SAMPLE

Introduction to Hydroponics & Plant Growth

Lesson Aim

Describe the nature and scope of hydroponic growing in a hobby situation.

INTRODUCTION

The word, hydroponics, is derived from two Greek words:

- **Hydro** - means water
- **Ponos** - means to work or labour

Today the word has been broadened to mean 'All ways of growing plants without the use of soil'. The 4th International Congress of Soilless Culture defined the different systems of hydroponics as follows:

- **Water Culture:** The roots of plants are submerged in a nutrient solution (e.g. Nutrient Film Technique or NFT).
- **Sand Culture:** The roots of plants are placed in a solid aggregate composed of particles with a diameter of less than 3mm (e.g. sand, perlite, plastics, and other in-organic materials).
- **Gravel Culture:** The roots of plants are grown in a solid aggregate composed of particles greater than 3 mm diameter (e.g. gravel, basalt, scoria, pumice, plastic, and other inorganic materials).
- **Vermiculaponics:** The rots of plants are grown in vermiculite or a mixture containing vermiculite.
- **Rockwool Culture:** The roots of plants are grown in Rockwool, Glasswool, or some similar material.
- **Hydroculture:** This can refer to all forms of hydroponics but is more commonly used to refer to growing ornamental or decorative plants inside.

What Is Involved?

Soil does four main things for the plants which grow in it. It provides:

1. **Support** - stops the plant falling over or blowing away by providing anchorage for the plant's roots.
2. **Water** - via the plant's roots.
3. **Air** - through the roots (yes, the plant absorbs gas out of the air through its roots! A plant's roots can starve for air just as much as they can starve for water!).
4. **Nutrients** - food in the form of very simple types of chemicals.

To be successful, hydroponics needs to adequately cater for these FOUR FUNCTIONS, which are usually handled by the soil.

If the roots are not grown in a hydroponic media which will enable adequate support for the plant, then a trellis or some other artificial means must be provided to support the plant.

It is essential to maintain a balance between the moisture and air content of the root environment. With some plants the air which is dissolved in water might be adequate but for the majority of plants, total immersion in water will result in air starvation and death. In anything other than water culture (aggregate culture), the ability of the medium to hold moisture and the relationship between this characteristic and their air-holding ability is critical.

A medium which drains very easily usually holds water well but might dry out very easily. This type of medium may need watering very frequently. A medium which holds water very well could become waterlogged and the plants could suffer from a lack of air if they are watered too often.

As you can see there is a relationship between how often you apply water AND the drainage and water holding characteristics of the medium. Nutrients are fed to the plants in the form of a nutrient solution (i.e. chemical fertilisers are dissolved in water). There are many different nutrients which must be included in the solution and all are essential to the plant's growth. The relative amount of each of the nutrients is also important. Although there are some similarities between the amounts of different nutrients which different plants require, to get the best out of plants, different balances of nutrients are needed for different plants at different stages of their growth.

Sounds Complex? It Is!

If you want the best out of hydroponics you have to know a lot about nutrients, and unless you are a chemist that does not come quickly. Do not be put off though. You can still grow plants in hydroponics without getting that involved. It is possible to buy standard nutrient mixtures from hydroponic suppliers. These may not be ideal, but they are adequate for most situations.

Depending on the type of system you are operating (and perhaps other factors) you might apply water only in the form of a nutrient solution, or perhaps both as nutrient solution and straight water (e.g. apply nutrient solution once a week then simply water once or twice a week).

A Simple System

There are many and varied ways of doing hydroponics - some are very complicated, controlled by electronic devices, and very costly to set up. Here is a system at the other end of the scale which is very cheap and very simple:

Materials required:

- 1 ice cream container (plastic bin) or a plastic bucket
- 1 terracotta (clay) pot (not glazed)
- Coarse granitic sand/aquarium sand
- Vermiculite or peat moss (you need enough sand and vermiculite/peat to fill the clay pot)
- Lettuce seedlings (2)
- 1 small packet of soluble complete plant food
- Gypsum
- Epsom salts

Procedure:

1. Mix 60% sand with 40% vermiculite or peat.
2. Fill the clay pot to within 3cm or so of its lip.
3. Wash soil off the roots of the lettuces (as much as you can without harming the roots).
4. Plant the lettuces in the pot.
5. Obtain a general inorganic fertiliser (powdered indoor plant foods which are mixed with water are typically best. General NPK fertilisers containing potash, superphosphate, and sulphate of ammonia are also suitable). Mix 6 parts of this general fertiliser to 5 parts gypsum and 1 part Epsom salts.
6. Mix one spoonful of the mixed fertiliser powder with 2 gallons (i.e. 9 litres or one bucket) of water.
7. Measure roughly the depth of the medium (i.e. sand and vermiculite) in the pot.
8. Place the pot with the lettuces in the bucket or ice cream container and pour the nutrient into the container until it reaches a level about one third of the depth of the medium as calculated in step 7.

9. Top up the nutrient solution as often as is necessary to keep the level always between ¼ and ⅓ of the depth of the medium.

Note: The nutrient is soaked up into the medium from below. This is called capillary action.

HISTORY

There have been attempts for thousands of years to culture plants through artificial techniques which have similarities to modern hydroponics. These early attempts were not strictly hydroponics but certainly had many of the characteristics of hydroponics. The Aztec Indians in South America cultivated crops on rafts. They would cover a raft with soil from a lake bed then float the raft on the lake and plant crops on it. The plant's roots would grow through the raft into the water below.

The hanging gardens of Babylon are regarded as one of the earliest attempts at cultivating plants in an artificial situation.

In 1699, John Woodward published "Some Thoughts and Experiments Concerning Vegetation" which was an account of the growth of plants in various types of water. Woodward found that he got improved growth when small amounts of garden soil were added to the water. In 1722, Priestly found that plants were able to increase the amount of oxygen in the air when he grew them in an atmosphere which was rich in carbon dioxide.

By the middle of the 1880's, Jean Boussingault was studying the growth of plants in sand, quartz, and charcoal, and he added solutions of known chemicals. Around the same time, a German scientist called Liebig demonstrated the value of the nutrient solution whilst studying the nutrition requirements of plants.

Nevertheless, it was Julius von Sachs and his pupils in the 1860's who were the ones who really laid the foundations for modern hydroponics by preparing solutions from mineral salts and thus freeing plants of the necessity of soil. Over the last half of the 19th century, the preparation and use of nutrient solutions by scientists in laboratory situations became a standard practice.

The first commercial hydroponic unit was set up in 1939 by Gericke in the USA. He grew tomatoes in water culture but encountered problems of poor aeration and iron deficiency. In 1936 and 1937 research was undertaken at universities in the USA, which led to the development of practical systems to overcome the problems previously encountered by Gericke and others.

1939-45	The American forces on Wake Island in the Pacific grew vegetables successfully by hydroponics.
1944	The US Army decided to used hydroponics to supply food for servicemen stationed on remote bases. Over the next few decades many hydroponic farms were established by the US military.
1950s	Commercial hydroponic farms were established mainly in the southern United States at first but later throughout many parts of the world.
1970's	Over this period there was a sharp increase in world interest in hydroponics for the production of vegetables, cut flowers, and strawberries. The Nutrient Film Technique and Rockwool culture developed over this period.
1980's	Hydroponics is a well-established part of the cut flower and vegetable growing industries in the UK and the Netherlands. Its significance has rapidly increased in more than a dozen other countries.
21st C	Hydroponics is firmly established throughout the developed world.

Hydroponics in Recent Years

Interest in hydroponics developed throughout the world during the 1960's and 1970's. Many vegetable growers attempted to convert their operations to hydroponics, inspired by tales of increased production. Unfortunately, many of these people failed to do their homework and embarked upon schemes without having a real understanding of the differences between soil and hydroponic culture. The result was many failures and the development of an attitude that hydroponics does not really work.

In Australia in 1981, CSR Ltd established a factory to produce horticultural grade Rockwool for hydroponic production. CSR did their homework, promoted their product well and supported it with excellent technical information. As a result, Growool ® became widely accepted and today is used extensively in the Australian cut flower industry. Nevertheless, Australian vegetable growers have continued to be slow in adopting hydroponics, perhaps due to bad experiences from the 1970's.

At the beginning of the 1990's commercial crops of vegetables, berry fruit and cut flowers were grown extensively in hydroponic culture in many countries. The most popular technique worldwide would be Rockwool culture, though NFT (Nutrient Film Technique), perlite and gravel bed culture are all very significant in commercial hydroponics.

The table below is derived from a paper written in 1989 by Rick Doonan. It provides an indication of the most popular hydroponic techniques used in different countries at this time as well as how much land was being dedicated to hydroponic use.

Table: Estimate of Hydroponic Systems and Areas Worldwide

Country	Hectares	Major System	Other Systems
Australia	60	Rockwool	Scoria, NFT
Canada	100	Sawdust	Rockwool, Foam, NFT
Holland	2880	Rockwool	Foam
Israel	240	Scoria	Rockwool, Sand
Japan	292	Water Culture	NFT, Rockwool
New Zealand	15	Sawdust	NFT
South Africa	75	Bark	Sawdust
UK	570	Rockwool	NFT, Perlite
USA	200	Bag Culture	Rockwool, NFT, Sand

Note: This is not a comprehensive listing.

HYDROPONICS - IS IT AS GOOD AS ORGANIC GROWING?

There is no real difference as far as a plant is concerned in the nutrients it receives from hydroponics compared with normal soil gardening or organic gardening.

1. The plant takes in and uses exactly the same molecules from the air in all three systems
2. The plant needs exactly the same temperature, light and moisture conditions with all three methods
3. The plant absorbs exactly the same plant nutrients into its roots from all three methods of growing.

The only differences are really in the way the nutrients are supplied to the plant as follows:

Organic Gardening

Nutrients are supplied as complex chemical molecules (in the main), which are from the tissues of decomposing animals or plants (or their by-products). These complex molecules are broken down in the area of the roots to form much simpler compounds which are then able to be taken in by the roots of the plant.

Soil Gardening

The soil contains both simple and complex compounds. Fertilisers applied are both simple and complex compounds. The simple compounds are absorbed direct. The complex compounds are broken down and then absorbed.

Hydroponics

Nutrients are applied as the same simple chemicals which occur in soil, or which organic compounds in soil break down to form. They are in a ready to use state as soon as applied.

NUTRICULTURE SYSTEMS

Growing plants without soil has intrigued and challenged gardeners, hobbyists, and commercial growers for many years. The terms - hydroponics, water culture, sand culture, gravel culture, aquaculture, solution culture, mist culture, drip irrigation, soilless culture and vermiculaculture are often used to describe a particular system of applying plant nutrients to the roots of the plant and each, in its own way, is a method of substituting some other medium for soil.

There is nothing magical, mystical, or foolproof about any of the systems. If there was such a thing as a perfect soil and sufficient pure water for irrigation, many of the possible advantages of these systems would be lost. Nutrient systems cannot replace proper temperature for plant growth, cannot overcome introduced plant diseases or insect problems, cannot make up for lack of sunlight, and nor can they prevent damage from smog-type gases. All systems deal with the placement of nutrients in intimate contact with the plant roots and thus the term 'nutriculture' has also been used in by Purdue University in its bulletins to describe most systems. The term 'hydroponics', on the other hand, has popular appeal and is generally used by the industry to describe the flowing systems and for identifying the products for advertising purposes. The term was coined to describe the one system where the roots are suspended in the nutrient solution without any solid anchorage.

In the past the many systems based on nutriculture have suffered from exaggerated claims, premature promotion, and inexperienced growers. However, there are many places in the world where these systems may be the only way that the apartment dweller or the homeowner with limited land area can have a garden.

Why Practice Nutriculture?

After more than 50 years of grower interest, nutriculture is more than a hobby. A number of commercial operations are adapting to some of the systems. The following points outline the general advantages and disadvantages of nutriculture systems:

Advantages

1. Crops can be grown where no suitable soil exists or where the soil is contaminated with disease.
2. Labour for tilling the soil, cultivation, fumigation, watering, and other traditional practices can be reduced and sometimes eliminated.
3. Maximum yields are possible, making the system economically feasible in high density and expensive land areas.
4. Conservation of water and nutrients is a feature of all systems. This can lead to a reduction in pollution of land and streams because valuable chemicals need not be lost.
5. Soil borne plant diseases are more easily eradicated in many nutriculture systems. This is particularly true in a 'closed system' which can be totally flooded with an eradicator.
6. More complete control of the environment is generally a feature of the system i.e. root environment, timely nutrient feeding or irrigation, and in greenhouse-type operations - the light, temperature, humidity and composition of the air can be manipulated.
7. Water carrying highly soluble salts may be used with extra care. If the soluble salts in the water supply are over 500 ppm (parts per million), an open system of nutriculture may be used and care given to frequent leaching of the growing medium to reduce the salt accumulations.
8. The amateur horticulturist can adapt a nutriculture system to home environments, even in high rise buildings. A nutriculture system can be clean, lightweight, and mechanised.

Disadvantages

1. The original construction cost per acre is great.
2. Trained plants men must direct the growing operation. Knowledge of how plants grow and the principles of nutrition are important.
3. Introduced soil borne diseases and nematodes may be quickly spread to all beds on the same nutrient tank of a closed system.
4. Most available plant varieties have been developed for growth in soil and in the open. Development of varieties which are specifically adapted to more controlled conditions is something which takes time.
5. The plants in hydroponics react more quickly to changes in growing conditions. This means that the hydroponic gardener needs to more closely watch his plants for changes.

HOW PLANTS GROW

Plants are made up of microscopic cells. The cells are able to take in nutrients, water, and gases, and absorb energy from the sun which is stored in chemicals within the cell.

Plants do not swallow food like animals. Plants take in food by it soaking (or filtering) through the walls of the cells, and moving in the same way from cell to cell throughout the plant. Air moves into the plant a little differently, through pores (called stomata) which open up on the under surface of the leaves. Dirty or polluted air can clog up these stomata and cause the plant to become starved for air. Once inside a plant air can diffuse or soak into the cells eventually going into solution. Plants take carbon out of the carbon dioxide in the air (40% of the dry weight of a plant is carbon which comes this way). Some oxygen is used, but most of it is lost back to the outside air, by reversing this whole process.

When rain falls on plants it washes the stomata clean. Obviously, this does not occur on indoor or greenhouse plants, which is why they can often benefit from a washing down. Up to 90% of the normal weight of a plant is water. From this you can see the need for a good water supply.

Water is normally taken in through the roots from where it moves up through the plant. Some of it is used and some is lost through the leaves to the air.

SIMILARITIES BETEEN SOIL AND HYDROPONIC GROWING

Hydroponics gives you more control over the way a plant grows, particularly with respect to nutrition. If this control is used you will obviously achieve more than you would be able to in soil, but if the control is not exercised (like a car without a driver) you may have been better to stay with the more natural way of doing things.

Chemistry

Atoms are the fundamental building blocks of our world. There are 103 different kinds of atoms known to man, of which some 92 occur naturally. The very large number of different substances found both in and on our planet are all aggregates of atoms arranged in an almost endless variety of ways.

The Atomic Nature of Matter

The atomic theory of matter proposes that all matter is composed of aggregates of very large numbers of small particles called atoms. These are extremely small and are indivisible by ordinary chemical means.

The Structure of Atoms

The atom may be pictured as consisting of a very small, positively charged nucleus, surrounded by a number of negatively charged electrons. The charge on the nucleus of an atom is characteristic for each element and is always a multiple of a fundamental unit of charge, i.e. 1.60206 x 10 to the power of minus 19 coulombs. For example, the charge on the sodium nucleus is +17.62266 x 10 to the power of minus 19 coulombs, which is just 11 times the fundamental unit of charge. Since the atom is electrically neutral the collective charge of the surrounding electrons is -17.6226 x 10 to the power of minus 19 coulombs, which is again just 11 times the fundamental unit of charge, but opposite in sign to the nuclear charge.

The radius of an atom may be determined experimentally and is found to be of the order of 10 to the power of minus 13 cm. Clearly the electrons occupy most of the volume of the atom.

BIOCHEMISTRY

Biochemistry is the chemistry of organisms. An organism is anything that is alive, or if not, was once alive (a dead organism). What, then, is the condition we call life? We cannot offer a rigid, precise definition, but we do know that living things are characterised by metabolism, growth, and reproduction. Metabolism is the process by which a body introduces into itself (ingests) various energy-rich materials from its environment (food), and transforms these materials, with the release of energy, into other substances, some of which are retained by the body (for growth or repair) and some eliminated. Reproduction is the process by which one body produces another that is like itself in properties, structure, composition, and function, including metabolism and reproduction.

The distinction between an organism and a material is not always clear. A virus consists of particles several hundred angstrom units in length or diameter. These particles can reproduce themselves in a suitable environment but they do not ingest food, or grow, or carry on any other metabolic processes. Are viruses, then, living organisms or are they chemical materials that consist of large molecules capable of replicating themselves under suitable conditions? To include viruses among the living the definition of life must be modified. Most broadly, we may consider anything living if it can bring order out of disorder at the expense of energy and has the capability to preserve accidental variations (called mutations) that may occur in the process.

In an organism, the structure called the cell may be considered to be a biochemical reactor. An organism consists of one or more cells, and the various groups of cells in a multi-cellular organism may be sharply differentiated as to biochemical function. The reactions in the cell are said to occur in vivo (Latin: 'in the living organism'). The corresponding reactions outside of the cell are said to occur in vitro (Latin: 'in glass').

The living cell is not merely a tiny membranous beaker with homogeneous contents. It is, rather, an entity of great complexity, not yet completely understood as to structure and function. There are specific sites within the cell at which specific reacting systems, metabolic or reproductive, operate. The biochemist seeks to identify these sites, and to illuminate the course and mechanism of the reactions that occur there. Sometimes he tries to remove a chemically reacting system from its cellular environment and duplicate it in vitro. He does this because reactions are usually easier to study under the more controllable conditions of laboratory reactors than they are in vivo.

Biochemical Processes in the Cell

Several anatomical features are so small that they can be revealed only with the aid of an electron microscope. Some of these fine structures of the cell are nonessential inclusions, like blobs of fat, or particles of starch. Others, called organelles, perform essential functions and are reproduced when the cell divides. Some of these functions are well known; others still elude us.

The mitochondria are organelles shaped like elongated slippers. Their cross-sectional diameters are about 1 micron. The highly differentiated structure of a mictochondrion contains some 40 enzymes which control a complex series of redox reactions, including the conversion of diverse organic substances into ATP. The energy reservoir that is thus stored up is available for biochemical work such as muscle contraction, for electrical work like the action of nerve impulses, and for the activation of other biochemical reactions. Because of these functions, the mitochondria have been called, by an analogy that not all mechanical engineers would accept, the "furnace of the cell".

Chloroplasts are organelles that occur in plant cells and that contain the green pigment chlorophyll. Chlorophyll is the catalyst for the endothermic process of photosynthesis, in which glucose is synthesized from carbon dioxide.

The nucleus is a well-defined structure which contains the genetic material of the cell; the nucleus thus is the site of the reproductive function. Each time a cell divides, it reconstitutes itself. This ability of self-duplication is retained by new cells and is transmitted repeatedly through successive generations of cells. The reliability of this transmittal accounts for the continuity of species.

PLANTS AND WATER

The application of water is the operation that accounts for the most loss in crop quality. Whilst it may appear to be a simple operation, watering at the wrong time or with the wrong volume of water causes irreparable damage to the quality of the crop.

Under Watering

This is when water is not applied frequently enough. Plants wilt and growth is slowed. This results in smaller leaves, shorter stems, and a hardened appearance to the plants.

Over Watering

This is when water is applied too frequently in small applications. Whilst the new foliage becomes large, it also becomes soft and plants grow taller. Over watering also affects the soil by reducing the oxygen content resulting in damage to the plant roots.

Note: The rule is to water thoroughly, so that water reaches the bottom of the planting media and can drain away.

Watering should be commenced prior to the plant displaying symptoms of moisture stress. It takes an experienced grower to be able to determine the most appropriate time to water. However, advances in technology now mean that watering can be computer automated by placing sensors into the root zone which activate the watering system as required.

Appropriate watering systems are designed to suit the crop. Watering is rarely from overhead sprinklers. Most are from a central pipe with smaller tubes coming off to individual plants.

Plants need both water and oxygen in their root environment. The trick to successful plant growing is often to provide the proper delicate balance between these two things. Too much air usually means too little water, and too much water usually means too little air. In aggregate culture, you should usually mix a well-draining medium (e.g. gravel) with a water retaining medium (e.g. vermiculite) to gain the required balance of water retention.

- In many fruits water constitutes 90% of the total weight
- In many leaves water constitutes 80% of the total weight
- In many seeds water constitutes 10% of the total weight.

Aside from its role in the composition of plants, water is also important for the movement of nutrients into the plant and the movement of waste products out. Everything in a plant moves in a dissolved form. If water is not constantly replaced a plant's cells lose turgidity and the plant wilts.

WATER EXCESS

Symptoms:

- Development of leggy seedlings: this usually happens when plants are close together and the soil is warm and moist. This often happens in glasshouses.
- Appearance of growth cracks (cracking of tomato fruit, cabbage heads, or carrots).
- Increase in cell size.
- Long internodes (longer gaps between buds on stems).
- Bursting cells (if you look under the microscope).
- This is usually caused by poor drainage or over watering.

- Water excess can lead to stunting, dieback of the top of the plant and in extreme situations death.
- There is a greater likelihood of infection of moulds, rots and other fungal diseases in a wet situation.

WATER DEFICIENCY

Symptoms:

- The first symptom is that the growth rate reduces.
- Leaves become smaller (though still well coloured).
- Stems later become slender, flowers and fruit are smaller.
- In some watery fruits (e.g. tomatoes, lemons, peaches etc) the plant sometimes draws water from half grown fruit causing the fruit to shrivel.
- Die back from the leading shoots can occur followed by death in extreme cases.

A lack of water can be due to under watering, a poor root system, excess drainage, or sometimes extreme heat (i.e. water is sometimes evaporated out of the leaves faster than it can be absorbed through the roots in hot or windy conditions).

CULTURE AND MANAGEMENT OF SOME GREENHOUSE CROPS

Conditions in a greenhouse or glasshouse can be different to growing plants out in the open. Whilst a greenhouse has some very positive effects on plants (e.g. protects from frost, wind and cold, etc.) it can, unless monitored, also have some negative effects on plants. Humidity (amount of water vapour in the air) is usually higher, imbalances can occur in the proportions of gasses making up the air and the temperature can sometimes go too high in a glasshouse unless proper controls are instituted. All of these three things can influence the performance of different plants in different ways.

Pollination

For fruit to be produced by most plants, pollen (a dust-like material which is equivalent to male sperm) must move from where it is formed on a flower to settle on the stigma (another flower part) and hence fertilise the female part of the flower. If this process does not happen properly, or on the right scale, the flower is not fertilised and usually the fruit will abort (drop off before developing). In a glasshouse, the high humidity can cause the pollen to stick and not move as easily. The fact that a glasshouse is shut off from the outside can restrict the movement of insects which might normally transfer pollen from flower to flower. It can become necessary with some plants for the grower to move the pollen about by hand.

Tomatoes grown in glasshouses are usually pollinated by hand every one or two days after flowering begins. The best time to do this is on bright sunny days between 10am and 3pm. If there is cloudy weather for more than 2 days, raise the temperature to 24 to 26 degrees C for 1 hour before you pollinate. Immediately afterwards, lower the temperature to 18 to 21 degrees C. Ventilation will also help pollination of tomatoes. If there is no significant problem with humidity, tomatoes may pollinate without assistance.

Low temperatures seem to affect tomato pollination of flowers a couple of weeks after the period of low temperature. Whilst flowers already open might pollinate, those flowers which open about 2 weeks after temperatures fall below 14 degrees C may pollinate poorly in a glasshouse. Day temperatures over 32 degrees C and night temps over 18 degrees C also improve pollination.

Fruit Cracking

This problem is more severe late spring and early autumn than at other times. Cracking becomes worse as fruit ripens. Shading the greenhouse (with tomatoes) in very warm weather or harvesting before full ripening will help reduce cracking problems. Excessive moisture (over watering) can also be a cause of cracking in a wide range of fruit and vegetables.

Ventilation

Use of vents and fans to control both temperature and the balance of gasses in the glasshouse environment is a very important aspect of the management of any greenhouse. In very large houses, the use of forced air fans becomes more necessary. Air passed through fans can be heated or cooled for additional temperature control. By connecting fans to an electronic thermostat it is possible to have them switch on and off automatically as and when ventilation is needed for temperature control. Plants inside a glasshouse should be kept clear of vents or fan outlets (temperature variations can be more extreme in these positions).

MORE OF THE BASICS

Studies into plant nutrition have shown that nutrient solutions must contain nitrogen, phosphorus, potassium, magnesium, calcium and perhaps sulphur to obtain reasonable plant growth. These nutrients are added in the form of chemical salts or compounds. In addition to these, the plant also needs oxygen, hydrogen, and carbon (but these are provided from air and water). More meticulous research has shown that a large number of other nutrients are also needed, but in very small quantities. These were not identified in the early research because they usually already existed in the water which was used for the nutrient solution (they would come from dust out of the air and other such contaminants). These so called 'trace elements' include such things as iron, copper, boron, manganese, zinc, cobalt and molybdenum. They are just as important as the more major nutrients but they are only needed in very small amounts.

PHOTOSYNTHESIS

Photosynthesis is the biochemical process used by plants to capture energy from the sun and store it in chemical substances within the tissue of the plant. At a later stage, when the plant needs that energy, it is able through a process of chemical reactions to release that energy to be used.

The process can basically be described be the following equation:

In the presence of light energy

Carbon Dioxide + Water ----------------------------------> Sugar + Oxygen

Inside a green plant cell

OPTIONAL READING

Commercial Hydroponics - by Mason, Chapters 1, 10 and p89

Hydroponics - by Dudley Harris, Chapter 1

Hydroponics: The Bengal System - by S. Douglas, Chapter 1 & 2

Hydroponics - by Dudley Harris, Chapters 2 & 3

Simple Hydroponics - by Sundstrom, Chapter 1

Plant Science - by Hartmann, Chapters 2, 6 & 7

Note: This optional reading is NOT necessary to the course. It is simply a reading guide for the enthusiastic student who wishes to go further.

SET TASK

Activity 1

Contact at least four 'Hydroponics Contacts'. These could be companies, other schools or colleges, commercial farms, or individuals (at least one must be a supplier of nutrients or equipment). By obtaining literature, asking questions, and if you are able to, inspecting some hydroponic systems - gather whatever information you can about hydroponics. These contacts can be made by emailing, writing, telephoning, or visiting.

Activity 2

Establish a simple system as described earlier in this lesson. You can use lettuce, another vegetable, or a flowering plant such as a carnation or gerbera.

Activity 3

Make up a list of hydroponic terminology and write definitions in your own words for each term. If you find a term which you cannot define, ask your tutor to define it when you submit your assignment. Terms which might be included would be "nutrient solution", "aggregate", "water culture", "system", etc.