

## Grafting Fruit Trees



By  
**George  
Tiger**

---

---

---

---

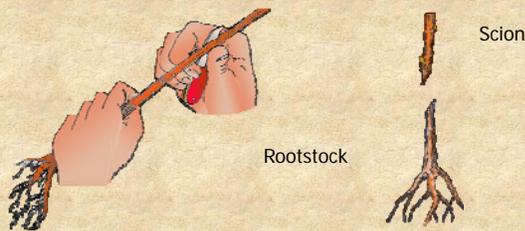
---

---

---

---

## Glossary of Grafting Terms



- **Grafting**—the process of inserting a part of one plant into or on another in a way that they will unite and continue growth as a single unit.

---

---

---

---

---

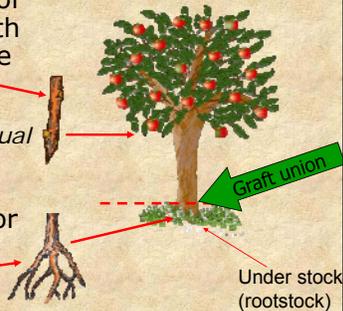
---

---

---

## What the Scion Brings to the Union

- **Scion**—A piece of last year's growth with two or three buds (*genetic material for vegetative—asexual propagation*); the part inserted on the understock or what we will call rootstock.



---

---

---

---

---

---

---

---

Why is it necessary to vegetatively propagate most tree fruit and nut cultivars by grafting (or budding)?

- **Vegetative (Asexual)** propagation maintains the genetic identity of the offspring



Scion: A detached shoot or twig containing buds from a woody plant, used in grafting. Alternate definition: A descendant; an heir; as, a scion of a royal stock.

- Trees are grafted (or budded) because they are often **difficult to root** or
- they **benefit from characteristics** of the rootstock variety.

---

---

---

---

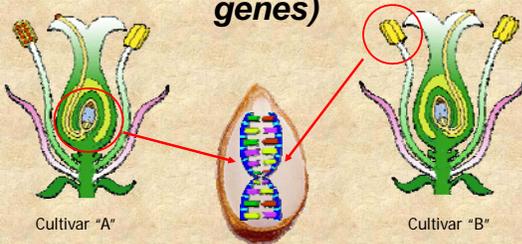
---

---

---

---

**Sexual propagation... (its all in the genes)**



.. allows for genetic *mixing* and *recombination* that requires a number of steps for diploid parents. ..They must first form haploid gametocytes, and that means their diploid chromosomes must partition themselves into two sets. ..This partitioning can be called genetic segregation.

---

---

---

---

---

---

---

---

**Only a few are selected**



Either  
or

**Winner**

It takes a tremendous amount of time, effort, and screening process to determine whether one of out of thousands or more resultant prodigies is discarded (a dog) or of commercial value (a winner).

**Dog**

---

---

---

---

---

---

---

---

## Honeycrisp

Dog or winner



- **Honeycrisp** (*Malus domestica* 'Honeycrisp') is an apple cultivar developed at the Minnesota Agricultural Experiment Station's Horticultural Research Center.
- Released in 1991, the Honeycrisp, once slated to be discarded, has rapidly become a prized commercial commodity.
- The Horticultural Research Center indicated that the Honeycrisp was a hybrid of the apple cultivars **Macoun** and **Honeygold**.
- However, genetic fingerprinting determined that neither of these cultivars is a parent of the Honeycrisp, but that the **Keepsake** is one of the parents. The other parent has not been identified, but it might be a numbered selection that could have been discarded since.

---

---

---

---

---

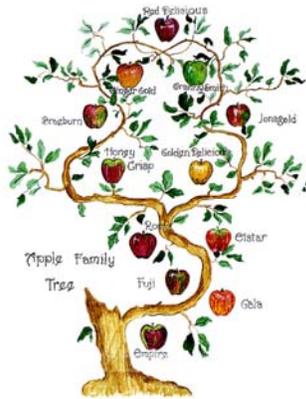
---

---

---

## Cultivar—

- Denotes a cultivated type of plant. (Now used in place of the term variety.)



---

---

---

---

---

---

---

---

## Cultivar is a label that denotes...

expectation of:

- Use & Flavor- sweet, tart
- Flowering and pollination-
- Disease resistance
  - mildew,
  - apple scab
- Fruiting- Annual vs biennial
  - early,
  - mid season,
  - late



---

---

---

---

---

---

---

---

## Scion Wood for Klamath Falls

Crimson Crisp  
Dayton  
Early Fuji  
Elstar  
Gala  
**Golden Delicious**  
Honeycrisp  
Rebella  
Royal Court  
Sansa

---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---

The image shows the cover of the "Apple Cultivars for Puget Sound" catalog on the left, which features a collage of various apple varieties. To the right is a page from the catalog displaying a grid of small photographs of different apple cultivars, each with a small label.

- **Apple Cultivars for Puget Sound (EB 1436)**  
Bloom and harvest dates, scab and mildew ratings, general descriptions and photographs.

<http://cru84.cahe.wsu.edu/cgi-bin/pubs/EB1436.html>

---

---

---

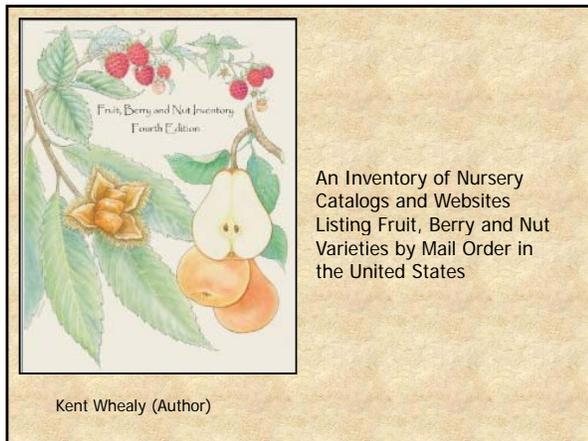
---

---

---

---

---



An Inventory of Nursery Catalogs and Websites Listing Fruit, Berry and Nut Varieties by Mail Order in the United States

Kent Whealy (Author)

---

---

---

---

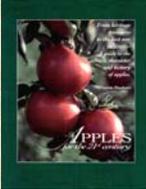
---

---

---

---

### Warren Manhart's Four Favorite Apples (from a list of 50 top cultivars)



- **Elstar:** All purpose apple
- **Spitzenberg:** "Very good to best."
- **Braeburn:** Best of newer late apples.
- **Newtown:** Rated the highest of all.

---

---

---

---

---

---

---

---




---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---



---

---

---

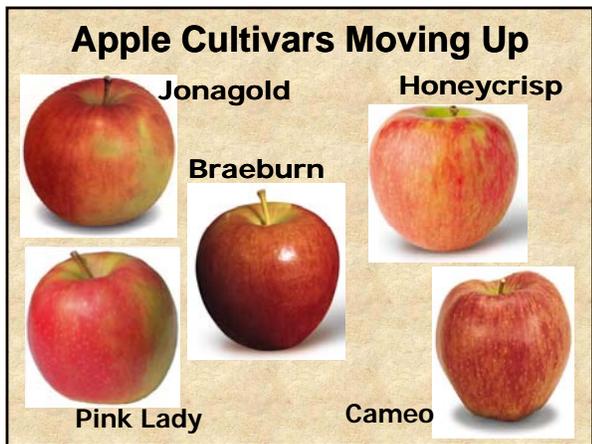
---

---

---

---

---



---

---

---

---

---

---

---

---

## Heirloom Varieties

Arkansas Black	Spitzenberg	Jonathan
		
Newtown Pippin		Cox Orange
	Northern Spy	
		

---

---

---

---

---

---

---

---

## Disease Resistance and Good Quality

	Akane	Redfree	Jonagold
			
			
			
			

- Cultivars that have shown good resistance and good quality are: 'Akane', 'Chehalis', 'Liberty', 'Dayton', and 'Redfree'.
- Intermediate resistance: 'Jonagold', 'Macoun', 'Melrose', 'Spartan', 'King'.

---

---

---

---

---

---

---

---




## Cider Apples

Cider quality inevitably depends on the type of apple used. Cider is traditionally made with one third each of sweet, bittersweet, and sharp apples.

<p><b>Bittersweet</b></p> <ul style="list-style-type: none"> <li>Dabinette</li> <li>Kingston Black</li> <li>Michelin</li> <li>Yarlington Mill</li> </ul>	<p><b>Sharp</b></p> <ul style="list-style-type: none"> <li>Duchess</li> <li>Melrose</li> <li>Rhode I. Greening</li> </ul>	<p><b>Sweet</b></p> <ul style="list-style-type: none"> <li>Cox's Orange Pippin</li> <li>Gravenstein</li> <li>Pitmaston Pineapple</li> <li>Newtown Pippin</li> </ul>
--	---	---

---

---

---

---

---

---

---

---



## Pollination



- The apple, *Malus domestica*, is considered to be **self-unfruitful**.
- All apple cultivars (varieties) require the pollen of a different cultivar to set a crop of fruit.
- A **pollen source** and **transfer** must be provided for these cultivars.

---

---

---

---

---

---

---

---

Cultivar A

Pollination

Compatible pollen source

Pollinator

Cultivar B

Self incompatible versus self pollination  
Diploid = two sets of chromosomes  
Triploid = three sets of chromosomes

Pollen sterile: Triploid will not fertilize diploid cultivars—Diploids (normal) will fertilize triploids.

---

---

---

---

---

---

---

---

## Other Pollinators or Transfer Agents



---

---

---

---

---

---

---

---





## Semi-dwarf and Dwarf Trees



- Dwarf trees have the additional advantage of being easier to prune, spray, thin, and harvest.

---

---

---

---

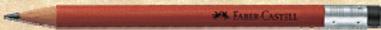
---

---

---

---

## Scion Wood Selection & Storage



- Collect scions of one-year-old wood in the fall, winter or early spring.
- They may come from trees whose fruit you desire -- perhaps those of neighbors or friends. Scion wood is also available from nurseries or experiment stations.
- Scion wood should be placed in closed plastic bags and stored under refrigeration (32 to 40°F) until used.
- The grafting is done in early spring, usually before growth starts.

---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---

## Scion Wood Source

**Nick Botner**  
4015 Eagle Valley Rd.  
Yoncalla, OR 97499  
(541) 849-2781

Neighbor  
Local Nursery  
Home Orchardist

WASHINGTON STATE UNIVERSITY  
Mount Vernon Research & Extension Unit  
16650 State Route 536  
Mount Vernon, WA 98273-9761  
360-848-6132 FAX: 360-848-6159  
E-mail kingjack@wsu.edu

<http://mountvernon.wsu.edu/FruitHorticulture/ScionwoodVarieties.html>

---

---

---

---

---

---

---

---

## Graft Compatibility

Sufficiently close genetic relationship  
for the formation of a successful  
graft union

- Limits of Compatibility

- Clone	Species	Genus	Family	Difficulty
S	S	S	S	No sweat
D	S	S	S	Easy
D	D	S	S	Moderate
D	D	D	S	Unlikely
D	D	D	D	Nil

---

---

---

---

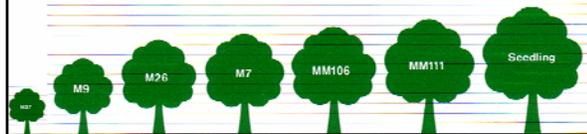
---

---

---

---

## Apple Rootstock listed by size class Size



Relative size of apple trees on various rootstocks.

Class 1 P.22 M.27 G.65	Size Class 3 M.9 Bud.9 P.2 G.16	Size Class 5 G.30	Size Class 7 MM.106 Bud.490	Size Class 9 Bud.118 P.18
Size Class 2 Bud.146 Bud.491 P.16 Mark	Size Class 4 G.11 M.26	Size Class 6 M.7	Size Class 8 MM.111	Size Class 10 Seedling

---

---

---

---

---

---

---

---

## Columnar Apple Trees




---

---

---

---

---

---

---

---

## Mini-dwarf apple trees



- Mini-dwarf apple trees are grown on our very dwarfing EMLA 27 rootstock.
- They are easily maintained at only four to six feet tall.
- These highly productive, compact trees, grown in large pots on patios or....
- ...are perfect to grow in a small backyard.

---

---

---

---

---

---

---

---

Tree and Rootstock vigor	Scion wood	Very Low Vigor	Low Vigor	Moderately Vigorous	Vigorous	Very Vigorous
		Spur Rome Super Spur Delicious Spur Winesap	Spur Delicious Spur Golden Spur Granny Smith	Delicious Golden Jonathan Akane Criterion Empire Spur Winter Banania	Jonagold Cortland Granny Smith	Cravenstein Mutsu Jonadel Spencer Winter Banania
Very Dwarf	M 27	N.R.*	N.R.*	N.R.*	N.R.*	1(?)
Dwarf	EM 9	N.R.*	N.R.*	1	1,2	2
	M 26	1,2	1,2	2,3	3,4	4,5
	MAC 9	1,2	1,2	2,3	3,4	4,5
Semi-Dwarf	EM 7	2	2,3	4	4,5	5
	M 7a	2	2,3	4	4,5	5
	EMLA 7	2	2,3	4	4,5	5
Moderately Vigorous	MM 106	2	3	4,5	5	5,6
	EM 4	2	3	4,5	5	5,6
	EM 2	2	3	4,5	5	5,6
	MM 111	2	3	4,5	5	5,6
	Interstem 9 on 2,3 very vigorous root		3	4,5	5	5
Vigorous	EM 1	3	3,4	5	5,6	6
	MM 104	3	3,4	5	5,6	6
Very Vigorous	Seedling	4	4,5	5	6	6+
	EM 16	4	4,5	5	6	6+
	Alnarp 2	4	4,5	5	6	6+

---

---

---

---

---

---

---

---

## Rootstock Selection

Selection on basis of :  
 Dwarfing  
 Precocious  
 Disease & Insect resistance  
 Soil type




Early fruiting



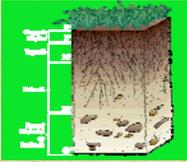
Woolly apple aphid



Scab fungi



Fire Blight



Soil site conditions

---

---

---

---

---

---

---

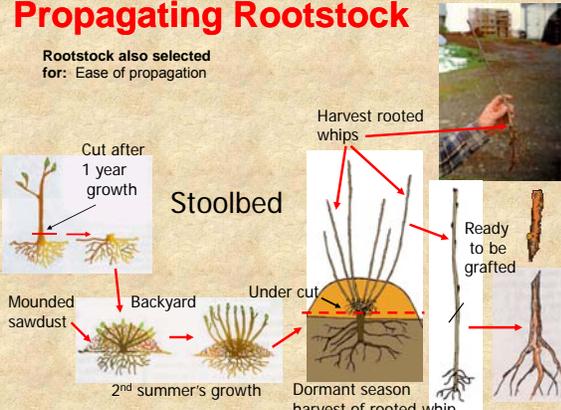
---

---

---

## Propagating Rootstock

Rootstock also selected for: Ease of propagation



Stoolbed

Harvest rooted whips

Ready to be grafted

Under cut

Dormant season harvest of rooted whip

2<sup>nd</sup> summer's growth

Backyard

Mounded sawdust

Cut after 1 year growth

---

---

---

---

---

---

---

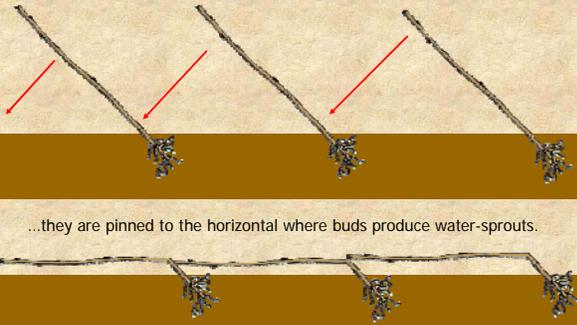
---

---

---

## Commercial Propagation

Rooted whips are planted at a 45° angle and once they are established...



...they are pinned to the horizontal where buds produce water-sprouts.

---

---

---

---

---

---

---

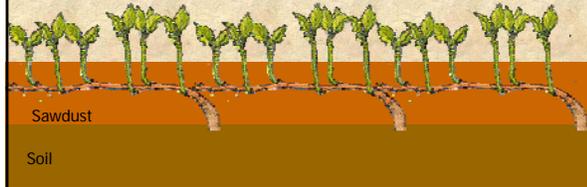
---

---

---

## Rootstock Propagation

Horizontal whips produce water-sprouts at each bud. Sawdust is mounded at the base of the upright sprouts which encourage roots to develop in the moist media.




---

---

---

---

---

---

---

---

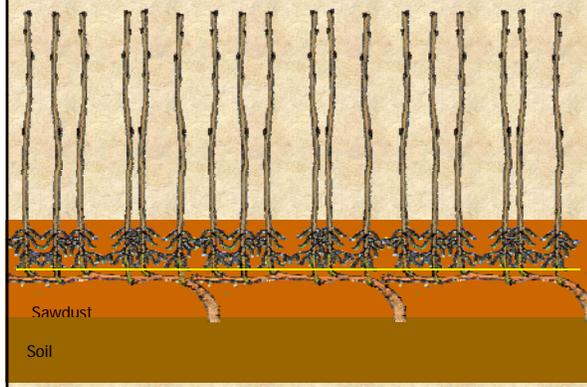
---

---

---

---

In dormant season, rooted whips are under cut and bundled




---

---

---

---

---

---

---

---

---

---

---

---



---

---

---

---

---

---

---

---

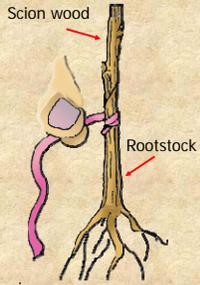
---

---

---

---

**Review: Four Criterion for Successful Graft Union Formation**



1. Cambial contact
2. Avoidance of desiccation
3. Compatibility
4. Pressure

---

---

---

---

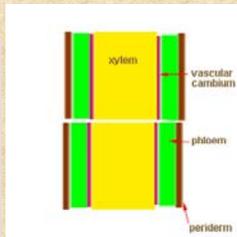
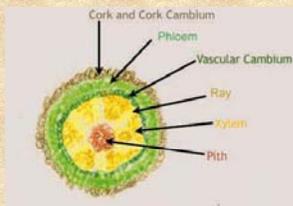
---

---

---

---

**Cambium—**



- The growing part of the tree; located between the wood and bark. At the season when bark separates freely, cambium will be both on the wood surface and on the inner bark.

---

---

---

---

---

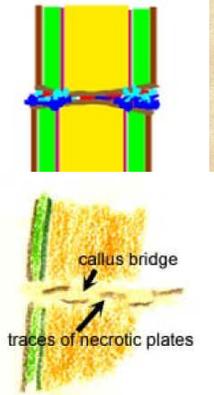
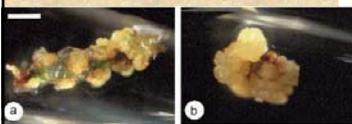
---

---

---

**Cambial Contact**

- In the first days or weeks after the two parts to be grafted are cut, cells proliferate at the site of the cut. This tissue is called "callus".




---

---

---

---

---

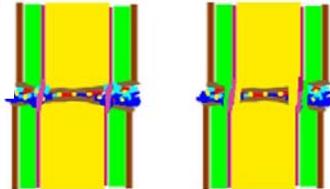
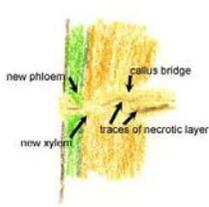
---

---

---

## Callus Bridge

If the two parts are in contact with pressure between the parts these two callus layers will begin to grow together, creating a "callus bridge."




---

---

---

---

---

---

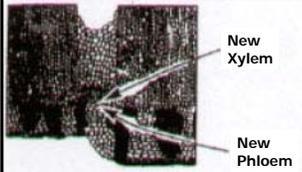
---

---

---

---

## Differentiation of new cambium.



- Parenchyma cells **differentiate** into cambium cells, thus uniting the cambium of the stock with the cambium of the scion.
- Formation of secondary xylem and phloem from new cambium allows translocation between the stock and scion.

---

---

---

---

---

---

---

---

---

---

## Avoidance of desiccation



2.) Use budding & grafting tape---or



3.) Use budding & grafting bands.



4.) Use tree seal

1.) Management during cuts. Keep cut edges moist.

---

---

---

---

---

---

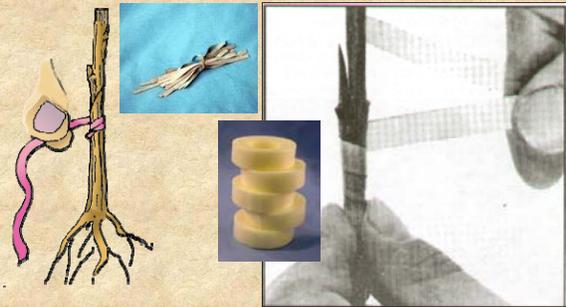
---

---

---

---

Wrap the splice cuts...



...firmly to create pressure and stability

---

---

---

---

---

---

---

---

Apply tree seal



---

---

---

---

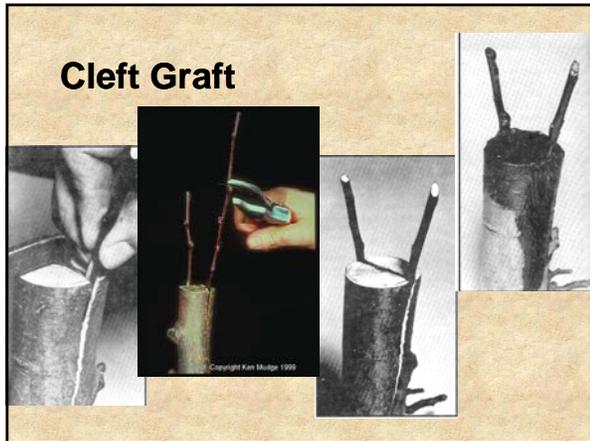
---

---

---

---

Cleft Graft



---

---

---

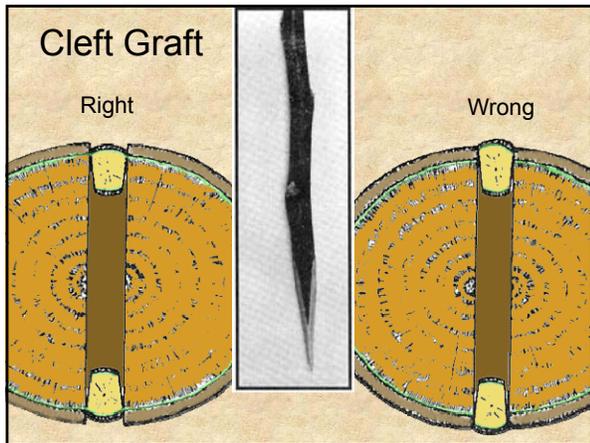
---

---

---

---

---




---

---

---

---

---

---

---

---

### Topworking

- When a desired variety is grafted onto the limbs of a hardy tree it is called "topworking."
- The operation of cutting back the branches and top of an established tree and budding or grafting part of another tree on it.

---

---

---

---

---

---

---

---

### Growing Multi-grafted Trees

Multi-graft apple tree

Open Center Leader

- Sometimes, more than one apple variety is grafted on the same tree.
  - This is reasonably satisfactory, but
  - varieties have different growth rates and maturity dates,
  - so it's more difficult to prune and spray such trees.
- You can avoid these problems by planting several dwarf trees of different varieties.

---

---

---

---

---

---

---

---

## Bud Graft



- Many of the apple trees and all of the stone fruit trees (plum relatives) sold in the area's nursery trade are propagated by a type of graft called budding.

---

---

---

---

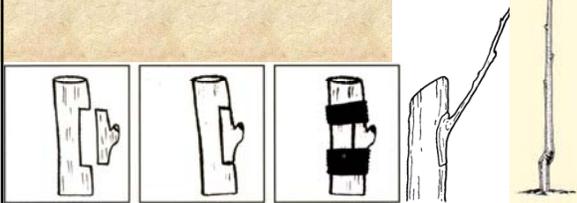
---

---

---

---

## Chip Budding



Chip budding is a technique that may be used whenever mature buds are available. Because the bark does not have to "slip," the chip-budding season is longer than the T-budding season.

---

---

---

---

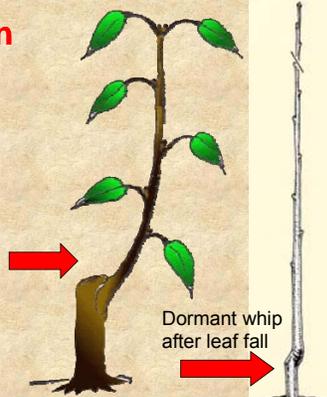
---

---

---

---

## Propagation



First summer's growth-select one shoot.

---

---

---

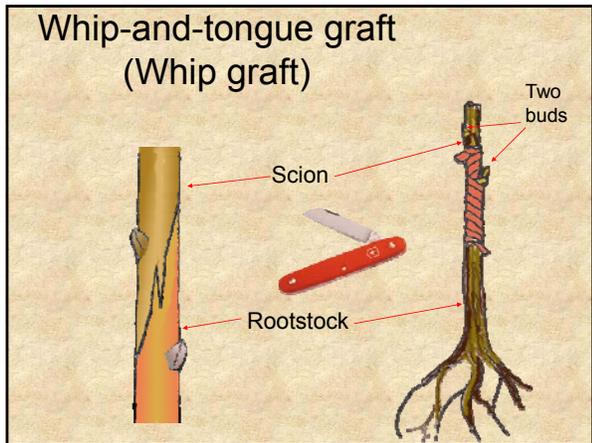
---

---

---

---

---



---

---

---

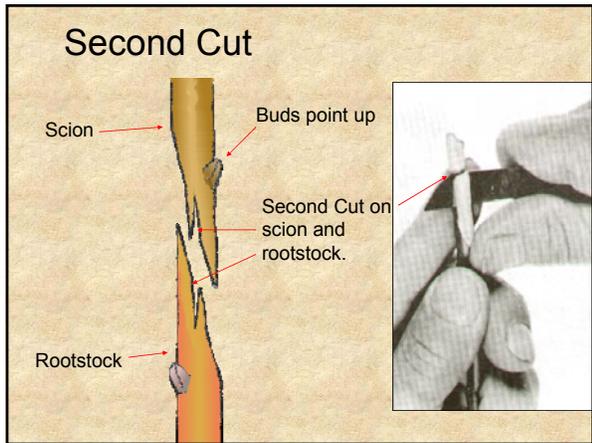
---

---

---

---

---



---

---

---

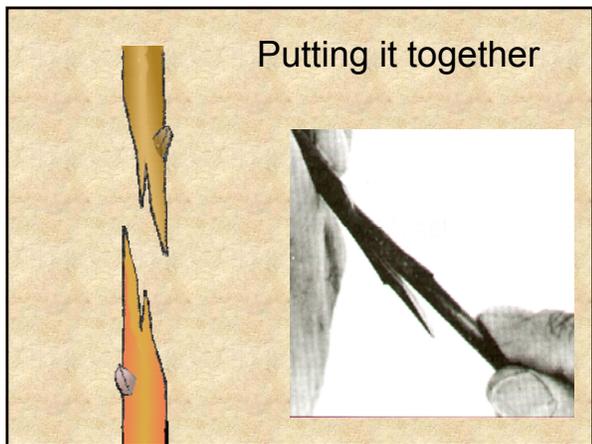
---

---

---

---

---



---

---

---

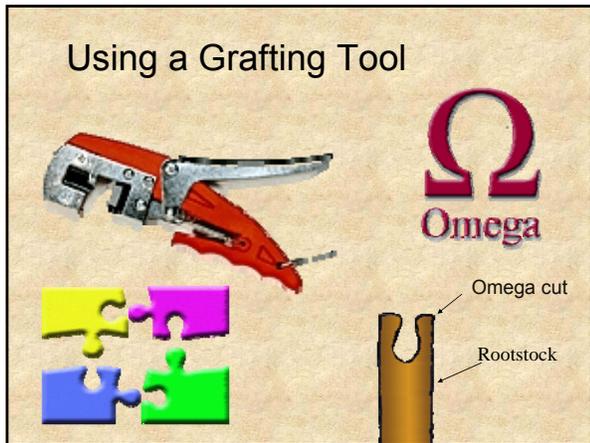
---

---

---

---

---




---

---

---

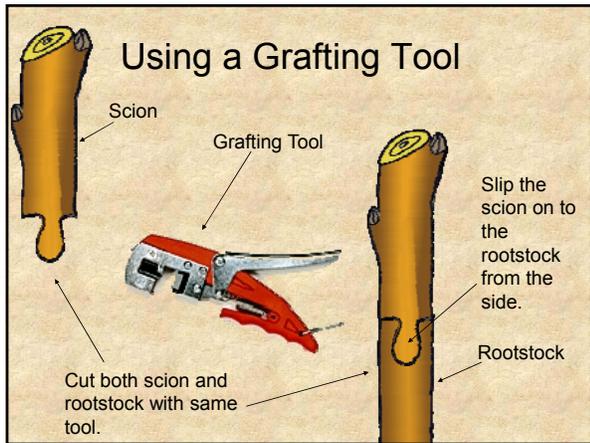
---

---

---

---

---




---

---

---

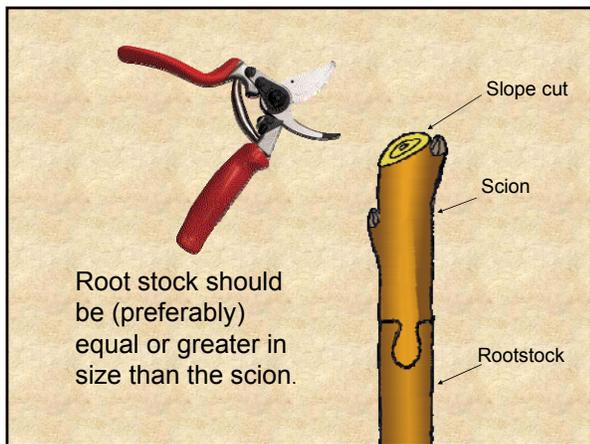
---

---

---

---

---




---

---

---

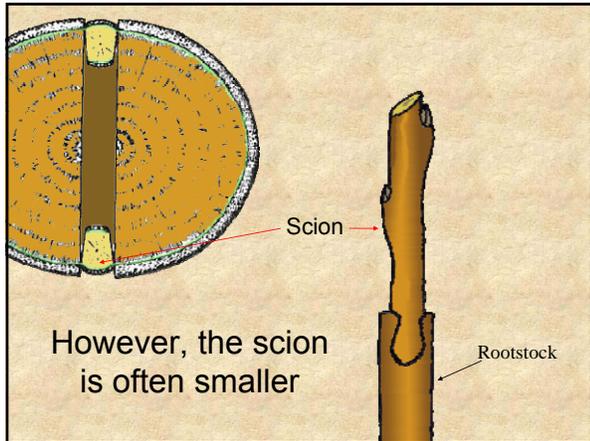
---

---

---

---

---




---



---



---



---



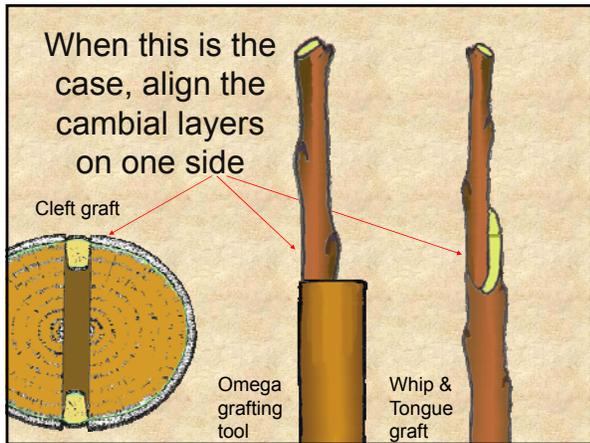
---



---



---




---



---



---



---



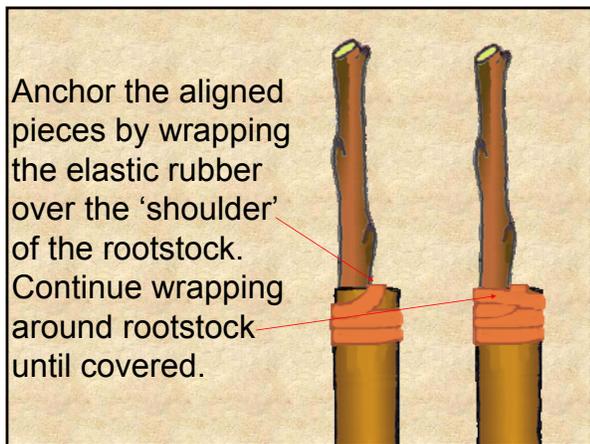
---



---



---




---



---



---



---



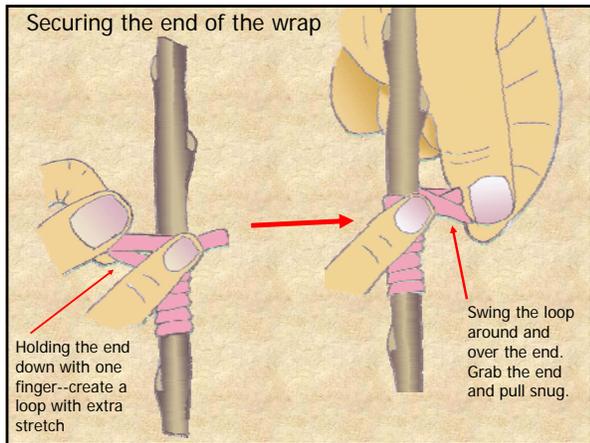
---



---



---




---

---

---

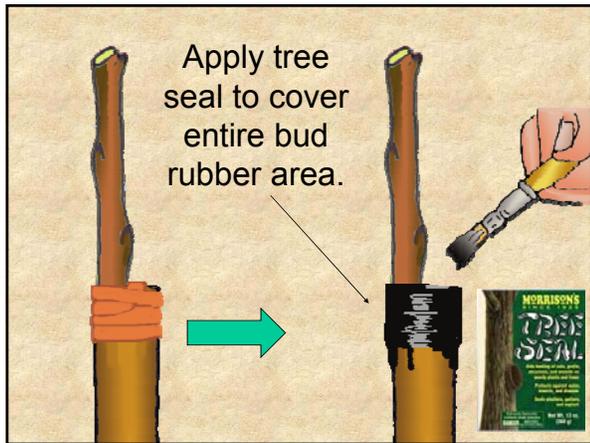
---

---

---

---

---




---

---

---

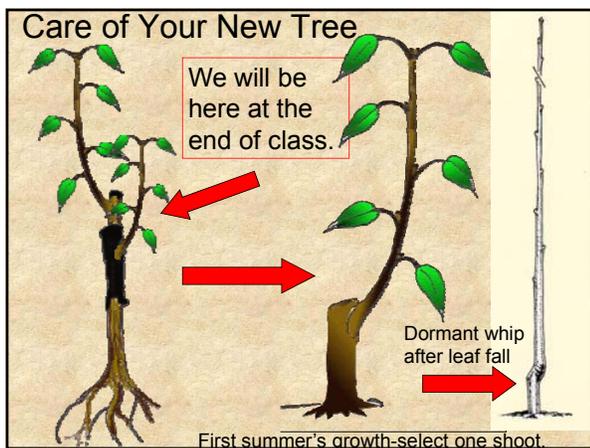
---

---

---

---

---




---

---

---

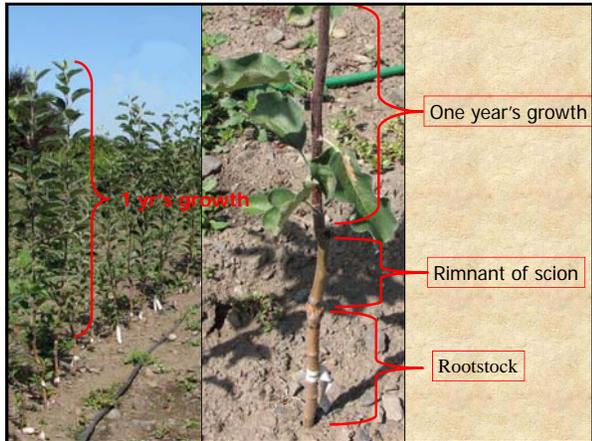
---

---

---

---

---




---

---

---

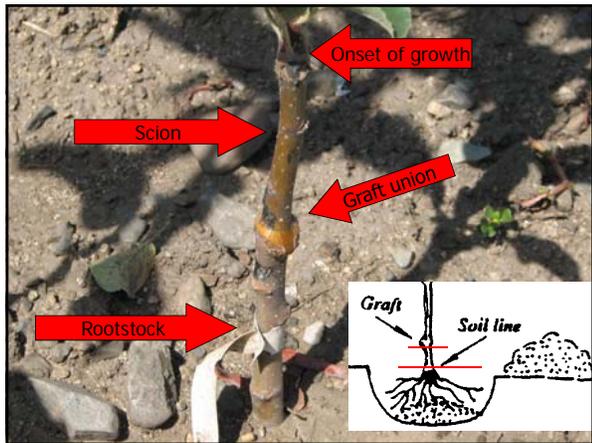
---

---

---

---

---




---

---

---

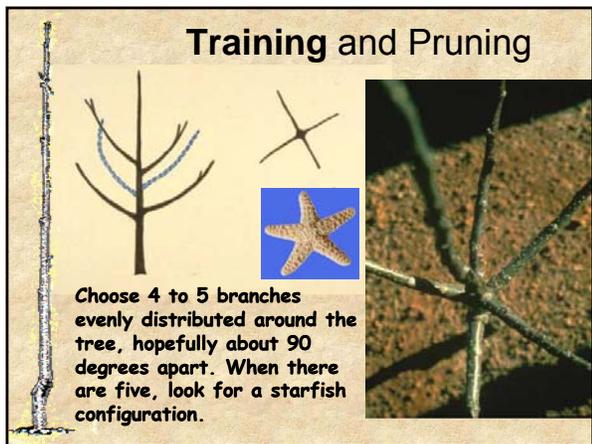
---

---

---

---

---




---

---

---

---

---

---

---

---

## Using spreaders




---

---

---

---

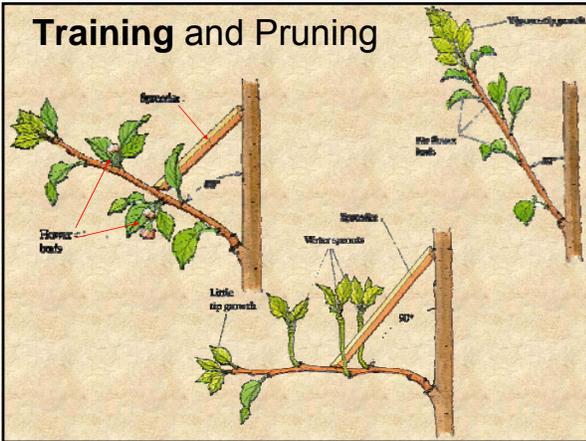
---

---

---

---

## Training and Pruning




---

---

---

---

---

---

---

---

## Training and Pruning

### SHAPING THE TREE WITH TWINE

1. The branches on a brand-new fruit tree tend to grow vertically. Prune away all but three or four. These will be the main fruit-bearing branches.
2. Tying down the branches encourages them to grow out and bear fruit, rather than grow up. This helps shape the tree. The tie-downs are shown in red.
3. When the tree makes new branches in its second summer, prune away all but three or four and tie them down, like the others, below.
4. Repeat the tying down every summer to create a basic shape for the tree, right. When the branches bear fruit, the weight of the fruit keeps them spread.

Source: OSU Extension Service

---

---

---

---

---

---

---

---

**Review: Four Criterion for Successful Graft Union Formation**

- 1. Cambial contact**
- 2. Avoidance of desiccation**
- 3. Compatibility**
- 4. Pressure**

---

---

---

---

---

---

---

---

**Cortland**



McIntosh X Ben Davis. Widely grown all purpose McIntosh type. One of the standards. Larger fruit with dark red skin underlaid with stripes. Crisp pure white flesh resists browning when cut. Tart tangy flavor. Dessert quality. Excellent for eating out of hand, cooking, and cider. Vigorous long lived tree is annually productive and starts bearing early. Excellent pollinator. Developed by New York Agricultural Experiment Station in 1898. Ripens 2-3 weeks before McIntosh. Does not drop as readily as McIntosh. Ripens mid September to early October. **Redcort, Royal Court**

**Crimson Crisp**

An exciting new disease resistant variety being offered for the first time in the spring of 2006. The fruit is medium in size with a very attractive crimson red color over 95% of the surface. Crimson Crisp has a very firm, crisp texture with a tart, complex flavor. The tree is very grower friendly with a spreading habit, fruiting throughout the tree on two and three year old branches. The fruit matures mid-season and will keep in cold storage for six months.



---

---

---

---

---

---

---

---

**Dayton**

was released in 1988. Its fruit ripens about 4 weeks before Delicious. Fruits are large with a glossy red color. Reports indicate that maximum storage may only be one month. The tree is vigorous, with strong, upright-growing branches. It has good resistance to mildew and cedar apple rust and moderate resistance to fire blight.



**Fuji**

Ralls Janet X Delicious. High quality apple with fairly poor appearance. Tall, rectangular, medium size fruit. Yellowish green skin with an orangish red flush and darker stripes. Darker blush on sun side. Crisp, juicy slightly subacid white flesh with outstanding texture. Good keeper. Vigorous, productive, somewhat bushy tree. Needs annual detailed pruning. Developed in Japan and introduced in 1962. Ripens very late. Very long storage life. **Auvil Early Fuji:**

---

---

---

---

---

---

---

---

### Golden Delicious

Originated in West Virginia. Thin skinned that ranges from pale green to medium yellow. The yellowier the skin, the sweeter and softer the flesh. Good baking apple if you choose the greenish ones. Particularly suited to open tarts (since it retains its shape through cooking). Resists browning after being cut. Needs very little sugar in cooking. Sweet eating and baking apple. Thin delicate peel. Bakes firm and makes a chunky sauce. Holds it's shape. Excellent pie apple. Sports of Golden Delicious listed below.

- Golden Delicious (Mullins cv.)
- Golden Supreme Golden Delicious (Carnefix cv.)
- Goldspur Golden Delicious (Sundale cv.), spur
- Nugget Spur Golden Delicious, spur
- Smoothee Improved Golden Delicious (Gibson cv.)
- Starkspur Golden Delicious, spur
- Yelo Spur Golden Delicious, spur



---

---

---

---

---

---

---

---

### Gala



The first Gala apple tree was one of many seedlings resulting from a cross between a Golden Delicious and a Kidd's Orange Red planted in New Zealand in the 1930s by orchardist J.H. Kidd. Donald W. McKenzie, an employee of Stark Bros Nursery, obtained a US plant patent for the cultivar on October 15, 1974. Terrific for eating out-of-hand, Gala is at its very best when purchased locally, in season. Autumn Gala, Brookfield Gala, Royal Gala.

**Honeycrisp** is an apple cultivar developed at the Minnesota Agricultural Experiment Station's Horticultural Research Center at the University of Minnesota, Twin Cities. Designated in 1974 as the MN 1711, and released in 1991, the Honeycrisp, once slated to be discarded, has rapidly become a prized commercial commodity, as its sweetness, firmness, and tartness make it an ideal apple for eating raw. The Honeycrisp also retains its pigment well and boasts a relatively long shelf life when stored in cool, dry conditions



---

---

---

---

---

---

---

---

### Rebella

A large elongated red apple with a delightful combination of sweet and tart flavors. Fruit ripens in late September and trees resist scab, mildew, fireblight, cedar apple rust, and red mite.

### Elstar

Originated in the Netherlands from a cross between 'Golden Delicious' x 'Ingrid Marie'. Fruits ripen on early to mid September. The Elstar is a medium-sized apple whose skin is mostly red with yellow showing. The flesh is white, and has a soft, crispy texture. It may be used for cooking and is especially good for making apple sauce. In general, however, it is used in desserts due to its sweet flavor. **Valstar:**

### Sansa

'Sansa' originated from a cross between 'Gala' and 'Akane' made in 1969. Sansa is attractive, crisp, aromatic, medium-sized, and sweet-flavored. It may be stored for up to 2 months. One report says that Sansa is resistant to apple scab. The fruit matures about 2 weeks before Gala. Good-quality fruit for its season.

---

---

---

---

---

---

---

---



Okay! Let's  
graft some  
apple trees.

---

---

---

---

---

---

---

---