Propagation in Plants - Advanced

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CHAPTER 1 Propagation in Plants - Advanced

Learning Objectives

- Define plant propagation.
- Relate propagation of plants to natural reproduction in plants.
- Describe the various methods used to propagate plants.
- Explore the practical and experimental use of micropropagation, or tissue culture.

Plant Propagation

We **propagate** plants when we facilitate or promote their reproduction. We can do this by growing plants from seeds or spores, the products of sexual reproduction (except in apomixis!). Techniques for breaking dormancy and inducing germination, discussed in the lesson on seeds, are used to produce seedlings, which can then be grown into plants which differ from their parents. Techniques for self- and cross- pollination further control this process.

We also use natural methods of asexual or vegetative reproduction, as discussed in the previous section, to propagate plants. Procedures such as grafting modify these natural methods to make artificial propagation more efficient.

Finally, we have gone beyond nature to develop completely new methods for propagating plants, such as tissue culture. The follow paragraphs summarize some of the many ways we propagate plants. Because (sexual) seed propagation was discussed in some detail in the last lesson, we will focus here on asexual methods of plant propagation.

Cuttings (Striking)

The most straightforward method of propagating plants is cutting or striking, in which a piece of parent plant containing at least one stem cell is removed and embedded in moist soil or other medium to form new roots. Some plants will root in water. Depending on the species, cuttings may be taken from stems, roots, dormant woody twigs, eyes, or leaves. Specific requirements for soil type, humidity, and light may be important. Stem cuttings are used to propagate fig and olive trees, and leaf cuttings are routinely used to propagate cultivars of African violets (**Figure** 1.1).

FIGURE 1.1
Cuttings remove a portion of stem, root, or leaf which includes one or more stem cells. These are embedded in a suitable medium to encourage root formation, which produces independent plants.

Layering

In nature, the tall branches of brambles such as blackberries arch over to the ground; where their tips touch the soil, they send out adventitious roots, which form new plants, which can grow on their own when connections are broken. New plants may take from several weeks to a year to become independent, but this ground **layering** is an effective method of vegetative reproduction, because young plants can continue to receive water and nutrition from their parents while becoming established.

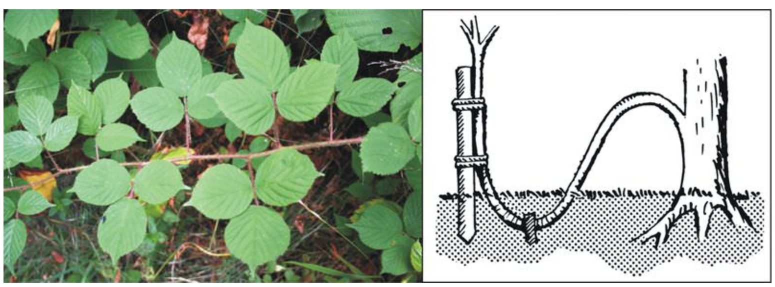

FIGURE 1.2
Using blackberry brambles as a model, horticulturists have developed techniques for propagating plants by ground layering (above) or air layering. Both stimulate plants such as apples and roses to develop adventitious roots for the formation of new, identical plants.

Horticulturalists encourage ground layering by wounding a target region to expose the stem and applying rooting hormones before burying the target region in the ground. A few varieties of apples are propagated by ground layering. Air layering is similar, but the wounded target stem area is wrapped in sphagnum moss and airtight polyethylene to hold in moisture and provide an environment within which roots will develop. After root development is well established, the stem is cut below the roots, and the branch with roots planted separately (see diagrammatic explanation referenced at end of lesson). Gardenias, roses, figs, and magnolias are sometimes propagated by air layering.

Division

Saffron, the most expensive spice in the world, is a brilliant yellow powder produced by drying the bright red stigmas and style of a certain mutant crocus (**Figure** 1.3). Alas, these organs of sexual reproduction are sterile, because the crocus, like dandelions (but much more precious!), is triploid. The crocus does produce corms, each of which reproduces up to 10 "cormlets" per season. Dug and separated by hand, the cormlets can be replanted as individuals to produce more saffron the following season. Such separation of naturally reproduced vegetative organs is known as **division** - a simple but effective method of propagation used for plants which form corms, tubers, bulbs, and rhizomes.

FIGURE 1.3
Division is a simple but effective method of vegetative propagation used for plants which form corms, tubers, bulbs, and rhizomes. Saffron (inset) is the most expensive spice on earth, formed from the bright red stigmas and style of a sterile triploid crocus. Division of "cormlets" formed by the corm is the labor-intensive and only form of propagation.

Twin-Scaling

In nature, bulbs reproduce very slowly - doubling only every two years or so. However, if they are injured, they will produce "bulblets" much more rapidly. Horticulturalists promote bulb reproduction with carefully controlled injuries, producing up to 100 clones per individual bulb under optimal sterile conditions. This practice is **twin scaling**. Amaryllis, snowdrop, narcissus, some lilies, and hyacinths are produced commercially through twin scaling.

FIGURE 1.4
Plants which grow from bulbs, such as (clockwise from top right) narcissus, amaryllis, and hyacinth, can be propagated rapidly by twin-scaling, which stimulates bulbs to reproduce more rapidly than in nature.

Grafting

You may have heard of skin grafting, in which skin from one part of the body is moved to another part which has been badly burned. Propagating plants by **grafting** is similar, except that it usually involves the fusion of tissues from two different kinds of plants, producing what might be called "chimaeras". Often used to produce hardy shrubs and trees, grafting fuses tissues from one plant with desirable root systems (the rootstock) with tissues from a second plant with hearty stems, leaves, flowers, and fruit. Grafting requires that the vascular cambium of both plants be in contact, so only eudicots and gymnosperms can be propagated by this method.

FIGURE 1.5

Grafting involves fusing the tissues of two different plants - usually one which has sturdy roots and another which has desirable stems, leaves, flowers, or fruits. Many different techniques use shoots or dormant side buds (top). Grafting produces dwarf trees easier to harvest (cherries, lower left) and novelty trees such as fuschia (lower right).

Grafting can solve many plant propagation problems:

- reducing the size of fruit trees, to bear more fruit and make it easier to pick (apples, pears, plums, cherries)
- propagating plants which are difficult to root (by grafting them onto other rootstock)
- reducing growing time (by grafting young plants onto established rootstock)
- to improve hardiness or adapt weak-rooted plants to heavy soils
- to provide trunks for plants with shrub-like growth forms, such as roses
- to attract pollinators
- to repair damage caused by animals or girdling
- to provide disease-resistant rootstocks
- to grow plants such as orchids which are otherwise difficult or impossible to grow from seed Grafting has saved European grapes, devastated by a soil insect which girdles their rootstocks. Grafting onto resistant rootstocks of American grapes protects them from this infestation.

Tissue Culture: Micropropagation

Like nearly all human cells, most plant cells have all the genetic information they need to build whole new plants; the problem in building a whole new plant from a single cell is to coax the cell to express each gene in the proper sequence. Tissue culture, or **micropropagation,** works to accomplish just this feat, much as scientists did for the sheep named "Dolly" in honor of the udder cells used to provide the information to grow her (see *Biotechnology* chapter). In general, cells from the plant's **meristem** tissue are most successful, as stem cells are most successful in animals.

FIGURE 1.6
Micropropagation or tissue culture reproduces plants at the cellular level, requiring precise, sterile conditions to stimulate development from cell to plant. Tissue culture may begin in Petri dishes, resembling bacterial culture. Later, hydroponics or aeroponics may be used. The technique produces clones, and has many uses in horticulture and scientific research.

Plant tissue culture requires:

- sterile conditions to prevent disease
- a precisely designed medium to supply necessary nutrients (salts, organic molecules, and vitamins)
- plant hormones to stimulate development (auxins for roots, cytokinins for shoots)
- the "starter tissue" or *explant*: a single cell, a cell whose cell wall has been removed (*protoplast*), or a small piece of shoot, leaf or (less often) root tip

Initially, plant tissue cultures may resemble bacterial culture; often agar is added to the nutrient medium for support. As the tissue grows, initially formless masses of cells may be subdivided and moved to different media to change growth patterns. For example, as shoots form, they may be cut off and placed into a rooting environment. Subdivision also simply multiples the number of plants eventually produced. Further growth may utilize *hydroponics* and *aeroponics*, techniques which employ nutrient-enriched water and air, rather than disease-harboring soils. Eventually, young plants must be weaned from their warm, high humidity, low-light environments and "hardened" to more natural conditions so that they grow the tough cuticle, necessary stomata, and immune systems needed to survive in nature.

Micropropagation produces clones, often desirable for select varieties or cultivars whose seeds, as the result of sexual reproduction, would have different genetic composition. The many uses of this technique include:

- *conservation:* propagating endangered species (although in this case, genetic uniformity is a drawback)

- *screening:* testing cells from whole plants for characteristics such as herbicide resistance
- *pharmaceutical production:* mass cultures in bioreactors
- *breeding:* hybridizing distantly related species by fusion of protoplasts
- *embryo rescue:* cultivation of "seedless" grapes, as discussed in the fruits and seeds lesson
- *genetic engineering:* introducing new genes or changing chromosome number (e.g., haploid to diploid)
- *treating disease:* for example, producing virus-free cells from virus-infected tissues

Summary

- Promoting or facilitating the reproduction of plants is plant propagation.
- Many methods of plant propagation use our understanding of sexual and vegetative plant reproduction.
- Cuttings and layering induce parts of plants to grow new roots in order to multiply them asexually.
- Clones can be obtained by division of naturally produced rhizomes, tubers, corms, and bulbs.
- Grafting combines parts from two plants to produce hardier, more productive "chimaeras".
- Micropropagation is useful in conservation, pharmaceuticals, breeding, hybridization, and disease control.