

CHQPITER 1/ Vegetative Multiplication

I. Spontaneous (Natural) Vegetative Multiplication

Some plants multiply naturally without going through sexual reproduction. A new individual is formed from an organ of the "mother" plant.

I.1. Propagules

These are individualized multicellular structures that separate from the mother plant and are capable of regenerating new individuals when conditions are favorable. They are very common in Bryophytes, where they form on the surface of the protonemal filaments, leafy gametophytes, or thalli; they are sometimes grouped in "baskets" at the upper part of the thallus, as in *Marchantia polymorpha*.

I.3. Stolons

These are plagiotropic stems whose internodes undergo significant elongation while the leaves are reduced to scales; their terminal bud is capable of rooting, producing in turn a new stoloniferous plant. The typical example of this mode of propagation is provided by the Strawberry, whose stolons are herbaceous and aerial.

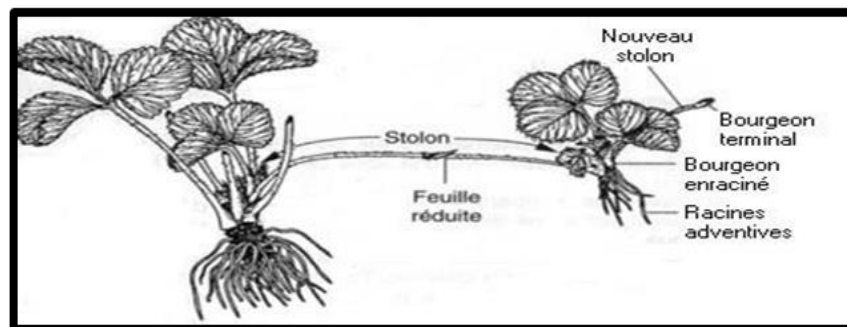


Figure 11: Strawberry Stolons (*Fragaria vesca*).

.4. Suckers

It is a leafy stem arising from an adventitious root bud and ensuring the vegetative multiplication of the individual that produces it (Fig. 12).

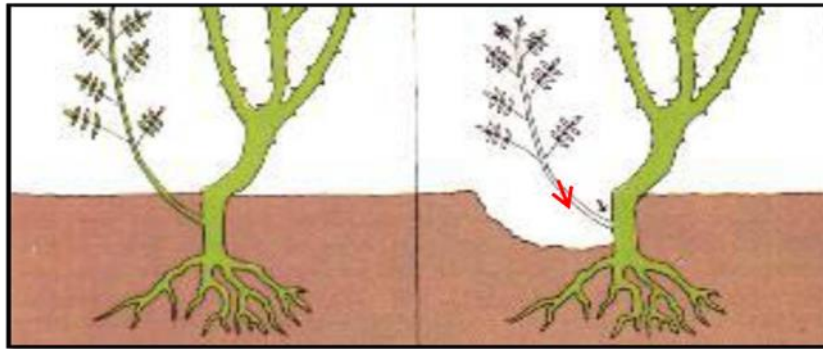


Figure 12: Dragon or leafy stem arising from an adventitious root bud

.5. Bulbils

These are fleshy, dormant buds transformed into true small bulbs rich in reserves (Fig.13). They remain in a state of slowed life as long as they are carried by the plant that formed them. Once fallen to the ground, each of them develops into a new individual. These bulbils ensure natural cutting.

Tubers

These massive, generally underground organs are formed by the hypertrophy of a portion of a stem, a root, or a hypocotyl and a root. The vegetative multiplication capacity of a species is linked to the number of tubers formed on the same plant. In the classic example of the Potato, it is underground plagiotropic stolons that become tuberized when the terminal growth ceases.

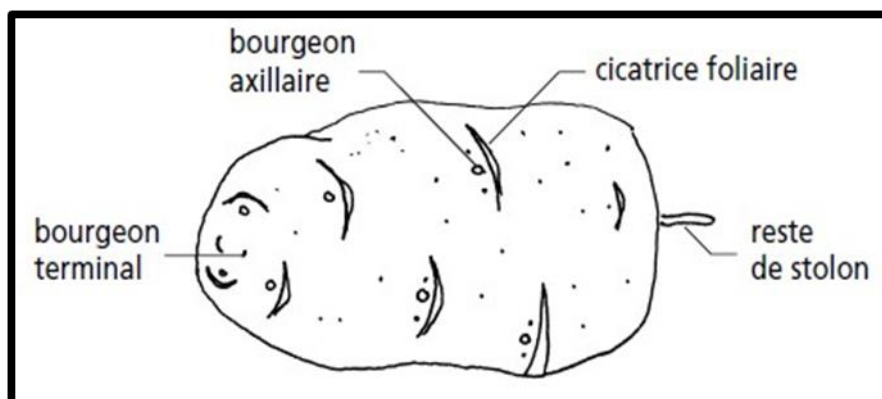


Figure 14: Potato tubers (*Solanum tuberosum*) are swollen underground stems that accumulate reserves at their tip.

I.7. Bulbs

These are underground plant organs filled with nutrient reserves that allow the plant to regenerate its aerial parts each year.

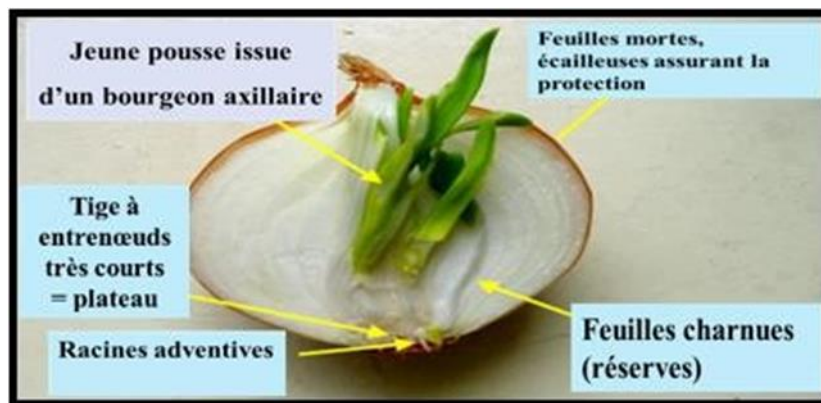


Figure 15: An onion bulb.

I.8. Rhizome

These are underground stems (with reserves storing, for example, starch or inulin) that can take root and produce a new plant. (Iris, ginger, bamboo, rice, asparagus, some ferns, couch grass, etc.)



Figure 16: Rhizome.

II. Artificial Vegetative Propagation

II.1. Traditional Techniques

II.1.1. Cutting

This involves planting a fragment of a plant lacking roots, called a cutting, which is capable of regenerating an entire plant through the formation of adventitious roots.

This ability to form adventitious organs is due to fundamental properties:

- **Totipotency:** Every living, differentiated plant cell possesses the necessary information to reconstitute all parts of a plant.
- **Dedifferentiation:** A differentiated cell can revert to a meristematic state, regain intense mitotic activity, and develop new points of growth.

Depending on the species, it is possible to take cuttings from shoots, stems, leaves, and even formations of adventitious buds. Cutting is carried out in a humid atmosphere on compost or sand to keep the cutting alive in the absence of the organs it lacks.

During cutting propagation, two types of behavior are observed:

- *De novo* formation: In response to the wound caused when taking the cutting, a suberized healing layer and an unorganized callus, due to the intense mitotic activity of the underlying living cells, are formed. Nearby, cells adjacent to the vascular tissues and the cambium dedifferentiate; they divide actively and organize into root primordia. The development of these primordia leads to the emergence of roots that grow through the other tissues. Simultaneously, vascular connections are established between these adventitious roots and the tissues of the cutting, thus achieving the physiological unity of the new plant.
- The development of preformed or latent root initials, which remain dormant on the stems until fragments are placed under favorable conditions.

Bud neoplasm:

Bud meristems are induced in the callus that develops following root fragmentation. Their origin can be internal (in the pericycle zone) or external (in the cortical zone).

Adventitious buds develop from leaves (or their fragments) only when the leaf is detached from the mother plant. The rupture of correlations in the mother plant therefore leads to physiological changes which result in mitotic activity and the establishment of specific organogenic programs. In general, a polarity is established in the development of the primordia:

- For stem and root fragments, buds form on the proximal face (directed towards the bud of the mother plant) and roots on the opposite side;
- For leaves, both types of neoplasm are observed only on the petiole side.
This is related to the basipetal movement of auxin and perhaps to the existence of a conduction stream of growth regulators or metabolic products. Experiments have shown that the application of exogenous auxins can reverse the polarity of the newly formed organs of a cutting.

Grafting

It is an agronomic practice that involves implanting, into the tissues of a plant, a bud or a fragment of an organ bearing buds, detached from the same individual or from another, with the aim of combining the respective qualities of the two plants. One, the rootstock, provides the root system, and the other, the scion, provides the aerial system. The fusion of the living tissues placed in contact allows the scion to continue to live and grow, becoming one with the rootstock.

Grafting generally concerns trees or shrubs, more rarely herbaceous plants. If the partners belong to the same individual, it is called autografting; if they come from different individuals of the same species or the same variety, it is a homograft; finally, heterografting brings together plants of different species or genera.

This technique is used:

- To propagate the aerial parts of agronomically interesting species and varieties.
- To exploit the advantages of certain root systems and replace fragile underground parts (grafting French grapevines sensitive to phylloxera onto resistant American rootstocks allowed the reconstruction of French vineyards in 1868).
- To renew or improve orchards.
- To accelerate the production maturity of selected young plants by grafting them onto older, more vigorous trees.
- To obtain particular growth habits (weeping trees, dwarf trees, standard roses), etc.

However, grafting has its limits:

- In particular, the longevity of the partners is generally reduced: a grafted vine lives 25 to 60 years while a vine on its own roots can produce grapes for 200 years.
- The transmission of viral, bacterial, or fungal diseases is favored.
- Establishing a graft requires long periods.

Grafting Techniques

- **Approach Grafting:** In this technique, the two partners are closely joined by a surface stripped of bark. Both retain their own root system and foliage until the union is complete (Figure 20A).
- **Grafting with a Detached Bud or Scion:** Here, the scion consists of an isolated stem segment bearing one or several buds along with a shield of bark (bud grafting, "Fig. 20 D"). If the rootstock and scion are of the same diameter, the whip or tongue grafting is used ("Fig.20 E"). However, if the rootstock has a larger diameter, cleft grafting (Fig.20 B) or crown grafting (Fig. 20 C) is performed. Grafting can be done directly onto the underground part of the rootstock (root grafting) or can be carried out on a simple cutting that will subsequently develop the root system (cutting-graft). Tissue culture grafting can also be performed *in vitro*.

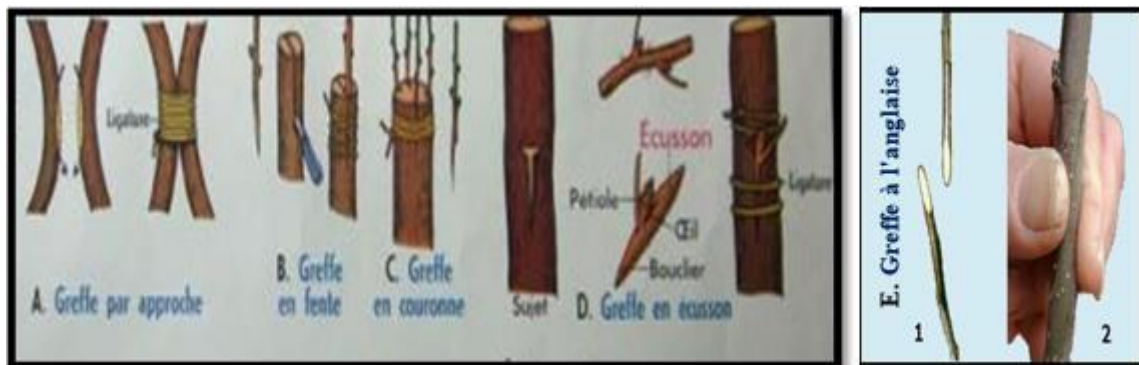


Fig2. Grafting techniques.

Conditions for Successful Grafting

External Conditions relate to environmental factors. An optimal temperature and high atmospheric humidity are necessary to avoid the desiccation of newly formed cells; the supply of oxygen is essential for rapidly dividing cells.

-Grafting Technique must ensure a tight but extensive contact between the cambial regions of the two partners for effective healing and regeneration. It must also match the polarity of the partners: the distal end of the scion must be inserted into the proximal part of the rootstock.

- **Intrinsic Characteristics of the Partners** concern:

Their **physiological state**: the rootstock and the scion must exhibit growth activity that allows the production of hormonal regulators capable of stimulating cell metabolism for the initiation of conductive tissues and the cambium.

Their **health status**: materials infected with viruses lead to graft failures or reduced vigor of the resulting plants.

The degree of **relatedness between the partners**: autografts and homografts in plants are easy, but heterografts yield highly variable results ranging from compatibility to incompatibility.

Graft Incompatibility

This occurs during the subsequent differentiation of vascular elements and cambial activity, which happen variably or fail to complete, preventing the vascular connection between the two partners. The production of phenolic compounds (suberization, lignification) in all cases leads to cell necrosis; this necrosis can affect only the scion or both partners. Based on this, there are three types of incompatibility.

- **Localized Incompatibility** corresponds to combinations of genotypes where the "rejection" reactions depend on the actual contact between the rootstock and the scion. In this case, inserting an intermediately compatible rootstock can overcome the incompatibility. An example is the 'Williams' pear grafted onto quince rootstock using a "compatible bridge," the 'Beurré Hardy' pear: the

tripartite combination shows perfect success. The intermediate rootstock acts as a "trap" for substances originating from the quince that are the cause of the incompatibility. Indeed, some pear cultivars are compatible with quince, while others are not.

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- **Translocated Incompatibility** is not overcome by inserting an intermediate rootstock; it is sometimes overcome by inverting the scion/rootstock combination (reciprocal grafting).
 - In this case, a substance produced by one partner and toxic to the other is transported through the intermediate subject to the graft union. The difference in response that allows for a compatible union would be explained by the polarized transport of the toxic substance. The cohesion of the partners and the proliferation of the callus generally occur well; the symptoms of incompatibility appear late (after about 1 year) in the conductive tissues of the union.
 - *Delayed incompatibility* develops several years after the grafting operation. It can be caused by pathogens (viruses, mycoplasmas, etc.) that become active late through toxins, or by secondary metabolites produced in response to aging: these substances cause necrosis of the cells in the graft union.