Plant Propagation PLS 3223/5222

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Chapters 11-13

Grafting and Budding
Graft Union Formation

FORMATION OF THE GRAFT UNION

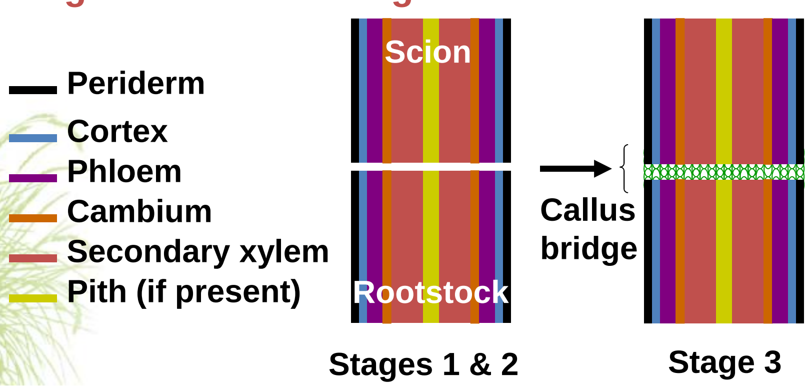
1. Lining Up Vascular Cambiums of the Rootstock and Scion
2. Wounding Response
3. Callus Bridge Formation
4. Wound-Repair Xylem and Phloem: Differentiation of Vascular Cambium Across the Callus Bridge
5. Production of Secondary Xylem and Phloem from the New Vascular Cambium in the Callus Bridge

Stages of graft union formation

Stage 1. **Line up vascular cambium of the rootstock and scion**

Stage 2. **Wounding response**

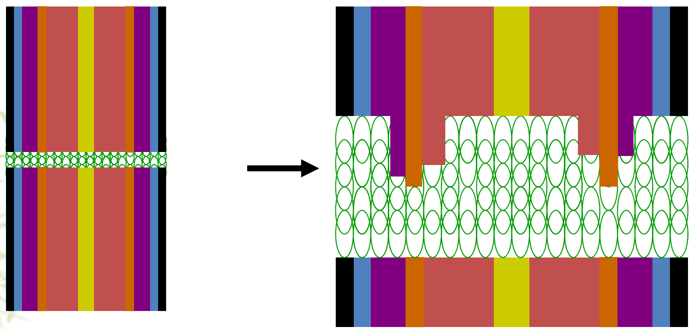
Stage 3. **Callus bridge formation**



Stages of graft union formation

Stage 3. Callus bridge formation

Stage 4. Wound repair xylem and phloem: differentiation of vascular cambium across the callus bridge

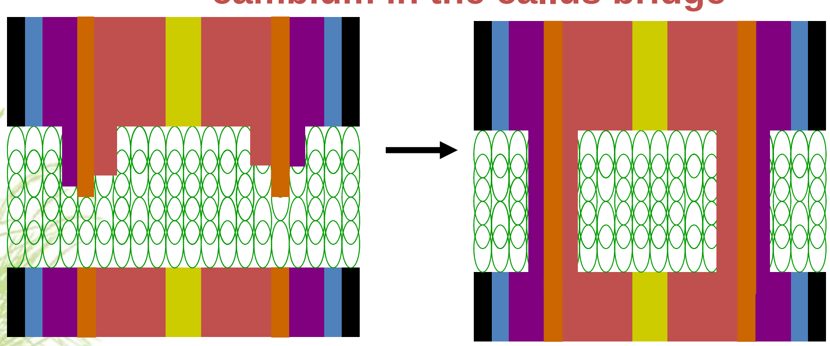


Stage 3 Stage 4

Phloem Cambium Secondary xylem

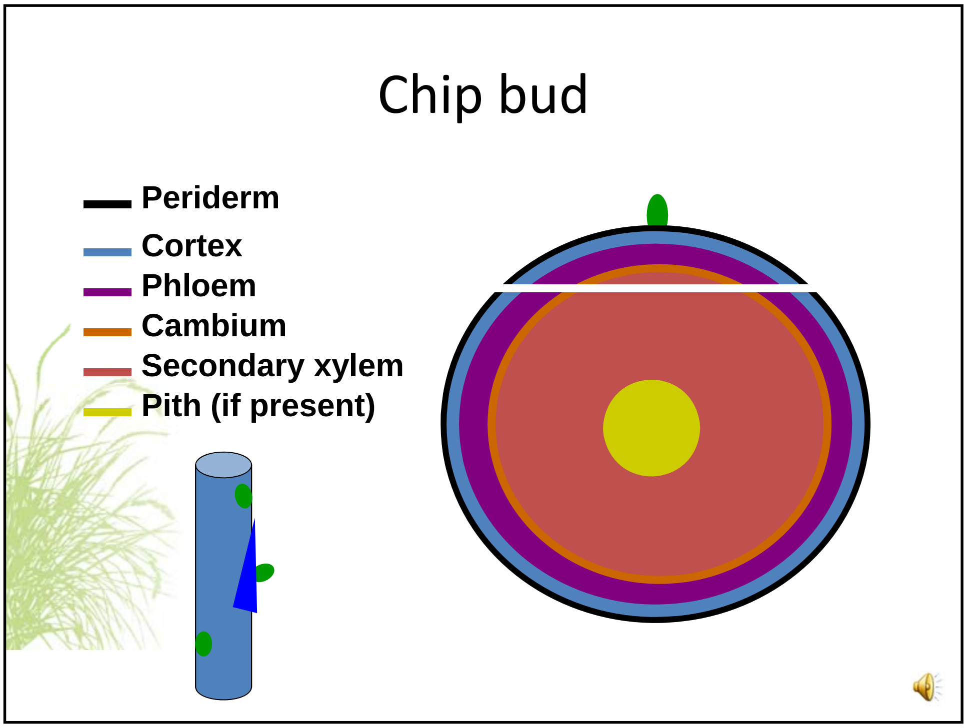
Stages of graft union formation

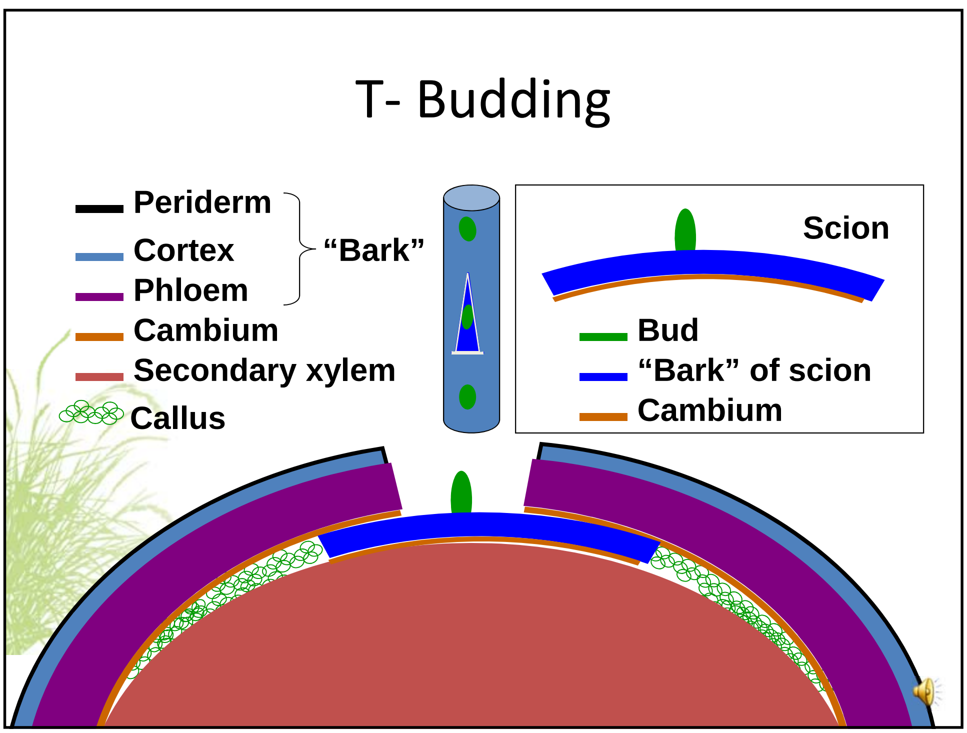
Stage 5. Production of secondary xylem and phloem from the new vascular cambium in the callus bridge



Stage 4 Stage 5

Phloem Cambium Secondary xylem


Chip bud
Periderm
Cortex
Phloem
Cambium
Secondary xylem
Pith (if present)


T- Budding
Periderm
Cortex
Phloem
"Bark"
Cambium
Secondary xylem
Callus
Scion
Bud
"Bark" of scion
Cambium

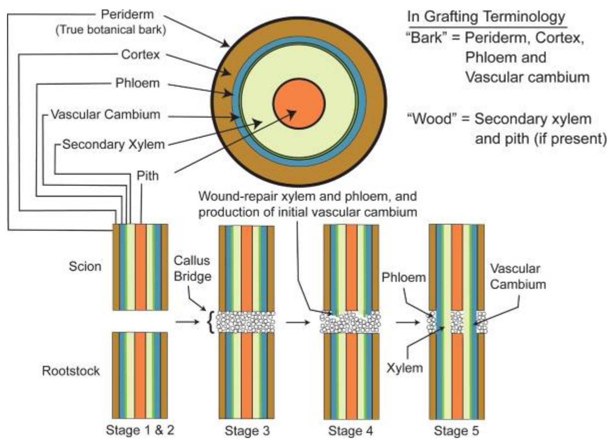


Figure 11–6 Top: Grafting terminology of the "bark" and "wood" and associated tissues with schematic drawing of a stem cross section of a young woody plant stem. Bottom: Schematic longitudinal section of the stages of graft union formation: (Stage 1) Lining up vascular cambiums of the rootstock and scion, and (Stage 2) subsequent wound healing response. (Stage 3) Callus bridge formation. (Stage 4) Wound-repair xylem and phloem occur in the callus bridge just prior to initial cambium formation. (Stage 5) The vascular cambium is completed across the callus bridge and is forming secondary xylem and phloem.

FORMATION OF THE GRAFT UNION

GRAFT UNION FORMATION IN PEA ROOTS

Day 1 - 2		Initial cell divisions to compartmentalize the wounds in both the scion and rootstock.
Day 2-7		Continued proliferation of parenchymatous callus from both grafting partners in the graft union area.
	Day 4	First wound-repair vascular tissue differentiation in the graft union area. The necrotic layer (cells killed by wounding) is disrupted and largely disappears.
	Day 7	Callus bridge formation is finished with the complete filling of graft union area with parenchymatous callus. Wound-repair xylem (from callus cells) links the callus bridge.
Day 8		Wound-repair phloem (from callus cells) links callus bridge.
Day 12		Wound-repair cambium (from callus cells) links the callus bridge.
After day 12		Production of secondary xylem and phloem by reconstituted cambium in the callus bridge.

Figure 11–14 Graft union formation in grafted pea roots (91, 159). This sequence of grafting events is common to topgrafting and root grafting in many other woody and herbaceous plant species. What will vary is the time period in grafting events with different species.

PEARSON AG
Hartmann and Kester's Plant Propagation Principles and Practices 8e
Hudson Hartman, Dale Kester, Fred Davies and Robert Geneve
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GRAFT UNION FORMATION IN T- AND CHIP BUDDING

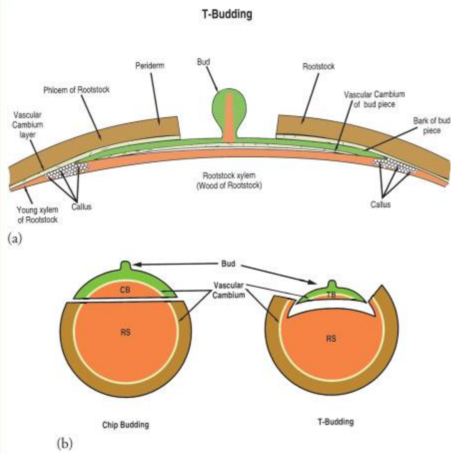
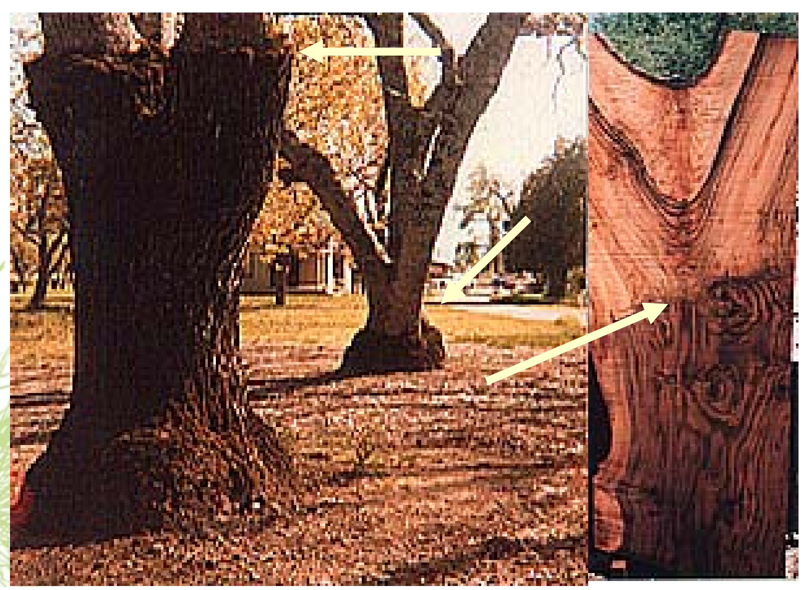


Figure 11–22 (a) Tissues involved in healing of an inserted T-bud as prepared with the "wood" (xylem) attached to the scion bud piece. Graft union formation occurs when callus cells developing from the young xylem of the rootstock intermingle with callus cells forming from exposed cambium and young xylem of the T-bud piece. As the bark is lifted on the rootstock for insertion of the bud piece it detaches by separation of the youngest xylem and cambial cells. (b) A cross section of a chip bud (CB), T-bud (TB), and rootstock (RS). Because the chip bud substitutes exactly for the part of the rootstock that is removed, the cambium of the roots and scion are placed close together, resulting in a rapid and strong union. When a T-bud (right) is slipped under the "bark," the cambium of the rootstock and scion are not adjacent, and the initial union formation can be weak and slow



Plant Growth Regulators and Graft Union Formation

- No plant growth regulators are used in commercial grafting and budding systems.
- In general, plant growth regulators do not uniformly enhance grafting, nor do they overcome graft incompatibility.

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FACTORS INFLUENCING GRAFT UNION SUCCESS

- Factors that influence graft union success include:
  - Incompatibility
  - Plant species and type of graft
  - Environmental conditions during and following grafting
  - Growth activity of the rootstock
  - Polarity
  - The craftsmanship of grafting
  - Virus contamination, insects, and diseases
  - Plant growth regulators and graft union formation
  - Post-graftage—bud-forcing bethods

1. Graft Incompatibility

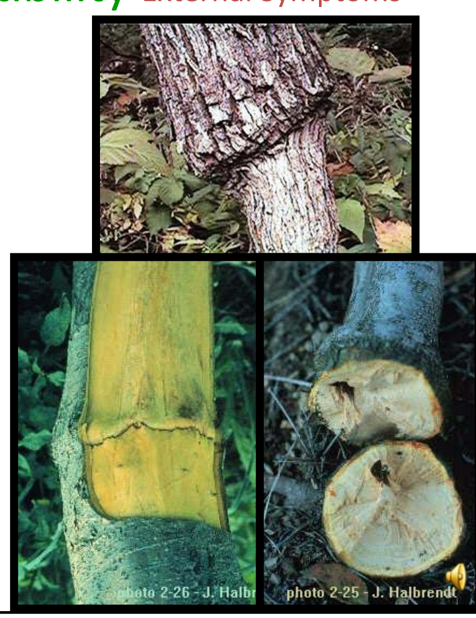
- <u>Graft Compatibility</u> - the ability of two different plants, grafted together, to produce a successful union and to develop satisfactorily into one composite plant.

- an interruption in cambial and vascular continuity leading to a smooth break at the point of the graft union, causing graft failure.

1. Graft Incompatibility External Symptoms

- Overgrowth at or below the graft union
- Suckering of the rootstock
- Breaking apart cleanly at the graft union.

- Review the detailed lecture on this subject.



2. Plant species and type of graft

- Gymnosperms - grafted
- Angiosperms - mostly budded
- Nut trees - Bark graft more than cleft graft
- Mango or Camellia - approach graft
  - Why the differences? –
  - Ability to produce callus parenchyma and differentiate a vascular system across the callus bridge.

3. Environmental Conditions

Temperature

- has a pronounced effect on the production of callus tissue.
  - Lower temperatures slow callus formation.
  - Too high temperatures will deplete carbohydrate reserves.
- Outdoor grafting - cambial activity

3. Environmental Conditions

Moisture and Plant Water Relations

- Air moisture levels below the saturation point inhibit callus formation
- Desiccation of cells increases as the humidity drops
  - Cambium, parenchyma, and callus cells all have tender thin cell walls
  - Water must be used initially from the scion tissue

4. Growth Activity of the Rootstock

- “Slipping Bark”
- Overactive rootstock
  - Excessive Sap Flow
- Underactive rootstock
  - Inadequate root growth

Grafting terminology

- Bench Graft – any graft procedure performed on a rootstock and scion that are not initially planted (bare root or potted liners).
- Seedling or clonal rootstock should be established in liner pots the previous season.

FACTORS INFLUENCING GRAFT UNION SUCCESS

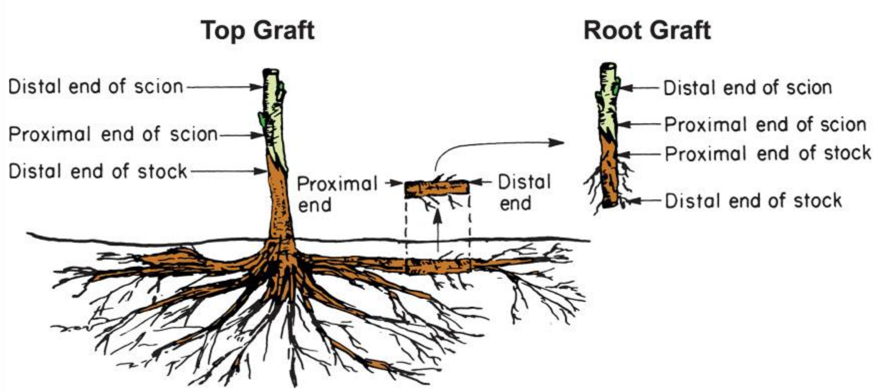


Figure 11–26 Polarity in grafting. In topgrafting, the proximal end of the scion is attached to the distal end of the rootstock. In root grafting, however, the proximal end of the scion is joined to the proximal end of the rootstock.

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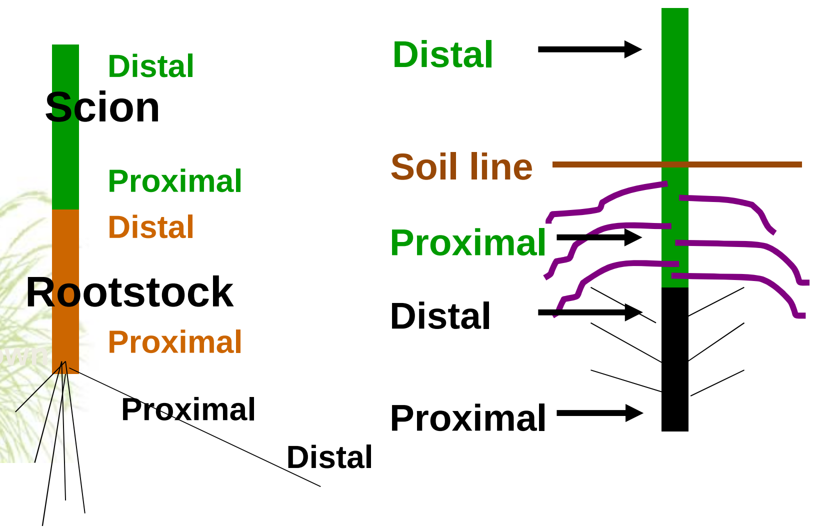
5. Polarity

Nurse-Root grafting



6. Craftsmanship of Grafting

- The lining up of the cambial layers
- Insufficient or delayed waxing
- Uneven cuts
- Use of desiccated scions
- Girdling by polyethylene tape after the graft “takes”

7. Virus Contamination, Insects, and Diseases

- Viruses and phytoplasma may cause delayed incompatibilities
- Insects may feed on the soft callus tissues
- Fungi may gain entrance through the wounds created by grafting or budding.

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Genetic Limits of Grafting

- Grafting is generally limited to Dicots (Angiosperms) and gymnosperms
- Grafting of Monocots (Angiosperms) is more difficult and less successful

Genetic Limits of Grafting

- Within a Clone ?
  - Yes
- Clones within a species ?
  - Usually
- Species within a genus ?
  - Sometimes
- Between genera within a family ?
  - Remote!
- Between families ?
  - Considered impossible!

Genetic limits

- Commercially important successes between genera within a family

Chamaecyparis nootkatensis + Thuja orientalis
Citrus sinensis (Orange) + *Poncirus trifoliata*
Pyrus communis + cydonia oblonga (Quince)
Lycopersicon (Tomato) + *Solanum* (Potato)

Scion-Rootstock Relationships

"Combining two or more plants (genotypes) into one plant by grafting can produce growth patterns that are different from those that would have occurred if each component part had been grown separately."

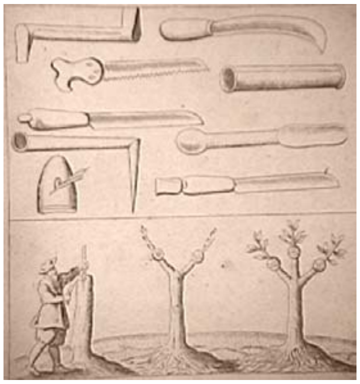
Why the altered characteristics?

Why the altered characteristics ?

- Characteristics of one graft partner not found in the other
  - resistance to diseases, insects or nematodes.
  - tolerance of adverse environmental or soil conditions
- Interactions between the scion and rootstock may alter attributes such as
  - plant size, growth, productivity or other horticultural attributes
- Incompatibility reactions

Effects of rootstock on scion

- Size control (and possibly tree shape)
- Apple
  - dwarfing
  - semi-dwarfing
  - vigorous
  - very vigorous
- cherry, citrus, pear



Effects of the rootstock on the scion

- Fruiting can be effected by rootstock selection
  - fruiting precocity, fruit bud formation, fruit set, yield
- Trees on dwarfing rootstocks are often more fruitful and produce higher yields
- Increased nitrogen efficiency
- Extending scion tolerance of adverse conditions (Cold hardiness)

Effects of the scion on the rootstock

- Scion vigor can effect rootstock growth
- The vigor of the scion cultivar may determine the rate of growth and ultimate size of the composite plant.

Effects of interstock on scion and rootstock

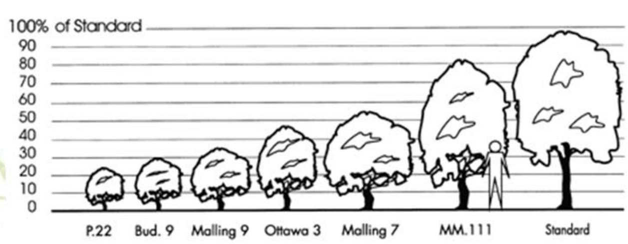
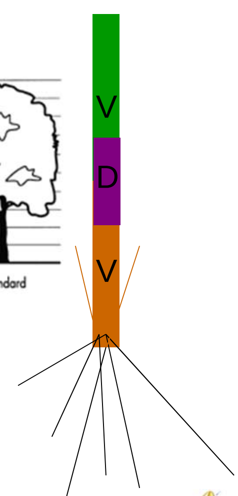


Figure 1. Comparative Dwarfing by Rootstocks for Apples.



Rootstock and Scion interactions

1. anatomical factors
2. nutritional and carbohydrate levels
3. absorption and translocation of nutrients and water
4. phytohormones and other physiological factors (correlative effects)