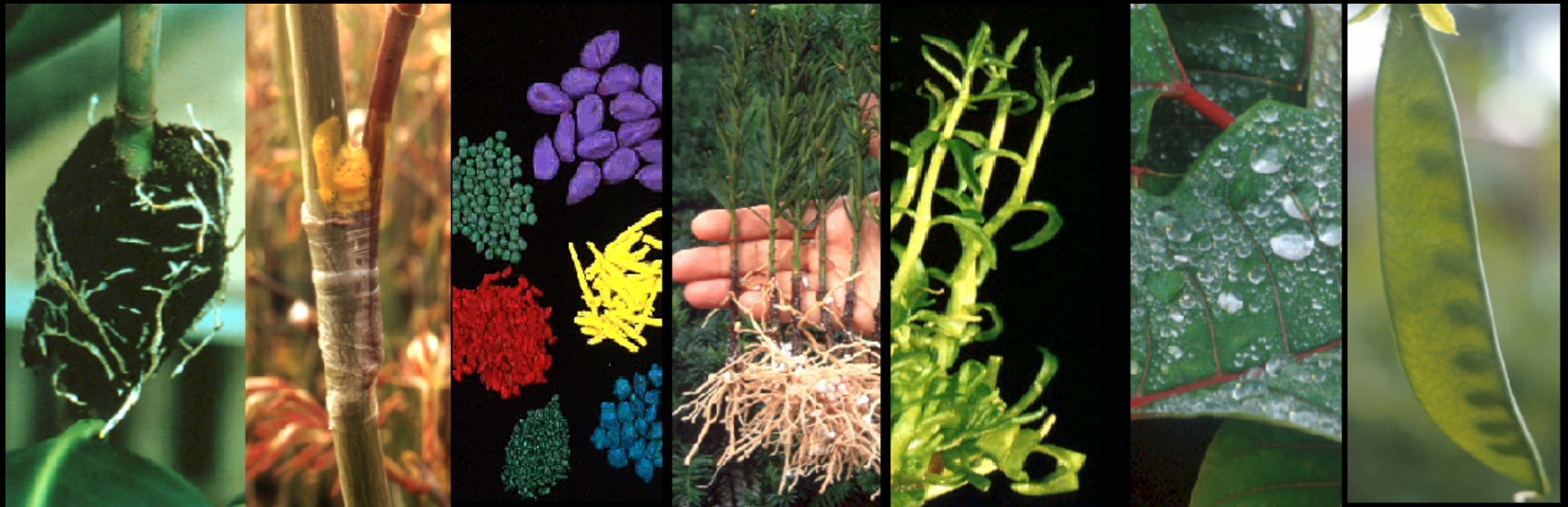


# Techniques of Plant Propagation: A Historical Perspective



Robert Geneve  
University of Kentucky

# Theophrastus

Theophrastus was a Greek philosopher (300 BC) and disciple of Aristotle. He described many aspects of plant propagation in his two books :

*Historia de Plantis  
and  
De Causis Plantarum).*





# Theophrastus

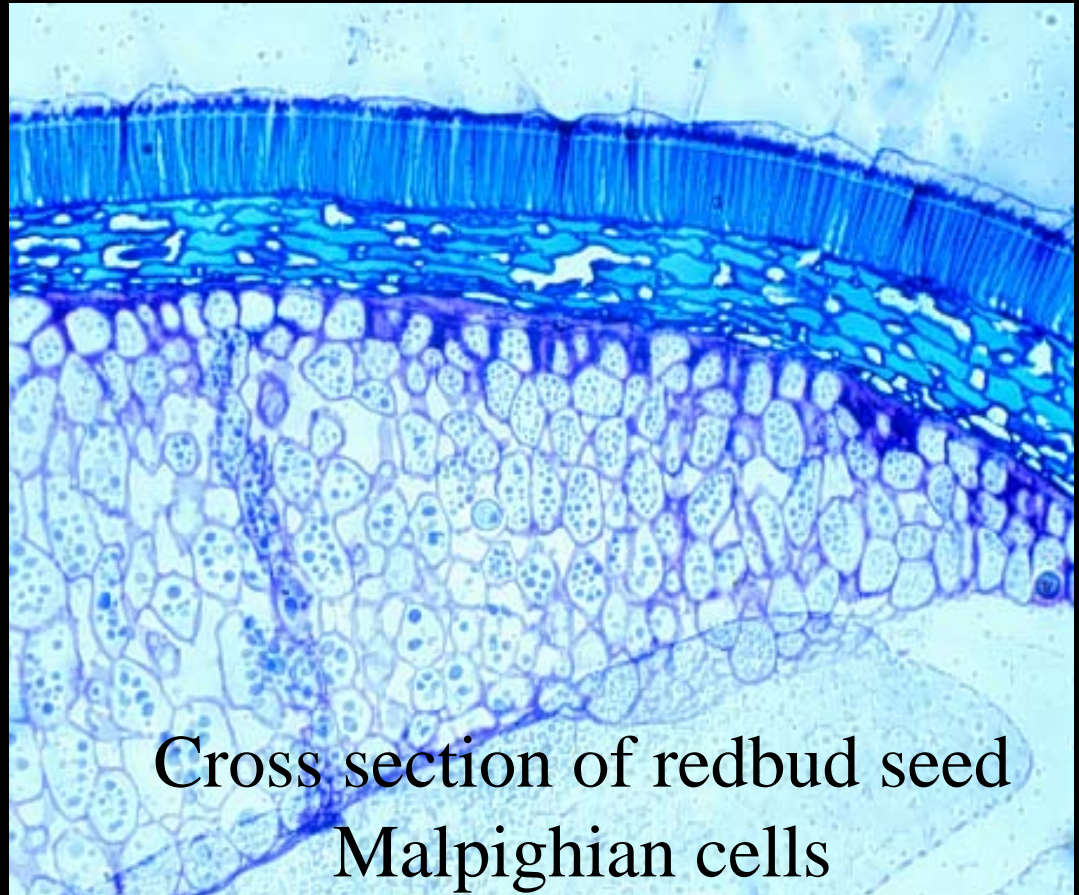
Theophrastus must be considered the **first seed biologist**. He described seed dispersal in pines.



"While the cones are still fast to the trees, the seeds leap forth and leave them empty."

**Hard seeds** with impermeable seed coats were also known to Theophrastus, where he notes that certain legume seeds need to be treated with "nitre" (possibly a caustic base) to germinate.

He also was aware that the climate during seed ripening affected the degree of hard seeds found at harvest.



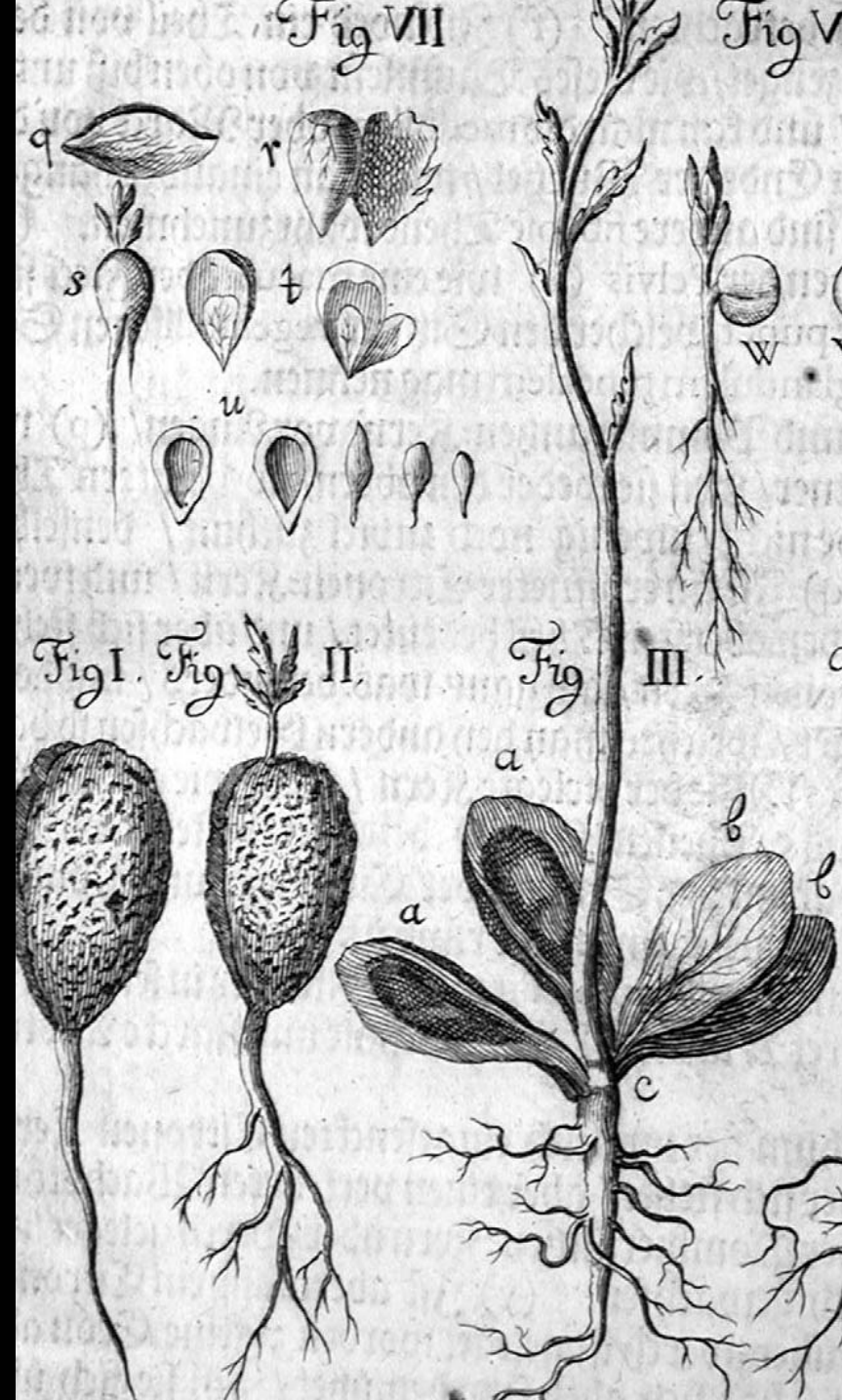
Cross section of redbud seed  
Malpighian cells



# Seed Technology

Modern advances in seed technology that improve seedling emergence include seed **priming**, **coating** and **pregermination**.

However, from a historical perspective, these are new practices based on old themes.





Primed seeds



Untreated seeds

## Seed Priming

Seed Priming is a controlled seed hydration treatment that enhances seed germination.

Established about  
1970.



# Seed Priming

Theophrastus (ca. 300 BC) observed that cucumber seeds soaked in water prior to sowing would induce faster emergence.



# Seed Priming

In 1600, Oliver de Serres described the "clever trick" of soaking grains (wheat, rye or barley) for two days in manure water followed by drying in the shade before planting the seeds.



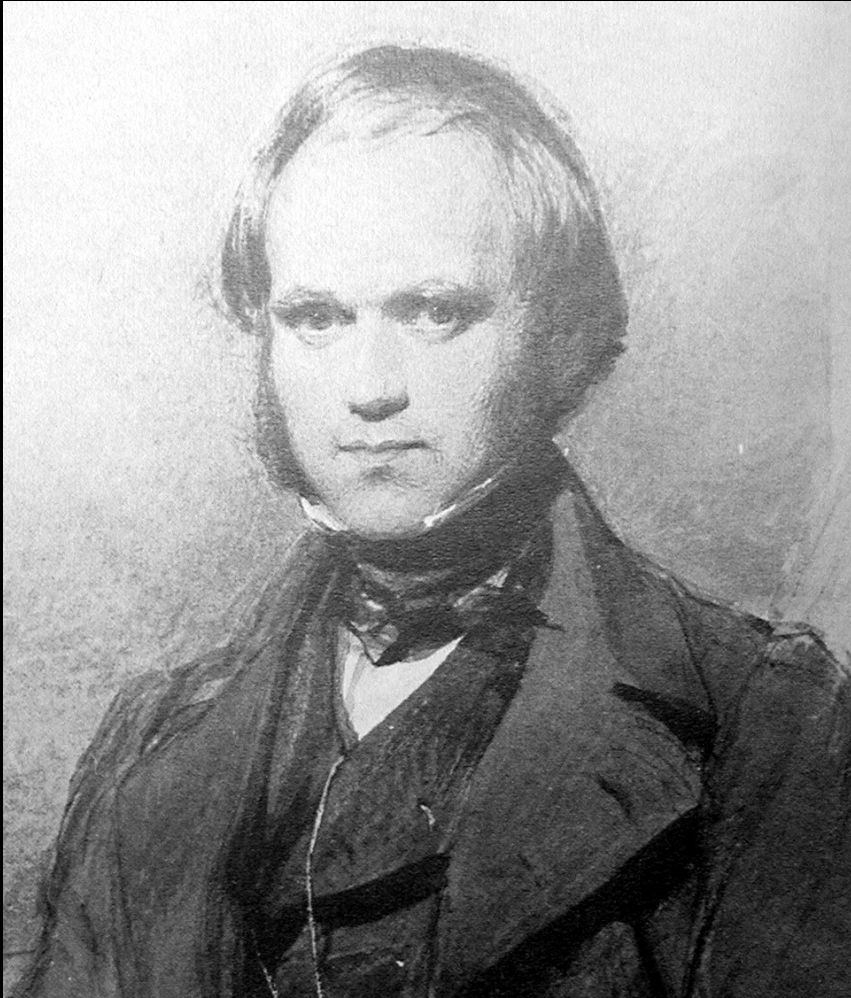


# Seed Priming

He noted that soaked seeds emerged more quickly avoiding "the danger of being eaten away by soil pests" .



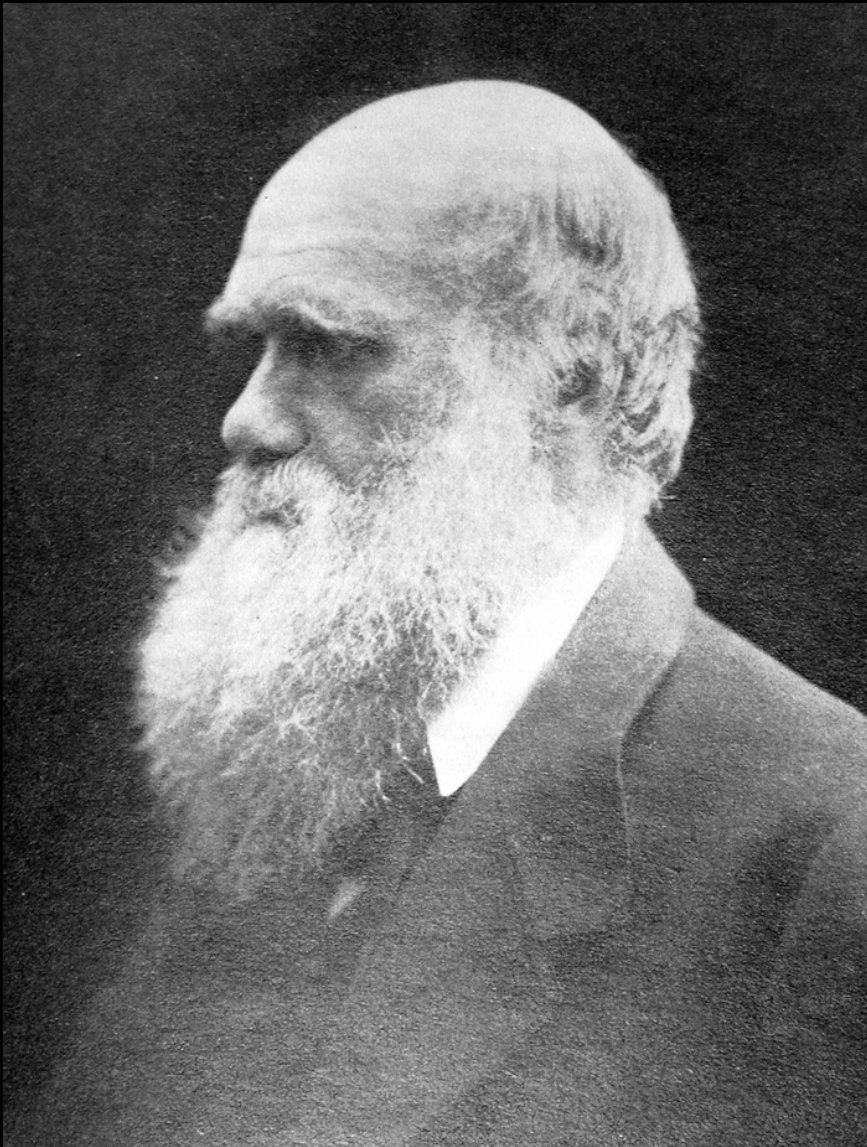
# Seed Priming



In experiments conducted in 1855, **Charles Darwin** hinted at the possibilities for osmotic seed priming.

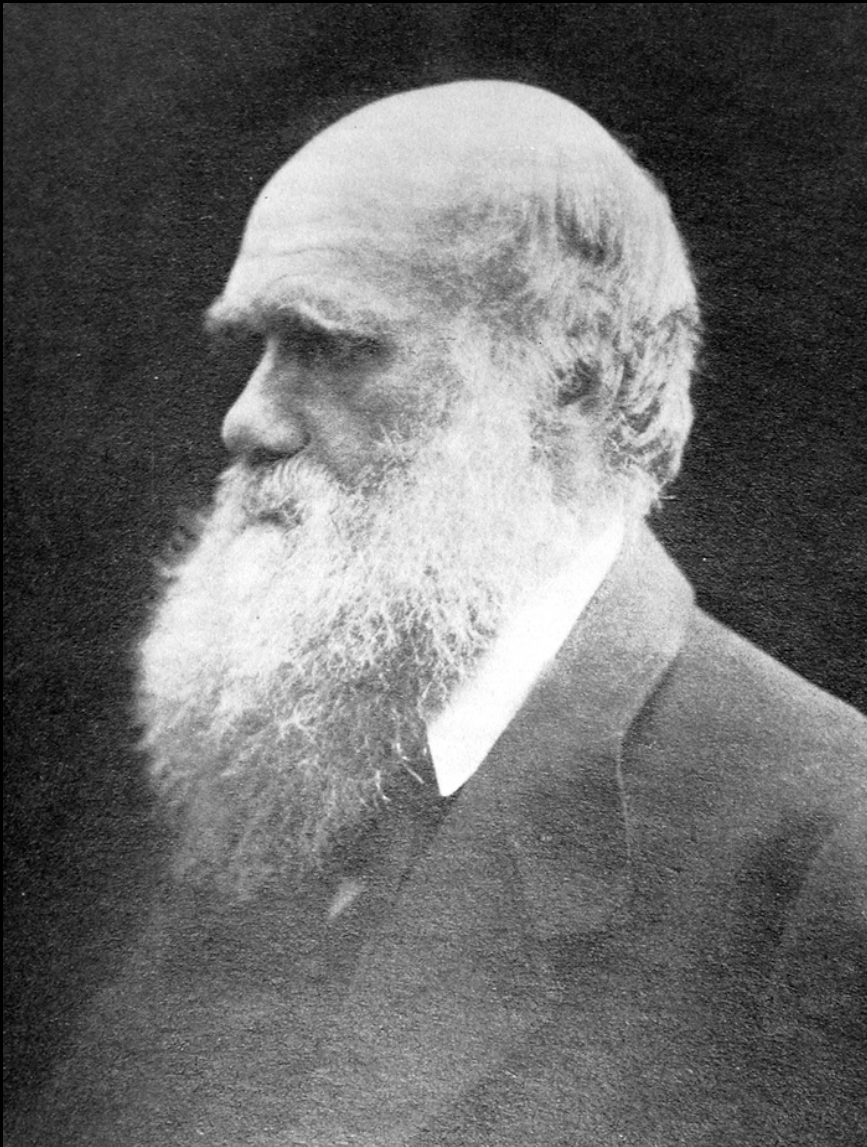


# Seed Priming



Darwin submerged seeds in salt water to show that they could move across the sea between landmasses as a means to explain geographic distribution of plant species.

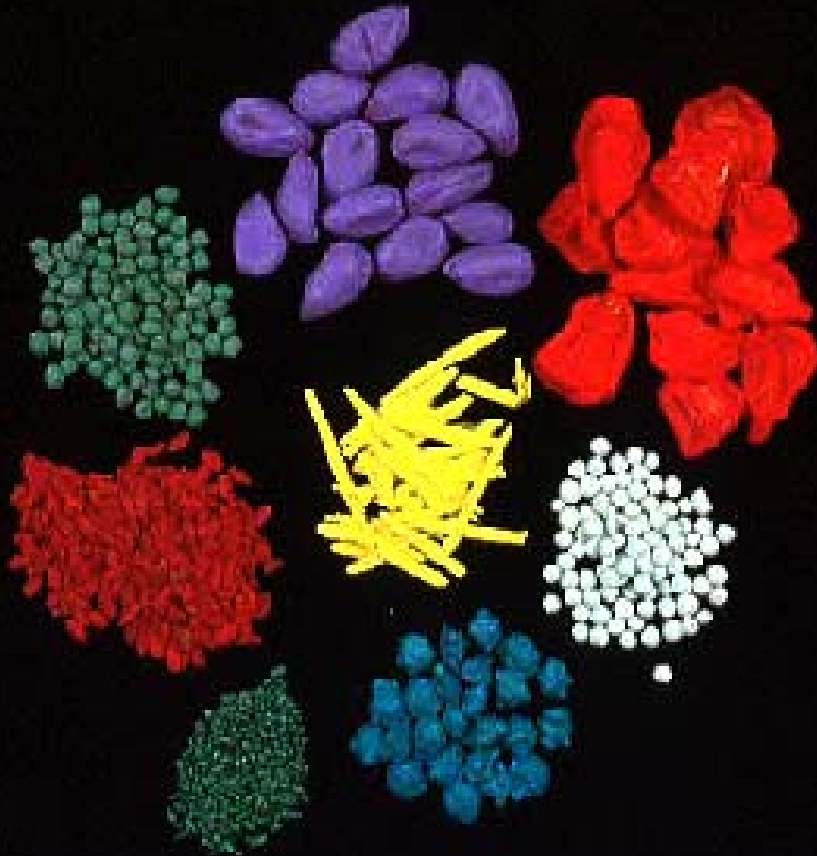
# Seed Priming



Not only did seeds survive immersion in cold salt water for several weeks, but some **species like cress and lettuce** showed **accelerated germination.**

# Seed Pelleting

Seed pelleting is the practice of surrounding the seed with an inert material to facilitate sowing.



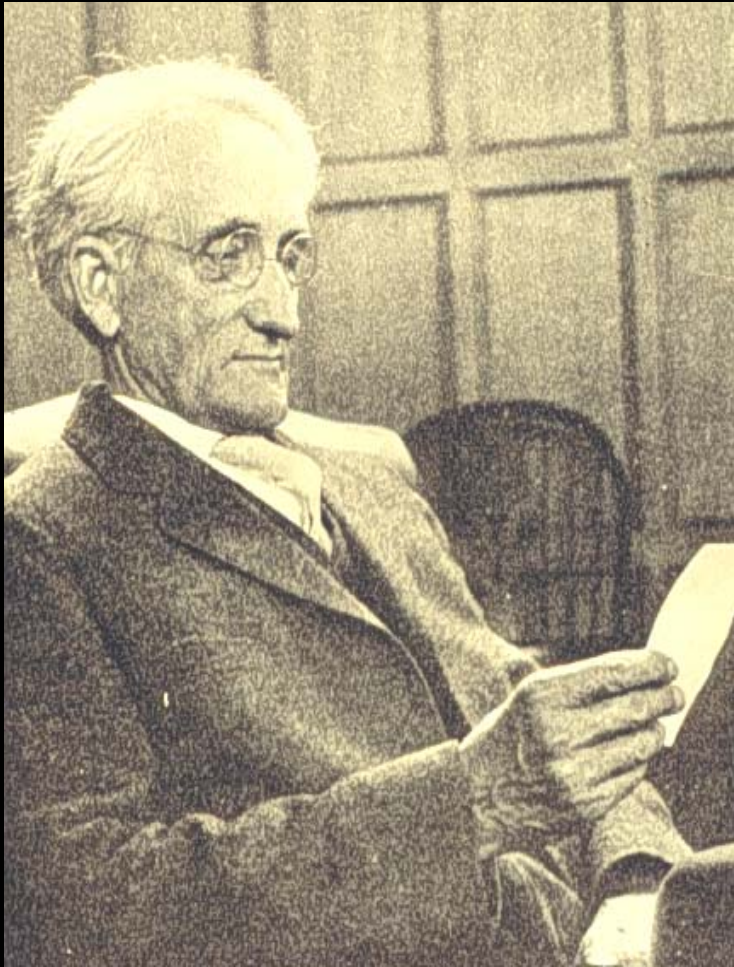


# Seed Pelleting



Pliny the Elder ca. 1 AD

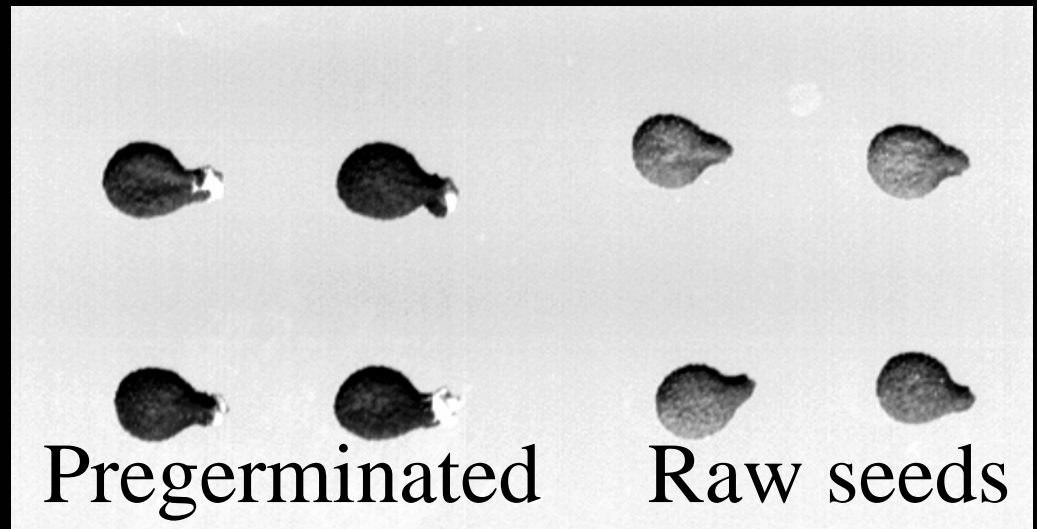
Seed pelleting was practiced in ancient times as **Pliny** describes treating vegetable seeds in "enclosed pellets of goats' dung, each seed in a separate pellet, they came up wonderfully".



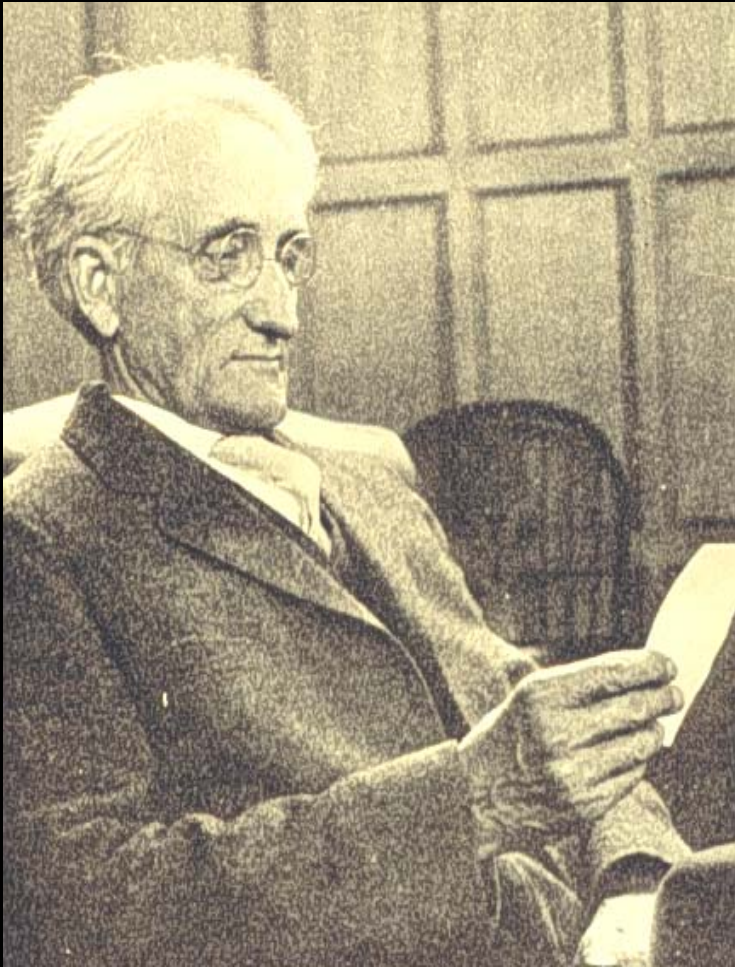
**Liberty Hyde Bailey**  
1858-1954

## Pregermination

Pregerminated seeds were introduced commercially in 1995 for bedding plant species (impatiens), but **Liberty H. Bailey** described the concept as early as 1897.







**Liberty Hyde Bailey**  
1858-1954

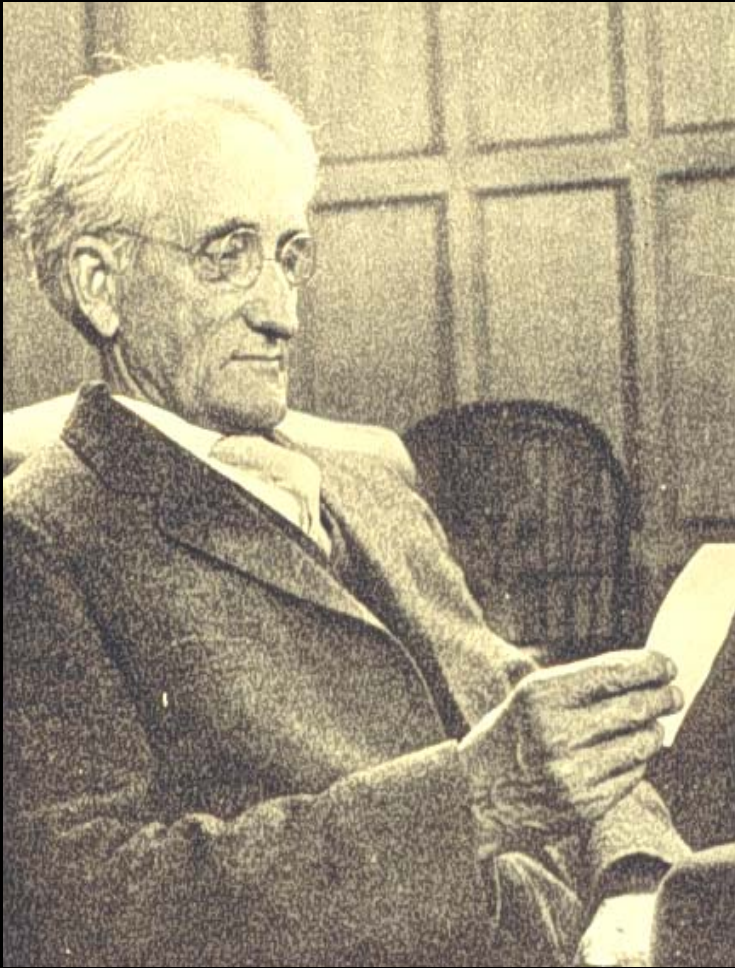
## Pregermination

“It is a common statement that seeds can never revive if allowed to become thoroughly dry after they have begun to sprout. This is an error. Wheat, oats, buckwheat, maize, pea, onion, radish and other seeds have been experimented upon in this direction,

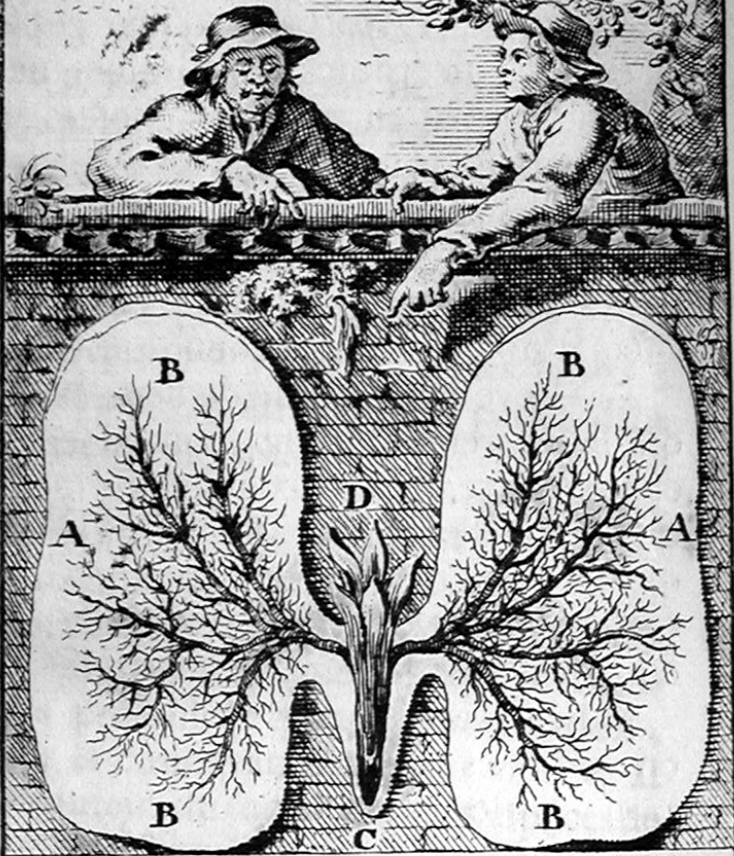


## Pregermination

and they are found to regerminate readily, even if allowed to become thoroughly dry and brittle after sprouting is well progressed. They will even regerminate several times.”

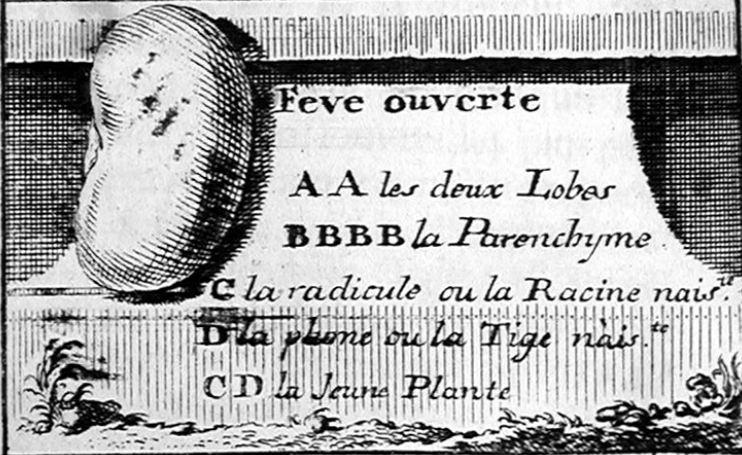


**Liberty Hyde Bailey**  
1858-1954



# Seed anatomy

Seed and plant structure became well documented after the 1600's.



**Fève ouverte**

**A A** les deux Lobes

**B B B B** la Parenchyme

**C** la radicule ou la Racine nais.<sup>se</sup>

**D** la plume ou la Tige nais.<sup>se</sup>

**CD** la Jeune Plante



# Seed anatomy

The Italian **Marcelli Malpighii** (1675) became the first seed anatomist.



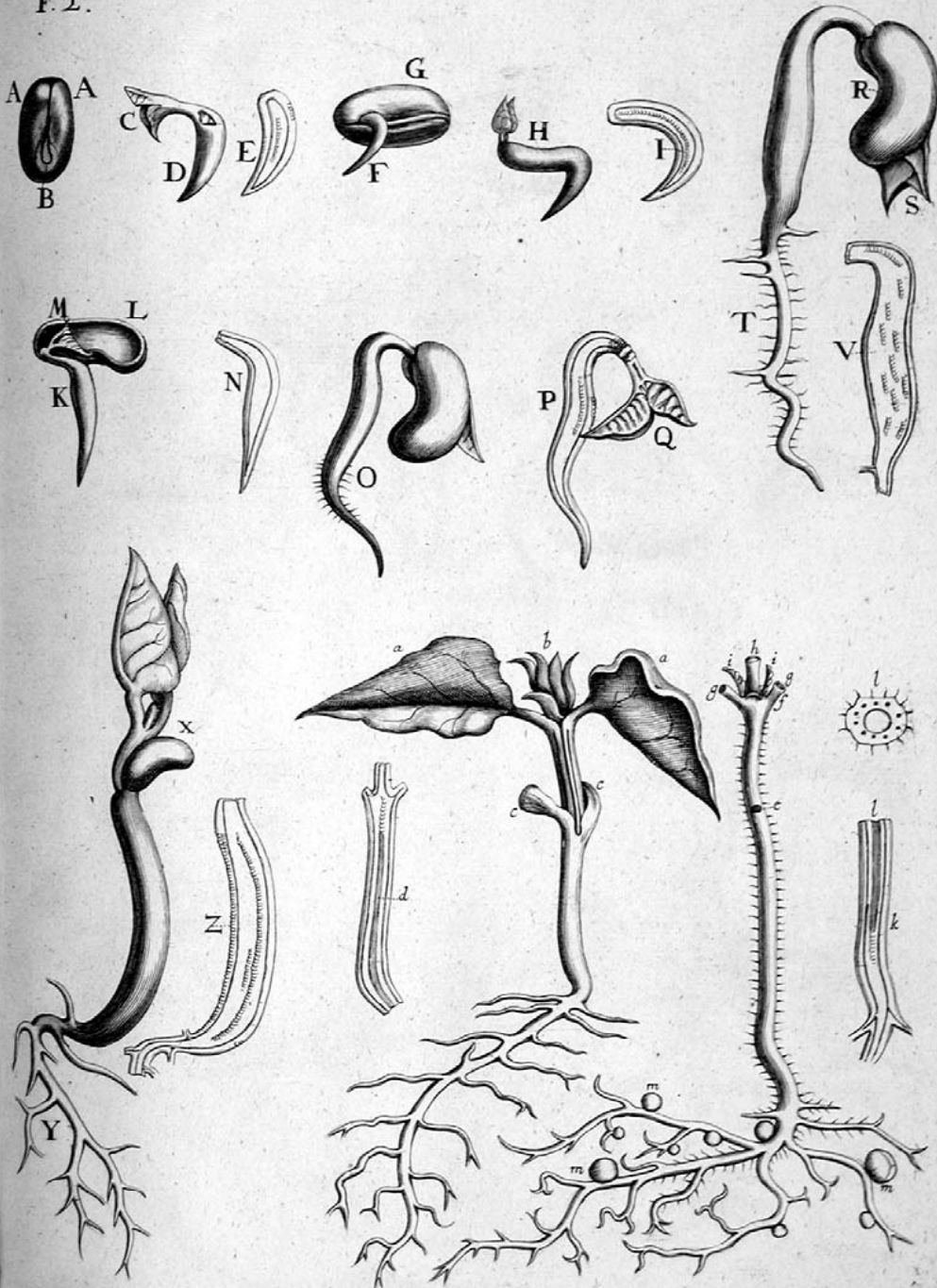
*Marcelli Malpighii ANATOMIE PLANTARUM.*

*R. White sculp.*



F. 2.

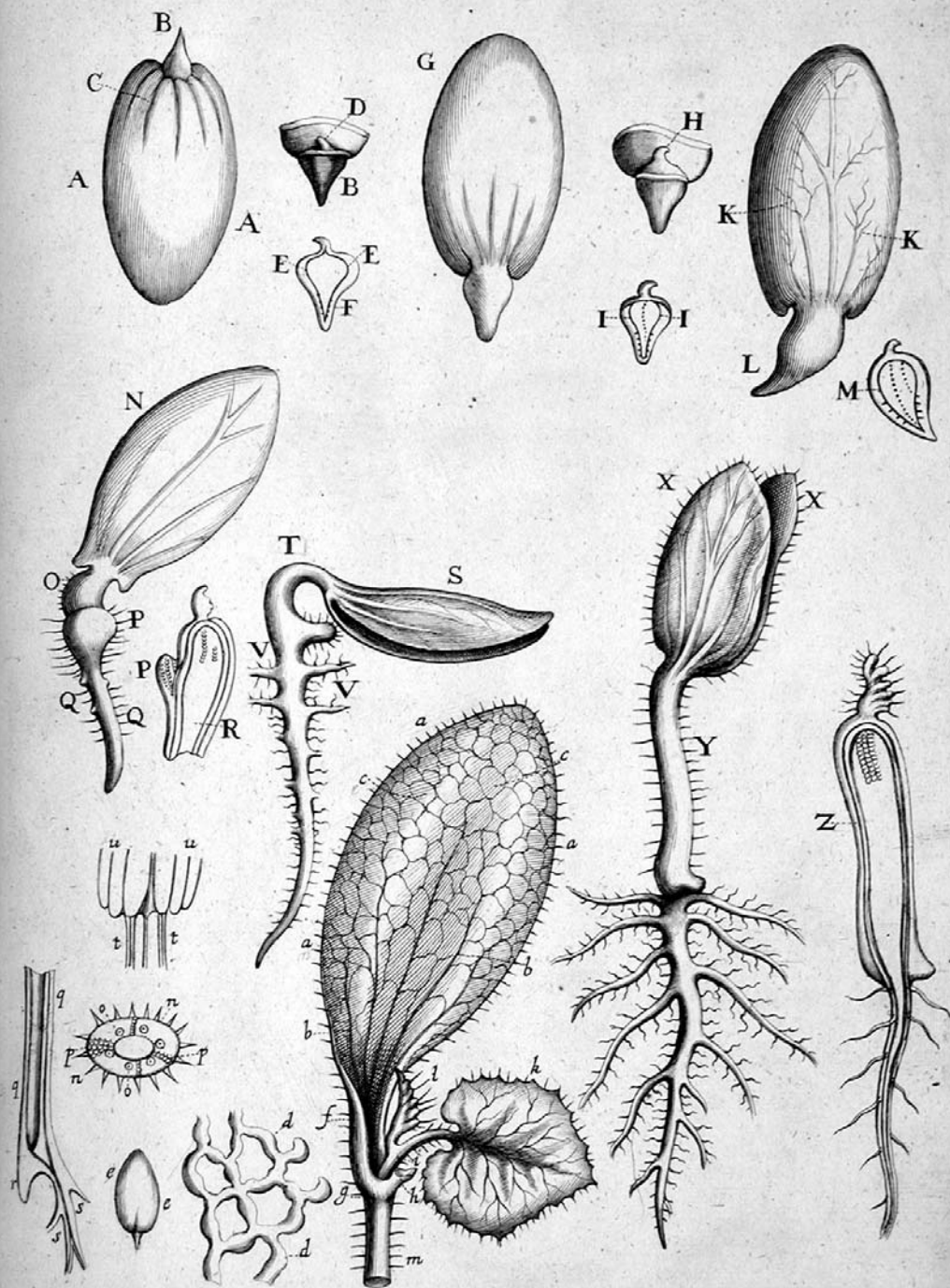
TAB. II.



# Seed anatomy

Marcelli Malpighii  
(1675)

Common bean  
*Phaseolus*



# Seed anatomy

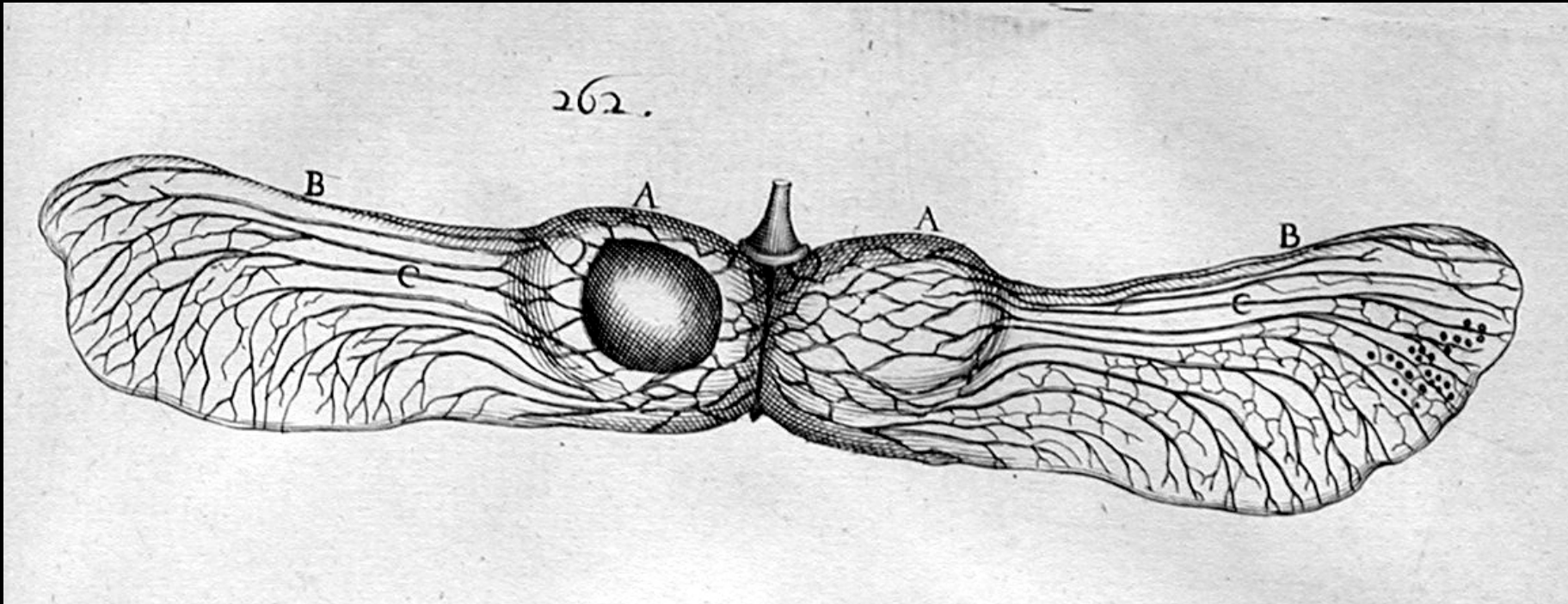
Marcelli Malpighii  
(1675)

Cucumber  
*Cucumis*



# Seed anatomy

Marcelli Malpighii (1675)



Maple samara  
*Acer*



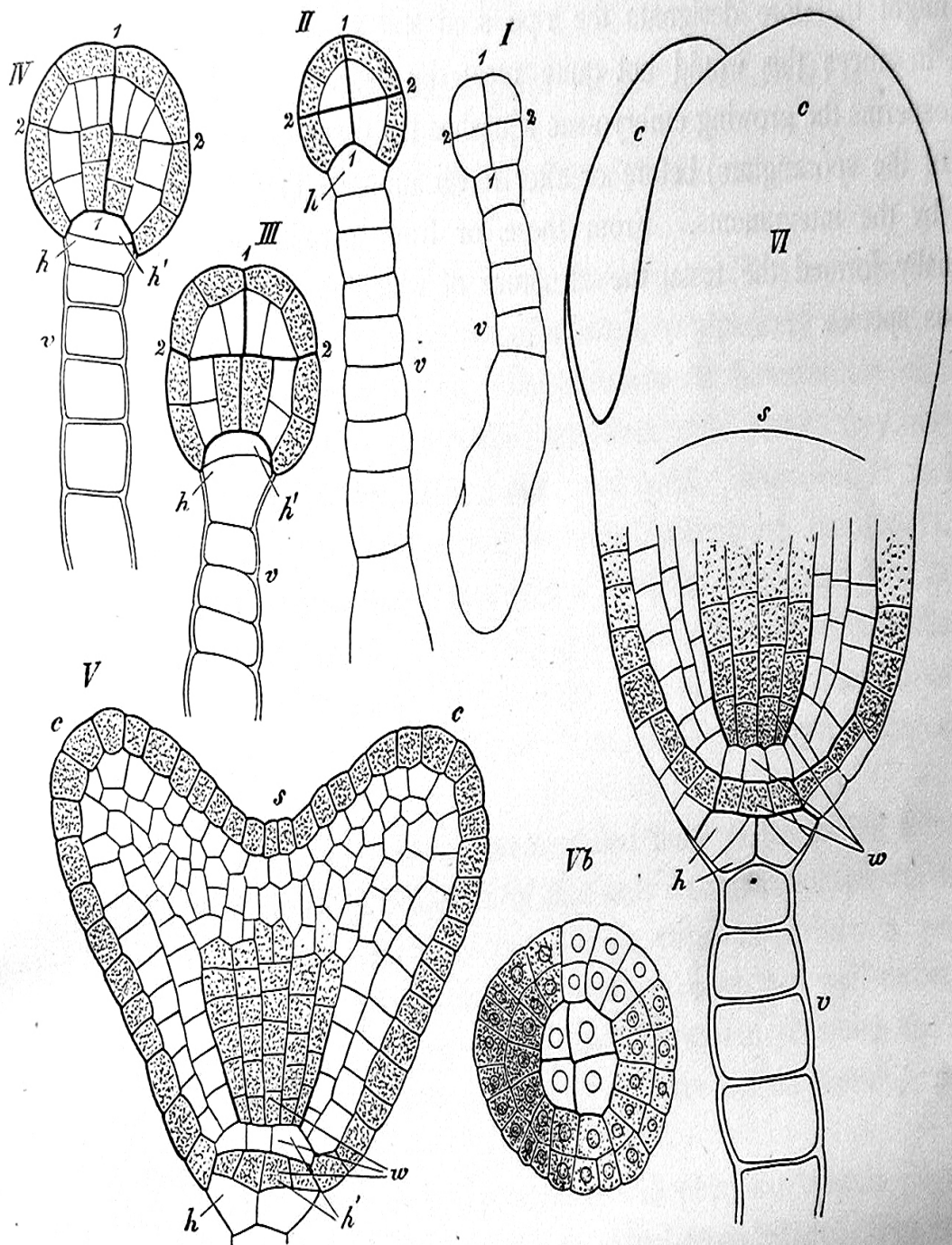
# Seed anatomy

Julius Sachs

1886

Shephard's purse

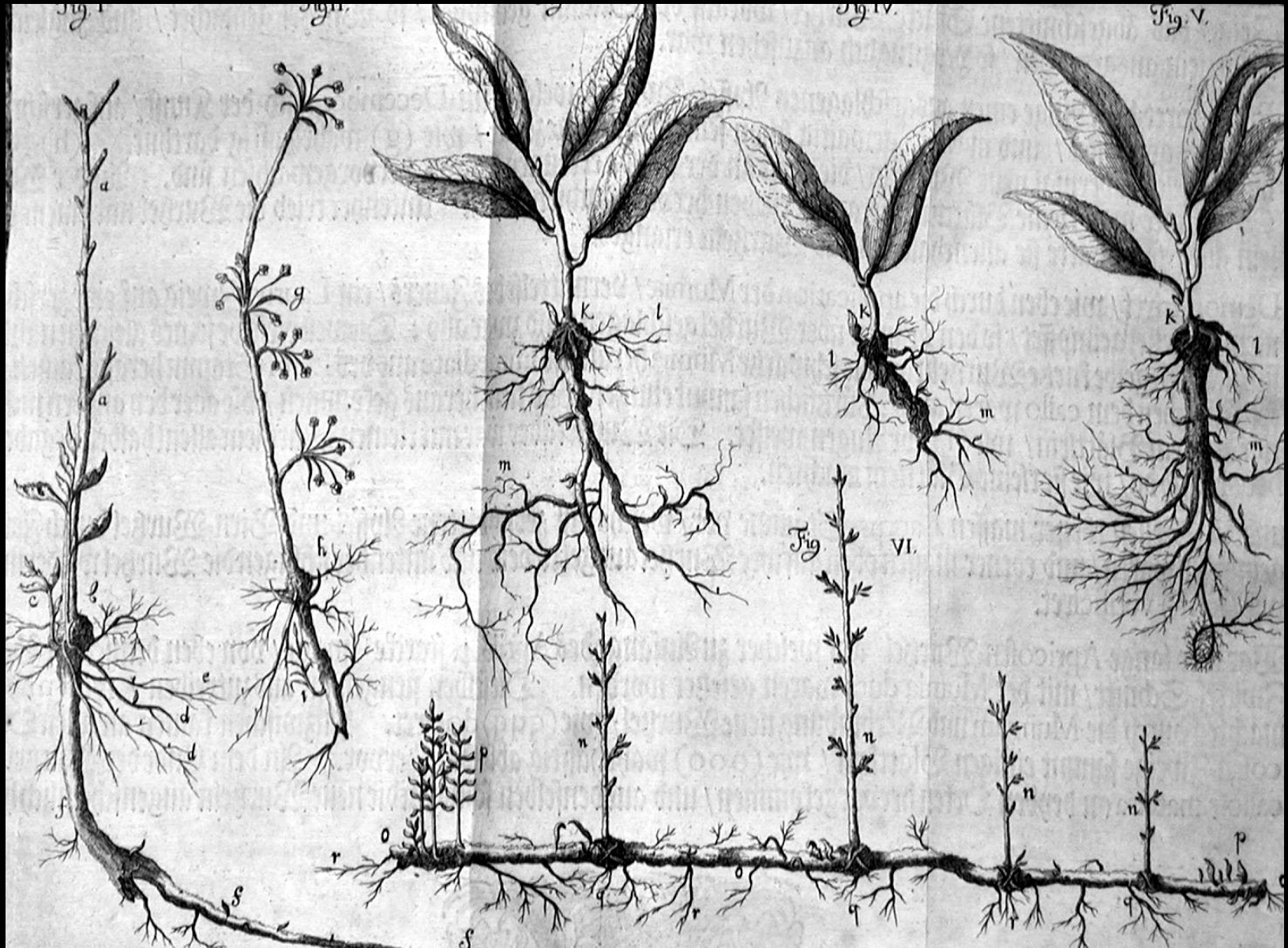
*Capsella*





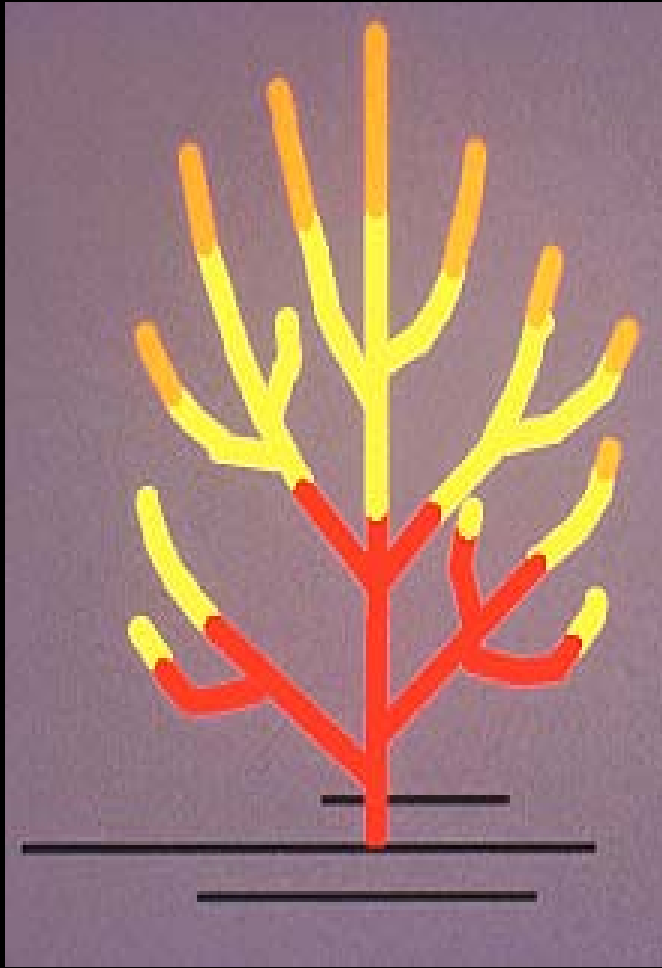


# Cutting propagation





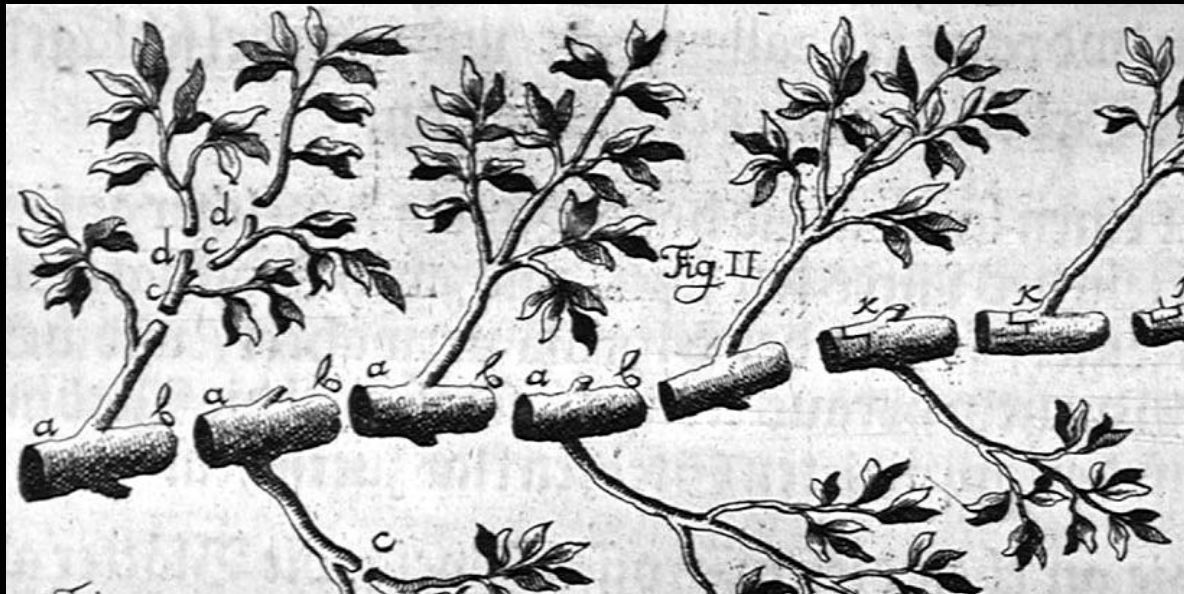
# Juvenility



**Theophrastus** describes propagation by both stem and root cuttings. In his description of taking stem cuttings in olive, he makes a reference to the concept of juvenility as it relates to rooting. He recommends **taking cuttings from the base of the tree rather than the tops.**

# Juvenility

The Roman, **Columella** (ca. 1 AD) in great detail describes taking mallet stem cuttings in grape. A **mallet cutting** is a combination of current and previous season's stem growth. He states that cuttings root better when taken from **non-fruiting wood**.





## Auxin

Although the concept of auxin and its ability to stimulate rooting in cuttings is a modern concept. **Theophrastus** describes improved rooting in fig cuttings by **setting them in squill bulbs.**



THEOPHRASTUS

# Willow extract

Dr. M. **Kawase** proposed using willow extract to improve rooting in 1971. However, **Agricola** (1721) described drilling holes in a willow branch into which stem cuttings of other species were inserted prior to planting them for propagation.

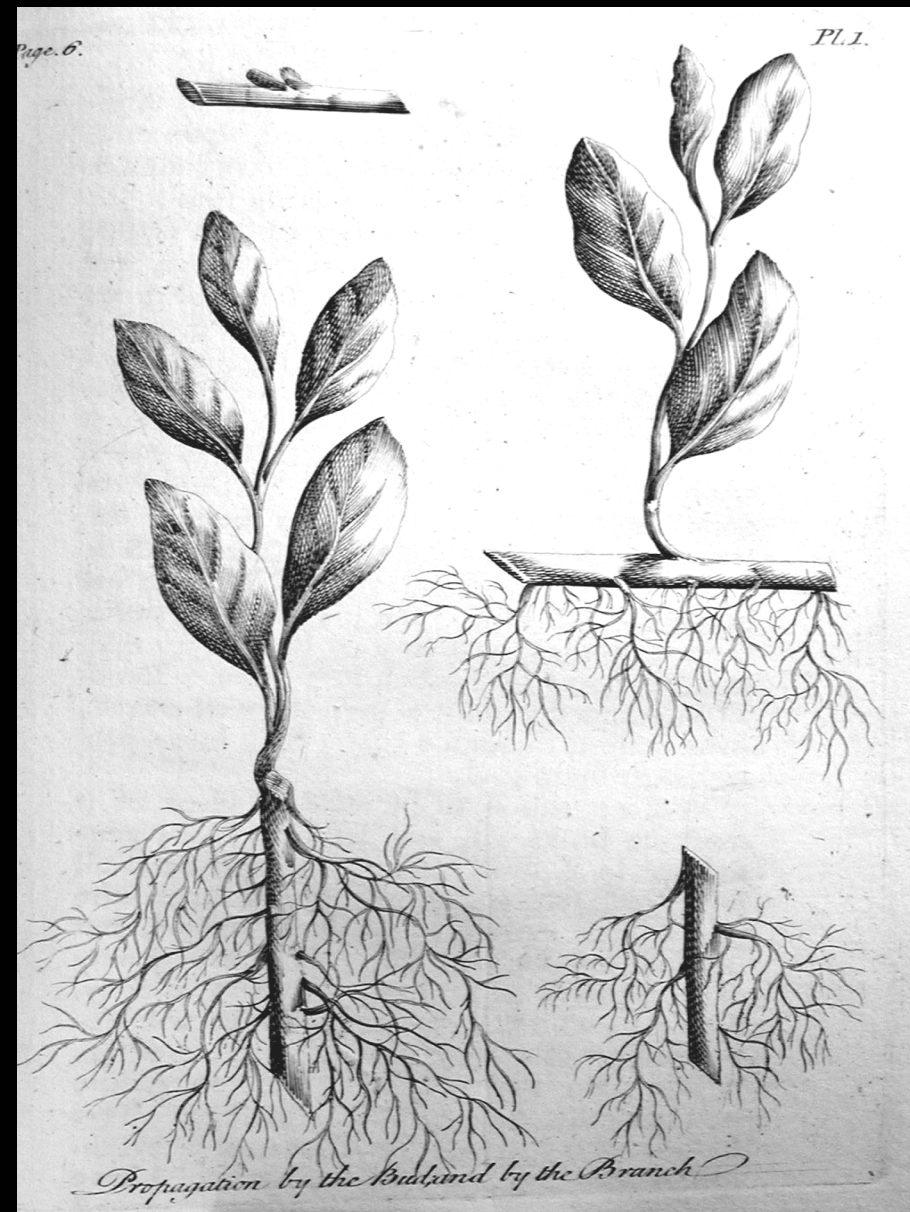




# Thomas Barnes

1758

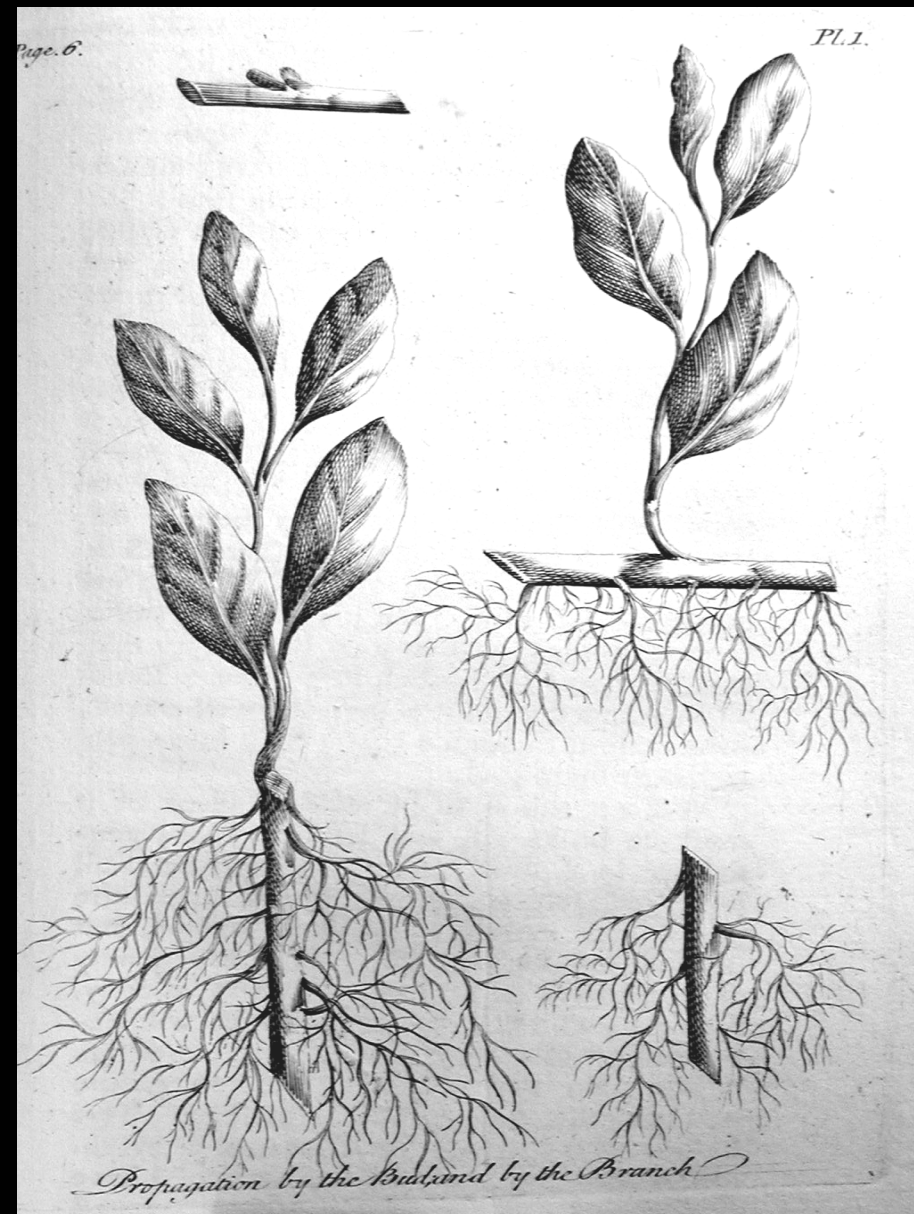
"The occasion and purpose of this work. The difficulty of propagating some shrubs in the common way, and the small increase that can be made from others by the usual methods, brought into my thoughts to try whether some expeditious manner could not be invented of raising a large number."



# Thomas Barnes

1758

"Every nurseryman will be glad to know this: for if he can, when he has got a new shrub, raise twenty or thirty instead of three or four, it will be a great increase for his profit. This made me resolve not to be disheartened at one or two trials."

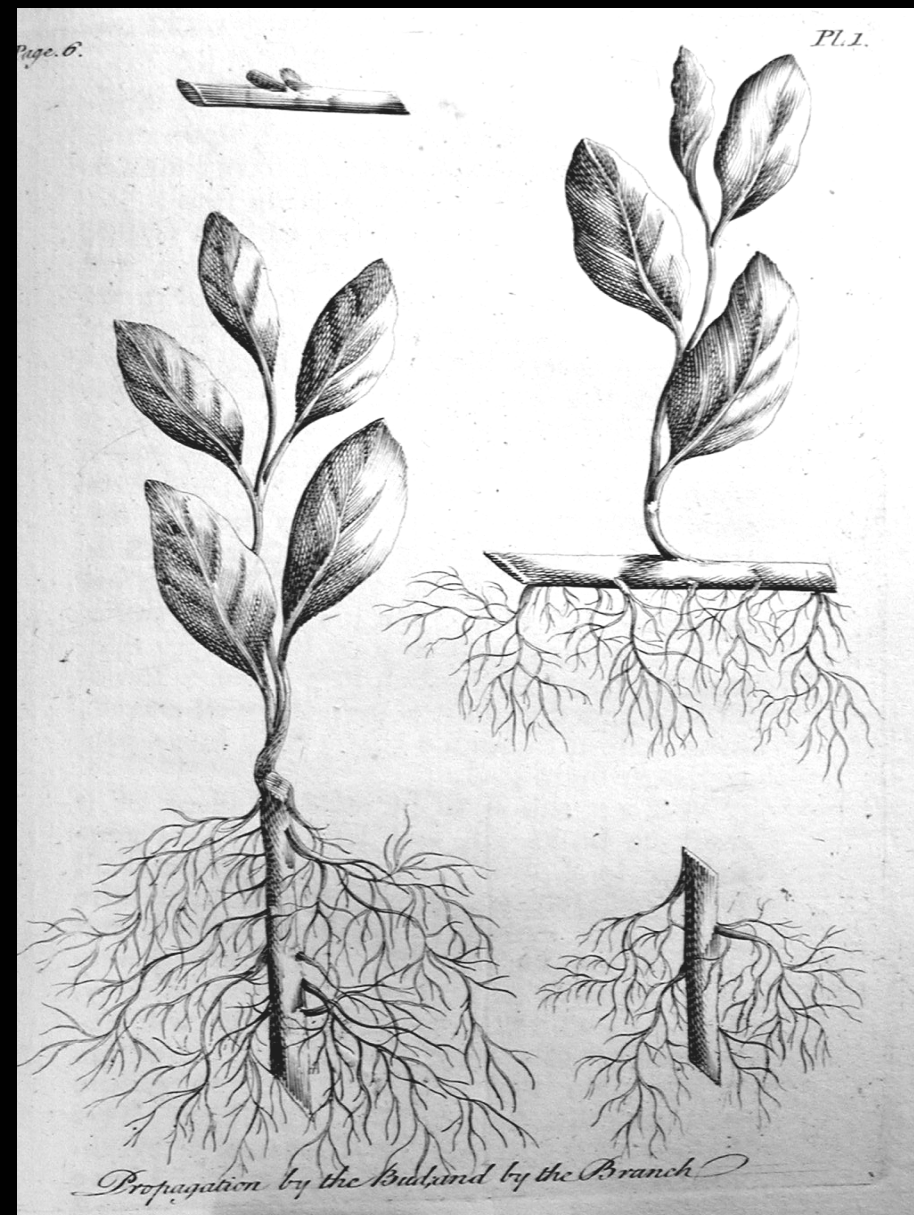




# Thomas Barnes

1758

" Not trusting to one or two samples of each, but using several dozens of every kind, and trying them in all the different conditions of culture. I kept a journal of them all, which I have here faithfully transmitted to the publick; every one will see how far each method succeeded, and which deserves the preference."



# Thomas Barnes

1758

" Melt together, in a large earthen pipkin, two pound and an half of common pitch, and half a pound of turpentine. When melted put in three quarters of an ounce of powder of aloes; stir them all together; and set the matter on fire; when it has flamed a moment, cover it up close, and it will go out."





# Thomas Barnes

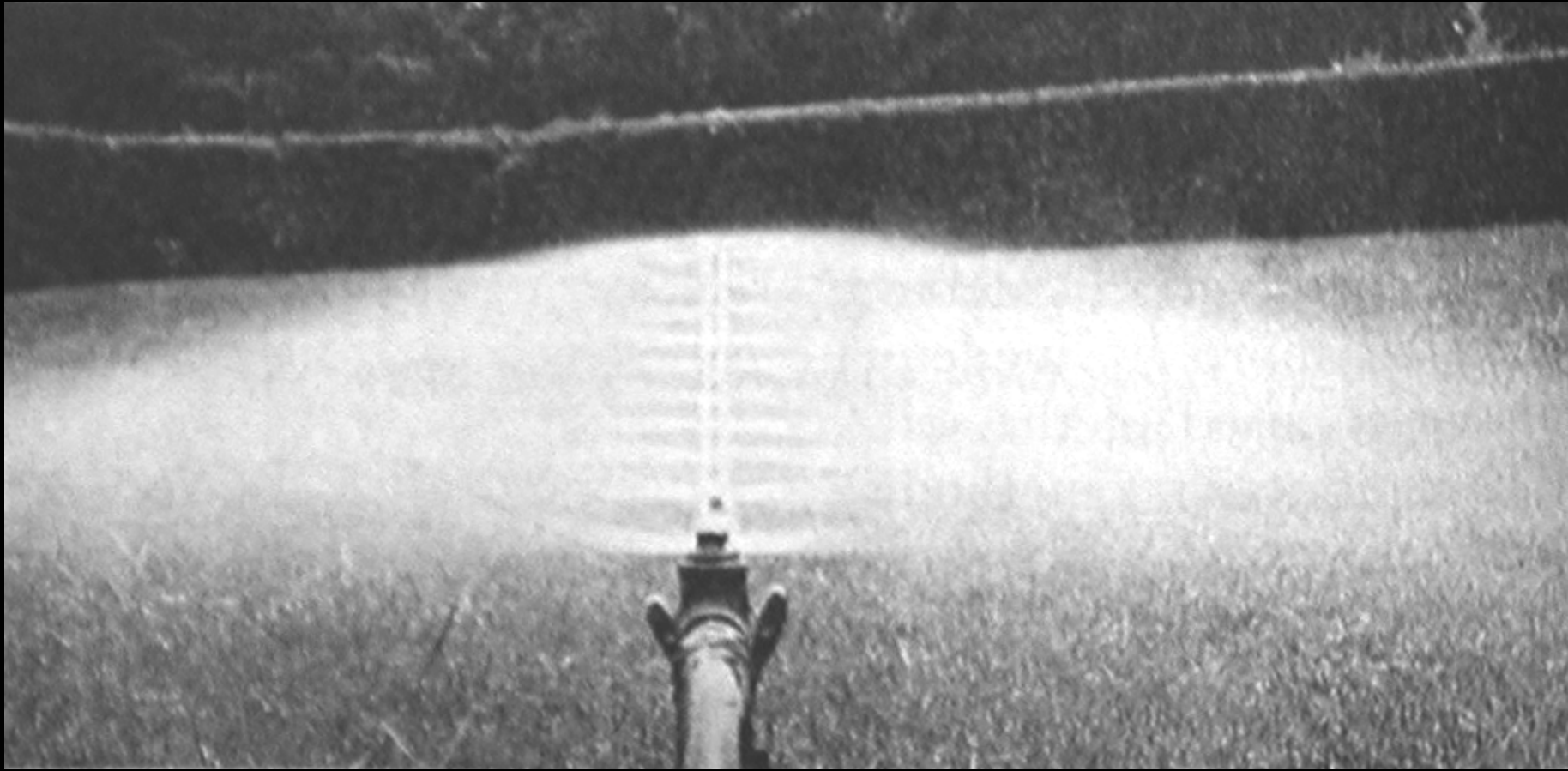
1758

" This must be done three times : it must be done in the open air, for it would fire a house. Melt it again, and put in three ounces of yellow wax shred very thin, and six drams of mastich in powder. Strain it through a coarse cloth into a pan, and set it by to cool ."



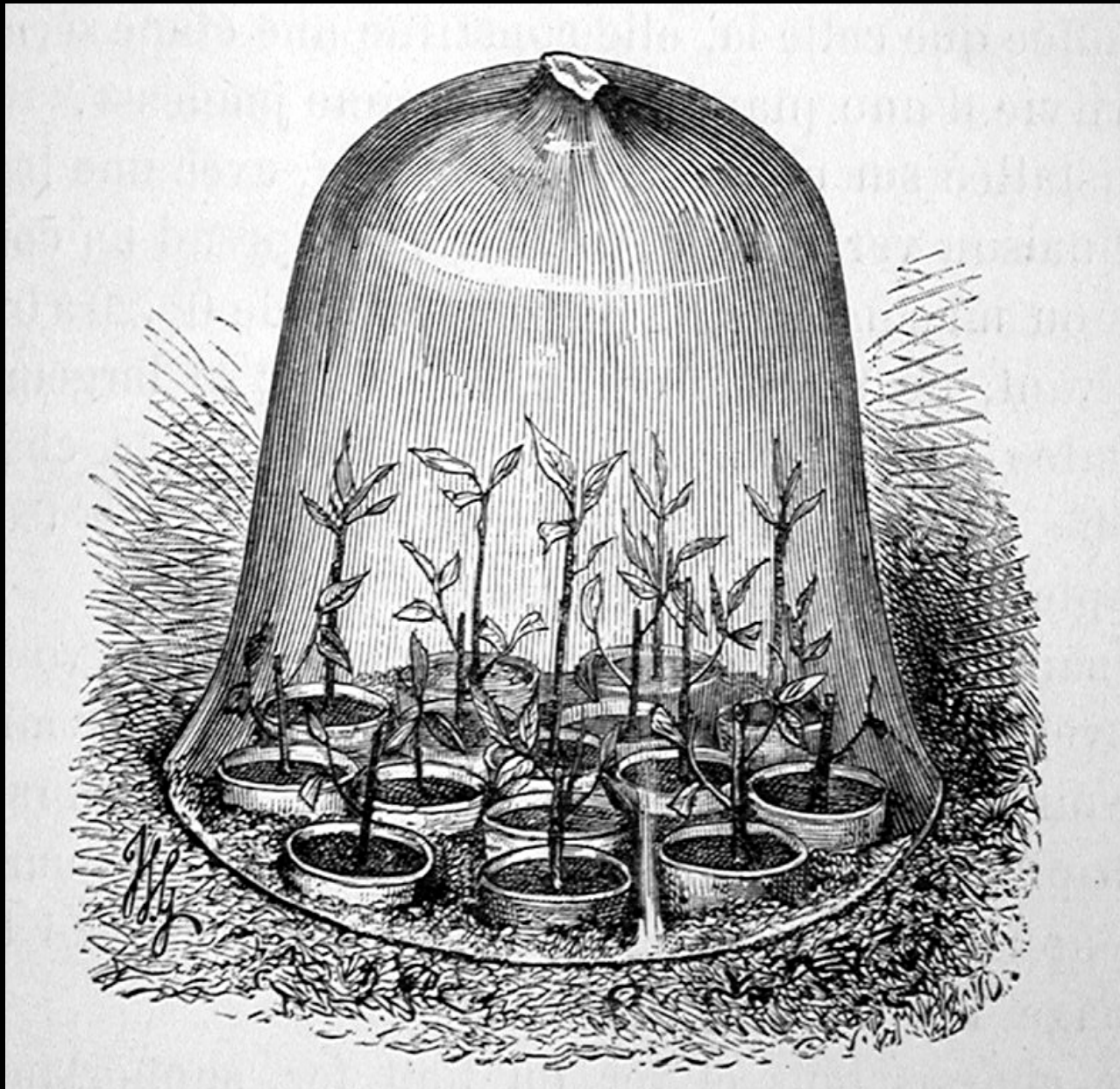


# Mist Propagation



Experimentally available in 1940's  
Commercially practiced in late 1950's

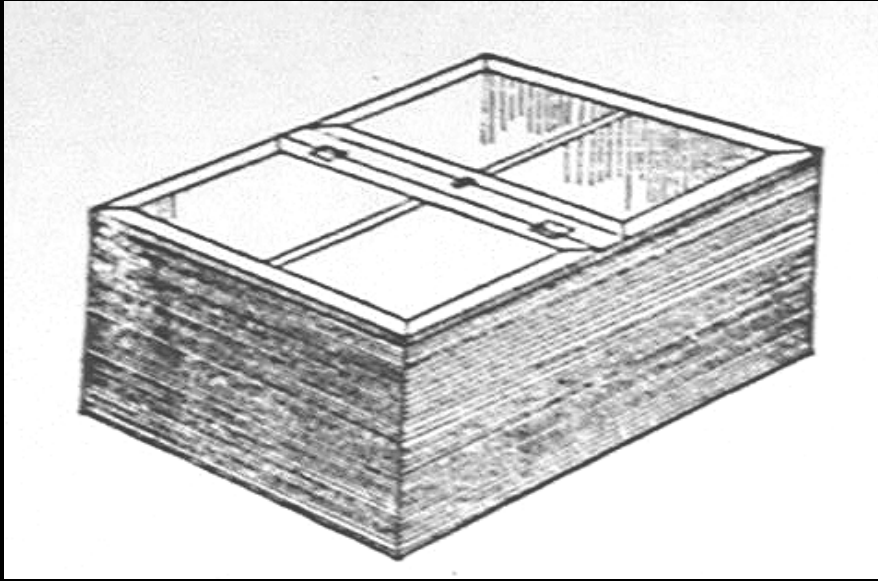
# Propagation Environment



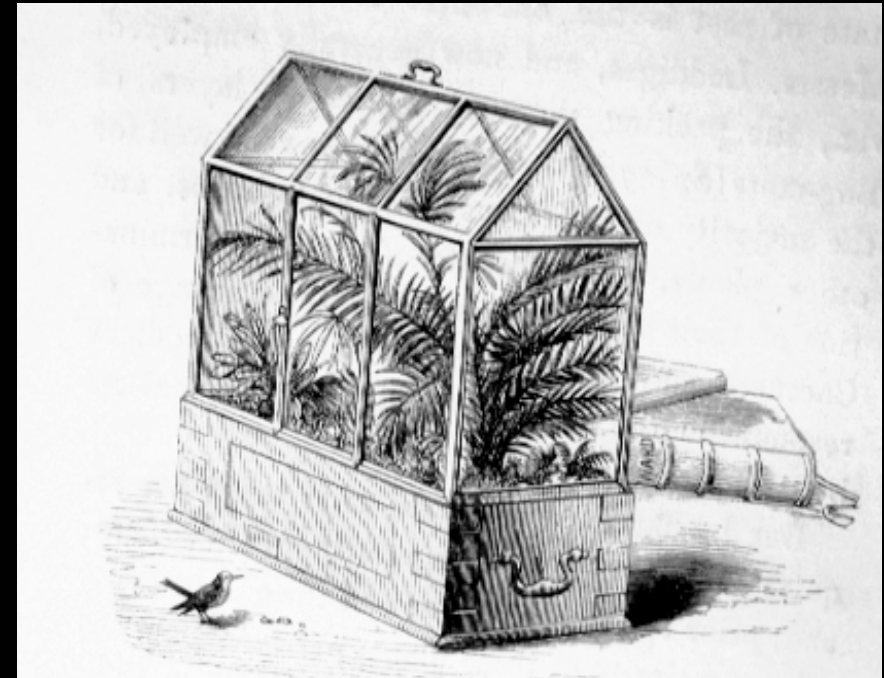
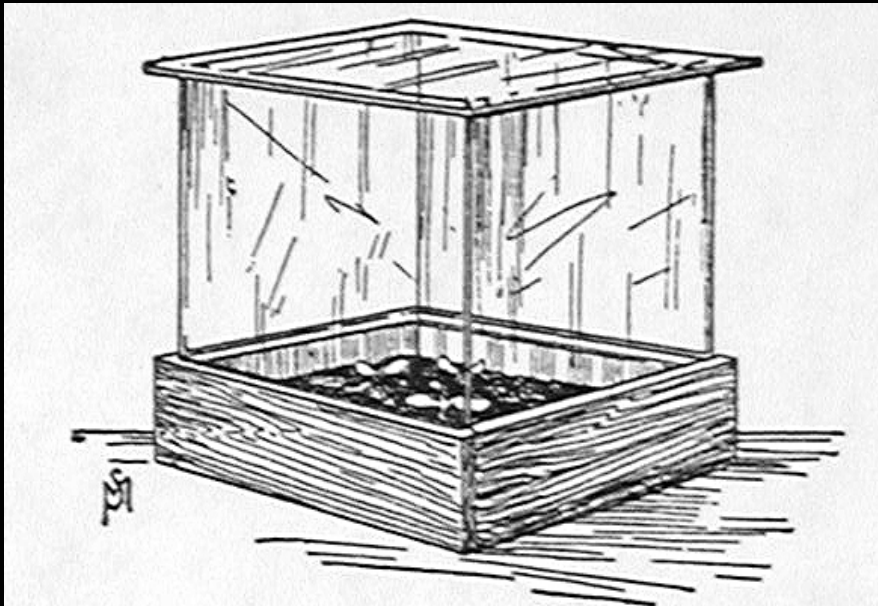
Bell jars.



# Propagation Environment

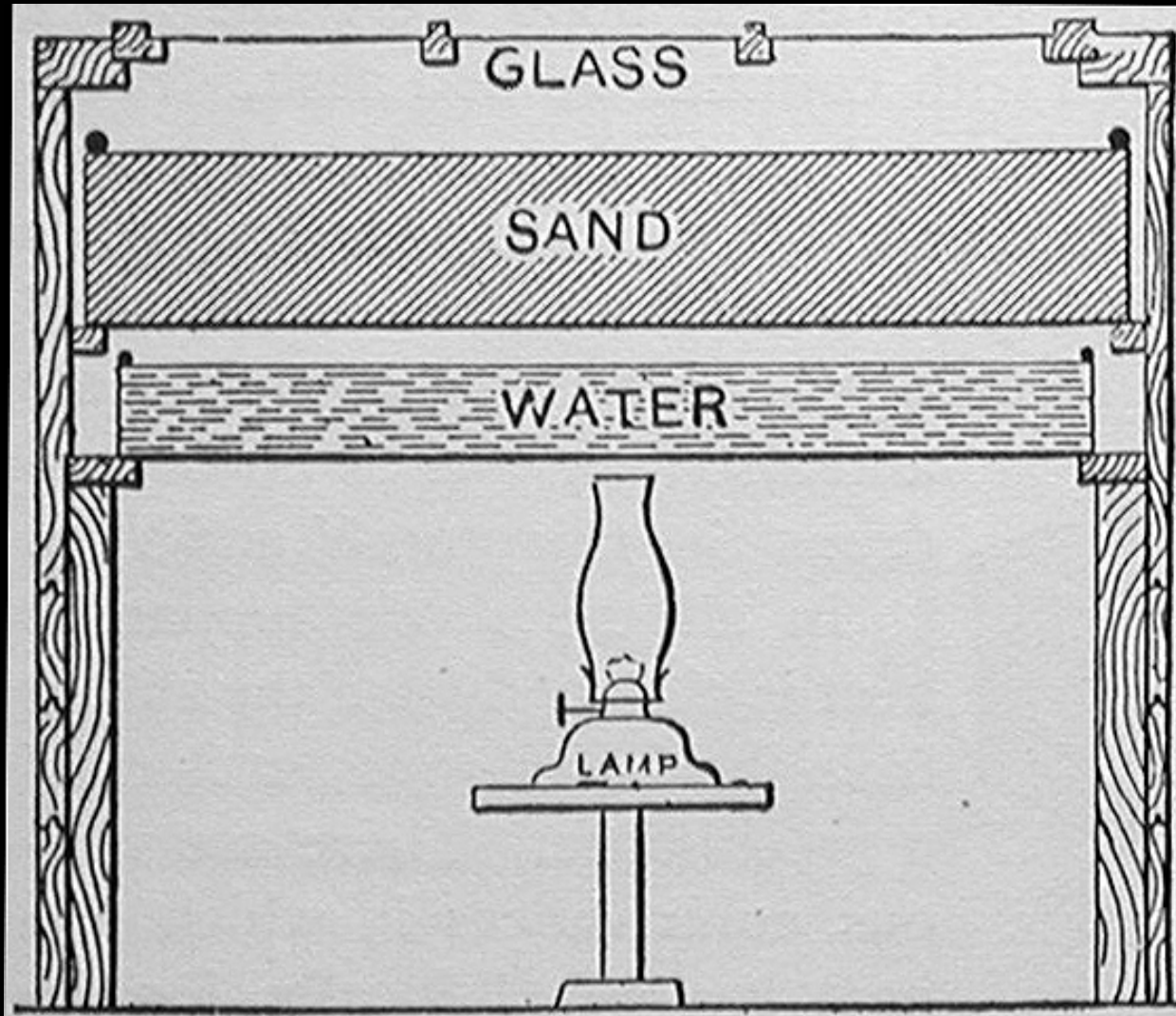


Propagation boxes  
and Wardian cases.





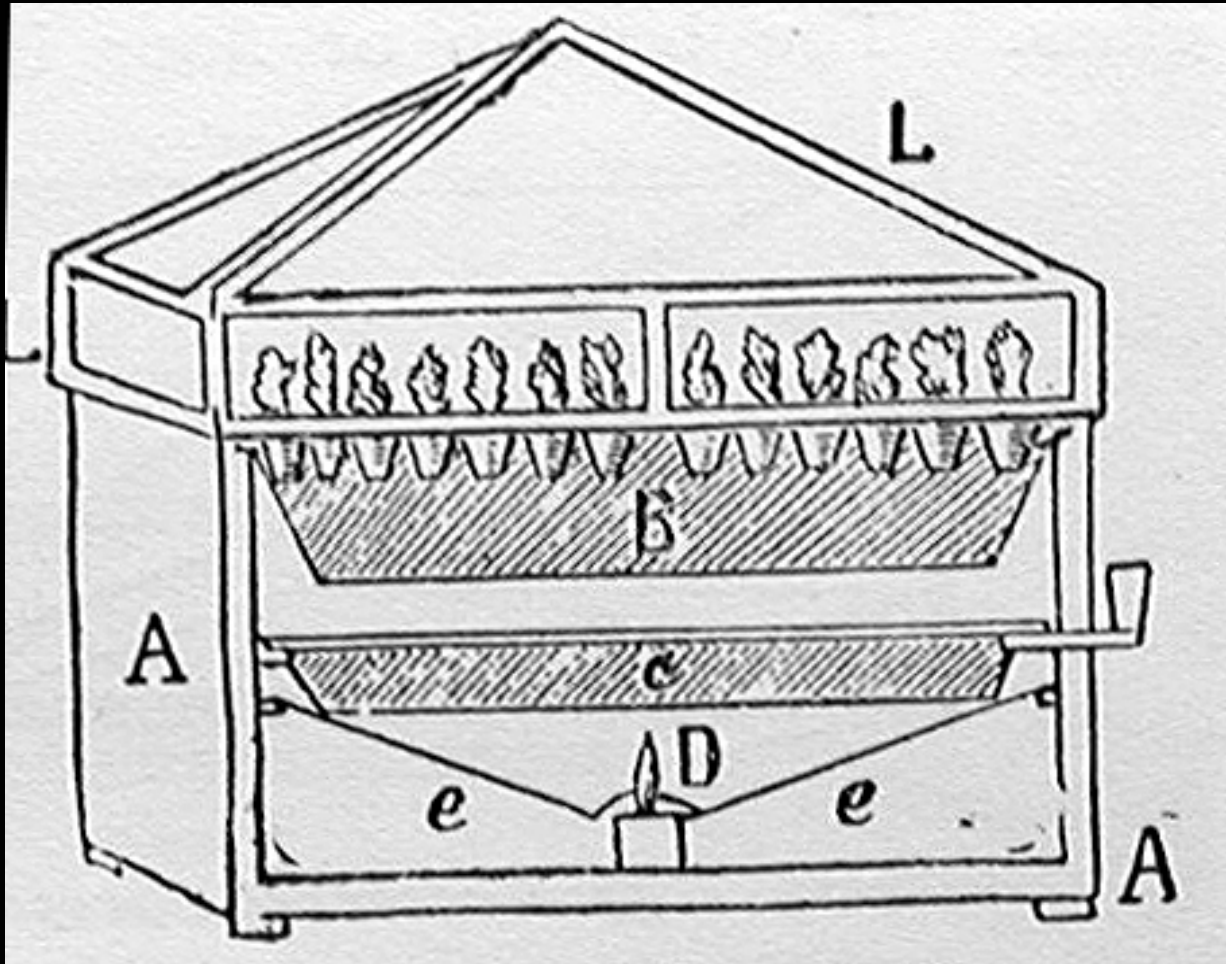
# Propagation Environment



Bottom heat

L.H. Bailey's Nursery Book 1891

# Propagation Environment



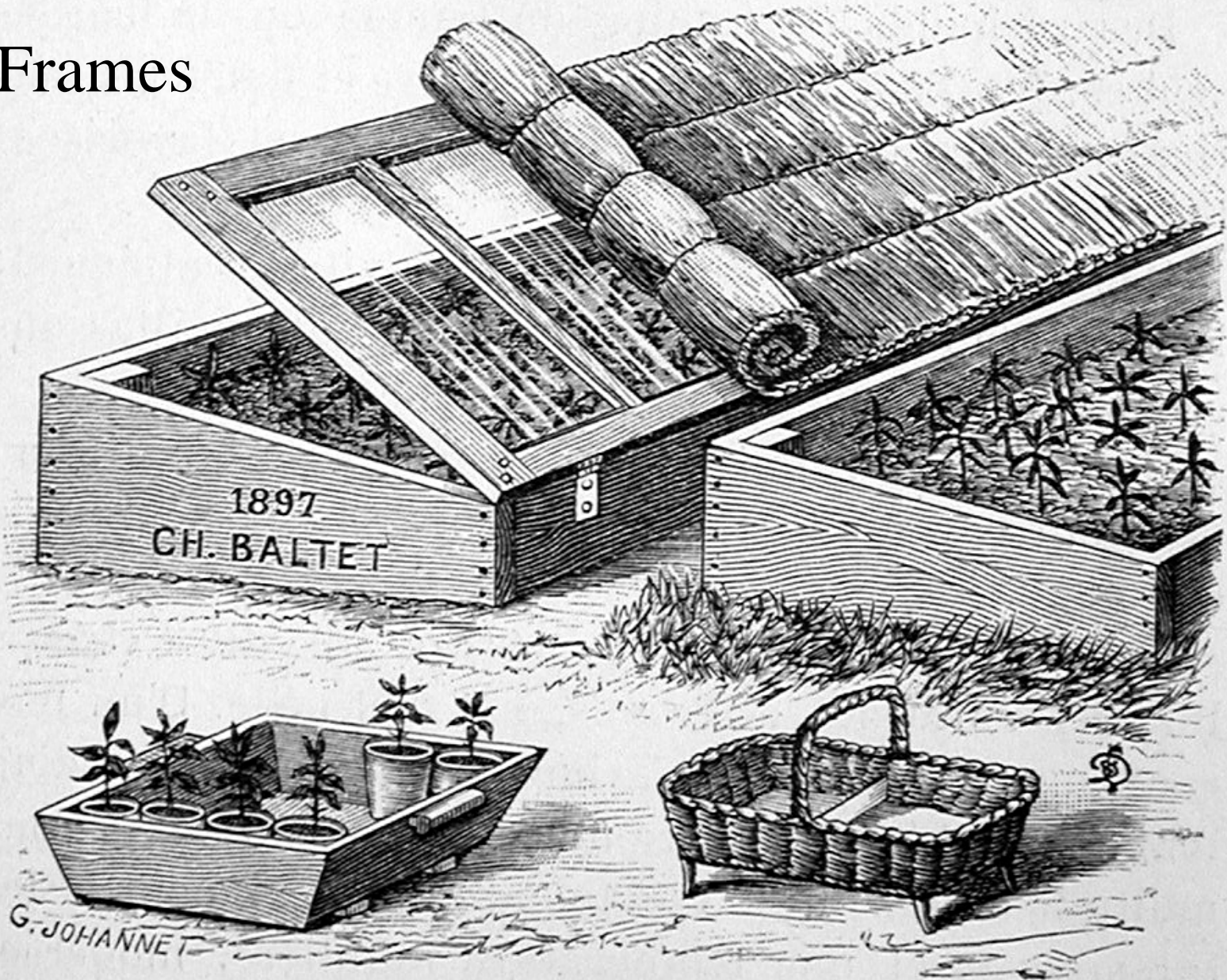
Bottom heat

L.H. Bailey's Nursery Book 1891



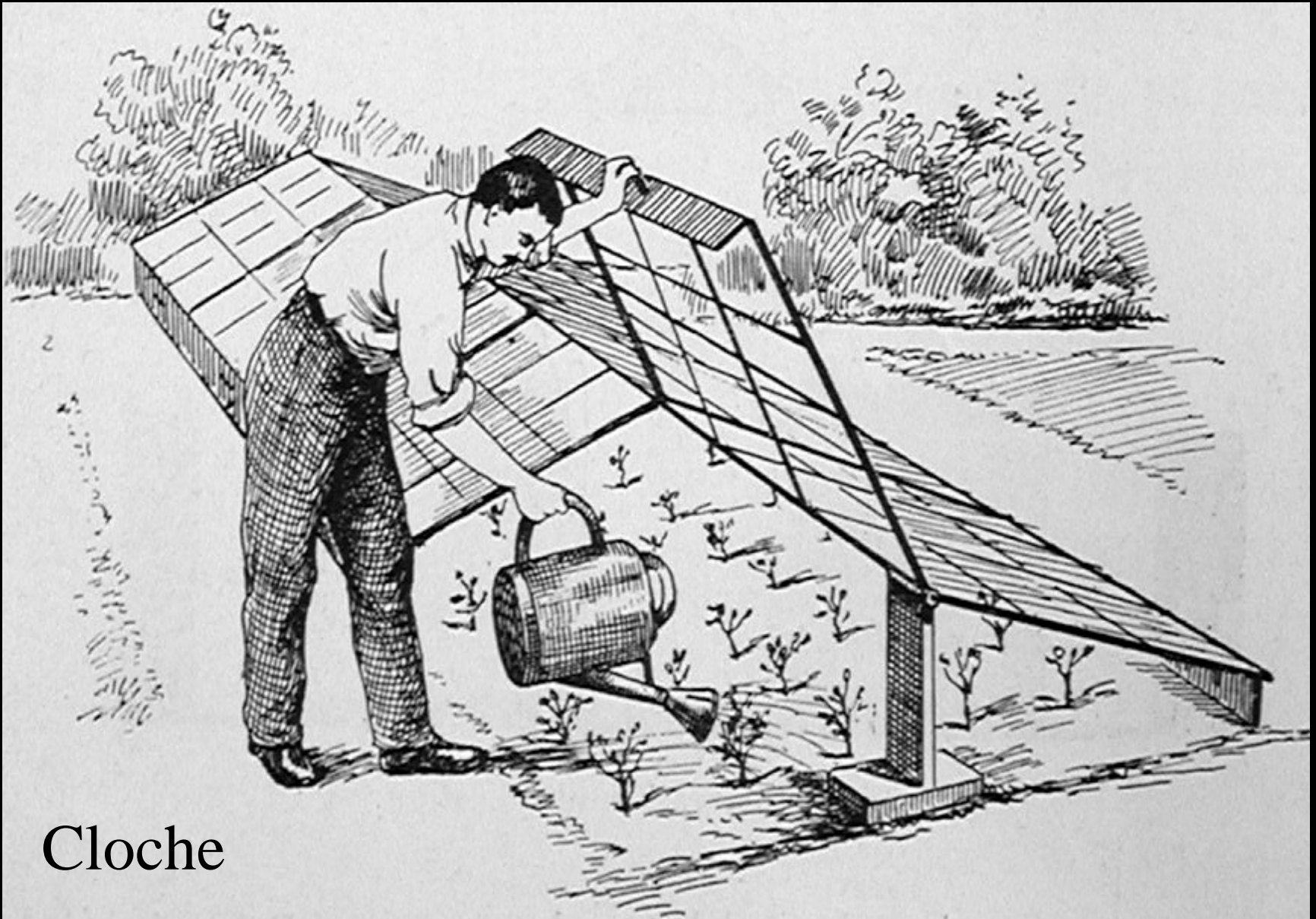
# Propagation Environment

## Frames





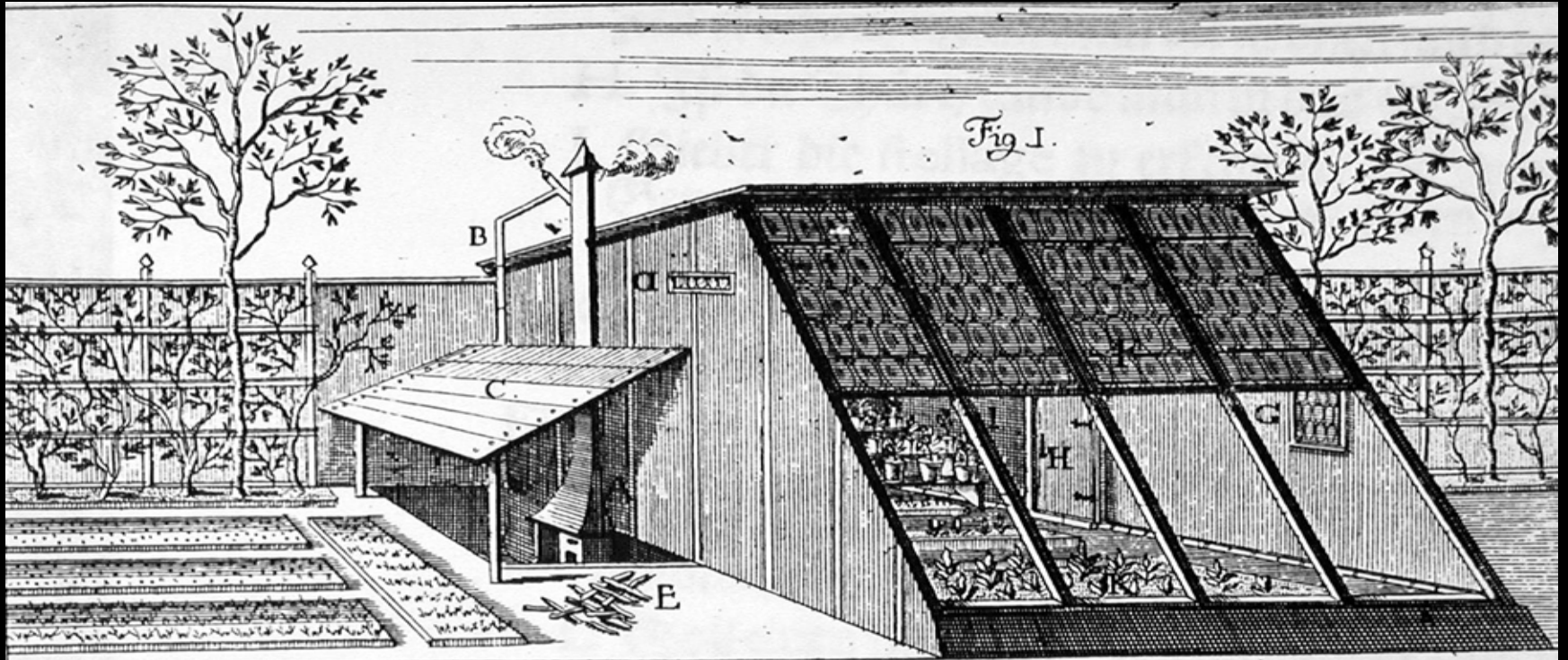
# Propagation Environment



Cloche

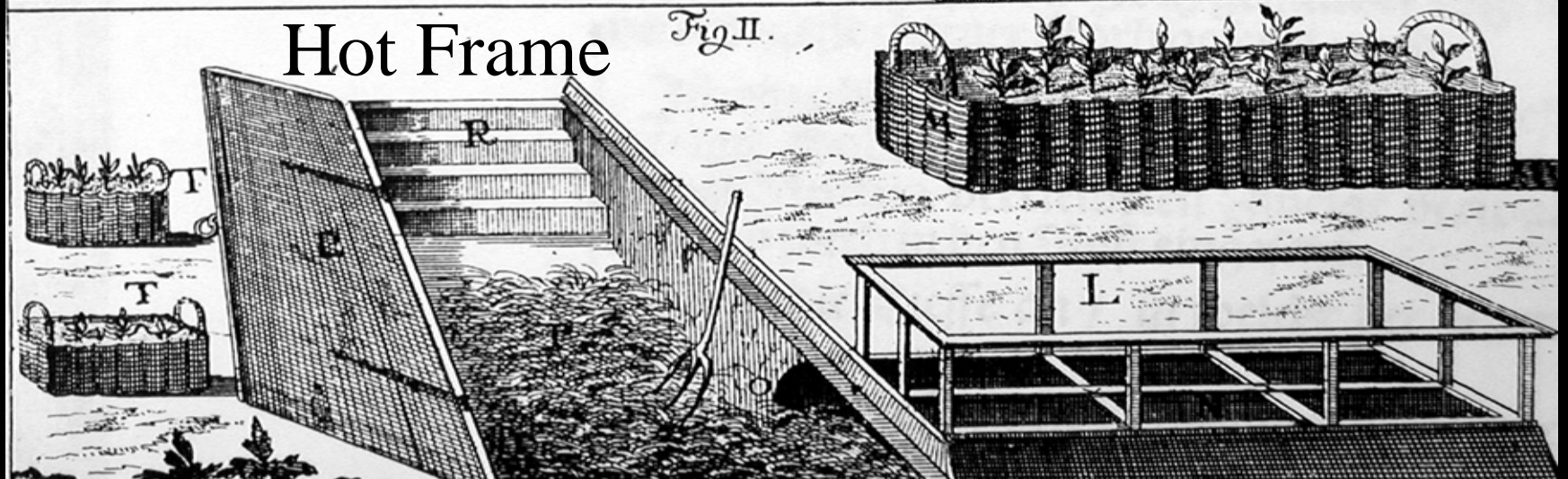


# Propagation Environment



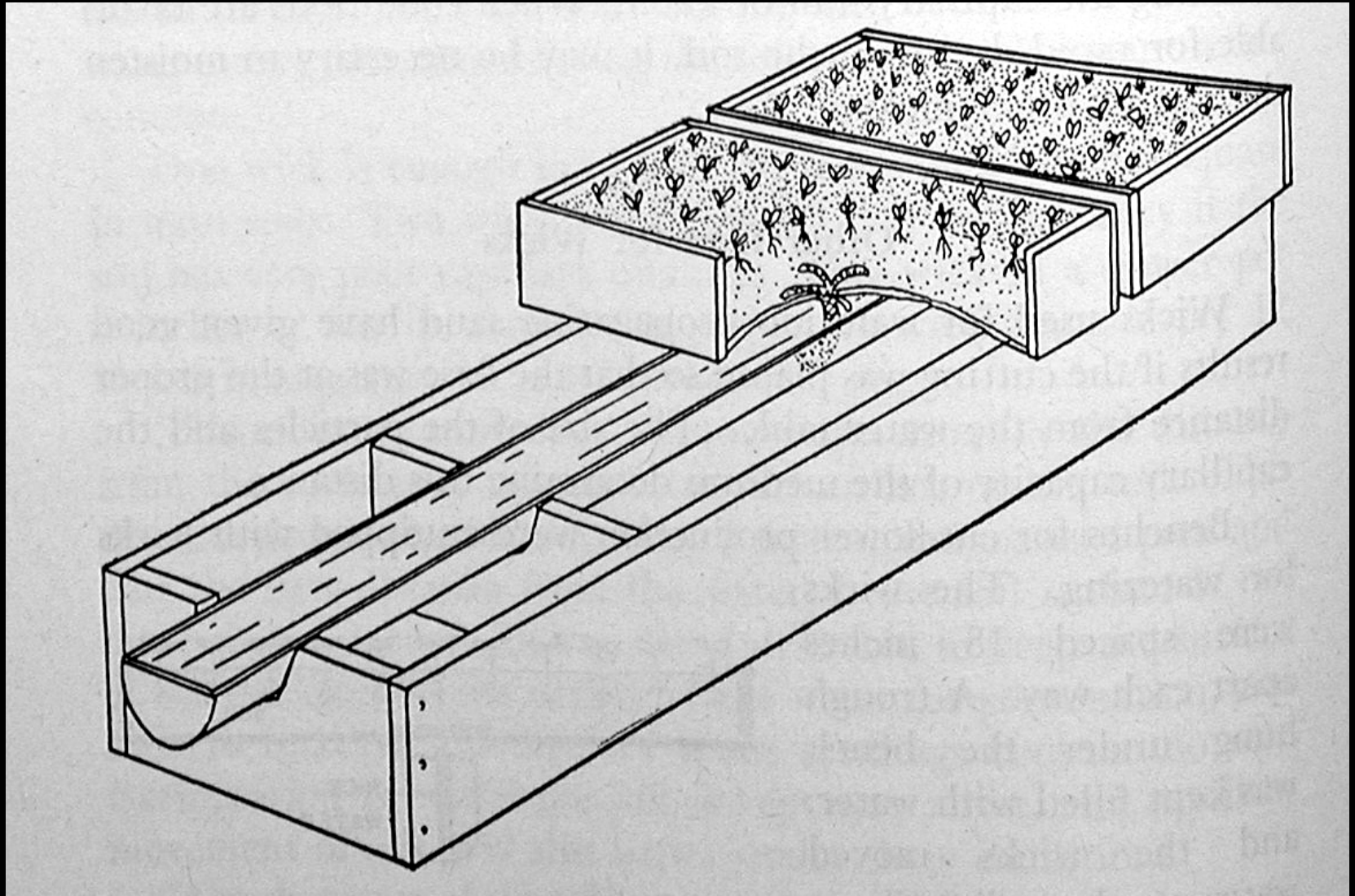
## Hot Frame

Fig. II.





# Subirrigation



Kenneth Post's Florist Crop Production and Marketing 1959



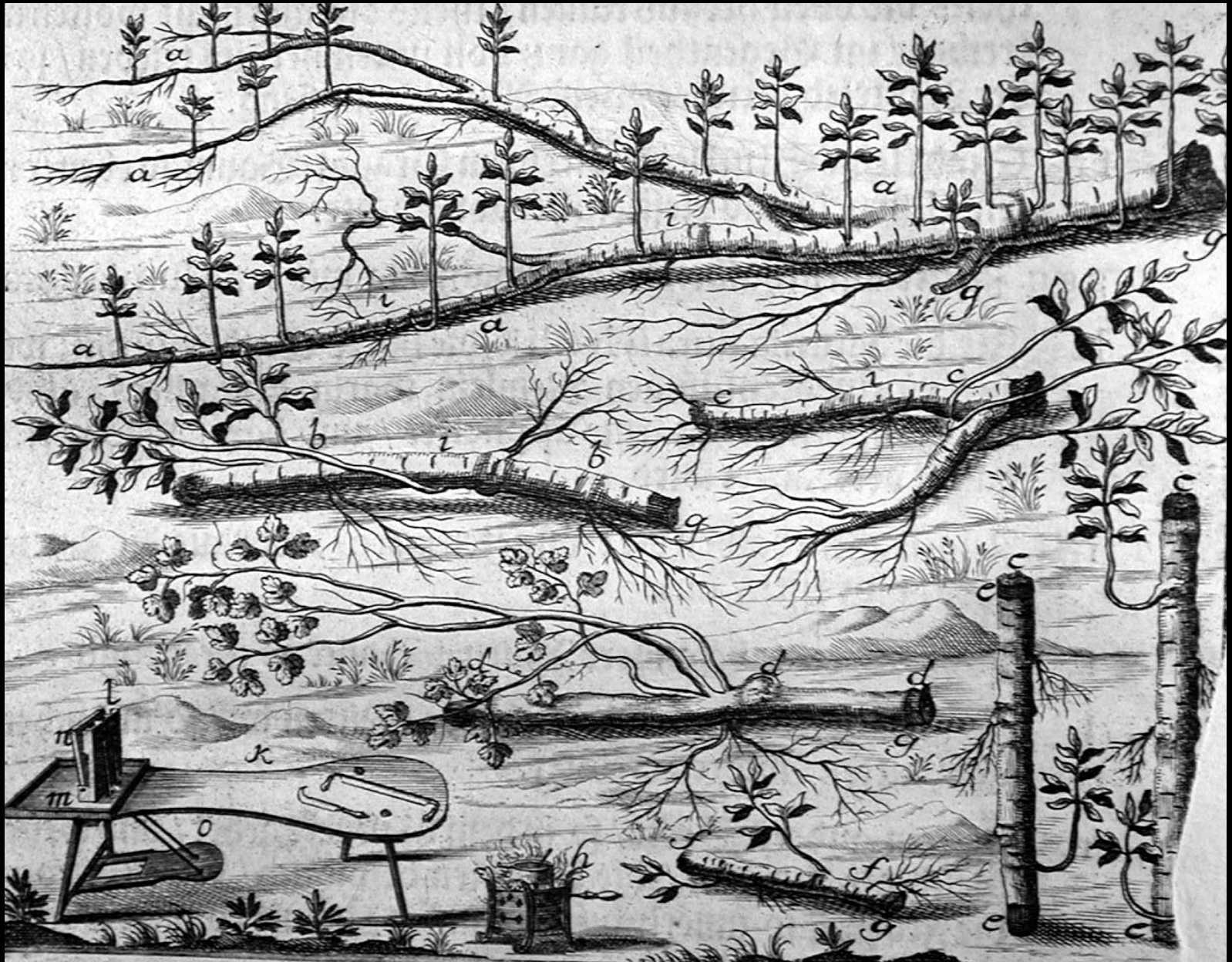
# Subirrigation



Kenneth Post's Florist Crop Production and Marketing 1959



# Layering



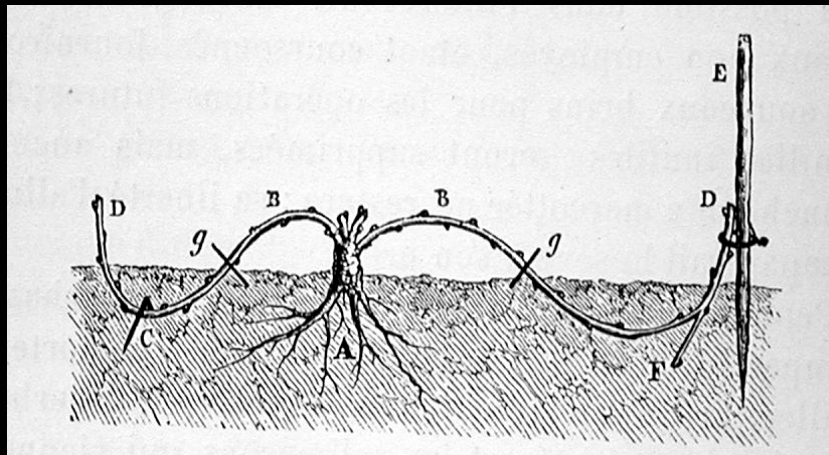


# Philip Miller

## Gardeners Dictionary

1754

"Take some of the boughs, and lay them into the ground about half a foot deep in fine fresh mould, leaving them with the end of the layer about a foot, or a foot and an half, out of the ground, and keep them moist during the summer season, and they will probably have taken, and be fit to remove, in autumn."

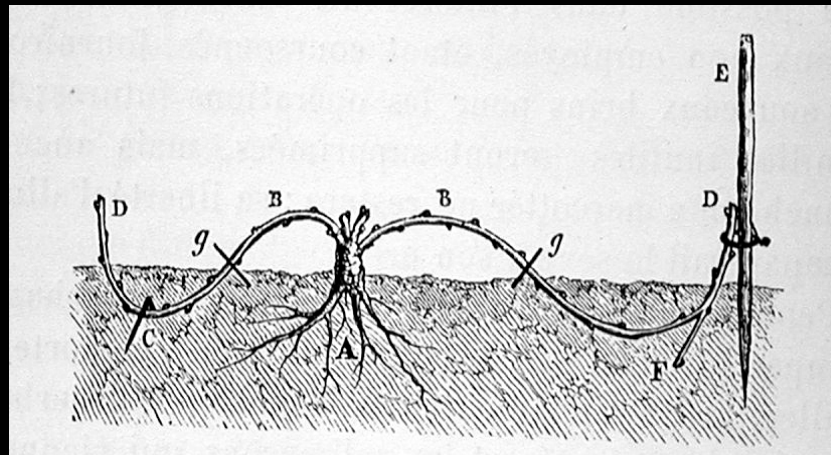


# Philip Miller

## Gardeners Dictionary

1754

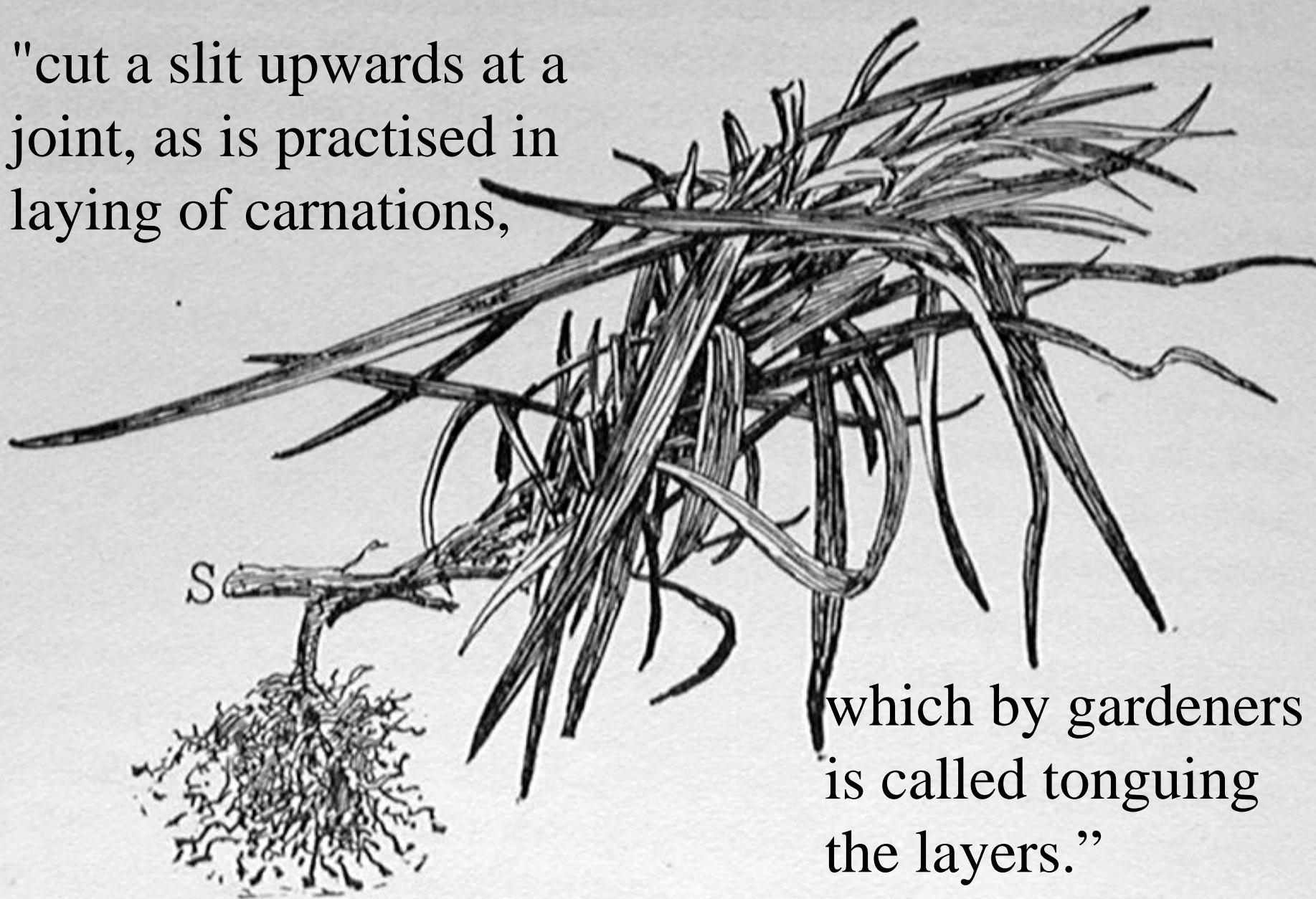
"Tie a piece of wire hard round the bark of the bough, at the place you intend to lay in the ground; prick the place above the wire thro' the bark with an awl in several places, and then lay it in the ground, as before directed."





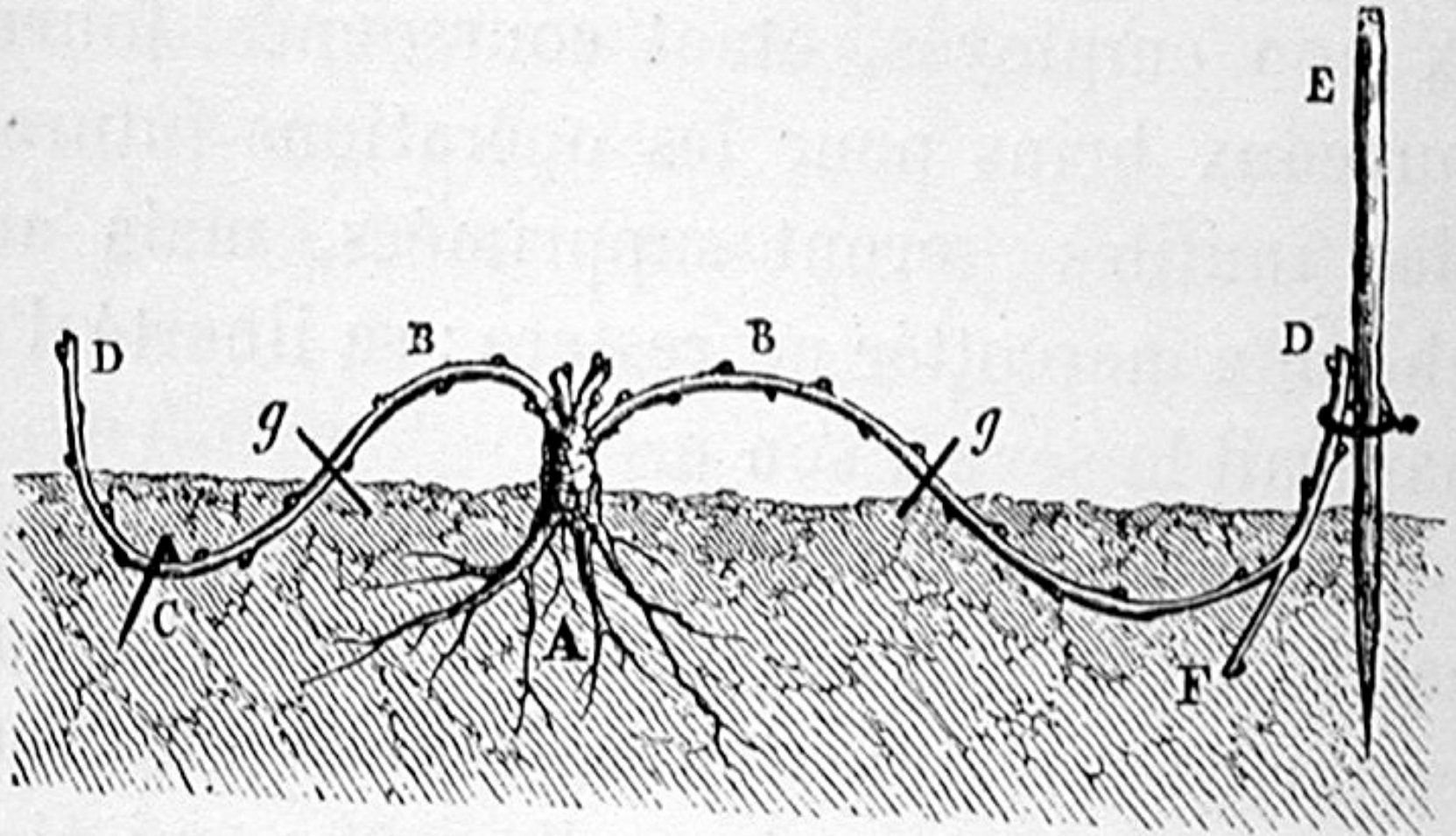
# Philip Miller

"cut a slit upwards at a joint, as is practised in laying of carnations,



which by gardeners is called tonguing the layers."

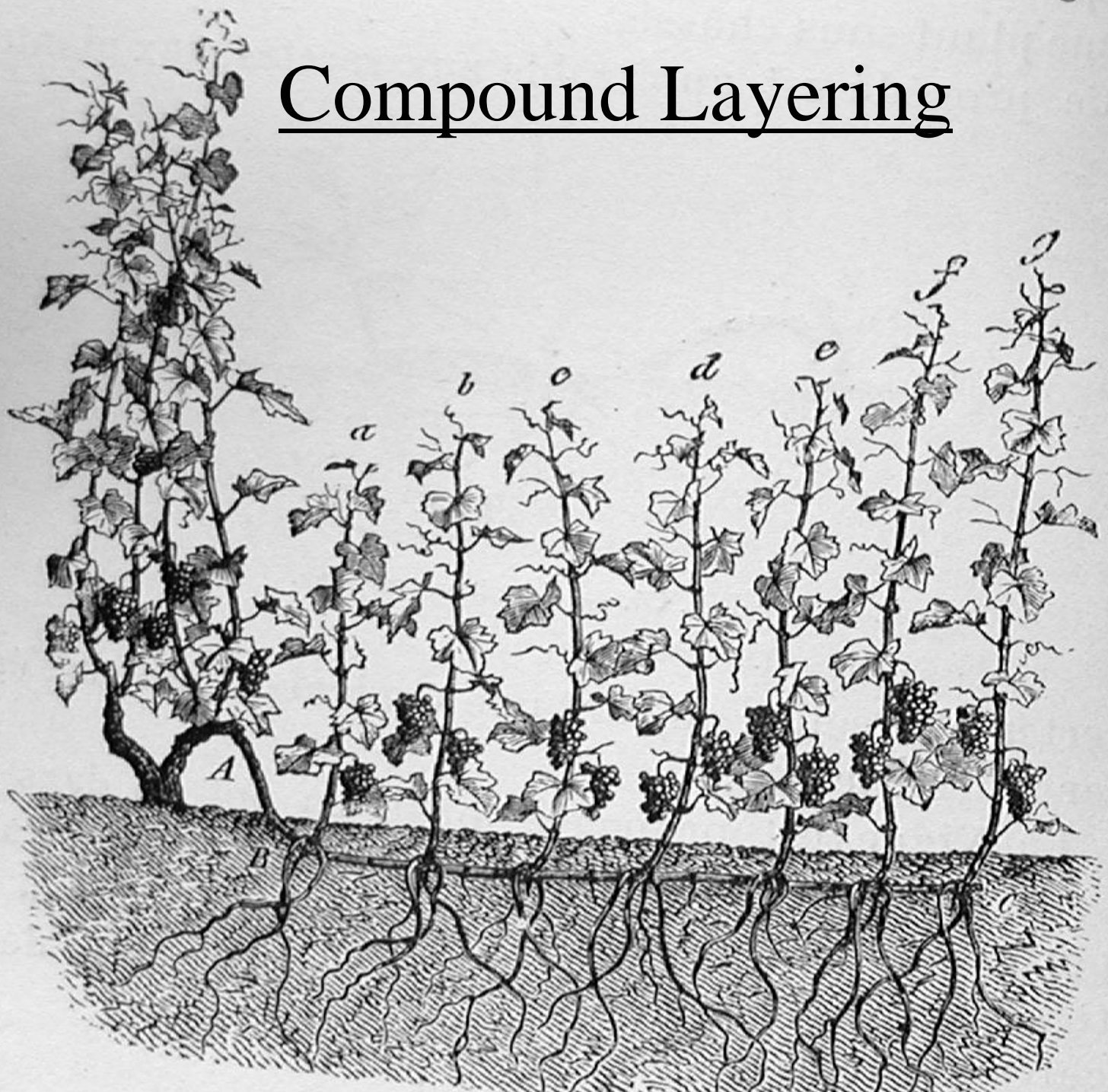
# Simple Layering



Charles Baltet 1903



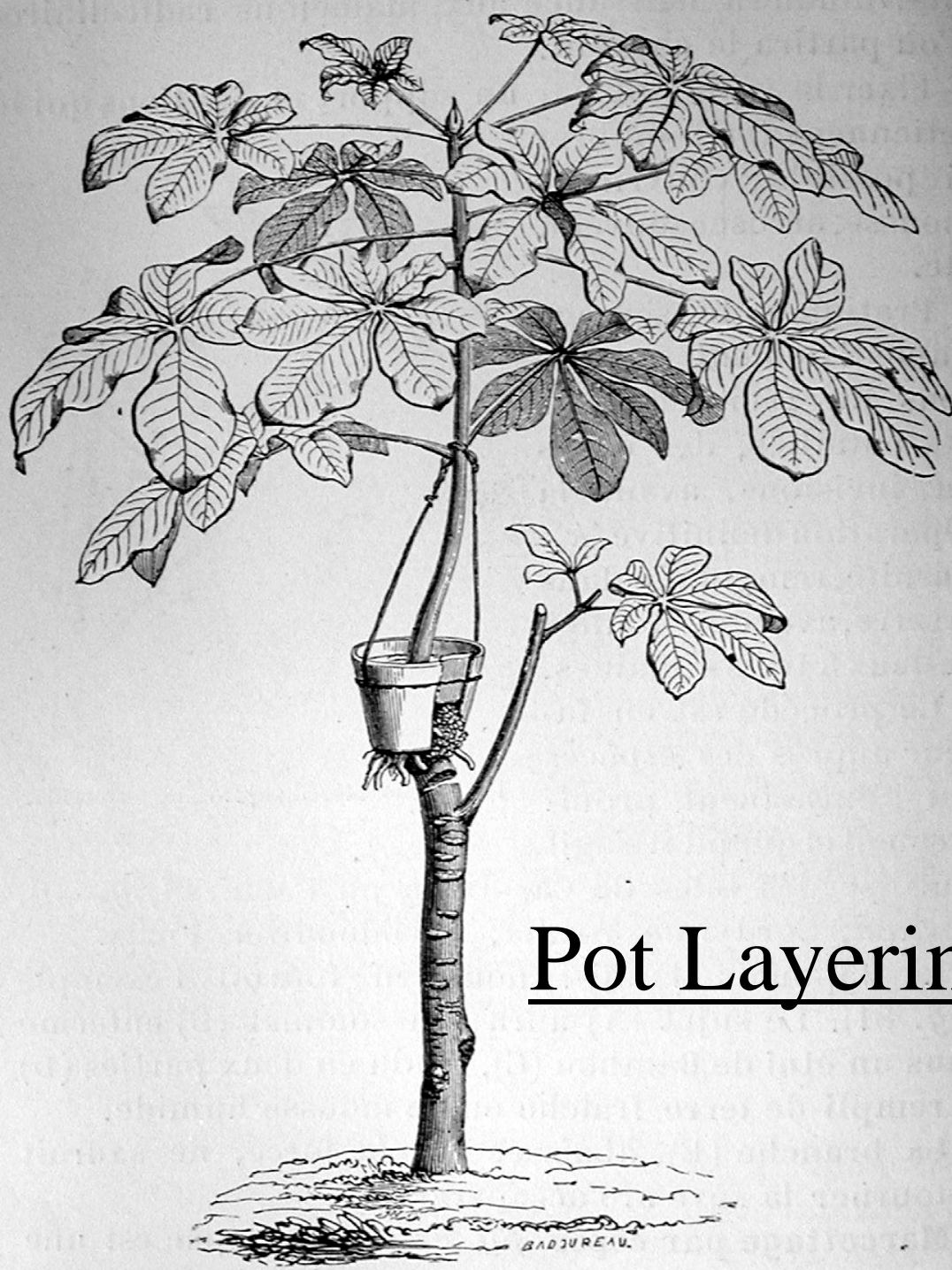
# Compound Layering





# Air Layering





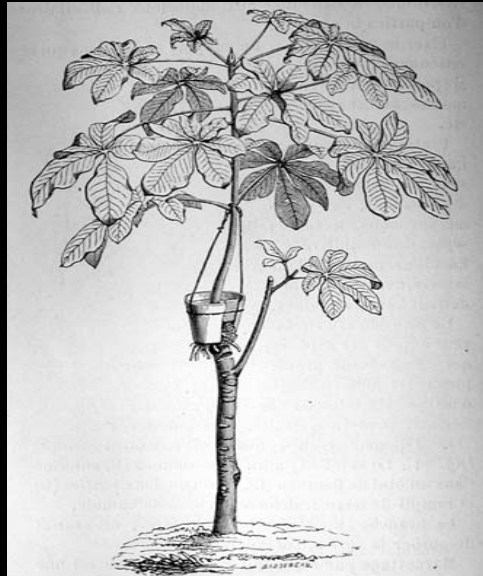
## Pot Layering

# Philip Miller

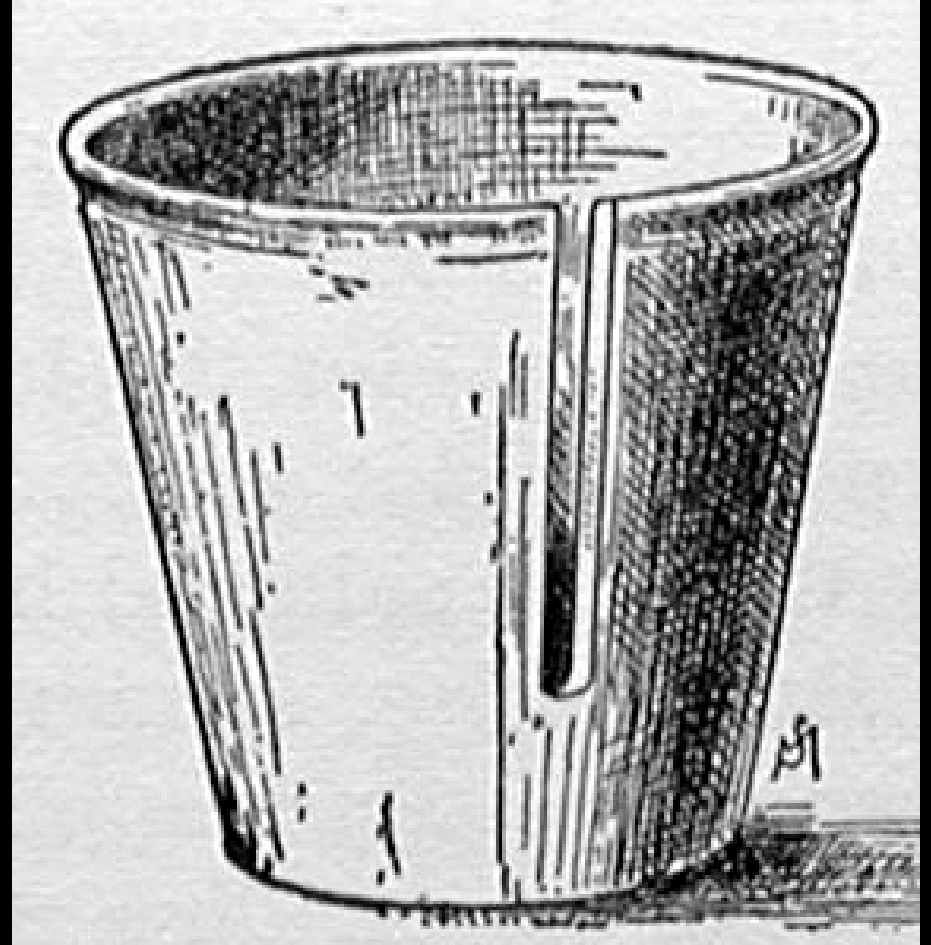
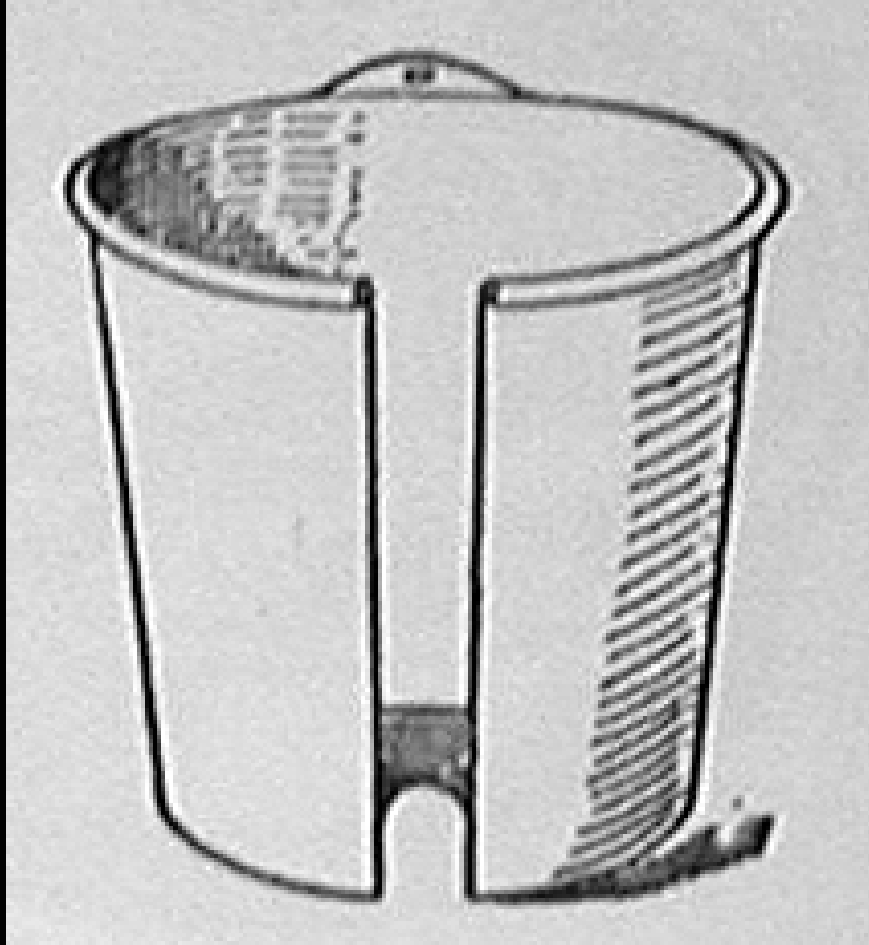
Gardeners Dictionary

1754

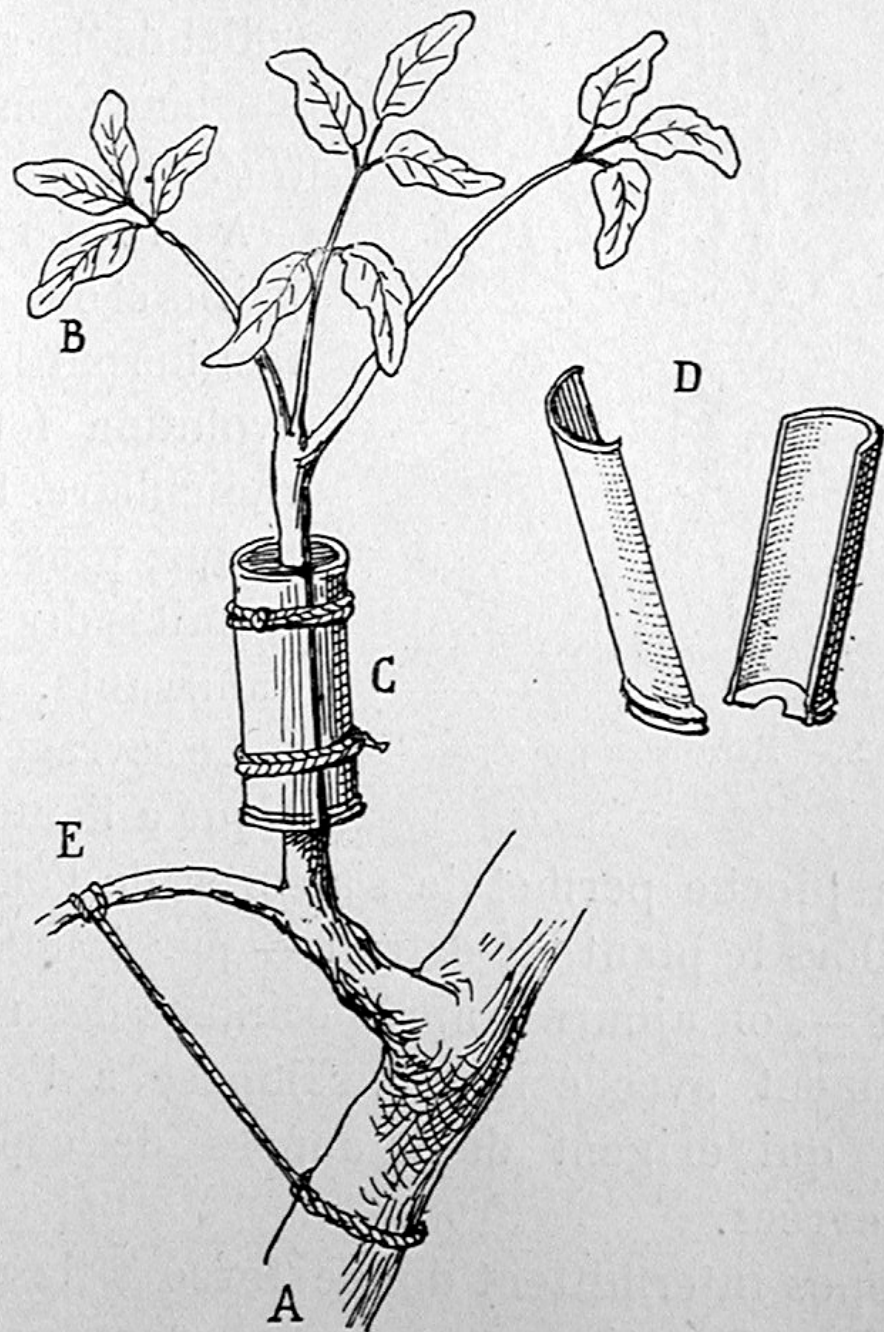
"If ... the boughs of which cannot be bent down to the ground, then you must make use of osier-baskets, boxes, or pots, fill'd with fine-sifted mould, mix'd with a little rotten willow-duft, which will keep moisture and assist the layer in taking root."



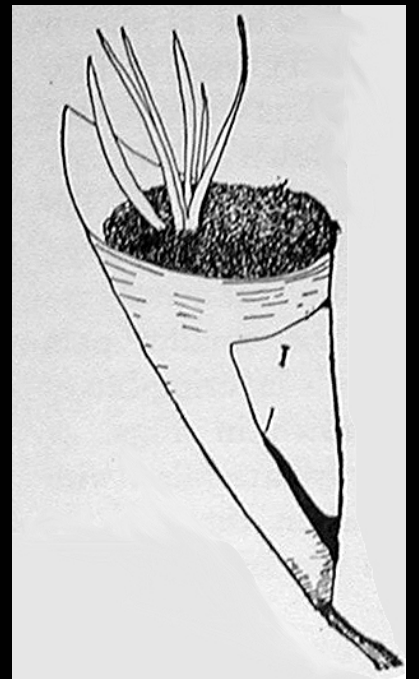
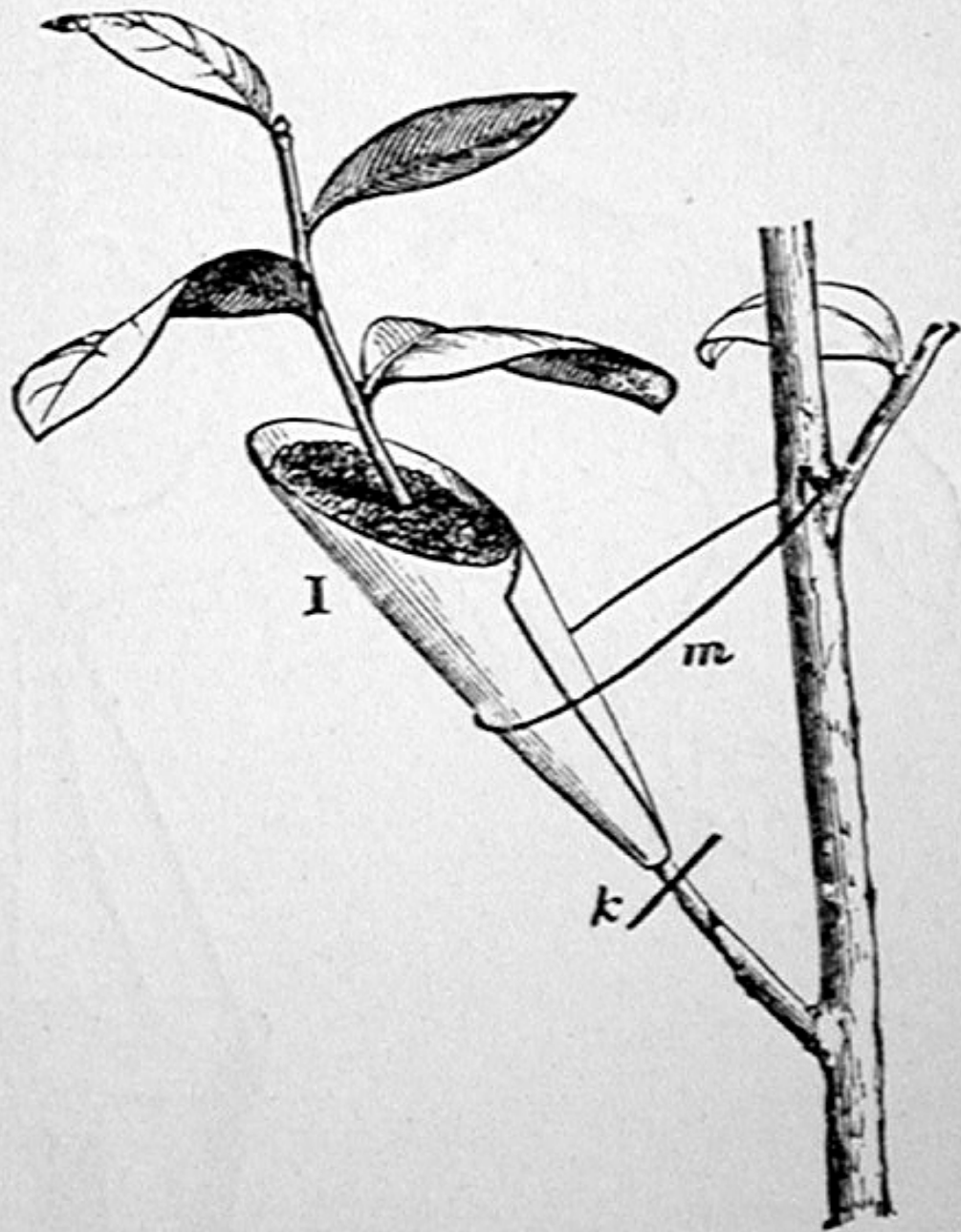




Charles Baltet 1903







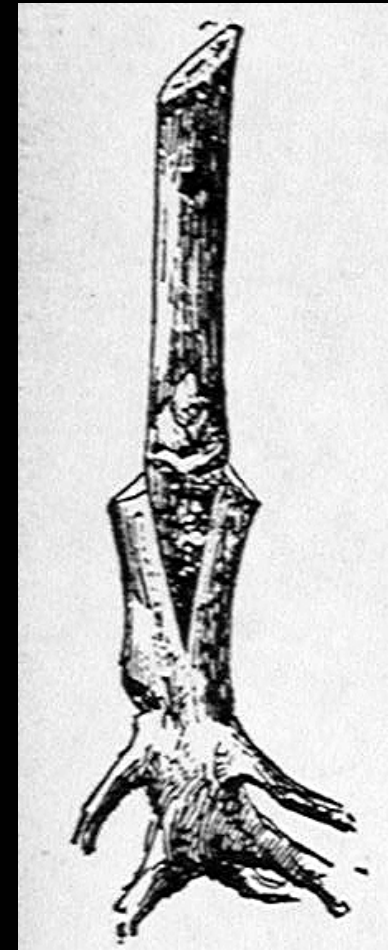
# Graftage





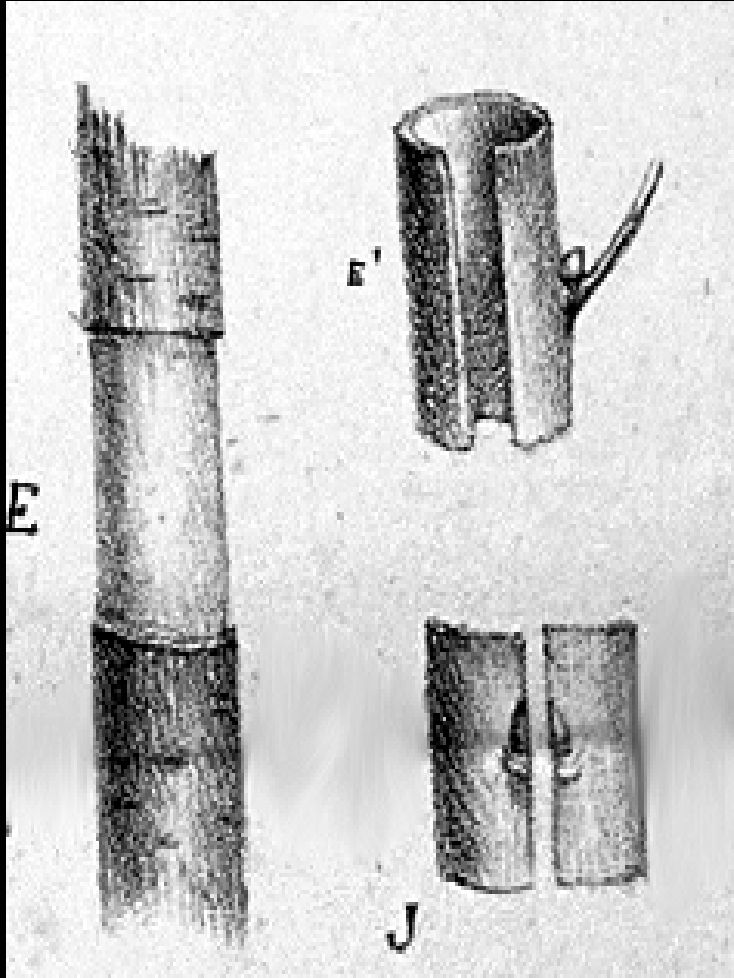
# Theophrastus (ca. 300 BC) on wedge grafting

"... after splitting the stock and giving the scion a wedge-like shape then drive it in with a mallet to make the fit as tight as possible. Then to avoid having the graft dry out."



"... first bandage the site with layers of lime bark and then plaster mud over it mixed with hair : to make the fluid remain and keep sun, rain and cold from doing any harm."

# Columella (ca. 1 AD)

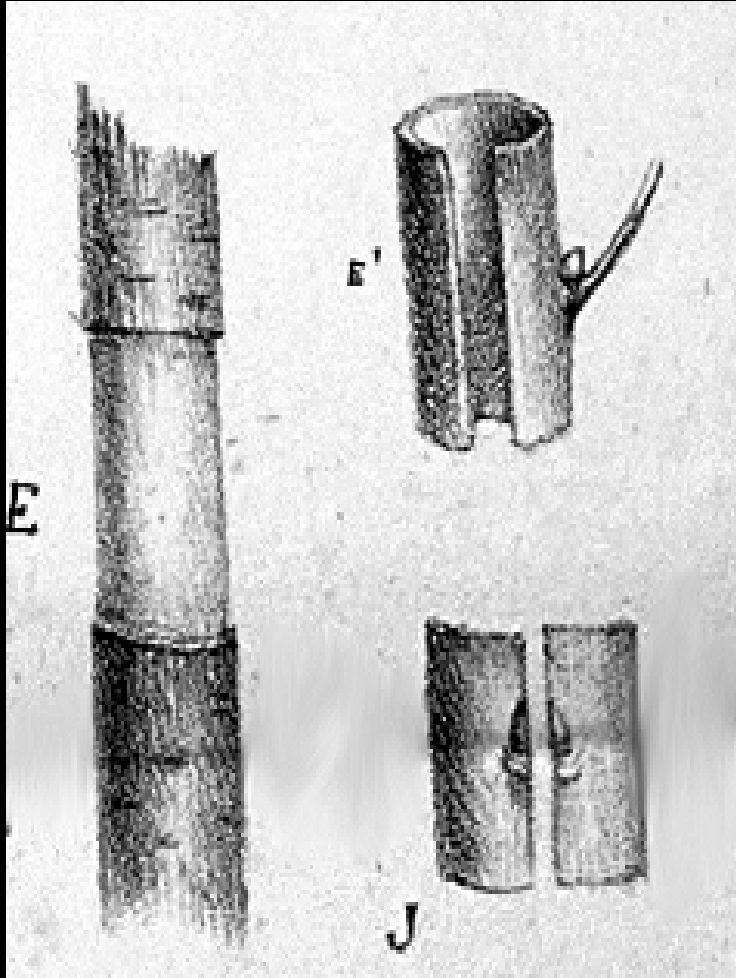


He describes one of the first types of budding as his own invention.

Ring or annular budding.



# Columella (ca. 1 AD)

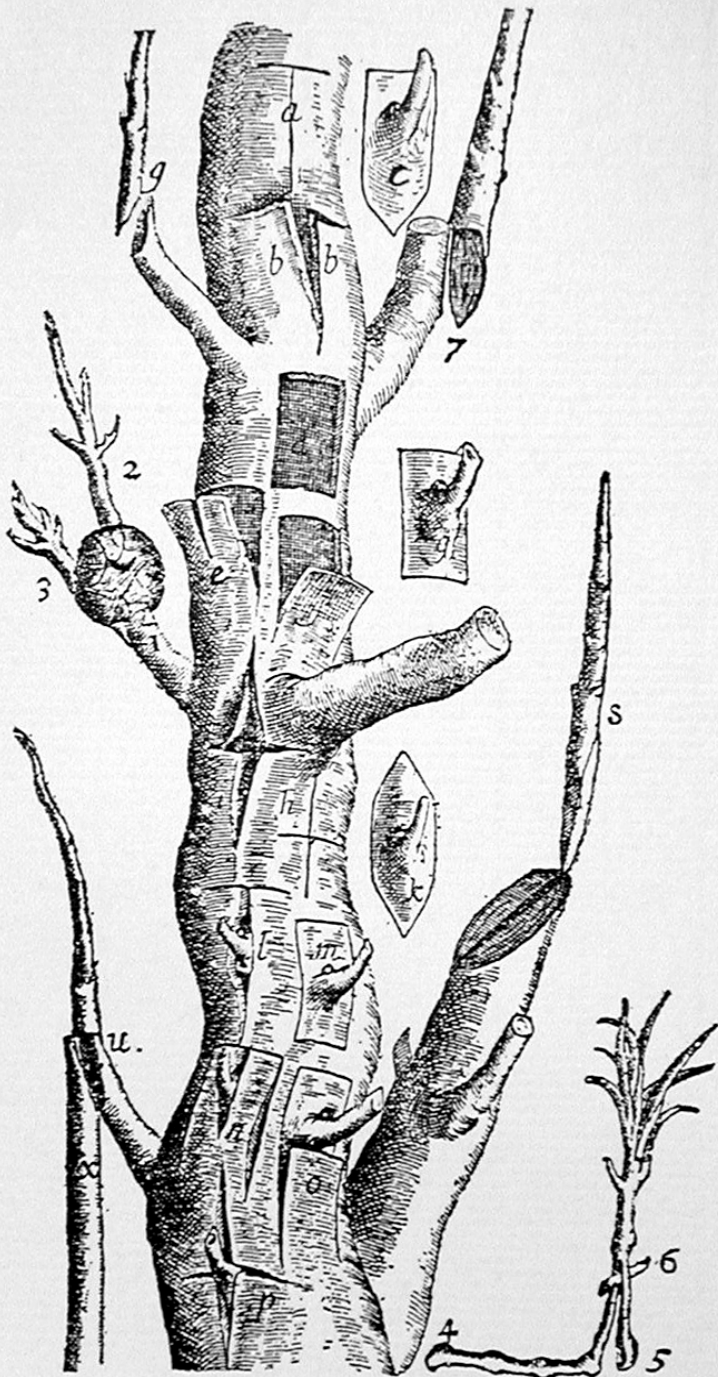


" ... also choose the healthiest branch of the other tree, which you are going to **inoculate**, and cut out a part of the bark of the same dimensions... Then fit the **scutcheon** which you prepared to the part which you have bared."

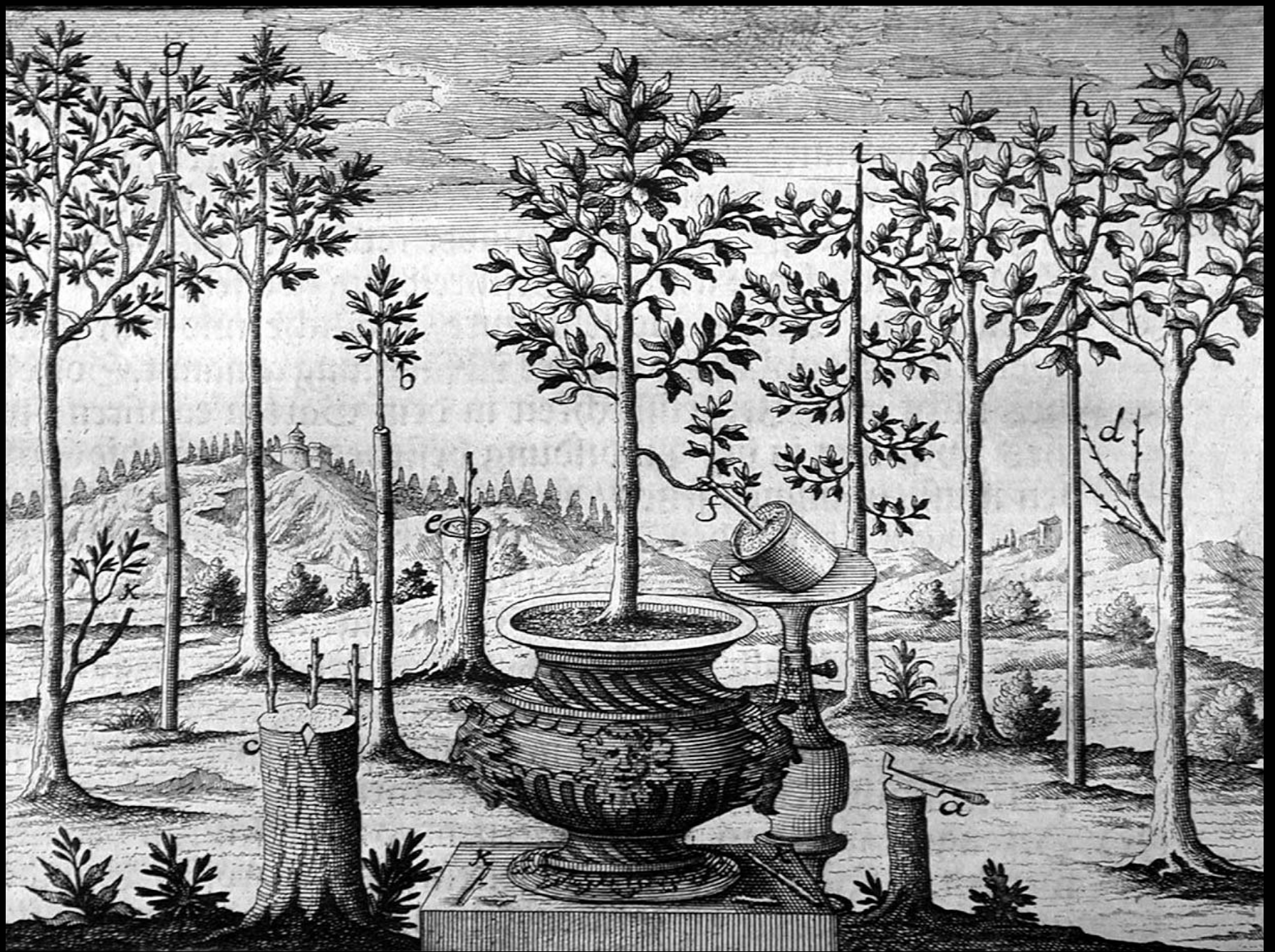
# Robert Sharrock

1672

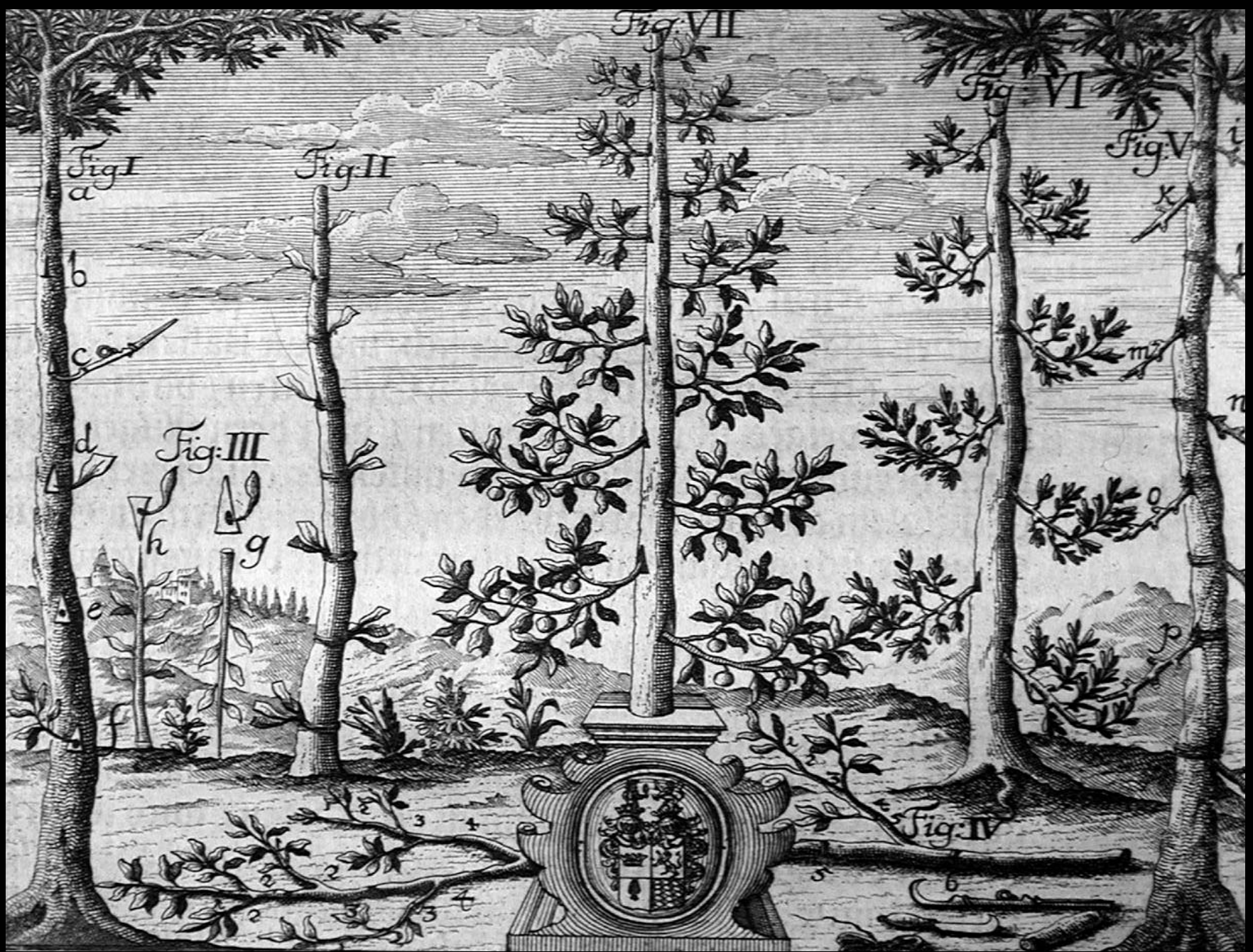
In a single figure from the “History of the Propagation and Improvement of Vegetables”, Sharrock demonstrates that most current grafting and budding techniques were in practice in the 1600’s.







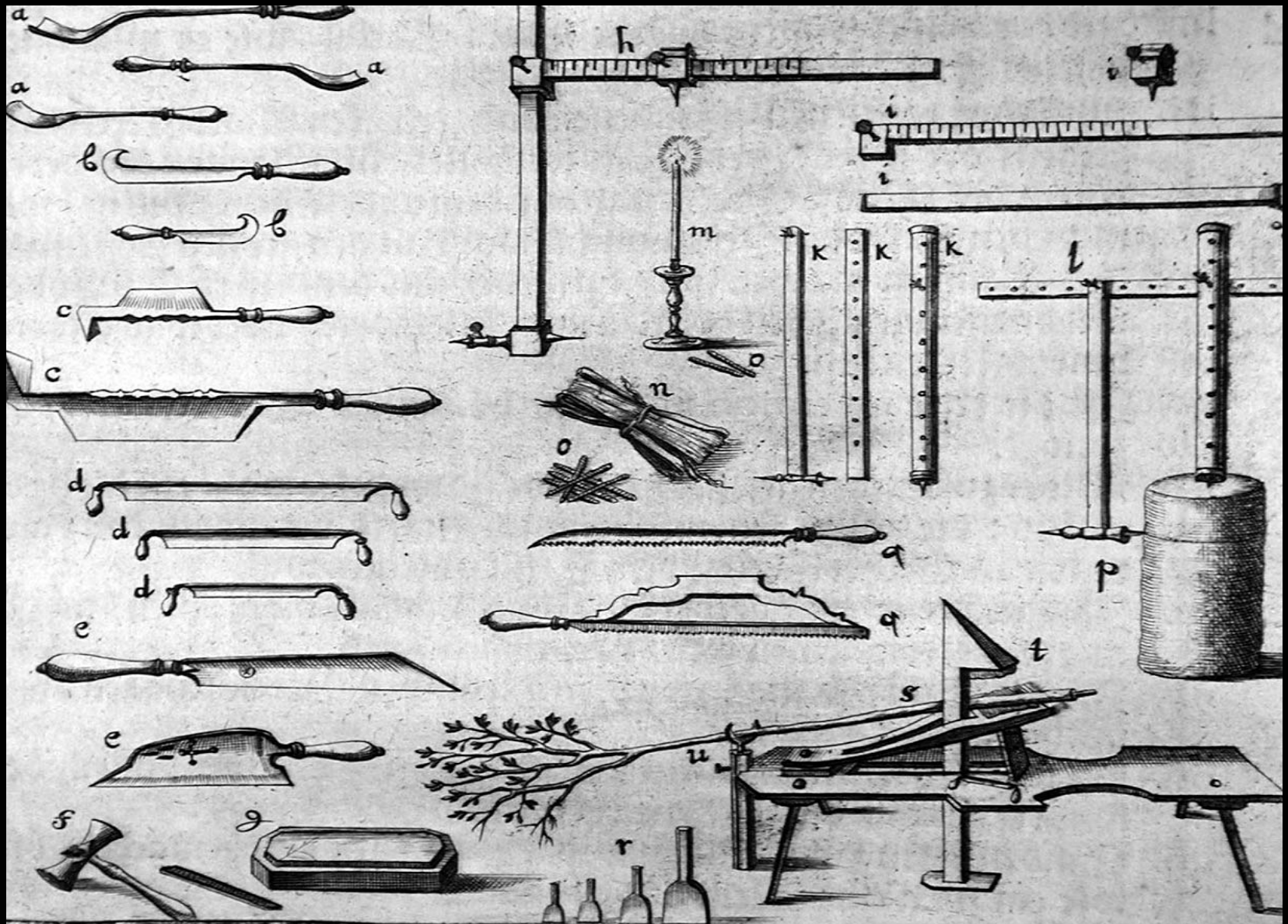
Georg Andreas Agricola 1716



Georg Andreas Agricola 1716



# Grafting tools



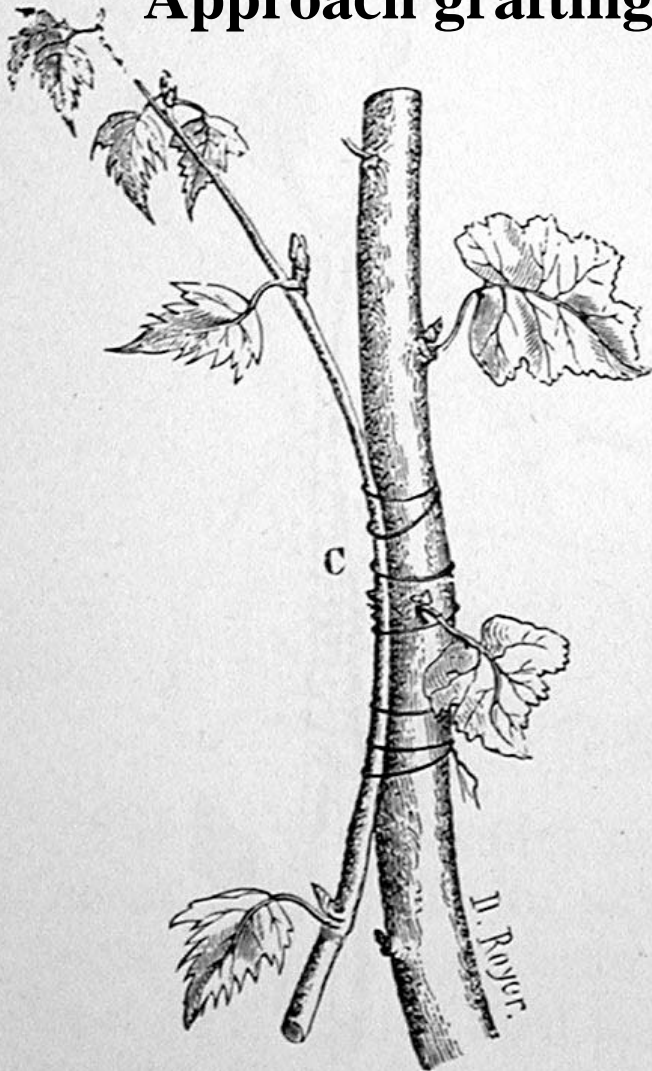
Georg Andreas Agricola 1716



Georg Andreas Agricola  
1716

# Philip Miller (1754)

## Approach grafting

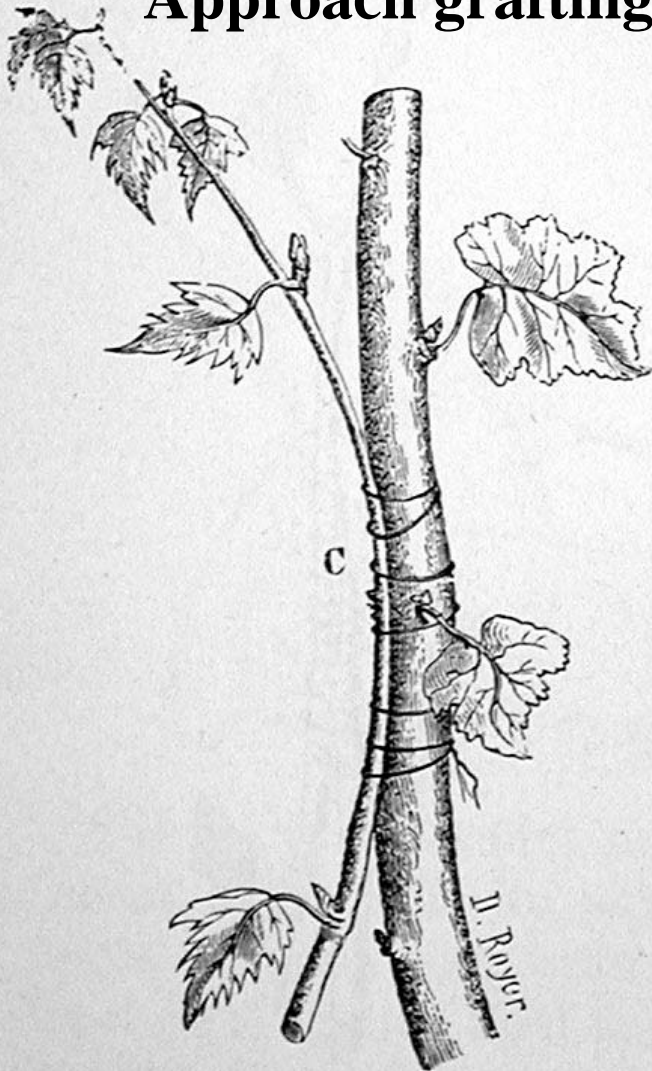


"This method of grafting is used, when the stock you intend to graft on, and the tree from which you would take the graft, stand so near (or can be brought so near), that they may be joined together."



# Philip Miller (1754)

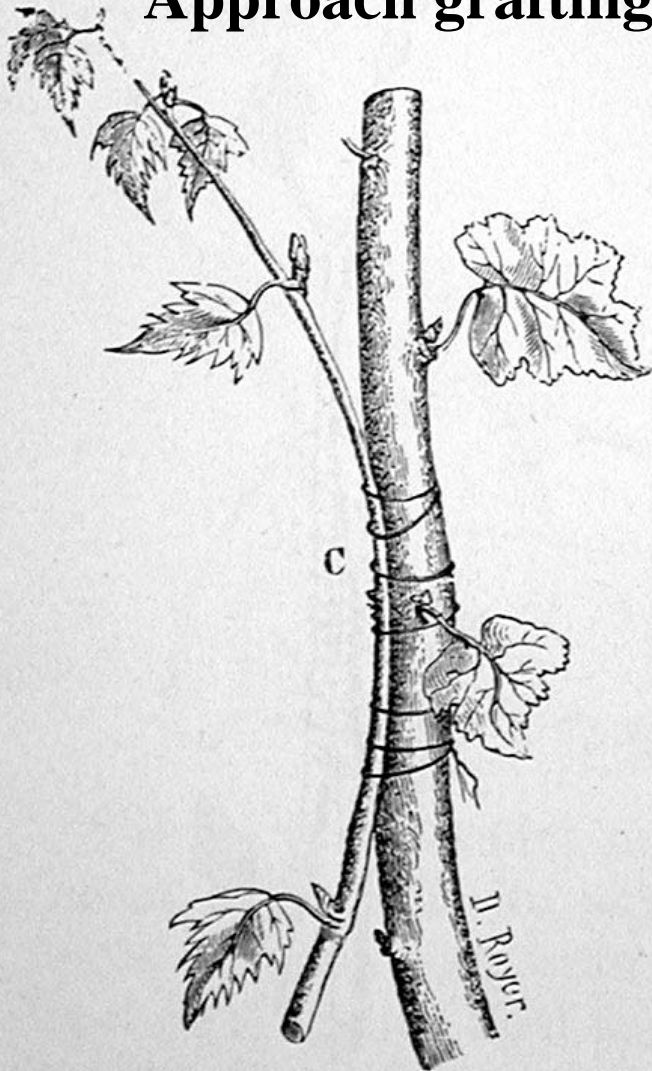
Approach grafting



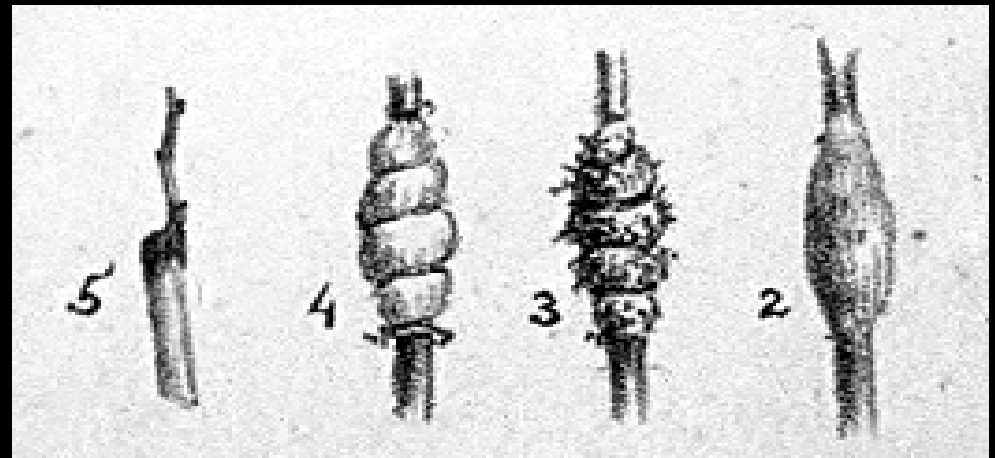
"pare away the rind and the wood on one side about three inches in length... then cut a little tongue upward in the graft, and make a notch in the stock to admit it... the tongue will prevent their flipping, and the graft will more closely unite with the stock."

# Philip Miller (1754)

Approach grafting

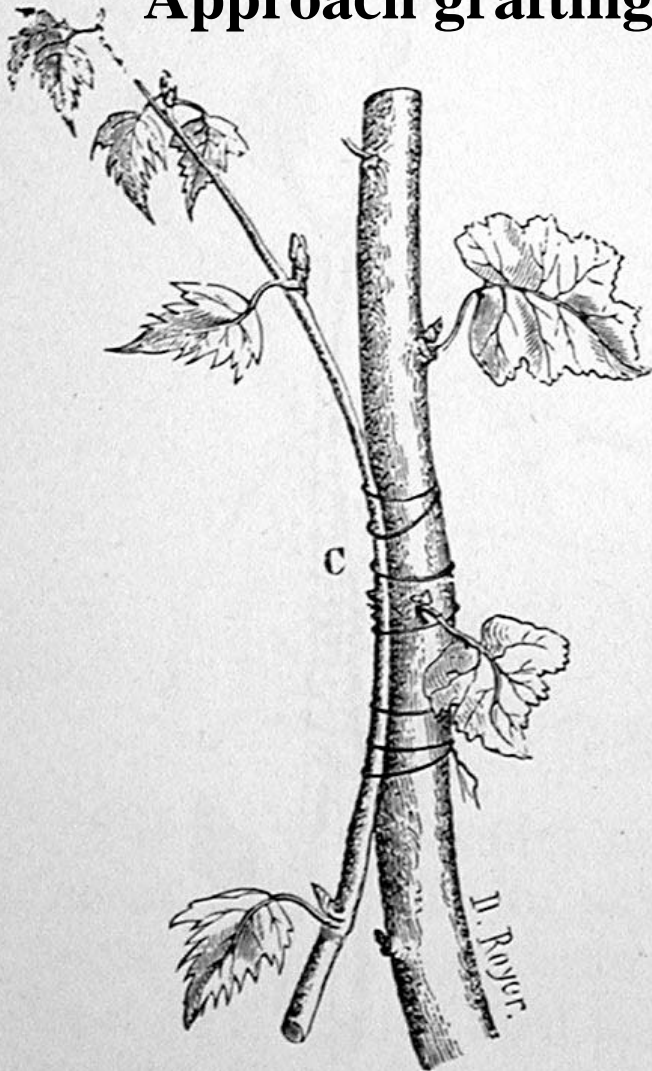


"You must tie them with some ... soft tying; then cover the place with grafting clay, to prevent the air from entering to dry the wound. This operation is always performed in April or May."



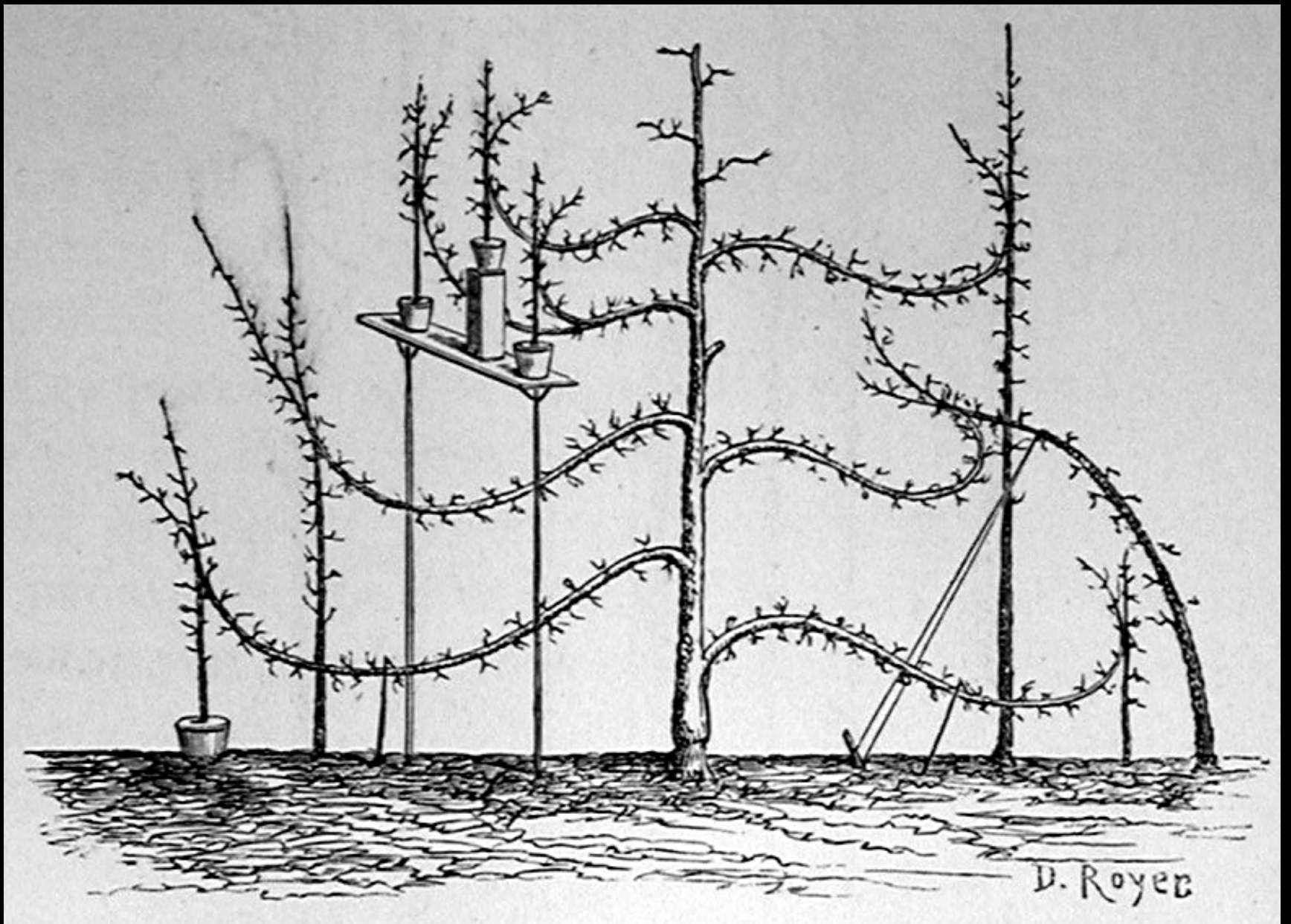
# Philip Miller (1754)

Approach grafting

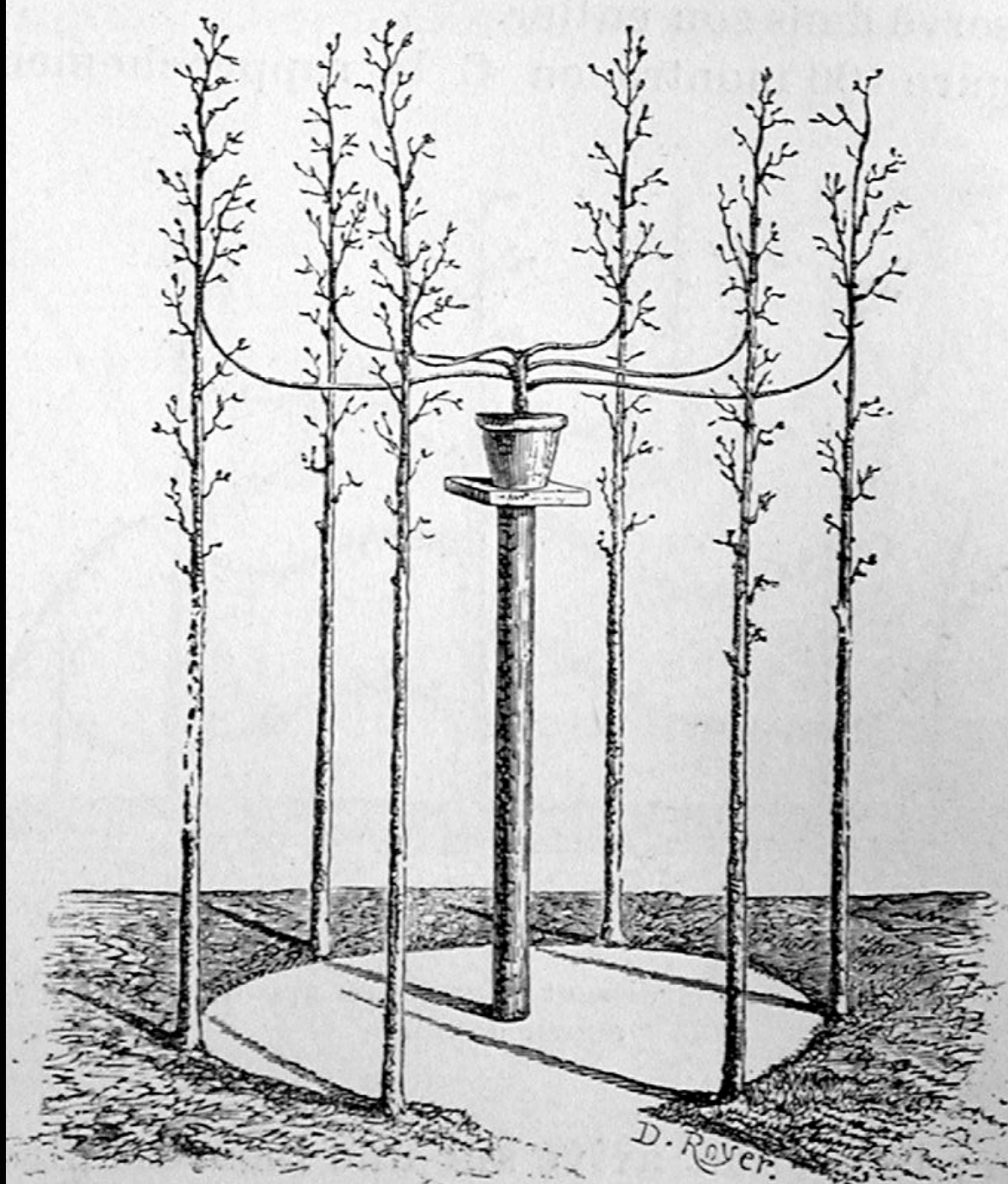


”It is commonly practiced upon oranges, myrtles, jasmines, walnuts, firs pines, and several other trees, which will not succeed by common grafting or budding.”



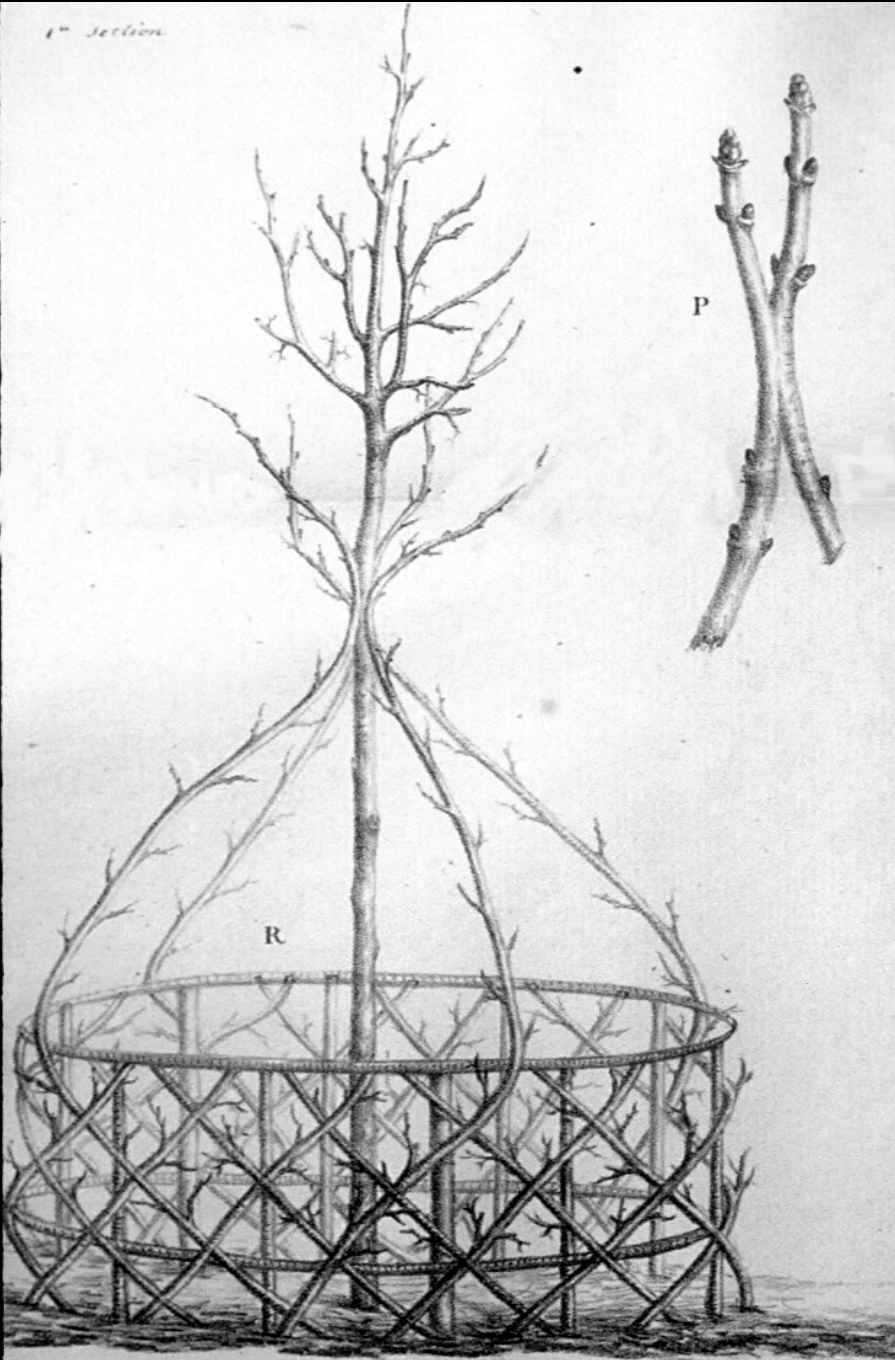


Charles Baltet 1903



Charles Baltet  
1903

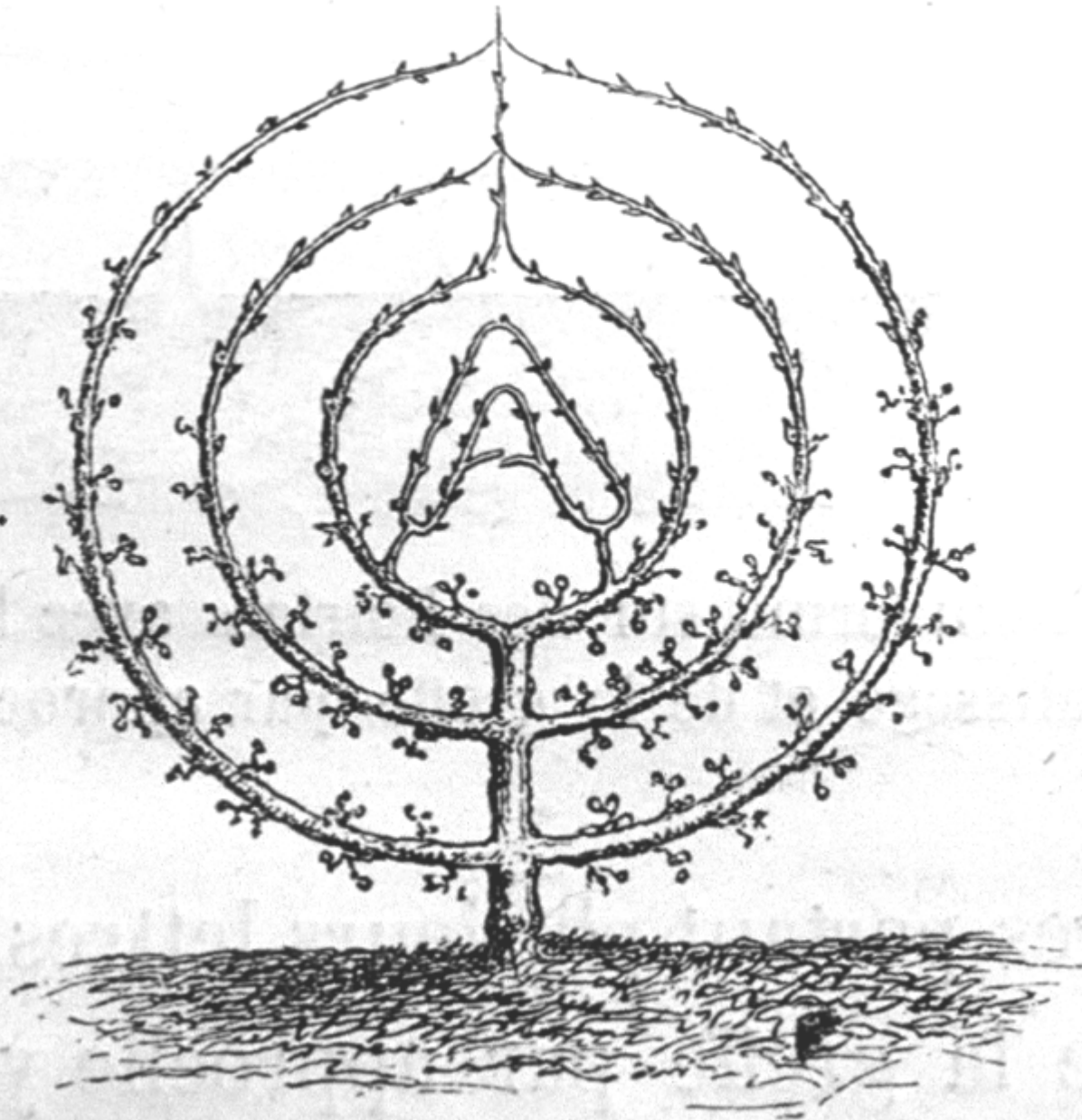
1<sup>re</sup> section



P. Thouin

Monographic des Greffes  
ou Description  
Techniques  
1921





Charles Baltet  
1903



# Joseph Curtis (1786 - 1882)



One grafting type was originated in the USA. **Joseph Curtis** (1786 - 1882) from Manchester, Ohio was grafting fruit trees at the age of 16. At that time, understocks for fruit trees was in limited supply. He decided to **use root pieces for understocks in apple grafting** and thus developed the method of root grafting.”



# Dwarfing understocks

Dwarfing understocks were developed at the East Malling experiment station in England during the early 1900's. However, using dwarfing stocks was described by Philip Miller (1754) as common practice over one-hundred years previous where he mentions Dutch dwarf-stock or Dutch **Paradise-apple**.



# Dwarfing understocks

"Apples are grafted or budded upon stocks raised from seeds which come from the cyder-press, or upon crab-stocks, ... but for small gardens, the **paradise-stock** hath been for some years past greatly esteem'd; it being of very **humble growth**, causeth the fruit-trees grafted, and kept in small compass.

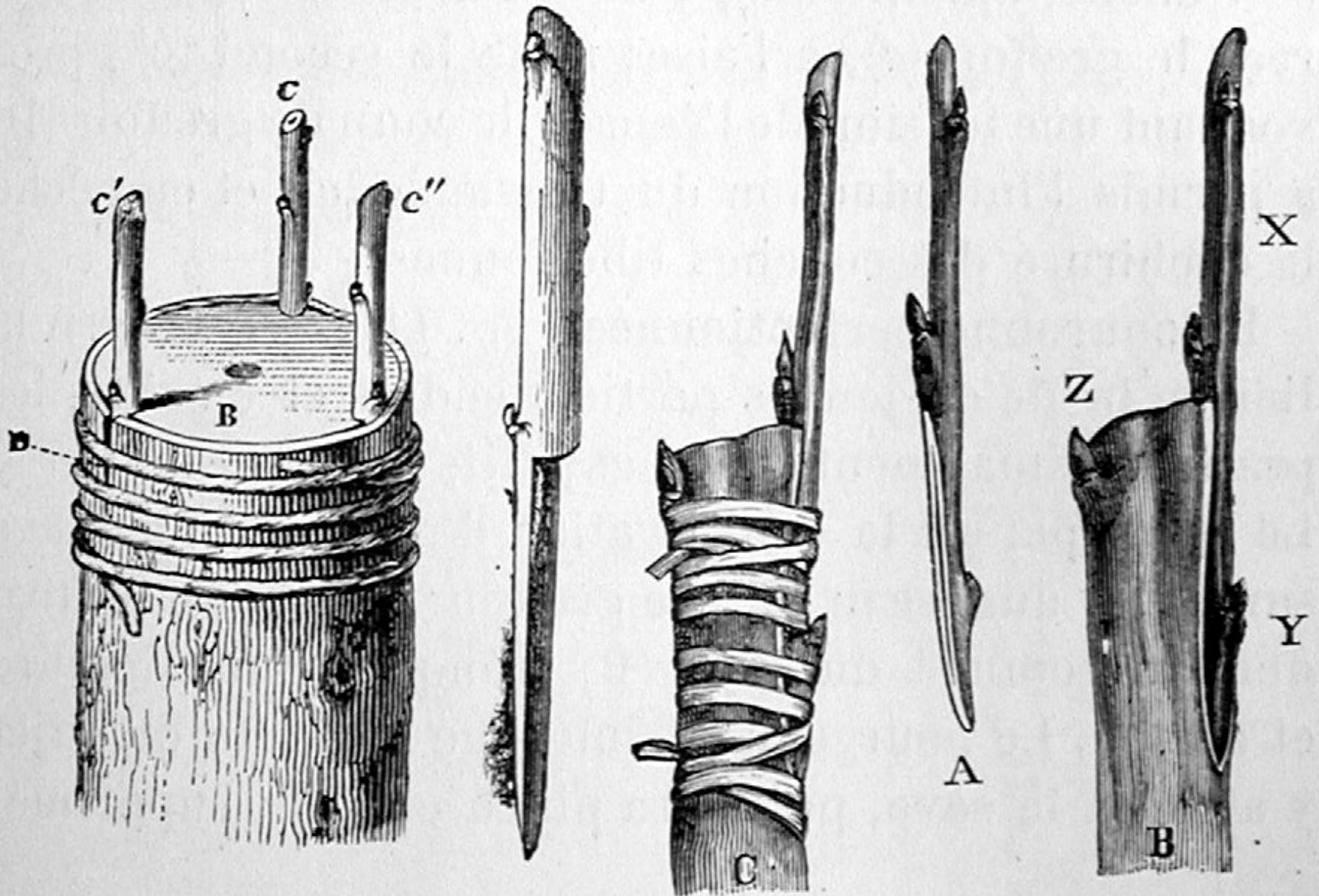




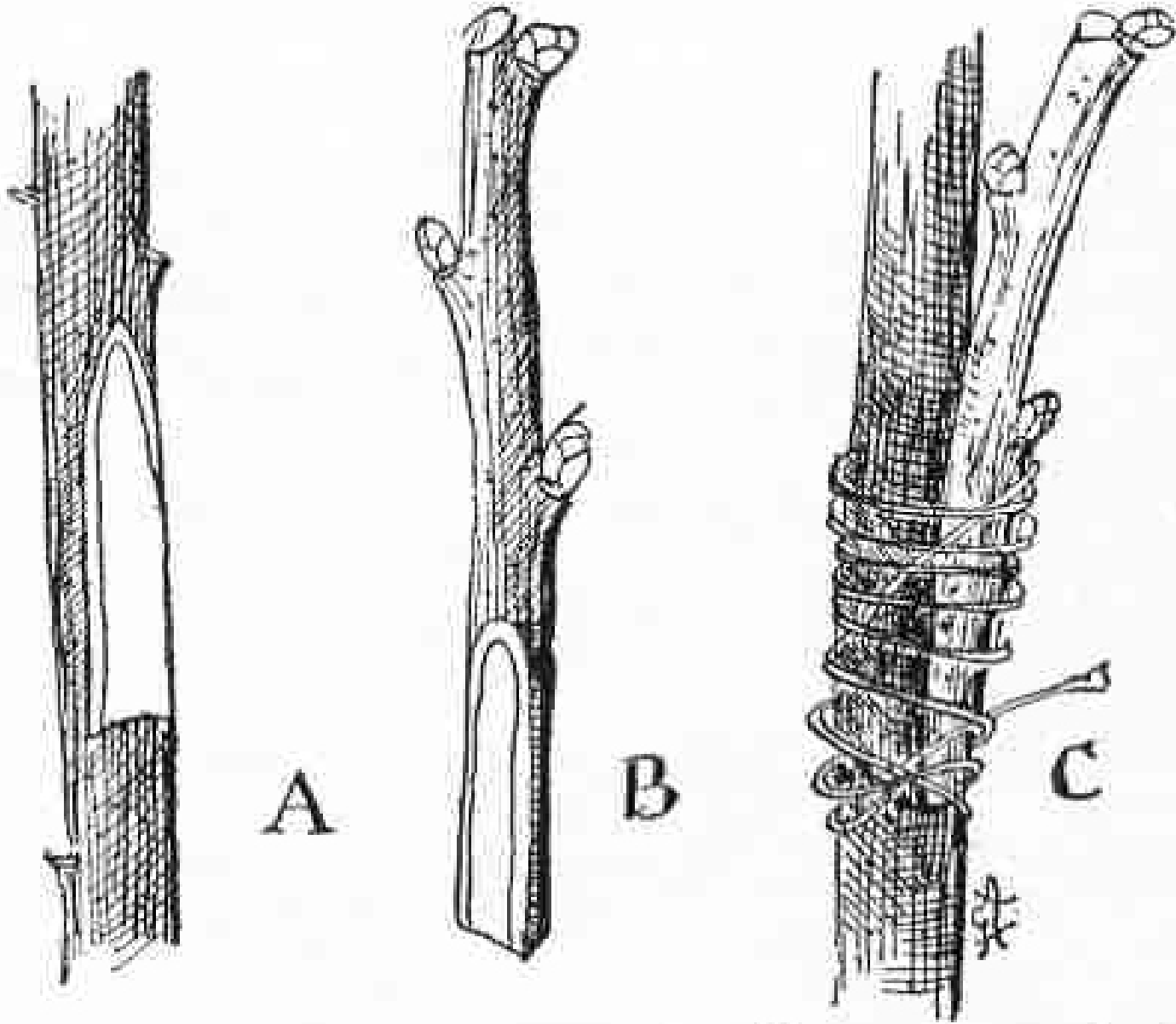


Charles Baltet 1903

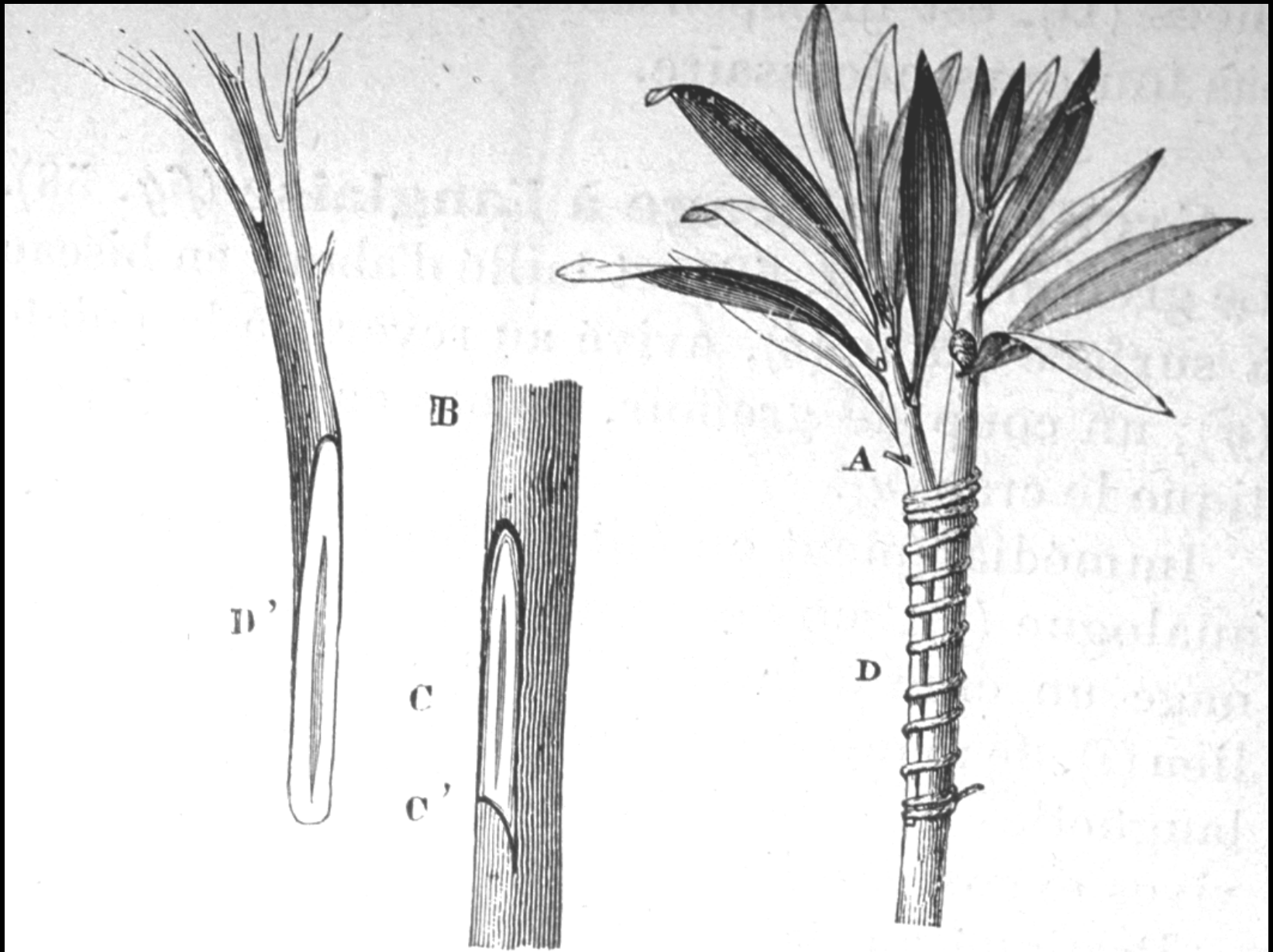




Charles Baltet 1903



Charles Baltet 1903



Charles Baltet 1903

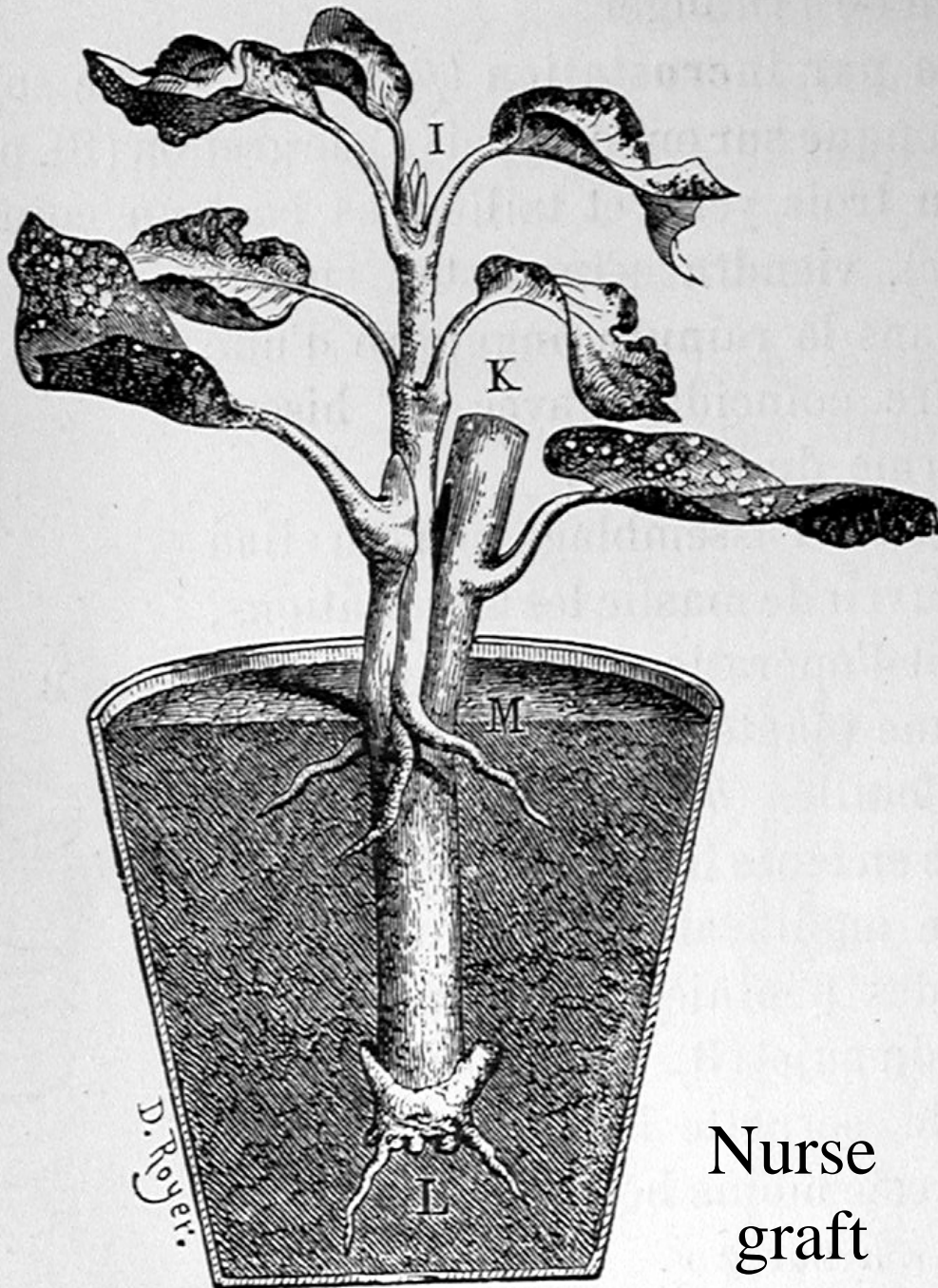




Charles Baltet 1903

# Charles Baltet 1903





Charles Baltet  
1903

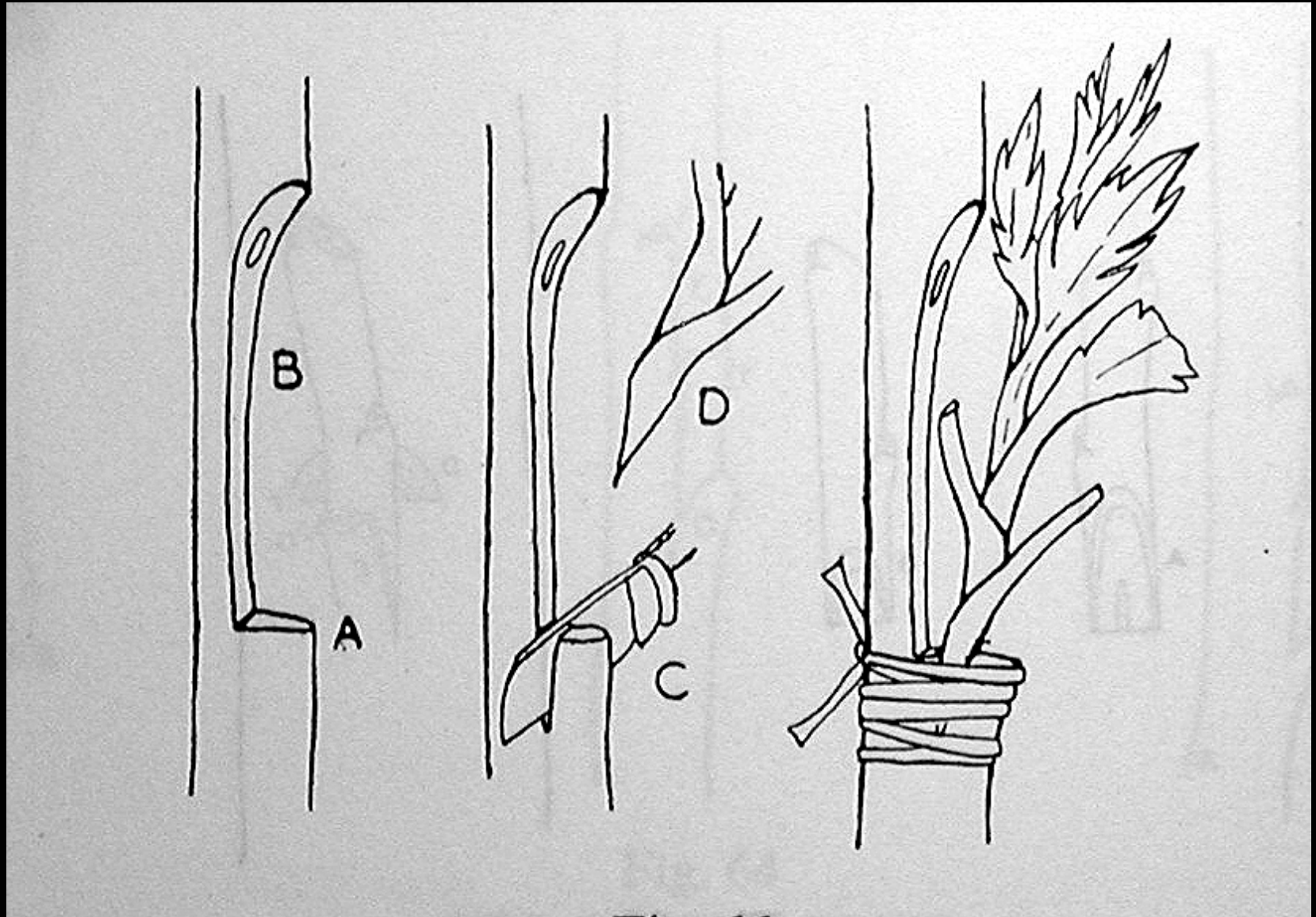
Nurse  
graft





## Topworking in Kiwi

# Scoop Graft



R. J. Garner (1949) *The Grafter's Handbook*

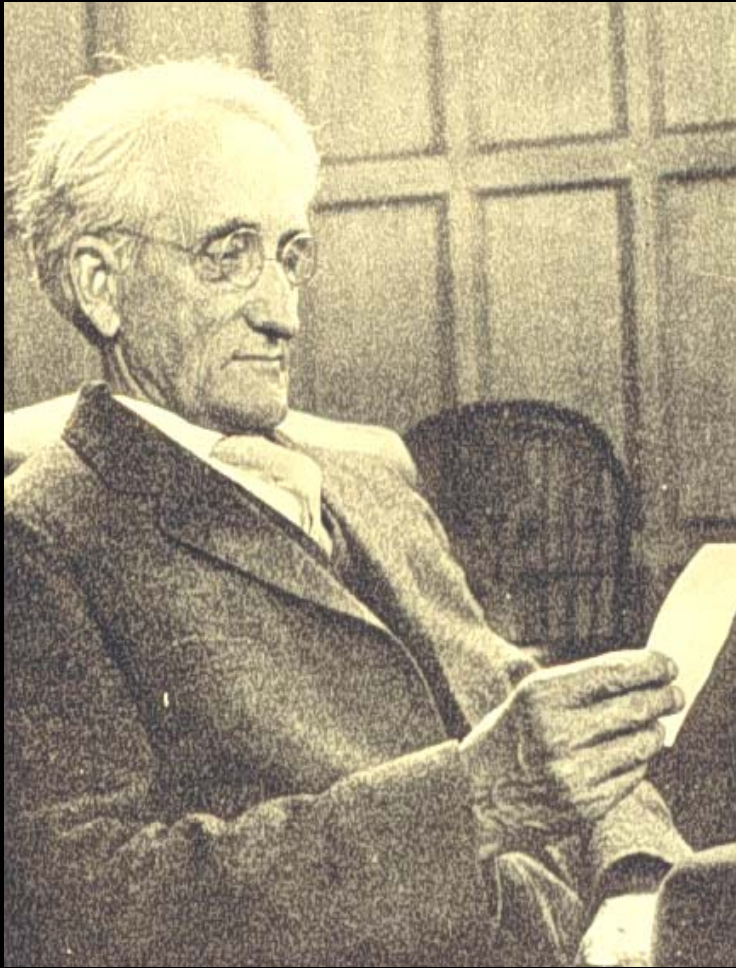
# Biotechnology vs. Grafting

**Genetic engineering** crop plants has become a controversial subject. To the general public, this procedure for crop improvement is unnatural and it is viewed with suspicion.



**Could grafting have ever evoked similar emotions?**

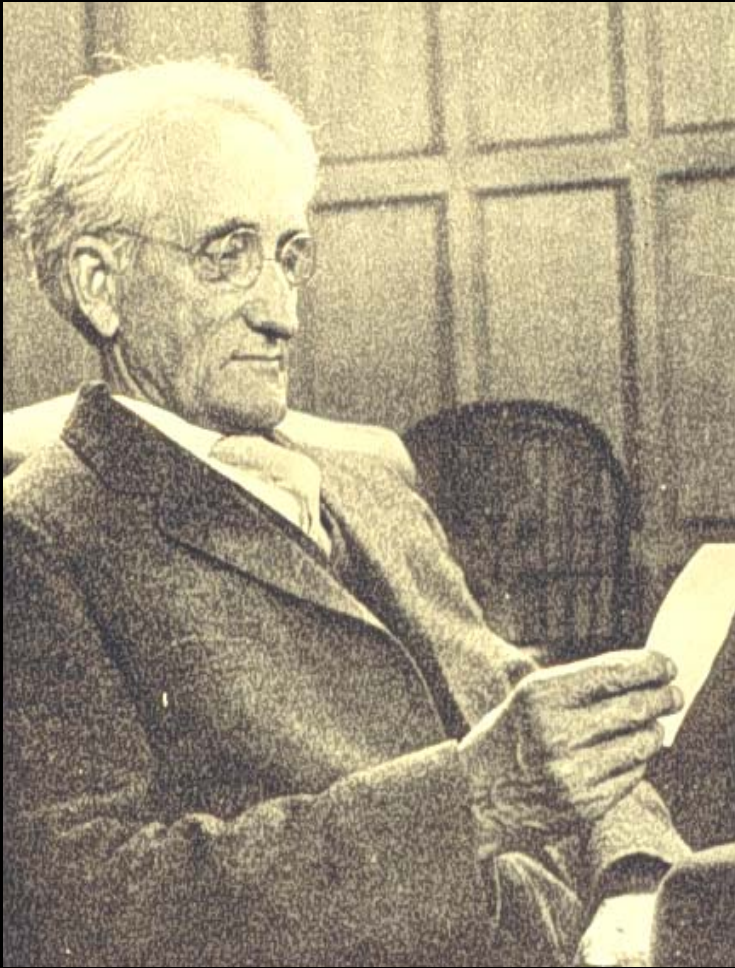




**Liberty Hyde Bailey**  
1858-1954

## Grafting

"To the popular mind there seems to be something mysterious in the process of graftage. People look upon it as something akin to magic, and entirely opposed to the laws of nature. It is popularly thought to represent the extreme power which man exercises over natural forces."



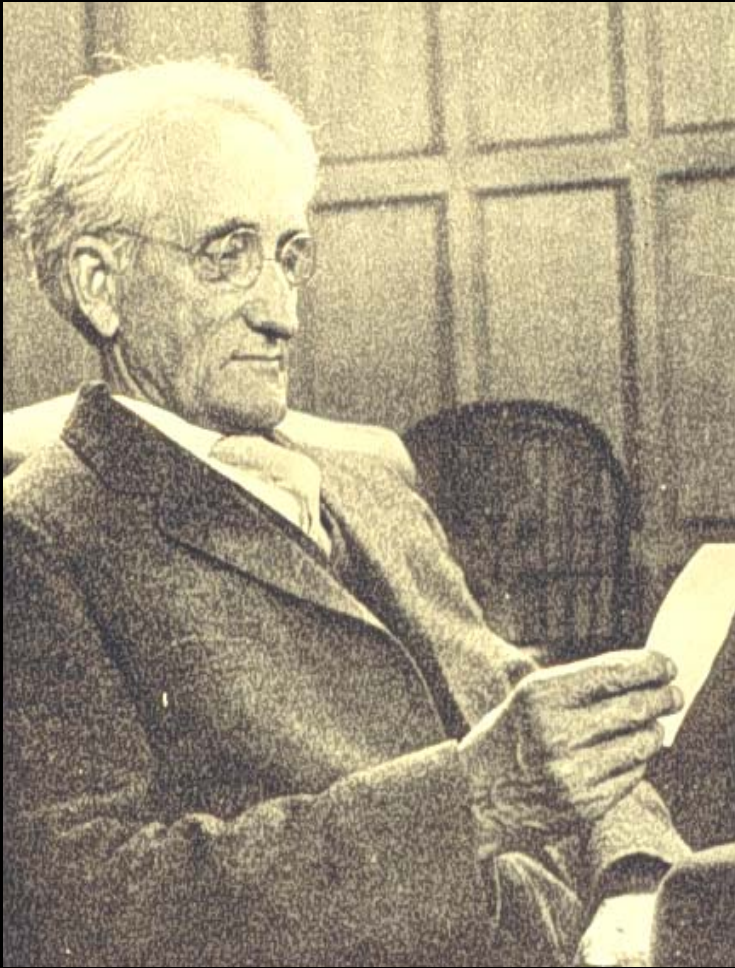
**Liberty Hyde Bailey**  
1858-1954

## Grafting

"Grafting is in effect a kind of adulteration ... grafting and budding will have to be abandoned, and real work must be begun on some sound and sensible plan. Any fruit-bearing or ornamental tree that will not succeed on its own roots had better go to the rubbish fire at once."

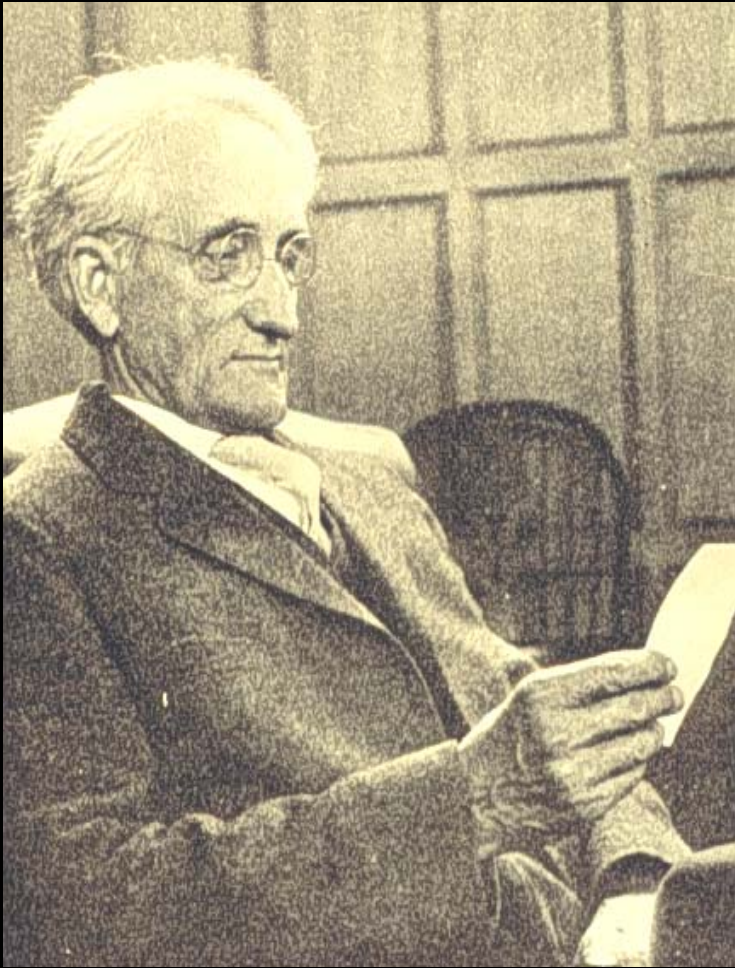
## Grafting

"But the whole discussion of the mere naturalness of any operation is really aside from the question, for every operation in the garden is in some sense unnatural."



**Liberty Hyde Bailey**  
1858-1954



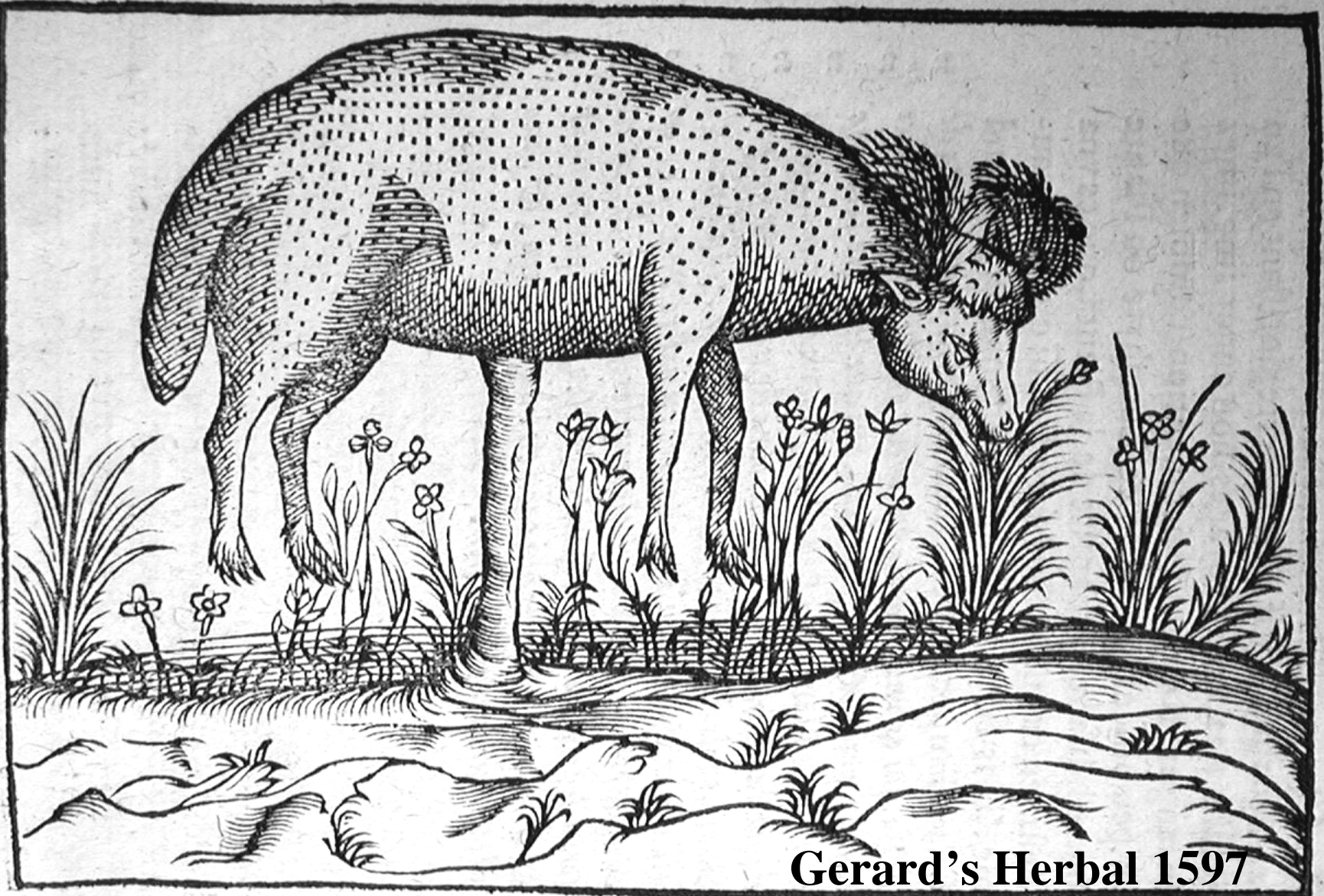


**Liberty Hyde Bailey**  
1858-1954

## Grafting

"It is impossible, if one considers the facts broadly and candidly, to arrive at any other conclusion than this: graftage is not suited to all plants, but in those to which it is adapted - and they are many - it is not a devitalizing process."

# New form of Cotton

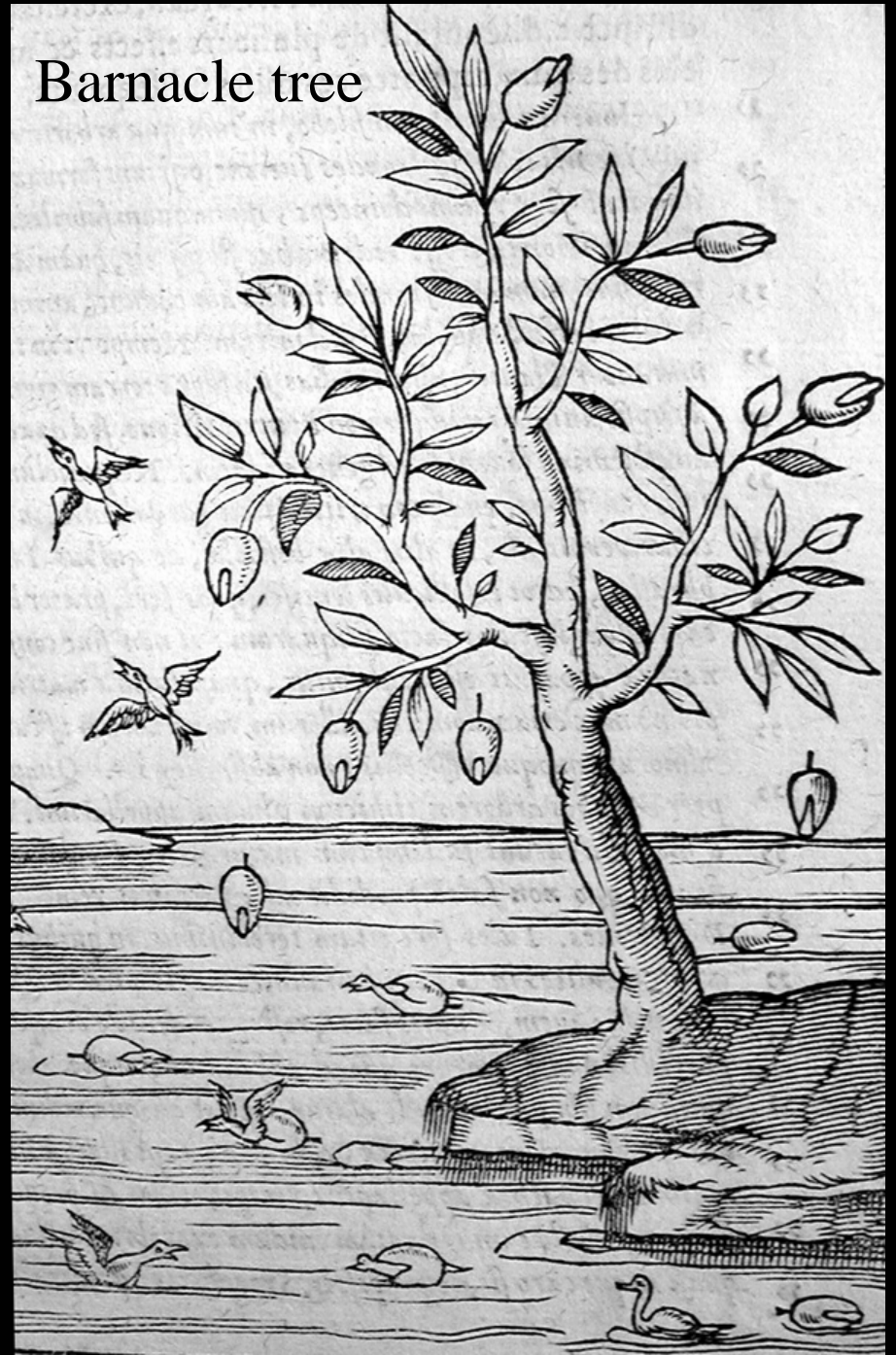


Gerard's Herbal 1597



# Spontaneous Generation

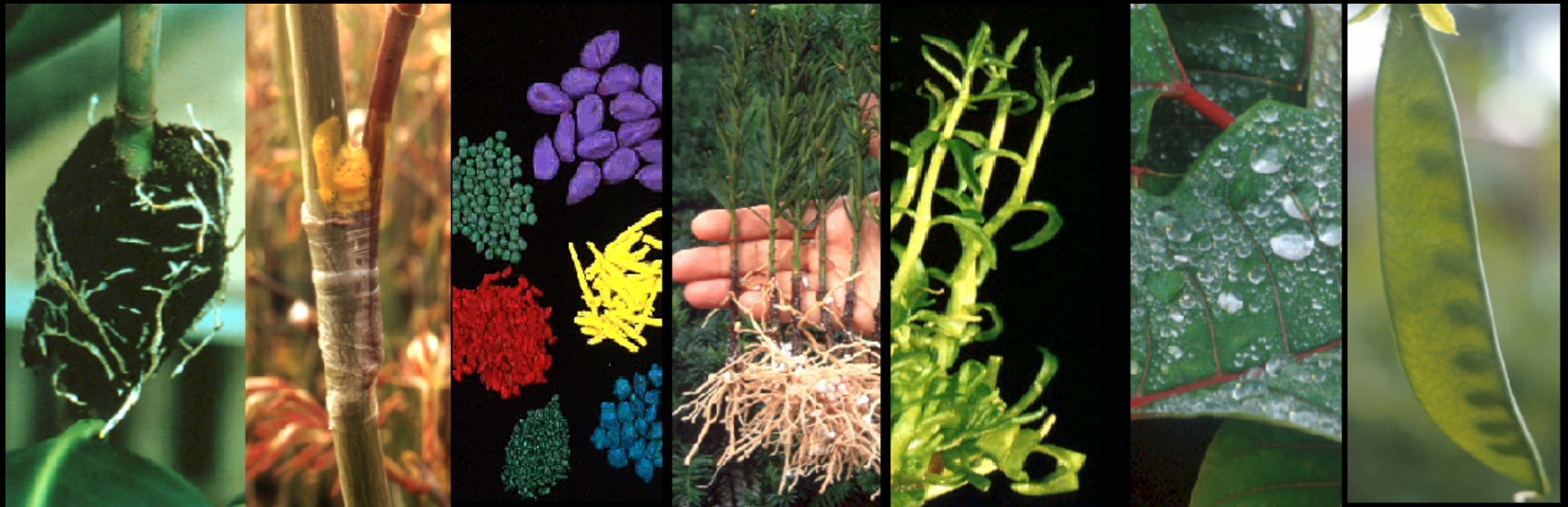
Barnacle tree



Gerard's Herbal 1597



# Techniques of Plant Propagation: A Historical Perspective



Robert Geneve  
University of Kentucky