

William Texier's book in translation

*Hydroponics for Everybody,  
All about Home Horticulture*

(American English Edition, Mama Publishing, 2015)

*L'Hydroponie pour tous,  
Tout sur l'horticulture à la maison*

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*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

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*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

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from proofreading to editing my strange English,  
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Noucetta. And of course, I can't 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.

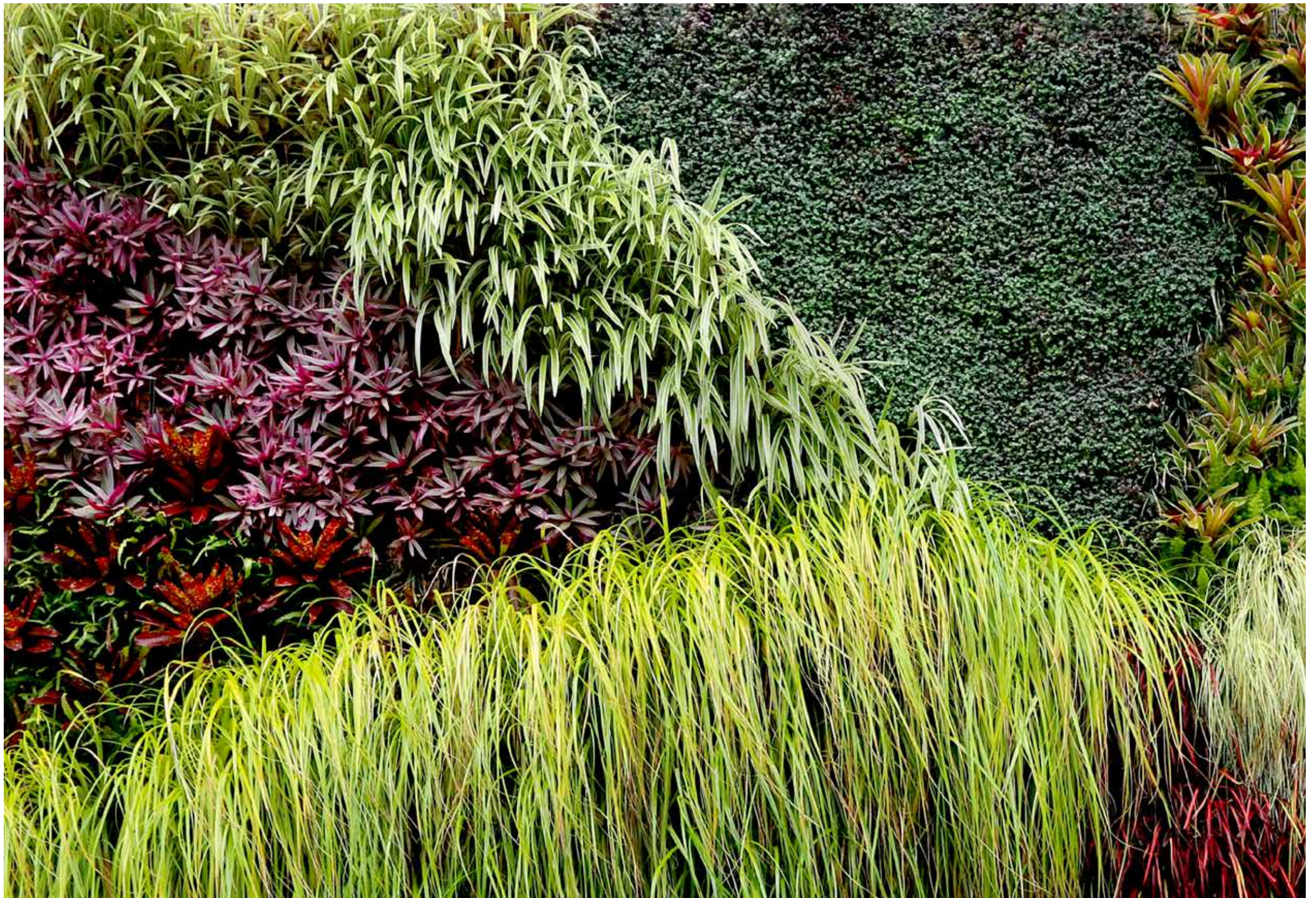
I also would like to dedicate this book to all of you  
growers and plant lovers.

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# 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 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 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: a nutrient solution must be kept oxygenated, at a tolerable temperature and provide the plants with the nutrients they need. Oxygenation is really at the heart of it. To make a good hydroponic system, the water has to be saturated with oxygen at all times. Once you know that, you could almost throw away the book, because you've learned the most important factor. This 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, doesn't 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 hydroponic products in the form of tasteless tomatoes and odourless 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 used to grow these products generate ungodly mountains of waste, old plastic mulching, used slabs of rock-wool and many other unwanted materials, none of them biodegradable.

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1. I often use 'hydro' as a 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's 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 rockwool slab; a nutrient solution is circulated several times a day, according to ambient temperature, subsequently releasing 25 to 30 per cent 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's still largely in use today because it's 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 waste water from the drain and disposing of it safely. Waste water 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 ground water.

These are the systems most likely to be encountered at your local suppliers. Because these systems 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 wasting 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 don't give their plants proper nutrition. They simply can't 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 of the same size and colour, and so hundreds of people can handle them in the shop without blemish. None of this has to do with taste or nutritional value. And yet, if you take a good variety, say your favourite tomato plant from your garden, and place it in a hydroponic 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 is sometimes 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 physical support. At most, the substrate might have a cation exchange capacity (like coco fibre 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's 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 the 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.

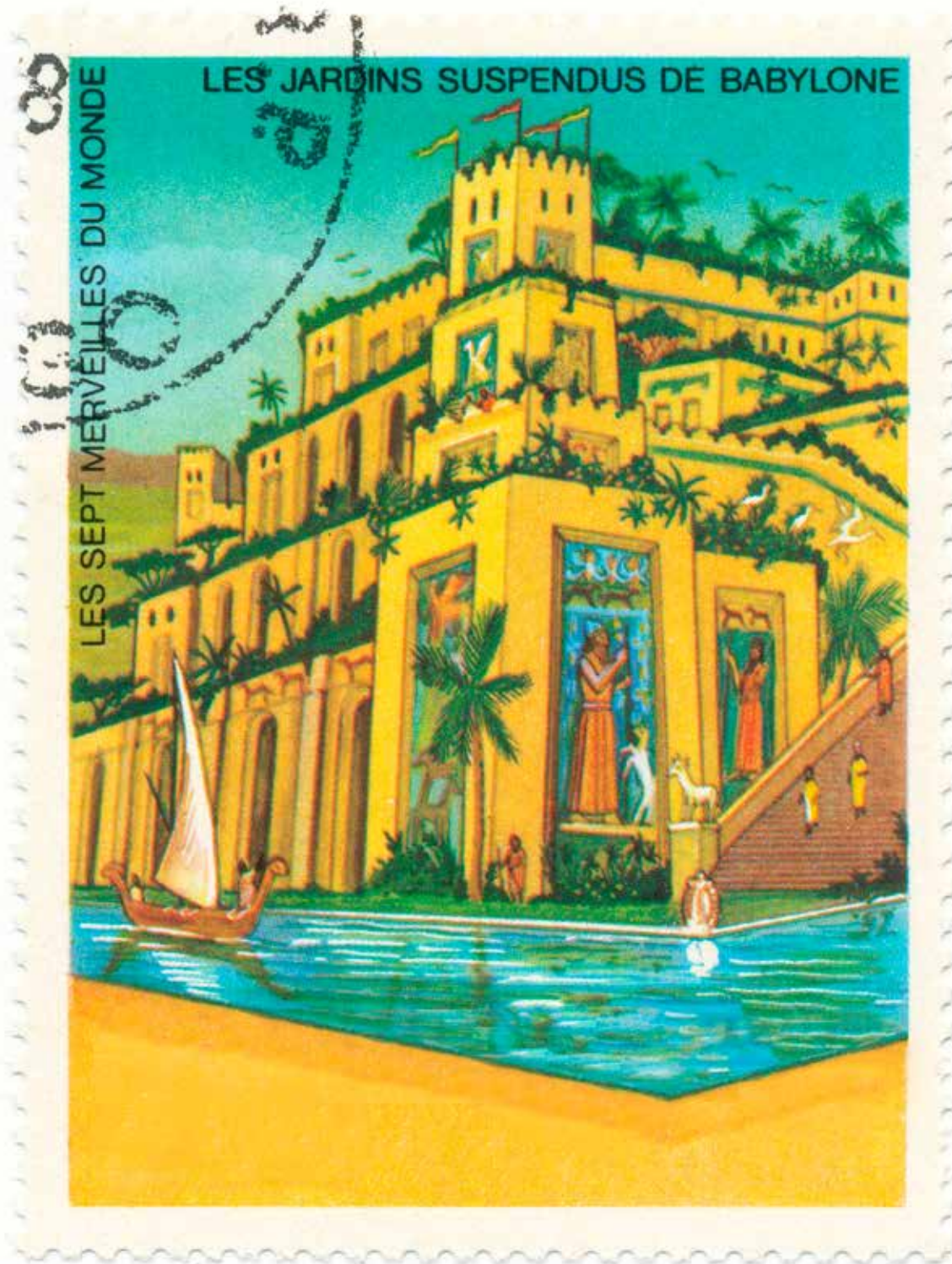
**-600 BC:** The famous hanging gardens of Babylon are often cited as being the first recorded use of hydroponics. **1** Sadly, the ancient fabled plantings don't strictly meet our definition of hydro: although the plants were grown in channels with a constant stream of water bathing their roots, the 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. They would place the rich mud from volcanic soil on these frames. 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 into 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 can't be certain where and when floating gardens were first used, they were the first true hydroponics technology.

**1699:** John Woodward, an English naturalist with an interest in botany, and a Fellow of the Royal Society, conducted the first experiment that demonstrated that plants get their nutrition from soil and by means of water. We don't know what other cultures knew about the subject at that time, but in the western world there was very little knowledge about how plants grew. In what was the first hydroponics experiment, Woodward showed that plants grew better in river water than they did in pure distilled water; in other words, plants extract something from the water to help them grow. By growing plants in water to which he had added varying amounts of soil, he demonstrated that the greater the amount of soil the better the growth, and therefore plants also benefit from nutrients in the soil.

After that, knowledge of plant physiology was gained slowly. It took a further 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 nineteenth 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 could be dissolved in water and used to grow plants. Together with Knop, an agricultural chemist, they laid the foundation for water-based culture. I couldn't find Von Sachs' exact formula, but in view of the limited range of mineral salts that they had to hand, it must have been rather primitive, and I doubt that they could sustain growth for very long with it. From then on, however, thanks to water culture, by trial and 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 are not.



1

**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 changing 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 calibre to grow a crop successfully. This led to many failures, as many people engaged wholeheartedly in commercial ventures that did not fulfil their promises. On the upside, 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 as recent as 2008.

At the same time as 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 basis is still there and it's still in use as the reference standard for routine experiments in many plant research laboratories. To be honest, I sometimes wonder why they still bother to use this formula, which is now quite outdated. It's also still used by commercial growers who don't 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 Hoagland's formula because it's 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 US 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 those 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 set-up was the basis 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 some time. The cost of starting an operation contributed to this lack of interest, but also the technology had not been perfected. One difficulty was that gravel or sand, the most popular substrates of the time, were 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 grow short cycle crops such as salad greens commercially.

**1970–1990:** During this period, different hydroponic 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 hydroponic systems with the goal of reducing them to the size of an urban grow room. He fuelled them 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.

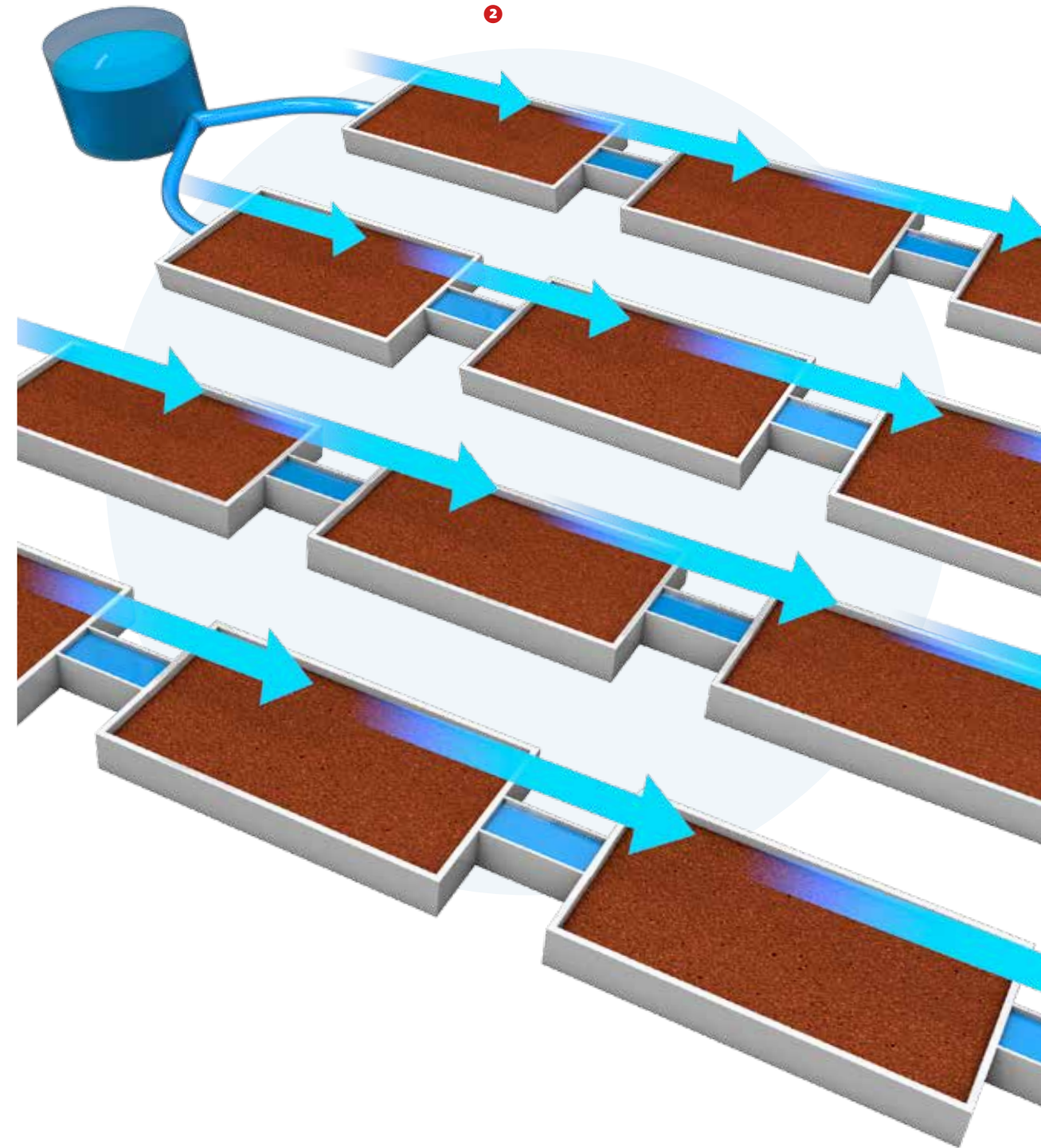
**1986:** Dr Hillel Soffer, working with the University of California at Davis, developed the vortex, which remains the most efficient hydroponic system on the market. His research first established a direct correlation between plant growth and dissolved oxygen level in the nutrient solution. By adjusting 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 US 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 businesses and home growers. Many of the latter 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–today:** On the commercial hydroponics front, the industry is growing rather rapidly, but also moving and adapting to changing 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 first adopted indoor hydroponics, then France, Spain, Italy, Portugal followed, all motivated by the pleasure and pride of consuming something one has produced oneself. Now it's the turn of eastern countries to build an indoor growing industry.





The introduction of hydroponics technologies for non-commercial public sector and 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 the 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 colours. 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 hydroponic 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 millions of reasons to use hydroponic 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's of the utmost importance – is that you can completely control the nutrition of your plant. Only the elements that you put in the water will be present in the root zone, 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 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 basis of the plants, have 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, therefore avoiding the danger of ground water pollution, and microbial life in the soil is not impacted.

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

The word 'pesticide' 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 healthily, allowing the plant to outgrow the pest, or be strong enough to resist it. This doesn't mean that you will never need pest controls with hydro, but rather that the need will be reduced and you can cure problems with gentler solutions rather than killing everything living at the perimeter of your plants. This, of course, is most true for fast-growing annuals. It's more debatable for perennials, even though the strong vigour 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 fact 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 clone it and then transplant the babies outside in soil, they will grow more vigorously than if they had 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 that 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 can happen often for many reasons. The plant now has optimal conditions to express its full potential. Genetics might become the weak link, if you don't choose your variety wisely. Over the years we have grown huge plants in our greenhouse never seen in nature: it's 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's 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 doesn't look like a cherry any more. 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

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 haven't managed to implant themselves around the stem. I have grown so used to this that it's strange for me to grow a plant without looking at its roots.

Using a hydro set-up is especially beneficial when cultivating a crop where the root is the main product. In most medicinal plants, the active principles are located in the roots. In some cases, the ones in the roots differ from those in the aerial part of the plant. It's 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 hydroponic 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; at 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's necessary to secure a market, and organize the commercialization of the product before starting the cultivation. However, in this case, it's 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 for the greenhouse industry, which is an endangered one.

## 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 could be converted into fuel. The technology exists and numerous successful experiments have been conducted. In one remarkable instance in Portugal, a research institute managed to clean the effluent from a pig farm, and it was as bad as you can get. They turned it 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 US space agency, I believe as early as the late 1960s, early 1970s. It would be 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 members of the team could come in turns to relax, get warm and take in some light. But of course the main benefit was to provide fresh staple foods, which are essential for a long-term expedition.

The setting doesn't 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 can't provide a large tourist population with fresh produce. Most is imported, yet it can be produced more cheaply on the island with hydroponic technologies.

Some experiments have been made to incorporate hydroponic 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 developing countries. They have projects in progress on different continents.

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

### Better use of space

The root mat doesn't 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, so to speak. 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 metre. Without going to that extreme, we will see later in this book that it is better to grow many small plants under lights than a few big ones, and hydroponics is extremely well suited for this technique.

### No soil to carry up and down

This, for me, is a big advantage. In fact, I came to hydro for this reason. In the 1980s, when I first decided that I wanted to have a grow room, I couldn't stand the idea of carrying all those heavy bags back and forth. It's 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. 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. I've 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 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 doesn't 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's 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 in salts of 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 almost too much, but if you need to produce a large quantity of cuttings continuously, there is nothing like a mother plant in an efficient hydroponic system. This 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 vigour, 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, that 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 micro-organisms in the top soil as well as the soil chemistry itself will tend to re-establish 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 racing car and driving your family car. At the wheel of a racing 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: 18° C to 22° C in the root zone is the range at which plants grow best in hydro. They can tolerate much more. Up to about 26° C nothing happens, but then growth slows down, and at around 35° C their roots, lacking dissolved oxygen, start dying fast, and so do the plants. There are means of fighting the heat that I will discuss later; nonetheless, it's a severe limitation, especially in tropical countries and indoors, where artificial lights generate a lot of heat.

Another limitation is that you can't grow every crop in hydroponics. All root and tuber crops, such as carrots or potatoes (that is everything 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 geo-



graphical 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 to people on the subject of hydro. The two main ones are that it's expensive to initiate and it's unnatural. I've even heard the expression 'plants on a drip' used in its medical sense.

It's true that hydroponic systems can be expensive, but with indoor cultivation you rapidly recover the money 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 really is money.

As for hydro being unnatural, I also find this debatable. After all, what is natural? Is planting an entire field with a single plant 'natural'? Nature is diverse. Think about it: by definition, all forms of agriculture 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 would take our food from our environment, but we didn't modify it very much at that 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, then city-states, fighting with each other for more land, and that led to the civilization we know today. All our 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 house plants in soil. They do it recklessly, with the risk of nutrients ending up in ground water or the city sewers. Conversely, they seem to mind using those same mineral salts in an even purer form in the safety of a plastic gutter. They resort to foliar feeding — 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 can't feed the large tourist population, tropical countries where the soil is full of hungry pests, places where the earth has been so abused that it has lost most of its fertility, leaving areas with no arable land at all. In all these situations, hydroponics could be one of the solutions to feed a hungry world without destroying our environment. It's a type of agriculture that can provide people with nutritious and delicious produce as well as medicines in places where it would be otherwise impossible. Its level of 'unnaturalness' is irrelevant.

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



# Chapter 1

## The different hydroponic systems

**W**hen you build a hydroponic system, the single most important thing to bear in mind is: keep it simple. Many failures derive from losing sight of this fundamental principle. In the end, all hydroponic 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 don't 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 useful in choosing a system to buy. When you go to a shop, you'll know if the sales person helping you is knowledgeable. Indoor garden shops open and close at such a rate that not all of them are completely familiar with the equipment they are selling. What might seem to you 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, substrate, no substrate – rather than trying to classify them, I have chosen to present them in chronological order, 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 doesn't 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 house plants, chiefly because foliar plants are the only ones these systems can keep alive for some time: green ornamentals with 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!