Jan Ingenhousz demonstrated that light is essential for photosynthesis to happen. So it was the dawn of the 19<sup>th</sup> century before we knew most of the mechanisms of plant growth, but not yet the exact elements needed for that growth.

**1860:** A German scientist, Julius Von Sachs, published a formula for a nutrient solution that can be dissolved in water and used to grow plants. Together with Knop, an agricultural chemist, they laid the foundation for water-based culture. I could not put my hands on Von Sachs' exact formula, but in view of the limited range of mineral salts that they had on hand, it must have been rather primitive, and I doubt that they could sustain growth for a very long time with it. From then on, however, thanks to water culture, by trial and



1

error, by adding or suppressing elements from the nutrient solution, scientists were able to find out which elements are essential for plant growth, and which ones are not.

**1920-1930:** Dr. William F. Gericke is considered, especially in the Anglo-Saxon world, the founder of modern hydroponics with two important developments to his credit. He was the first to take water-based culture out of the lab and turn it into a commercial-scale operation. He also coined the word “hydroponics.” His work attracted a lot of attention. These were heady times, and society was mutating rapidly with exciting scientific discoveries being made more and more frequently. Some writers went so far as to declare that arable land was now a thing of the past. This premature attention was unfortunate. The technology was in its infancy, and it would take a scientist of Gericke’s caliber to grow a crop successfully. This led to many failures, as many people engaged wholeheartedly in commercial ventures that did not hold true to their promises. On the good side, this publicity generated a lot of research in laboratories, public as well as private. His book *The Complete Guide to Soilless Gardening* is still available; the last reprint was as recent as 2008.

During the same years that Gericke was perfecting the “hardware,” the physical systems, Dennis R. Hoagland was working on the software side of hydroponics, *i.e.* the nutrient. In 1933, he published the formula for his famous Hoagland’s solution. This formula evolved slightly during the following years (notably through the introduction of iron chelate), but the base is still there. It is still in use as the reference standard for routine experiments in many plant research laboratories. To be honest, sometimes I wonder why they still bother to use this formula, which is now quite outdated. It is also still used by commercial growers who do not want to spend more money on a better formula. You might even have bought some Hoagland’s solution yourself. Recently, many nutrient supply companies have sprung up; people hoping to prosper selling nutrients generally use the Hoagland’s formula because it is easy to find (it’s all over the Internet) and cheap to make.

**1940-1944:** The first use of hydroponics on a large scale. Unfortunately, it took a war. In the Pacific Islands, the U.S. army was faced with the challenge of feeding large numbers of soldiers. Food supplies, especially fresh, were hazardous to ship and difficult to grow on these rocky islands, where the soil is often saturated with salt and water is scarce. Therefore, they resorted to hydroponics. They must have liked it, because the practice continued well after the war and into the 1950s. They utilized a gravel bed system developed by Robert and Alice Withrow at Purdue University, the so-called “Nutriculture System.” This setup was the base for what is now called “flood and drain,” or “ebb and flow” (it has nothing to do with the brand name known as Nutriculture today). It was a large-scale bed system. The beds were filled with gravel, flooded with nutrient solution a few times a day, and then allowed to drain slowly. 2

After that, nothing really happened for sometime. The cost of starting an operation contributed to this lack of interest, but also the technology was not quite perfected. One difficulty was that gravel or sand, the most popular substrates of the time, are too heavy or too compact for the purpose. There was still no way to keep iron effectively in solution. These were the years when many projects were started in desert regions of the world. Most if not all failed, marking the decline of the technology for the next few decades.

**1960-1970:** Around this time, a number of important developments contributed to the rebirth of hydroponics. Rockwool, a material principally used for building insulation, began to be used, with slight modifications, as a substrate for plant growth. Artificial chelates were being manufactured, making it possible to keep the micronutrients in

solution more efficiently. Some complex salts such as MAP (mono ammonium phosphate) appeared on the market, diversifying the sources of soluble phosphorus. Concurrently, the plastic industry was booming, and many new products were developed for use in the greenhouse industry. Greenhouses were slowly shifting from glass to plastic covering. The hydroponics concrete beds were replaced by plastic channels, plastic trays, and plastic sheeting. We were entering into our brave new world.

**1970:** Dr. Allen Cooper developed the “Nutrient Film Technique” (“NFT”). In 1979, he published the *ABC of NFT*, a little book that is still popular. NFT was immediately adopted around the world to commercially grow short cycle crops such as salad greens.

**1970-1990:** During this period, different hydroponics technologies gained acceptance in various places around the world. More food crops were grown this way, not always for the best. Meanwhile, an important new phenomenon appeared: indoor home growing.

**1978:** Lawrence Brooke founded General Hydroponics. He modified and improved large-scale hydroponics systems with the goal of reducing them to the size of an urban grow room. He fueled it with the best nutrient at the time, one formulated with Dr. Cal Herrmann of the NASA Ames Research Center. For the first time, this technology was offered to small-scale urban growers. However, the market was slow to grow, at first, even in California. Then, in the mid-1980s, it suddenly exploded as scores of people began dedicating themselves to home growing.

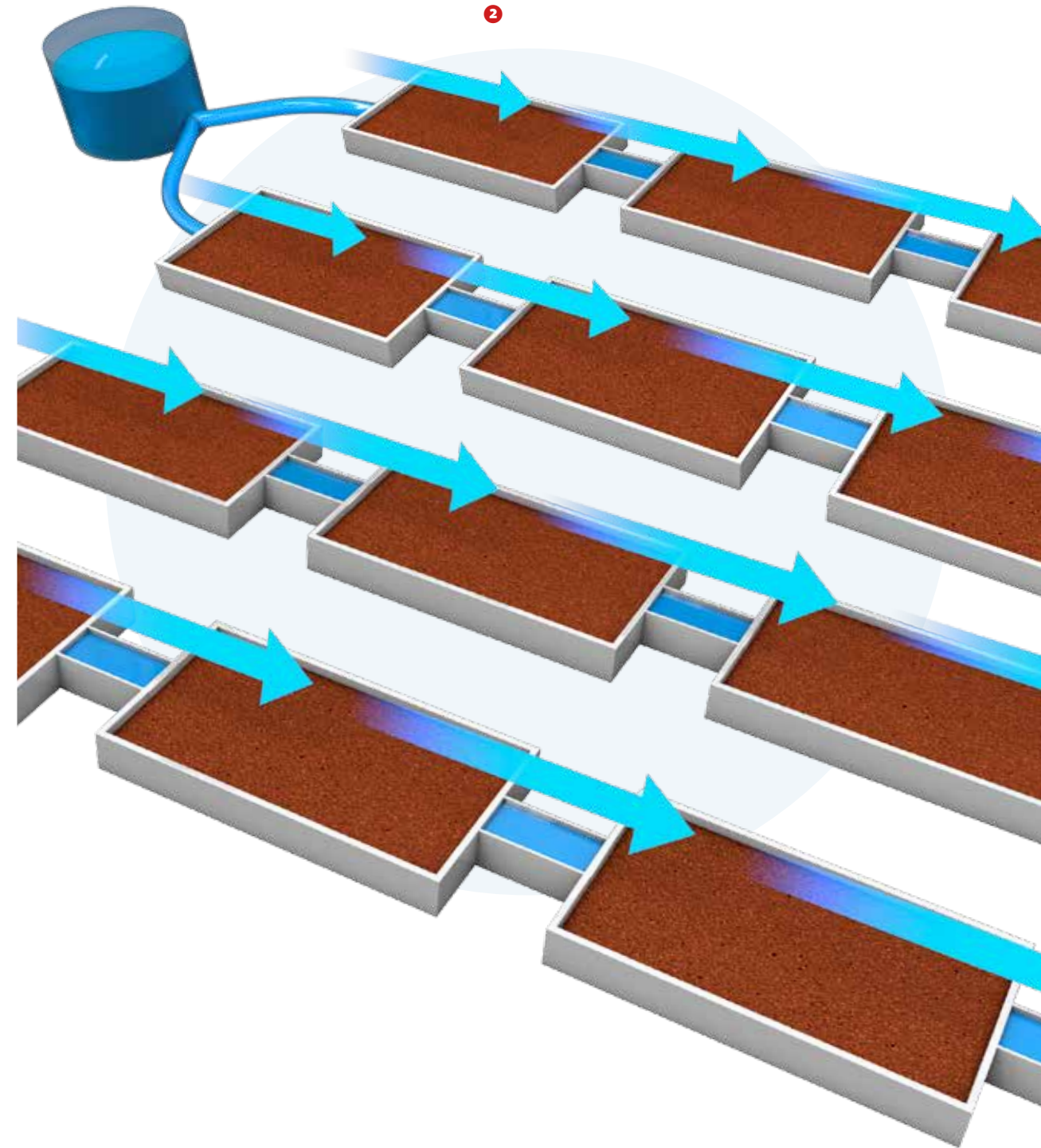
**1986:** Dr. Hillel Soffer, working with the University of California at Davis, developed the vortex, which remains the most efficient hydroponics system on the market. His research first established a direct correlation between plant growth and dissolved oxygen level in the nutrient solution. By adjusting the level of dissolved oxygen, he was able to change the speed of growth in *Ficus benjamina*. This was the foundation for Aero Hydroponics, an important branch in modern hydro.

Also around this time, most of the U.S. and Canadian companies still active today appeared on the market. So, since about the mid-1980s, there have been two contrasting branches of hydroponics: the large scale commercial one and the home growers. Many are aficionados of tropical or medicinal specimens, or they are collectors of specific varieties of plants.

Meanwhile, in Europe, not much was going on except in Holland. While growing many different crops, mostly flowers in huge greenhouse operations, the Dutch practiced their own version of indoor growing. Among other things, they can be credited for developing the “sea of green” technique: growing many small plants instead of a few big ones.

**1995 - present:** On the commercial hydroponics front, the industry is growing rather rapidly, but also changing and adapting to new times. More sophisticated systems, which are eco-friendly, have become profitable, especially for short-term crops such as lettuce and herbs.

On the indoor growing front, General Hydroponics opened a sister company in Europe in 1995. At about the same time, Nutriculture, a British-based corporation, started European distribution. Soon many companies joined, based in Europe or exporting material from North America. The technology slowly gained ground, country by country, as more grow shops were opened. Northern countries adopted indoor hydroponics first, followed by France, Spain, Italy, and Portugal, all motivated by the pleasure and pride of consuming food produced personally. Now, it is the eastern countries’ turn to build an indoor growing industry.



The introduction of hydroponics technologies for noncommercial public sector and beautiful private home use has opened the door to scores of applications, from growing one's own medicinal and culinary herbs to growing flowers. Even more recently, a fascinating new trend of hydro has appeared: integrating hydroponics into architectural design as interior and exterior decoration elements, house facades, and on roofs. Vegetation growing on a house front or on its roof makes for excellent insulation as well as an efficient sink for carbon dioxide (CO<sub>2</sub>). Indoors, one can grow plants to clean all sorts of pollutants from the air, while at the same time creating exquisite, living textures, and colors. This movement is rapidly expanding as urban dwellers seek to incorporate more green life into their environment. 3

Each one of the three branches of hydroponics: commercial, home growing, and decoration / insulation / de-pollution, could be the subject of a full book, but in the next chapters, I will concentrate chiefly on the second, indoor growing, a large subject in itself.

## *Advantages: Why Hydro?*

You might very well ask yourself: why bother to spend money on hydroponics systems when you can just put a plant in a pot with soil and grow it with no major investment? In fact, I think this reasoning is incorrect. There are zillions of reasons to use hydroponics technologies. Let's review what hydro can do, first in the wide world, and then in your own growing space.

### **Control of nutrition**

The first benefit—and it is of utmost importance—is that you can control completely the nutrition of your plant. Only the elements that you put in the water will be present in the root zone, and in the proportions that you choose. You can control the quality as well as the quantity of the nutrients dissolved in the water at all times. Remember that it is thanks to hydroponic technologies that plant science has advanced for the past 200 years, in particular in the field of plant nutrition. Today, most research around plants involves hydroponics. As controversial as it might be, it is also used for research in genetics and gene transfer.

### **Conservation of water**

Don't get this wrong. A plant needs to transpire a certain quantity of water to sustain healthy growth. The fast, lush growth happening in hydroponics will mean significant water consumption. However, all the water used will be transpired by the plant. None is wasted in the soil or by evaporation. The savings in water as compared to similar plants grown in soil is quite dramatic. Recent improvements in irrigation practices, from spraying a whole field to delivering water at the base of the plants, has significantly improved water consumption in horticulture. However, hydroponics is still many times more efficient in this regard.



## Conservation of nutrient

By the same token, all the nutrient used is absorbed by the plant. None is lost into the ground, thereby avoiding the danger of groundwater pollution, and microbial life in the soil is not impacted.

## Better health and faster growth reduces the need for pesticides

The word “pesticide” by itself is a misnomer. These substances should be called “biocides,” because they kill anything alive (but who would buy a biocide!) Many people mistakenly believe that pesticides kill only pests. In fact, they are not selective; they also kill beneficial organisms. Their use should be restricted to the rare exception. A plant in hydro, if well tended, will grow fast and healthy, allowing the plant to outgrow the pest, or be strong enough to resist it. This does not mean that you will never need pest control with hydro, but rather that the need will be reduced and you can cure problems with gentler solutions than killing everything alive at the perimeters of your plants. This, of course, is the most true for fast growing annuals. It is more debatable for perennials, even though the strong vigor exhibited by hydroponically grown plants also helps in that case.

## No need for herbicide

This is rather obvious. In the plastic trays or plastic channels used in hydroponics, there is no room for weeds to grow. The facts that herbicide is not needed and that pests can be killed gently makes hydroponics a very clean technology.

## A plant started in hydroponics is vigorous

If you keep a mother plant in hydro to then clone it and transplant the babies outside in soil, they will grow more vigorously than if they come from a mother in soil. I have performed this experiment myself many times, and the difference is always dramatic.

## Optimum utilization of plant genetic potentials

A classic image of a growing operation is a chain, which is only as strong as its weakest link. What this means in cultivation is that there will always be a limiting factor. It could be light, carbon dioxide (CO<sub>2</sub>), humidity, nutritional deficiency, or whatever. When growing hydroponically, you remove most of the weak links in the chain, especially everything related to element blockage in soil, which happens often for many reasons. The plant now has optimal conditions to express its full potential. Genetics might become the weak link, if you did not choose your variety wisely. Over the years, we have grown in our greenhouse huge plants never seen in nature; it is not that we do anything special; we just reinforce weak links. In your grow room, you can often put your plants in ideal situations in terms of nutrition, light level, temperature, and humidity. Your weak link will then be carbon dioxide.

## Increase both size and quality of crops

It is obvious that if you improve the overall health of the plant, you will also increase the output, the harvest. Hydroponically grown produce is noticeably larger than soil-grown. Suddenly, a cherry tomato does not look like a cherry anymore. Also, on the nutritional

front, analyses of hydroponically grown produce systematically demonstrate a large increase, often double, in the quantities of both vitamins and mineral salts content. This also holds true for active principles in medicinal plants.

## Access to the roots

It is very practical to check the health of your roots at all times. With hydro, plant roots are not buried in soil, which makes it much more convenient to check on root health. Frequent checking for possible pathogens allows early detection; early treatment increases effectiveness. Root inspection will also tell you a lot about your plant's health and how it will develop in the future. In most hydro systems, one has easy access to the roots. With experience, you can discard the cuttings that are alive and grow healthy roots, but don't have a nice implantation around the stem. I have grown so used to this that it is weird for me to grow a plant without looking at its roots.

Using a hydro setup is especially beneficial when cultivating a crop where the root is the main product. In most medicinal plants, the active principles are located (or are also) in the roots. In some cases, the ones in the roots differ from those in the aerial part of the plant. It is impossible to extract them without destroying the plant. As a result, many medicinals are over-harvested in nature, sometimes to the point of extinction. In some closed hydroponics systems, the roots are bare and soak in a flow of nutrient. In this situation, you can harvest a large quantity of the roots on an almost continuous basis without destroying the plants. Obviously, you have to cut some of the aerial parts at the same time to keep the plant in good balance. In some cases, this green biomass is by itself another source of extraction; other times, it is simply composted. Harvesting roots in this manner keeps them clean, not requiring a wash or any other process before extraction. They are also very rich in active principles, but concentration can be increased even further by adapting the plant nutrition to the type of molecule that one wishes to produce. Furthermore, we can increase the growth of the roots themselves by controlling the level of dissolved oxygen in the nutrient solution. In this field, as in all the others when it comes to cultivation, it is necessary to secure a market and organize the commercialization of the product before starting the cultivation. However, in this case, it is less critical than with fruits or vegetables, because the dry roots can be kept for a long time with no damage. This opens new horizons to the endangered greenhouse industry.

## Production of a large quantity of biomass

Hydroponics does this. The high level of nitrate in the nutrient solution allows the plant to explode its vegetative growth. This is an advantage when a large mass of green is needed. Hydroponic basins could be used to clean heavily polluted waters. The by-product would be a large green mass that can be converted into fuel. The technology exists, and numerous successful experiments have been conducted. In one remarkable instance that occurred in Portugal, a research institute managed to clean the effluents from a pig farm, and they are as bad as you can get. They turned them into a profitable crop. Why this method is not used more widely is a puzzle to me.

## Growing a crop in extreme conditions

The first serious research in modern hydroponics was made by NASA, the U.S. space agency, I believe as early as the late 1960s, early 1970s. It is impossible for man to live in space for a long time without having the means to produce fresh food. NASA even did

some experiments in growing at zero gravity, which was quite a challenge. Closer to us on Earth, most isolated research stations, in places like Antarctica, the Arctic, and many other inhospitable environments, use hydro to supplement their diet. A hydro system that stays in my memory is one that we made for a mission in Antarctica. The igloo-shaped cultivation room was also equipped with hammocks so the members of the team could come in turns to relax, get warm, and take in some light. Of course, there again the main benefit was to provide fresh staple foods, which are priceless for a long-term expedition.

The setting does not have to be so dramatic. Hydroponics also has its place on tourist islands, such as in the Caribbean. The land is poor, salty, and obviously cannot provide a large tourist population with fresh produce. Most is imported, yet it can be produced cheaper on the island with hydroponics technologies.

Some experiments have been done to incorporate hydroponics units in emergency shelters, the type used after an earthquake or a typhoon. In a little over a month, it should be possible for a family to rebuild a portion of its vegetable garden. This was experimented with a couple of times in South America. The Institute of Simplified Hydroponics, (<http://www.carbon.org/index.html>) dedicates itself to the development of “low-tech hydro” suited for the third world. They have projects in progress on different continents.

Let’s review now the advantages more specifically related to grow rooms:

### Better use of space

The root mat does not have to extend as much as it does in soil. The plants can get all the nutrition they need in a restricted space without competition between them, to speak of. As a result, plants can be grown much closer to each other than they can in soil. This allows practices such as the “sea of green,” in which the plant density is incredible; it can reach 60/70 plants per square yard. Without going to this extreme, we will see later in this book that under lights it is better to grow many small plants than a few big ones, and hydroponics is extremely suited for this technique.

### No soil to carry up and down

This, for me, is a big advantage. In fact, I first came to hydro just for this reason. In the 1980s, when I first decided that I wanted to have a grow room, I could not stand the idea of carrying all those heavy bags back and forth. It is not much of a concern when you live in a house, but when you are in an apartment carrying large quantities of bags full of soil is not very practical. It can even turn into a real pain. Hydro generates little refuse, and there is not much to be replaced between each crop. That makes it a perfect technology for small, confined spaces. I started out with water-culture technologies thanks to a certain laziness, and I’ve never stopped since then. I have never regretted this choice, and nothing would make me put my plants back into earth. I’d rather work on ways of incorporating the benefits of earth into water.

### Control of nutrition

I list this here again because it takes another meaning in this context. Unlike plants such as tomatoes or peppers, and many others growing and reproducing at the same time, there is a group of plants with a marked vegetative stage followed by a marked flowering and fruiting stage. For these plants, the two stages require utterly different nutrition.

This can be accomplished in soil, at the expense of a certain waste, by flushing repeatedly with water. In hydro, this is only “empty the tank, fill up the tank.” The leftover vegetative solution does not have to be discarded. It goes on your house or garden plants, not down the drain. I think this drastic change in the composition of the nutrient solution is one of the reasons why the flowering and fruiting go faster. The plants get a strong signal that it is time to flower, and at the same time they are provided with all the elements they need to do it. After all these years of growing hydroponically, I am still amazed how a minute change in the equilibrium of the nutrient solution results in a large difference in plant growth. It can be plant morphology, or taste and nutritional value of the crop. Apparently, the composition of salts in the nutrient solution is the main factor that will influence the final product.

### Accelerated growth of a mother plant

A plant grown hydroponically with a nutrition rich in nitrogen will grow lush green vegetation. For some people, it is even too much, but if you need to produce a large quantity of cuttings continuously, there is nothing like a mother plant in an efficient hydroponics system. This fact is widely used in the horticulture industry to propagate many species of plants in large quantities. Again, clones can be grown in hydroponics but also in soil, where they will have the famous cutting vigor, but with an extra edge.

This is too good to be true, you say, and yes, there are some disadvantages.

## Limitations

The first and most important disadvantage is that the plants are not protected from your mistakes. Soil has a buffering capacity, which provides a certain stability around the root mat. In healthy soil, all the physical and biological parameters are in balance. If you give your plants too much nutrient, a wrong mix, or something with the pH completely off, the microorganisms in the top soil as well as the soil chemistry itself will tend to reestablish equilibrium. This also happens in hydro, but only to a limited extent. The nutrient solution has some buffering capacity, especially in terms of pH, but nothing comparable with soil. Something as trivial as a pH meter off scale can have dire consequences, such as killing your entire crop in a day. Things happen fast in hydro. An image that I like to use is the comparison between driving a race car and driving your family car. At the wheel of a race car, you go much faster, but an accident is likely to have much worse consequences. Growing in hydro is the same. It goes so fast that you can literally see the plants grow, but you can also kill them in one hour.

Temperature is also a limitation; 64 °F to 71 °F in the root zone is the range at which plants grow best in hydro. They can tolerate much more. Up to about 79 °F, nothing happens, but then growth slows down. At around 95 °F, the roots, lacking dissolved oxygen, start dying fast, and so do the plants. There are means of fighting the heat, which we will see later; nonetheless, it is a severe limitation, especially in tropical countries and indoors, where artificial lights generate a lot of heat.

Another limitation is that you cannot grow every crop in hydroponics. All roots and tuber crops, such as carrots or potatoes (everything that is harvested from under the ground), require very special systems. The economics of a crop are also a limitation.

For instance, wheat would grow well in hydro, but this would not be economically feasible. The geographical location, as well as the local market, will determine which crops are feasible to grow and which are not.

There are other criticisms I often hear when I talk with people on the subject of hydro. The two main ones are that it is expensive to initiate and it is unnatural. I even have heard the expression “plants on a drip,” used in the medical sense.

It is true that hydroponics systems have a cost that can be steep, but with indoor cultivation you rapidly recover the money you spent. The reason is simple: electricity is expensive. When you grow plants under lights, you want to harvest your crop as fast as possible because the total usage of electricity, between the lights and climate control, is significant, even for the smallest growing operation. The faster you get your harvest, the lower your production costs. Hydroponics saves time, and a lot of it. In this case, time is really money.

As for hydro being unnatural, I find this also debatable. After all, what is natural? Is planting an entire field with a single plant “natural”? Nature is diversity. Think about it; by definition all forms of agricultures are “unnatural” practices, strange as that may sound. When humans were still at the hunter/gatherer stage, our impact on the planet was nearly nil. Like all other living organisms, we took our food from our environment, but we did not modify it very much most of the time. The problem started when we passed on to the agricultural stage and began planting crops in fields. This allowed man to change from a nomadic life to a sedentary one. Soon the villages became cities, and then the cities became states, fighting with each other for more land. This led to the civilization we have today. All of today’s problems can be traced back to the first man who planted a field. Hydroponics, with its plastic tubes and mineral salts, might seem weird at first sight, but in the end it is no more or less unnatural than agriculture itself.

Strangely, people don’t seem to mind using mineral salts to feed their houseplants in soil. They do it recklessly, with the risk of nutrients ending up in groundwater or the city sewer. Conversely, they seem to mind using those same mineral salts, in an even purer form, in the safety of a plastic gutter. They would resort to foliar feeding, which is not very common in nature you must admit, but they see roots bathing in a nutrient solution as unnatural.

There are many islands where the land cannot feed the large tourist population, tropical countries where the soil is full of hungry pests, and places where the land has been so abused that it has lost most of its fertility, leaving places with no arable land at all. Everywhere that organic cultivation cannot be the only option, hydroponics could be one of the solutions to feed a hungry world without destroying our environment. It is a type of agriculture that can provide man with nutritious and delicious produce as well as medicines in places where it would be impossible otherwise. Its level of “unnaturalness” is irrelevant.

That said, let’s enter the subject in more detail. A first step will be to review the different systems encompassed by the word “hydroponics,” and get oriented to the ones available in the shops today. We will also examine which of the hydroponics technologies are best suited for the different stages of growth in a grow room.



# Chapter 1

## The Different Hydroponics Systems

**W**hen you build a hydroponics system, the single most important thing to keep in mind is: keep it simple. Many failures derive from losing sight of this fundamental principle. In the end, all hydroponics systems are made more or less of the same parts: a tank, a pump, some kind of support system, feed lines, return lines, and a growing container, be it a channel or tray. Nonetheless, there are many variations in the way you can design and organize the different parts. This results in different classes and subclasses of systems that do not have the same purpose, but have different efficiencies. Reviewing all the systems is a bit tedious, even boring, because it is much the same in different versions, but this knowledge will be practical and invaluable in choosing a system to purchase. When you go to a store, you will know if the salesperson in front of you is knowledgeable. Indoor garden shops open and close at such a rate that not all of the salespersons know thoroughly the equipment they are selling. What might seem to you to be a small difference in design might make a big difference in terms of results and ease of maintenance of the system you eventually choose.

Although systems can be classified in different ways: air pump, water pump, and substrate or no substrate, rather than trying to classify them, I chose arbitrarily to present them by order of historical appearance, *i.e.* in the same order they were developed.

### *Passive Systems*

First let's get rid of something called "passive hydroponics," or wick systems, often referred to as "hydro cultivation." The term "passive" means that the system does not have a pump, instead relying on a capillary wick effect to bring the nutrient solution from the storage tank to the root zone. These techniques, but with soil in the pot, have been used in nurseries or flower shops for many years. They are often used with houseplants, chiefly because foliar plants are the only ones these systems can keep alive for some time. Green ornamentals have a very slow growth rate, if any. When these systems are used with potting soil, the wick or the capillary mat keeps the soil moist, providing efficient automatic watering with a reservoir large enough for 2 to 3 weeks—great!