Plant Propagation

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Propagating new plants is both a science and an art. The study of it can provide a lifetime of challenges and opportunities to learn more about this fascinating craft, or a basic knowledge of it can provide the home gardener with the skills and techniques to keep their garden well stocked with new plants. Plant propagation is the multiplication of plants by both sexual and asexual means. From the home gardener starting a few tomato plants from seed on the kitchen windowsill, to the conservationist growing endangered species of orchids in test tubes, to the nurseries that grow the millions of annuals, perennials, bulbs, shrubs and trees sold ever year, a working knowledge of plant propagation makes all of these endeavors possible.

Propagation Methods

There are probably as many methods of propagating plants as there are reasons for wanting to do so, but there are basically two types of propagation -- **sexual** and **asexual**. Nearly all plants in nature have the ability to reproduce sexually, that is, by **seed**. Along with producing seed they have developed many modifications that aid in the dispersal of that seed. Such modifications include:

- Seeds being enclosed in colorful fruits that are attractive to animals that eat the fruits and deposit the seeds elsewhere.
- Seeds with wing-like or tufted appendages that enable the seed to be carried by the wind.
- Seeds that are hooked or barbed that are easily attached to the coats of animals or out clothing and carried away.
- Seeds that can float thousands of miles away to wash up on a tropical island (such as a coconut).

Many types of plants in nature have also evolved means by which they can reproduce asexually. Some such means include strawberry runners, potato tubers, and Johnsongrass rhizomes.

Along with all the natural modifications, people have developed many ways to propagate plants more efficiently and ways that meet the needs of both the agricultural communities and the horticultural trade. Seeds can be treated in various ways to achieve better and more uniform germination rates. Cuttings of various plants can be rooted in greenhouses when the parent plants are under three feet of snow. The highly specialized techniques involved in micropropagation allow growers to produce thousands of genetically identical plants, tissues (thus the term tissue culture), or cells. Learning about these procedures and many others makes plant propagaton a tremendous way to expand one's knowledge of plants and gardening, and can lead to an interesting and rewarding profession.

Sexual Plant Propagation

Sexual propagation of flowering plants, as opposed to ferns and mosses, begins with flowering, followed by pollination, fertilization and seed production. Seeds are used in large-scale agriculture and forestry operations for growing wheat, corn, alfalfa and tree seedlings for reforestation projects. Propagation by seeds is also critical to many aspects of horticulture including the establishment of many turfgrasses, bedding plants, and a wide range of trees and shrubs, although propagation of many of these types of plants is not restricted to sexual propagation. Sexual propagation has several advantages when compared with asexual methods.

- It is generally the cheapest method.
- It generally requires the fewest skills, specialized equipment or facilities, and is thus the easiest method.
- Seed can be easily stored, often for several years, and still successfully germinated.
- Seeds are cheaply and easily shipped or transported around the world.
- If properly cleaned and stored, seeds are less likely to carry diseases.

Seedlings are likely to be genetically different from the parent plant – this may be desirable for research, breeding, plant selection and conservation work, but may be undesirable in regards to other interests.

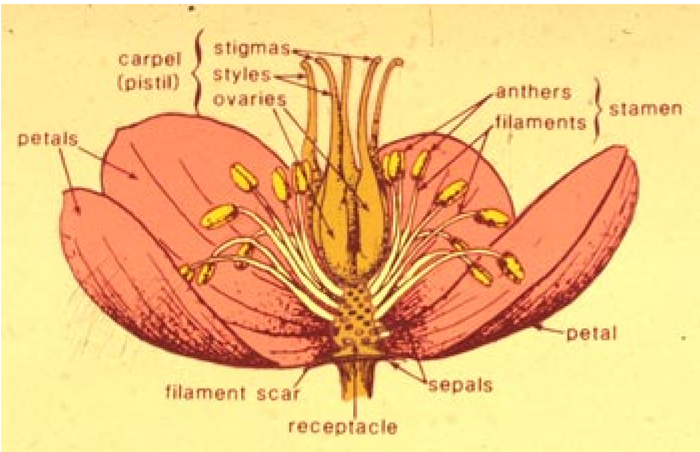
Some disadvantages of using this method include:

- Some plants don't produce live, (viable), seeds, and thus can not be grown this way.
- Seeds may take a long time to grow into mature plants.
- Seedlings are likely to be genetically different from parent plant, and may not have the same desirable characteristics.

The genetically difference is often especially true for many cultivars and hybrids.

Development of Seeds

For centuries people have grown plants for the beauty of the flowers – the spectrum of colors, the multitude of shapes, the intoxicating fragrances and the meaning we have associated with various flowers in relation to holidays and traditions. However, the basic function of flowers is to be pollinated so seeds can develop, grow and perpetuate the species. It is obvious just by casual observation that all flowers are not created equal, but flower types can be grouped in terms of their structure and how it relates to pollination and seed production.



Perfect flowers are individual flowers that have both male and female parts. The male part of a flower is known as the **stamen** and is made up of the **anther** and the **filament**. The female part of the flower is known as the **pistil** and is composed of the **stigma**, **style** and **ovary**. Perfect flowers may have one or many stamens and pistils in each flower. **Imperfect flowers** lack one or more of the parts that make up the stamen or pistil.

Some flowers contain only male or only female parts. When a plant develops separate male flowers, (**staminate flowers**), and separate female flowers, (**pistillate flowers**), and both occur on the same plant, the plant is referred to as **monoecious**. Examples of monoecious plants include corn, walnuts and many conifers. With corn, the tassels at the top of the plant are the male flowers, and the silks and young ear represent the female flowers.

Dioecious plants have separate pistillate and staminate flowers, but they are **always on separate plants**, thus you will have plants with **only female flowers** and others with **only male flowers**. Dioecious plants include hollies, date palm, asparagus and Ginkgo biloba. Male plants will never produce seeds or fruit. Females will only set fruit if a compatible male plant is nearby, neither male nor female plants will die if they are not close to each other however.

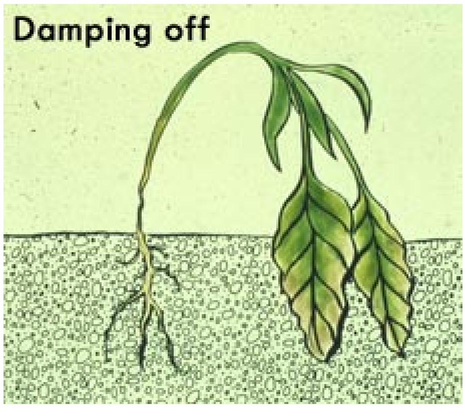
Pollination involves the transfer of pollen grains from the anther to the stigma. A variety of bees, butterflies, moths and birds are responsible for pollinating a wide range of plants. Flowers often attract pollinators by various characteristics such as color and color patterns, shape, fragrance, offer of food, or, in the case of many orchids, resembling a potential mate for the would-be pollinator. Other plants rely on wind to carry the pollen grains. Conifers and grasses, including many of our grain crops, are wind pollinated.

Once the pollen grain lands on a receptive stigma a **pollen tube** begins to grow downward through the style to the ovary where fertilization occurs. Often there are many ovules (eggs) within the ovary. The ovary will develop into the fruit and each **ovule** will develop into a seed.

Growing Plants from Seed

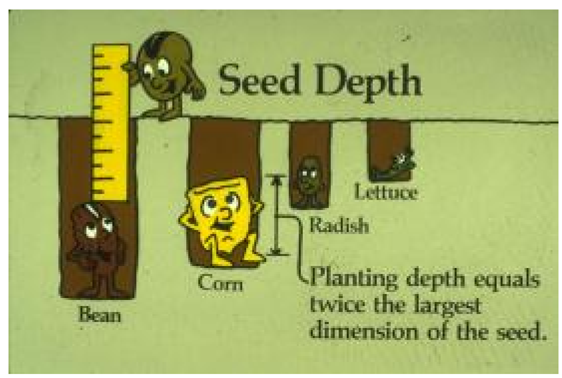
The success achieved when growing plants from seed is dependent on several factors including the seed itself, the medium and the conditions to which the seed and seedlings are subjected. The seed used should be of high quality and, usually, the newer the seed, the better the germination and subsequent seedling growth will be.

The **medium** refers to the soil into or onto which the seeds are sown. Whatever seed sowing mix is used, it should be free of weed seeds, harmful insects and pathogens that may prevent germination or kill the young seedlings.



A disease known as **damping-off** is one of the most troublesome problems encountered if soil and sowing containers are contaminated. The mix should also be free-draining and should not remain soggy after watering. There are several ingredients that can be used to create a suitable medium. Common components include peat moss, vermiculite (a mineral), perlite (a material of volcanic origin – often mistakenly identified as Styrofoam in soil mixes), sand, fine milled bark, compost and milled sphagnum moss. Fortunately there are several very good, bagged mixes available in garden centers, but as you experiment with growing various types of plants from seed you may prefer to mix your own special blend.

The most common bagged mixes contain peat moss and vermiculite, and often a small amount of fertilizer to get the seedlings off to a strong start. Whatever seed mix is used, it need not be particularly rich in nutrients. It is much more important to have a mix with proper physical qualities. Once the seedlings are growing, attention can then be shifted to proper feeding with a dilute, water soluble fertilizer if necessary.



Seeds can be sown into almost any type of container, but of course, clay or plastic pots or flats are logical choices. The pots or flats should be sterilized before use (a dilute solution of bleach and water works well), and there must be drainage holes to allow excess water to drain away. When sowing the seed, the surface of the media should be even, firm (but not compacted), and slightly moistened. The depth of planting will vary with the type of plant being grown. A general rule is to **plant seed at a depth of one to four times the thickness of the seed**. There are, however, some seeds that require light for germination and should be left uncovered, and just to keep you on your toes, there are others for which light can inhibit germination! This is one reason why it is wise to do a little background check on the seed you are about to sow, or at the very least, read the seed packet that often has much useful information. Once sown, it is essential that the medium remains moist but not overly wet. Maintain the correct moisture level by placing seed pots in a plastic bag or a propagating case (creating an enclosed environment for high humidity), but keep a close eye on the temperature within. The widest range of the most commonly grown annual and biennial flowers, and vegetable plants germinate best between 65-75°F.

Depending on the seeds, germination will often occur within one to three weeks, but there are others that will take longer. Once the seedlings emerge, it is important that they receive good light, otherwise seedlings will be spindly, weak and quite difficult to transplant. It is often a good idea to lower the temperature by 5-10°F which will slow growth, but will help to keep the plants stocky.

Seeds of many plants, especially woody plants and perennials, have physical or chemical inhibitors within the seed that prevent the seed from germinating even if the proper medium, temperature and moisture levels are present. The good propagator has several techniques that will effectively overcome these natural barriers to germination. One such method is called **stratification**. This involves giving the seeds a moist, cool treatment. Frequently seeds are mixed with moist peat moss, vermiculite or sand, put in a plastic bag and placed in the refrigerator, (35-40°F), for a certain length of time - 90 days is a common duration.

The process of soaking up water is known as **imbibition**, and is the first step in germination. Certain seeds have hard, impervious seed coats that prevent water from being absorbed thus delaying germination. **Scarification** is a method often used to overcome this problem. Scarification involves wearing away at the seed coat to allow water in to the embryo. This can be done mechanically with a file, piece of sandpaper, or by carefully nicking the seed coat with a knife. Some propagators dealing with large numbers of seed will use various acids to eat away at the seed coat, but this is a very refined technique in which great attention must be paid to the concentration of acid, and to the duration for which the seeds are soaked.

There are many other techniques and "tricks" that propagators employ to get certain seeds to germinate. Many plants that have adapted to habitats prone to fire have developed seeds that rely on fire as a precondition to germinating. Other seeds germinate only when a certain microorganism is present in the soil, or when a particular plant is already growing. With many South African plants, exposing the seed to smoke is beneficial or necessary to germination. As much as we know about seeds and how to grow them, there is still much that we do not fully understand. Until we have all the "recipes" for germinating seeds down to an exact science, a good basic knowledge of the techniques along with personal experience will go a long way in bringing success to your seed sowing efforts.

Ferns from Spores

Ferns are one of the first groups of plants to be trendy. They were all the rage in Victorian times, but have since quietly gone out of favor. That is, up until recently when there has been renewed interest in this diverse group of plants, largely from native plant enthusiasts. Ferns belong to a group of plants known as Pteridophytes which also includes mosses and others. In terms of plant classification, they are amongst the most primitive members of the plant kingdom. As a group, the pteridophytes are often referred to as the lower plants with flowering plants being known as higher plants. Ferns do not flower and thus do not produce seeds, but rather produce spores. Because of this, ferns have a distinctly different life cycle. Ferns typically produce a great abundance of spores that makes it possible to grow thousands of plants from a single, mature fern plant if the conditions are suitable.

To propagate ferns from spores, the spores must be ripe (just as with seed). The medium onto which spores should be sown can be the same as that used for seed sowing, although it is critical that it be sterile. Spores are dust-like, therefore sow them very sparsely, as it is very easy to sow too many! The pot containing the spores should go in a plastic bag and then be placed in a warm, bright spot, but not in direct sun. The humidity within the bag should remain high. The speed at which fern spores germinate varies greatly depending on the species. Check the bag frequently to make sure the pot doesn't dry out. The first signs of life will be a green film developing on the surface of the medium. When this appears, mist the surface often. Gradually, young fern plants will begin to develop. When the young plants are large enough to handle easily, they can be transplanted to individual pots.

Many ferns can also be propagated using various asexual methods including division, bulblets, plantlets and micropropagation.

Asexual Plant Propagations

Asexual propagation is the production of plants using the vegetative parts of a plant. Vegetative parts include stems, leaves, roots, bulbs, corms, tubers, tuberous roots, rhizomes, and undifferentiated tissue often used in micropropagation. Propagation by division, cuttings, layering and grafting are all forms of asexual propagation. Although many plants can be propagated by at least one asexual method, there are some that for one reason or another can not. When compared to sexual methods, asexual methods have certain advantages.

- Plants are genetically identical to the parents so plants with desirable characteristics can be reliably cloned.
- It allows propagation of plants that do not produce seed, produce little seed, or are difficult or impossible to grow from seed.
- A grower can get a saleable or mature plant more quickly for many plants.

Some disadvantages include:

- Asexual methods are generally more expensive.
- Many asexual methods require greater skill, and/or special equipment or facilities.
- There is an increased likelihood of spreading or perpetuating certain diseases.
- Clones can become weakened and lose vigor after years of asexual production, although this is by no means a general rule.

Division

Dividing plants is probably the simplest form of asexual propagation. This method is regularly used in the propagation of a wide range of herbaceous perennials such as daylilies, Siberian iris, bee balm and ornamental grasses. It essentially involves splitting a single large plant with many crowns or growing points into several individual smaller plants. It is labor intensive, and for that reason is a last option for commercial nurseries when there is no other viable method of propagating a particular plant.

Cuttings

Cuttings can be taken from a variety of plant parts – stems, leaves, roots, buds – but not all plants can be propagated by cuttings and certainly few, if any, can be grown from all types mentioned. The plant from which the cuttings are taken is referred to as the stock plant or parent plant. There are many factors that effect the type of cutting used as well as the success achieved with a certain type of cutting, and include:

- The type of plant being considered for propagation,
- The age and health of the stock plant,
- The time of year, and
- The facilities, equipment and material available for propagation.

When taking any type of cutting, keep in mind that by removing the cutting from the parent plant, it is cut off from its supply of moisture and is instantly under stress. This is a particularly important consideration when dealing with leafy cuttings such as herbaceous, softwood and semihardwood cuttings. To reduce stress on the cuttings, take cuttings on cool, cloudy days; place cuttings in a plastic bag along with a damp paper towel until they can be inserted in the rooting medium; and prepare cuttings quickly. Also, make sure that cuttings are labeled with the plant name, the date taken and any special treatment given the cuttings, such as a particular hormone used. This can help you learn more about a plant and may be useful if you want to take cuttings again next year.

The **rooting medium** used can vary greatly from grower to grower, and may vary depending on the type of plant being propagated. The medium must provide support for the cutting to keep it upright. It must also hold an adequate amount of moisture and allow for oxygen to reach the root zone. Although rooting media are similar to seed sowing mixes, they are generally coarser. A mix of half peat moss and half perlite is commonly used, but many mixes exist to meet the needs of different plants, or simply produce good results for the nursery or gardener using them.

Water is the most critical aspect in the rooting process – too much and the cuttings are deprived of oxygen and the likelihood of disease is greatly increased, too little and the cuttings suffer, wilt and will root slowly, if at all. Professional growers and nurseries use mist or fog systems to maintain ideal moisture and humidity levels. These systems are controlled by a humidistat, timer, or a unit called an electronic leaf.

Light is also an important factor, at least for stem cuttings with leaves and leaf cuttings. Light is necessary for these types so the plant can continue to photosynthesize and produce carbohydrates needed for the development of roots. Too much sunlight, however is to be avoided as this can cause the cuttings to dry out too quickly. The **temperature** can also have an effect on root formation. Good success can be achieved with an air temperature of around 65°F for a wide range of cuttings. Often, roots will form even more quickly if bottom heat maintains the rooting media about 10°F warmer.

Auxins are one class of **plant hormones** that occur naturally in plants. **Rooting hormones** used by propagators are synthetic versions of these compounds. Used correctly, these types of hormones can hasten rooting, lead to denser root systems and help avoid certain disease problems. They are available as liquids or powders and vary in their concentrations of active ingredient. The bases of stem cuttings are dipped into the material and then inserted in the medium. Two common rooting hormones are **napthaleneacetic acid**, (NAA), and **indolebutyric acid**, (IBA). Care should be taken when using hormones as certain cuttings can be damaged by the incorrect strength. These materials break down quite quickly in light so they should be stored in an appropriate manner.

Types of Cuttings

Stem cuttings are certainly the most important type of cuttings in regards to commercial plant production. They can be divided into four groups based on the nature and maturity of the piece of stem used – hardwood, semi-hardwood, softwood and herbaceous. With the exception of hardwood cuttings which are often longer, cuttings of approximately three to five inches are ideal, although cuttings taken from certain dwarf plants will necessarily be shorter.

When taking cuttings work with a clean, sharp, knife or hand pruners. Cuts should generally be made just below a node, (the point at which a leaf joins the stem, and the point at which roots form most readily), and the leaves on the lower one-third to one-half of the stem should be removed prior to insertion into the media. The basic cutting is referred to as a **simple** or **straight cutting**. **Heal cuttings** are made by breaking a small, young shoot from the side of a branch. This will keep a small portion of the stem attached to the cutting. **Mallet cuttings** are similar but have a complete cross section of the main stem. Some evergreens root better when heal or mallet cuttings are used.

Wounding the base of cuttings of certain plants such as rhododendrons, hollies, magnolias and others can promote root production. Wounds are generally made by stripping lower leaves and some bark from the cutting or by cutting off a thin slice of bark from the lower third of the cutting.

Leaf cuttings and **leaf bud cuttings** are useful for propagating plants such as African violets, snakeplant, piggy-back plant and some begonias. A section of leaf, the entire leaf or the leaf and associated bud are inserted into a typical cutting media. In all cases, the cutting does not became a permanent part of the plant, but gradually disintegrates after the new, young plant is established.

A fairly wide range of plants can be propagated by **root cuttings**. Oriental poppies, certain species of phlox and roses, blackberries, raspberries, Japanese flowering quince among others are all likely candidates for this method. The biggest drawback to this technique is that it involves digging the parent plant out of the ground, or at the very least, severing much of the root system to get at the necessary root pieces. Root pieces can be from 1-6 inches long depending on how coarse the roots are – the finer the roots the shorter the segments. If root cuttings are inserted into media vertically it is essential that they avoid being put in upside down, thus maintaining correct **polarity**. In other words, the end of the root closest to the crown of the plant should be up and the farthest point should be down. Root cuttings of some plants can be laid horizontally, side stepping this problem altogether.

Bulbs are specialized organs with a growing point surrounded by thick fleshy scales. Tulips, onions, lilies and daffodils are all bulbous plants. Techniques for propagating bulbous plants include scaling, basal cutting, offsets and micropropagation.

Layering is yet another form of asexual propagation and is a method that encourages the development of roots on a stem while it is still attached to the parent plant. Tip layering involves bending a branch to the ground, wounding the branch where it touches the ground and covering it with some soil. Roots develop and soon send out new shoots. At this point the new plant can be cut off from the stock plant, lifted from the ground and transplanted. Black and purple raspberries, forsythia, spirea and many other common shrubs can be grown from tip layers.

Air layering is a similar technique but is a bit more involved and is used when a branch can not be bent to the ground. This technique can be used to propagate several tropical and sub-tropical trees and shrubs such as croton, rubber trees, and philodendron. The stem is wounded and the wound is covered with a generous amount of longfibered sphagnum moss. The moss is then wrapped in a sheet of plastic that is tied off above and below the wound. The new plant can be cut off and planted once roots are visible through the plastic.

Underground Structures

Many plants produce specialized structures beneath the soil that are generally used as food storage organs on which the plant relies during adverse growing conditions. Bulbs, corms, tuberous roots, tuberous stems, tubers, rhizomes and pseudobulbs are all such organs. Frequently, though technically incorrect, all or several of these structures are referred to as "bulbs." To the propagator they are often convenient means of producing plants that have developed these sorts of structures.

A **corm** is made up of the swollen base of a stem surrounded by dry, scaly leaves. Crocus and gladiolus grow from corms. Corms are propagated by inducing the natural reproduction of new corms and by the cultivation of cormels, which are also naturally produced during the plants life cycle.

A **rhizome** is a specialized stem structure that grows at or just below ground level such as in bearded Iris, lily of the valley, sugar cane and many grasses. Typically they are easily propagated by simple division or by a special type of cutting.

A **tuber** is a swollen stem structure that serves as an underground storage organ with nodes, often called eyes, from which shoots emerge. The potato, Jerusalem artichoke and caladiums are all tuber-producing plans. Tubers are easily propagated by dividing them into sections, with each section containing at least one eye.

Pseudobulbs, (meaning, "false bulb"), are typical storage structure of members of the orchid family. Pseudobulbs are readily separated from the parent plant as a means of propagation.

Grafting and Budding

Grafting and budding are both forms of asexual plant propagation. They both consist of connecting two pieces of living plant tissue in a way that allows the parts to unite and subsequently grow and develop as a single plant.

In any form of grafting, a piece of stem or shoot with dormant buds is the part that will grow and develop with branches. This part is known as the **scion**. In budding, the scion is reduced to a single bud with an attached pad of bark and cambium. The part of the graft that will develop into the root system is known as the **stock**, **rootstock** or **understock**. The stock can be comprised of a root system, a sapling or, for the purposes of topworking, a mature tree that has been reduced to a trunk and main scaffold branches. Fruits and nuts, as well as roses, lilacs, dwarf conifers and many ornamentals with unique habits are examples of plants that are frequently grafted.

There are several different types of grafts – splice, whip, cleft, approach, wedge, and others are all variations that have different applications for different situations and reasons for wanting to graft in the first place.

The reasons for grafting are quite varied and, among others, include:

- To perpetuate clones that can not be propagated, or are not easily done so by other methods.
- To obtain the benefits of certain root stocks, such as to control height, habit or vigor, or to impart disease resistance.
- To change the cultivar of established plants through a technique known as topworking.
- To obtain special growth habits or forms.
- To repair damaged parts of trees.

There are, however, certain disadvantages:

- It is frequently more expensive.
- Grafting and budding are fairly specialized skills, thus require great experience to be able to make grafts.
- Diseases are readily transmitted.
- Rootstock suckers can be troublesome and can weaken the growth of the scion.

Not just any scion and stock can be grafted successfully. The two parts must be from closely related plants. Plants from different families are incompatible and this is frequently true for plants in different genera within the same family. A scion and stock that can be successfully grafted are said to be **compatible**. A pairing that is incompatible will simply not grow, or will grow but never form a successful graft union leading to failure sometimes years from the time when the graft was first made. The time of year can also play a role in the success or failure of a graft. One technique that is sometimes employed to overcome the problem of incompatibility is to use an interstock. An interstock is a piece of stem inserted between the scion and stock that forms graft unions with both. An interstock is also useful, in some cases, for imparting hardiness or a growth regulating property.

When it comes to the actual act of grafting, the most critical point is that the cambium layers in the scion and stock be in close contact. The cambium is a layer of cells between the bark and the heartwood. This layer of cells is capable of dividing and forming new cells, forming callus in the process, that are necessary in order for the graft to be successful. It is important that the cambium layers do not dry out during the grafting process. The graft union is where the scion and stock are joined.

Micropropagation

Micropropagation, or tissue **culture** as it is also called, is the most cutting-edge means of propagating plants. It involves propagating plants from small plant parts, tissues or cells in specialized conditions in which the growing environment and nutrition are strictly controlled.

The basic principles of tissue culture have been known for about 100 years and such theories were suggested as long ago as the early 1800's. By 1939 scientists in the United States and France had made significant discoveries. Within another ten years, researchers had laid a solid foundation for today's large-scale tissue culture laboratories, propagation facilities, and further advances through ongoing research. It was not until recent decades that micropropagation became a feasible means of producing plants for the nursery industry. Today, many plants are propagated in this way. In catalogs, the names of plants that have been propagated by tissue culture methods are often followed by "TC" in parentheses. With every passing year more and more advances are made, and an increasingly wide range of plants find their way into the many tissue culture facilities which are appearing at an equally rapid pace.

Tissue culture makes use of an in vitro system. In vitro is from the Latin for "in glass," that is in reference to the fact that plant tissues are developed in test tubes and flasks under laboratory conditions. The multiplication of plants in vitro does not create a new process within the plant, it simply directs and enhances the plants natural potential to put forth new growth and multiply in a highly efficient and predictable way.

There are several advantages to micropropagation when compared with traditional asexual methods of propagation.

- Plants can be mass-produced rapidly.
- A new plant can generally be introduced to the nursery industry more quickly.
- Tissue cultured plants are free of insect and disease pests when removed from test tubes.
- The growth of in vitro cultures requires little care on a day to day basis, apart from casual surveillance.

There are also several disadvantages.

- More expensive. The start-up costs for a commercial micropropagation facility are high.
- The techniques used require greater skill and training.
- Not all plants can be produced through tissue culture.
- Mutations may occur during the culturing process resulting in plants different from the parent. This can be disastrous if not noticed at an early stage.

The success of tissue culture for reproducing new plants is based on the ability of small plant parts, tissues or cells to undergo rapid cell multiplication under the proper chemical and physical conditions, and then to differentiate into the various parts that make up an entire plant. The plant part, tissue or cell type that is removed from a stock plant for purposes of being cultured is known as the explant. The explant can be a shoot tip, root tip, leaf tissue, pollen grain, seedling tissue, bulb scales and others.

There exist a number of factors that will effect the success of generating new plants by micropropagation. Sterility is of the utmost importance at all stages. Lab conditions are essential and much of the great expense is attributable to the need for such facilities. All surfaces with which the explant may come in contact, including countertops, tools and human hands, need to be sterile. The growth medium and glassware in which the new plants will be cultured must also be sterile. Apart from sterility, the explant itself and the culture conditions (light, medium, temperature) all play significant roles in the success.

The type of explant taken from a parent plant will also effect the generation of new cell growth and the subsequent new plants. Certain explant types work better for certain plants.

The medium used in tissue culture is unlike that used in any other type of plant propagation. A semi-solid, gelatinous material called agar is used. This provides support for the culture, but by itself is essentially inert. What is mixed in with the agar is what stimulates new growth. These ingredients will vary depending on the plant being cultured, as will the concentrations used. Ingredients include inorganic salts of many essential plant nutrients and organic compounds like carbohydrates, vitamins, various hormones and growth regulators.

The four sequential stages in all tissue culture systems are:

1. Establishment
2. Multiplication
3. Pre-transplant
4. Transplant

The purpose of the **establishment stage** is to establish a sterile explant in culture. The initial explants from the first stage have developed a mass of shoots that are separated into individual propagules and transferred to a fresh medium culture. This second medium is frequently the same or similar to that used in Stage 1, but the concentrations of certain ingredients may be altered.

The **pre-transplant stage** is necessary to prepare the grown propagules, now known as plantlets, for the shift from the rigidly controlled in vitro environment to that of a more typical plant growth environment, usually in a greenhouse. The pre-transplant stage also offers an opportunity to cull mutated propagules or ones that somehow became infected with a disease.

The **transplant stage** is the point at which the plantlets are moved to a pasteurized soil mix essentially as seedlings would be transplanted. At this point the plantlets are very tender and dry air and/or bright sunlight can easily burn them. Gradually, humidity levels can be reduced and more sunlight provided to the young plants at which point they should be established and growing under standard conditions.