Unit C: Maintaining the Fruit and Nut Tree

Lesson 2: Plant Propagation Techniques Utilized in Fruit and Nut Production

Student Learning Objectives: Instruction in this lesson should result in students achieving the following objectives:

1. Correctly propagate appropriate fruit species by cuttings.
2. Recognize the asexual propagation methods of layering.
3. Understand the asexual propagation methods of budding and grafting
4. Demonstrate grafting and budding in the fruit and nut orchard.

Recommended Teaching Time: 6 hours

Recommended Resources: The following resources may be useful in teaching this lesson:

- A PowerPoint has also been developed for use with this lesson plan.
- http://pubs.cas.psu.edu/FreePubs/pdfs/UJ255.pdf
- http://aces.nmsu.edu/pubs/_h/h-322.html
- http://www.rootsofpeace.org/assets/Vegetative%20Propagation%20Techniques.pdf

List of Equipment, Tools, Supplies, and Facilities

Writing surface
PowerPoint Projector
PowerPoint slides
Transparency masters
Student lab sheets
Rootstocks and scions
Grafting tools (knives, wax, tape, plastic bags etc)
Document found at
http://www.rootsofpeace.org/assets/Vegetative%20Propagation%20Techniques.pdf *This document discusses propagation in Afghanistan and can be used as a supplementary text to the lesson. It will be cited as "Roots of Peace document". It will be beneficial if students can view a copy of this publication online or printed out.*

Terms: The following terms are presented in this lesson (shown in bold italics and on PowerPoint Slide #2):

Air layering	Proximal end
Cambium layer	Rootstock
Cleft graft	Runner
Compound layering	Scion
Distal end	Side graft
Division	Simple layering
Hardwood	Softwood
Inarching	Stolon
Interstock	Tip layering
Mound layering	Topworking
Node	Vermiculite
Perlite	Whip and tongue graft

Interest Approach: Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Bring in apples, or a young apple tree seedling, and pictures of mature apple trees or apple trees in an orchard. Ask students to discuss how long it would take to grow an apple producing orchard if the trees were planted from seed. Introduce grafting as a technique that can greatly speed the propagation process by uniting the stem portion (scion) to the existing root portion (stock) of another similar plant. You may also discuss the fact that apple trees grown from seed rarely produce good fruit and that grafting transplants a good variety of a fruit tree onto the rootstock of perhaps a poor fruit bearing variety of the tree.

**** Use this activity to lead into Objective 1.**

Summary of Content and Teaching Strategies

Objective 1: Correctly propagate appropriate fruit species by cuttings.

(PowerPoint Slide #3)

I. **Cuttings** are the most common method of vegetative propagation.

A. A cutting is any vegetative plant part such as stem, leaves, or roots that, when detached from the parent plan is capable of reproducing a plant exactly like the parent.

(PowerPoint Slide #4)

1. Cuttings for fruit and nut trees will be **softwood** or **hardwood**.
   a. Softwood cuttings are normally from woody plants and come from the new growth before it hardens.

b. Hardwood cuttings come from a woody plant after the stem has hardened.

(PowerPoint Slide #5)

B. Propagation by cuttings are less commonly used by fruit and nut trees.
   1. Grapes are the main fruit which can be successfully propagated by cuttings.
      a. This is one reason that some of our grape cultivars are so ancient.
   2. Fig and pomegranate can be propagated by stem cuttings.
   3. Traditional fruit trees such as pears and apples can be propagated by stem cuttings but not without great trouble and sometimes little success.
   4.

(PowerPoint Slide #6) *This slide shows some pomegranate cuttings that have begun rooting.*

(PowerPoint Slide #7)

C. The procedure for stem cuttings of fruit and nut trees depends upon the species.
   1. Stem cuttings should be 15 centimeters long with five to six buds.
      a. Avoid using cuttings from the tip of the cane. This wood will be younger and more prone to cold damage.

(PowerPoint Slide #8)

   2. Cut the stem at a forty-five-degree angle immediately below a **node.**
      a. a node is the area of a stem where one or more leaves are attached
      b. roots commonly initiate from the node in some species of plants.

(PowerPoint Slide #9) *This slide shows an example of a node.*

(PowerPoint Slide #10)

   3. Only healthy, insect-free cuttings should be selected.
   4. Early morning is the best time to take cuttings
   5. Keep the cut end moist until it is rooted.

(PowerPoint Slide #11)

   6. Cuttings should be taken with a sharp knife or razor blade to reduce injury to the parent plant.
      a. Dipping the tool in rubbing alcohol or a mixture of one part bleach and nine parts water prevents the transmission of disease from infected plant parts to healthy ones.

(PowerPoint Slide #12)

   7. Flowers should be removed from the stem in order to conserve energy and stored carbohydrates for root and shoot formation rather than flowering and fruiting.

(PowerPoint Slide #13)

   8. An artificial rooting hormone can be used to promote quicker rooting.
      a. Rooting hormone is not required but will improve the success and speed of rooting in cuttings.

(PowerPoint Slide #14)

D. After taking the cutting be sure to maintain the vertical orientation of the cutting.

1. The end of the cutting that was closest to the roots, **proximal end**, should go into the growing medium and the end closest to the tip, **distal end**, should be pointing out of the growing medium
    a. Roots will only form from the proximal end and inserting the distal end of a cutting into the growing media will not succeed.

(PowerPoint Slide #15) *This slide shows an illustration of distal and proximal end of cuttings.*

(PowerPoint Slide #16)

2. Remembering which end is which can be done by always cutting the proximal end at an angle and the distal end straight.

(PowerPoint Slide #17)

E. After cuttings are taken they should be placed in a moist rooting medium such as coarse sand, **vermiculite**, soil, water or mixture of peat and **perlite**.

(PowerPoint Slide #18)

1. Selection of the correct rooting medium is important to get optimum rooting in the shortest time.
2. The rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress.
    a. The medium should be moist before inserting cuttings and kept evenly moist while cuttings are rooting and forming new shorts.

F. Stem cuttings can be placed in bright but indirect light so they do not dry out.

Review pages 14 and 15 in the Roots of Peace document. Complete LS: C2-1 "Propagation by Cuttings." If enough supplies are not available for each group to propagate, conduct the lab as a group activity and have one student complete each step.

Objective 2: Recognize the asexual propagation methods of layering.

(PowerPoint Slide #19)

II. Layering is another very simple method of asexual propagation.

A. Layering is commonly done on bramble fruits and can also be done with grapes.
B. Stems still attached to their parent plants may form roots where they touch rooting medium or soil.
C. Severed from the parent plant, the rooted stem becomes a new plant.

(PowerPoint Slide #20)

D. Layering promotes a high success rate because it prevents the water stress and carbohydrate shortage that plague cuttings.
E. Some plants, especially brambles, layer themselves naturally.

(PowerPoint Slide #21)

F. There are various methods of layering.
    1. In **tip layering** the shoot tips is inserted in a hole three to four inches deep and covered with soil.
        a. The tip grows down first and then bends sharply and grows upward.
        b. Roots from at the bend and the recurved tip becomes a new plant.

c. Tip layering can be used on purple and black raspberries and trailing blackberries.

(PowerPoint Slide #22) *This slide is an illustration of tip layering.*

(PowerPoint Slide #23)

2. **Simple layering** involves bending a stem to the ground and partially covering it with soil, leaving the last 15 to 30 centimeters exposed.
   a. the tip is bent into a vertical position and staked in place.
   b. The sharp bend will often induce rooting, but wounding the lower side of the branch or loosening the bark by twisting the stem may help.

(PowerPoint Slide #24) *This slide is an illustration of simple layering.*

(PowerPoint Slide #25)

3. **Compound layering** is just like simple layering except multiple sections of the same stem are alternately covered and exposed.

(PowerPoint Slide #26)

4. **Mound layering** consists of cutting back the plant to once about the ground in the dormant season and then piling soil around it in the Spring to induce root production from the new shoots.
   a. This type of layering works for apple rootstocks.

(PowerPoint Slide #27)

5. **Air layering** is not commonly used in fruit propagation but is possible.
   a. In air layering the stem is slit just below a node.
   b. The slit is then opened up and surrounded with wet sphagnum moss.
   c. Plastic or foil is wrapped around the moss and tied in place.
   d. When roots grow out of the moss the plant is cut off below the root ball and planted.

(PowerPoint Slide #28) *This slide illustrates the procedure for air layering.*

(PowerPoint Slide #29)

6. **Stolons** and **runners** are specialized plant structures which can be used to propagate plants.
   a. A **stolon** is a horizontal, often fleshy, stem that can root, then produce new shoots where it touches the medium.
   b. A **runner** is a slender stem that originates in a leaf axil and grows along the ground.
   c. The main fruit that is propagated by this method is strawberry.

Review the information in the Roots of Peace document on pages 12 and 13. Complete the lab activity on LS: C2-2 "Propagation by Layering". If enough material for each student is not available put the students in groups or make one class project and have the entire class observe the procedure for layering.

Objective 3: Understand the asexual propagation methods of budding and grafting

(PowerPoint Slide #30)

III. **Grafting** and **budding** are the main propagation methods used in fruit and nut production.

A. **Grafting** and **budding** are horticultural techniques used to join parts from two or more plants so that they appear to grow as a single plant.

(PowerPoint Slide #31)

1. In grafting, the upper part (**scion**) of one plant grows on the root system (**rootstock**) of another plant.

(PowerPoint Slide #32)

2. In the budding process, a bud is taken from one plant and grown on another.

(PowerPoint Slide #33)

3. When the two parts are joined the **cambium layer** must match up.
    a. The cambium layer is a thin layer of cells between the bark and the inner wood where the tree grows most actively and also where most of the nutrients are transported.
    b. If the scion's cambium layer does not match with the rootstock's cambium layer the scion will die and the graft will not heal, or take.
    c.

(PowerPoint Slide #34) *This slide illustrates where the cambium layer is located in woody plants.*

(PowerPoint Slide #35)

B. Since grafting and budding are asexual or vegetative methods of propagation, the new plant that grows from the scion or bud will be exactly like the plant it came from.
    1. These methods of plant reproduction are usually chosen because cuttings from the desired plant root poorly (or not at all).
    2. Also, these methods give the plant a certain characteristic of the rootstock - for example, hardiness, drought tolerance, or disease resistance.

C. The timing of grafting depends on the species and the technique used.

(PowerPoint Slide #36)

D. The reasons for grafting and budding are numerous and important.
    1. Change varieties or cultivars.
        a. An older established orchard of fruiting trees may become obsolete as newer varieties or cultivars are developed.
        b. The newer varieties may offer improved insect or disease resistance, better drought tolerance, or higher yields.
        c. As long as the scion is compatible with the rootstock, the older orchard may be top worked using the improved variety or cultivar.

(PowerPoint Slide #37)

2. Optimize cross-pollination and pollination.
    a. Certain fruit trees require cross-pollination.
    b. Portions of a tree or entire trees may be pollinated with the second variety to ensure fruit set.

c. Where cross-pollination is not possible, the chances that cross-pollination will occur can be increased by grafting a scion from a male plant onto the female plant.

(PowerPoint Slide #38)

3. Take advantage of particular rootstocks.
    a. Compared to the selected scion, certain rootstocks have superior growth habits, disease and insect resistance, and drought tolerance.
    b. For example, when used as rootstock for commercial apple varieties, the French crabapple *(Malus sylvestris,* Mill.) can increase resistance to crown gall and hairy root.
    c. Malling VIII and Malling IX are used as dwarfing rootstocks for apple trees when full-sized trees are not desired, such as in the home garden.

(PowerPoint Slide #39)

4. Benefit from interstocks.
    a. An interstock can be particularly valuable when the scion and rootstock are incompatible.
    b. In such cases, an **interstock** that is compatible with both rootstock and scion is used.
    c. An interstock could increase the disease resistance or cold hardiness of the scion.
    d. Plants also may be double worked to impart dwarfness or influence flowering and fruiting of a scion.

(PowerPoint Slide #40) *This slide illustrates where an interstock is located. Hold a discussion with the class about interstocks and why they are used.*

(PowerPoint Slide #41)

5. Perpetuate clones.
    a. If a fruit tree has desirable characteristics that would be beneficial throughout the orchard, such as disease resistance, grafting and budding allow that tree to be cloned.

(PowerPoint Slide #42)

6. Produce certain plant forms.
    a. Numerous horticultural plants owe their beauty to the fact that they are grafted or budded onto a standard, especially those that have a weeping or cascading form.
    b. In most cases, multiple scions are grafted or budded 91.4 centimeters or higher on the main stem of the rootstock.
    c. When used this way, the rootstock is referred to as a standard. It may require staking for several years until the standard is large enough to support the cascading or weeping top.

(PowerPoint Slide #43) *This slide shows an example of a weeping mulberry which was produced by grafting.*

(PowerPoint Slide #44)

7. Repair damaged plants.
    a. Large trees or specimen plants can be damaged easily at or slightly above the soil line.
    b. The damage may be caused by maintenance equipment (such as lawn mowers, trenchers, or construction equipment), or by disease, rodents, or winter storms.
    c. The damage can often be repaired by planting several seedlings of the same species around the injured tree and grafting them above the injury.
    d. This procedure is referred to as **inarching**, approach grafting, or bridge grafting.

(PowerPoint Slide #45) *This slide shows a tree that has been inarched. The arrow is pointing to a watersport that was used to graft to the tree.*

(PowerPoint Slide #46)

8. Increase the growth rate of seedlings.
    a. The seedling progeny of many fruit and nut breeding programs, if left to develop naturally, may require 8 to 12 years to become fruitful.
        i. However, if these progeny are grafted onto established plants, the time required for them to flower and fruit is reduced dramatically.
    b. Another way to increase the growth rate of seedlings is to graft more than one seedling onto a mature plant.
    c. Using this procedure as a breeding tool saves time, space, and money.

Review pages 17 through 31 in the Roots of Peace document. It will go into more detail about grafting procedures commonly used in orchards. Have the students break up into groups and pick one type of graft to read about. Once the group has read about their graft they should briefly discuss it with the class. The next objective will discuss a few methods of grafting in more depth.

Objective 4: Demonstrate grafting and budding in the fruit and nut orchard.

(PowerPoint Slide #47)

IV. Grafting and budding is a practice that takes much practice but is very beneficial to the fruit and nut orchard.

1. Grafting requires different tools depending upon the graft.

(PowerPoint Slide #48)

2. The most important tool is a sharp knife.
    a. A sharp knife makes cleaner cuts thus improving the quality of the graft.

b. A sharp knife also reduces the risk of personal injury as a dull blade can cause more damage to skin than a sharp blade in the event of an accident.

(PowerPoint Slide #49)

3. A fine-tooth saw for cleft grafting

(PowerPoint Slide #50)

4. Pruning shears
    a. Just like the grafting knife, pruning shears should be kept sharp and clean.

(PowerPoint Slide #51)

5. Tying material such as grafting tape, adhesive tape, electrician's tape or rubber strips
    a. Whatever is used for a graft covering should be resistant to sun degradation while the graft is healing and should be able to hold the graft together without girdling the tree.
    b. The tying material will be removed once the graft has healed.

(PowerPoint Slide #52)

6. Wax or similar substance to cover grafts
    a. All grafts should be covered with a protective coating immediately after completing the graft.

(PowerPoint Slide #53)

7. Grafting tool
    a. A grafting tool is not necessary as the jobs it completes can be done by individual tools, it is just convenient to only carry one tool to the orchard to complete budding and grafting.

(PowerPoint Slide #54)

8. Hammer
    a. A hammer is only used for cleft grafting and a few others where the rootstock may need to be pried apart or a scion may need to be nailed on to be kept in place.

(PowerPoint Slide #55)

9. Some grafts can be completed with special tools.
    a. An Omega cutter creates a shape like the Greek letter omega in the scion wood and a matching tab in the rootstock.
        i. This gives a very tight fit and greatly improves the success of the graft.
    b. A chip graft machine easily creates a notch in the rootstock and the bud from the scion that will be grafted.
    c. A V-graft machine is similar to the Omega tool except it creates a wedge shape in the rootstock and complementary notch in the scion.

(PowerPoint Slide #56) *This slide illustrates a grafting machine commonly used in the orchard industry.*

(PowerPoint Slide #57)

d. The Omega, chip and V grafting tools are commonly used in very large grafting operations and orchards where hundreds or thousands of grafts are done a week.

(PowerPoint Slide #58)

B. There are many methods of grafting. The most common is the **whip graft, or whip and tongue graft,** which is used mostly on young apple and pear trees when the branches are relatively small (not more than 1.27 centimeters in diameter) and the rootstock is about the same diameter as the scion of the new cultivar.

(PowerPoint Slide #59)

1. Cut off a branch of the rootstock, leaving a stub at least 31 centimeters long.

(PowerPoint Slide #60)

2. Make a straight, slanting cut about 3.81 centimeters long on both the scion and the stock.
    a. Make the cut straight and even—one stroke with a sharp knife will do it.

(PowerPoint Slide #61)

    b. For the tongue, make a straight draw cut (not split), beginning near the top and cutting about the full length of the level.
    c. Match the two parts together by sliding the tongues into each other so they interlock.

(PowerPoint Slide #62)

3. Bind tightly with tape, then carefully cover the union and binding material with grafting compound or wax
    a. Remove wrapping as soon as the scion has started to grow to prevent girdling of the tree.
    b. This type of graft is difficult for the beginner but is used extensively by experienced operators. It lends itself to the tape method of binding. Tape serves to seal the wound and bind the parts together.
4. Remove wrapping as soon as the scion has started to grow to prevent girdling of the tree.

TM: C2-1 illustrates whip and tongue grafting and can be shown in class to further discuss and understand whip and tongue grafting.

(PowerPoint Slide #63)

C. The **cleft graft** is used for **topworking** (placing a new variety on an older established tree) older established apple and pear trees, either on the trunk of a small tree or on the side branches of a larger tree.
    1. It is best adapted to branches 2.54 to 5.08 centimeters in diameter.
        a. The grafts are made within 61 to 91 centimeters of the trunk or main branches and preferably not more than 1.2 to 1.8 meters from the ground, or near the top of the tree will be too high.

(PowerPoint Slide #64)

    2. Select a place free from knots and cut off the stock with a saw.

3. Cut the cleft (avoid splitting if possible) with a grafting tool, large knife or hatchet. After a few trials you will learn the proper depth of cleft.

(PowerPoint Slide #65)

4. With a sloping cut about .64 centimeters above the upper bud, cut the scions to include three buds, and to a blunt wedge about 3.81 centimeters in length with one side slightly thicker than the other.
    a. If the scion wedge is cut to a sharp point there is danger of the bark peeling. Also a sharp scion wedge' will not fit the cleft as well.

(PowerPoint Slide #66)

5. Open the cleft slightly with a grafting tool or screw driver. Insert a scion on each side, with the inner bark of stock and scion in contact. Have the thick side of the scion outward.

(PowerPoint Slide #67)

6. Cover the unions with grafting compound or tape and be sure the cleft is covered its full length.

(PowerPoint Slide #68)

7. During the first season, let all scions and the shoot growth from below the graft grow undisturbed. However, do not permit this rootstock growth to shade out the scions.
    a. The second Spring, select the most suitable scion as the permanent branch and consider the others as spares. Leave the spare scions on to assist in healing over the stub, but cut them back to a few buds on each.
    b. The third Spring, severely cut back the spare scions again.
    c. In the fourth season, or when crowding is noted, cut off all of the spare scions as seems necessary.

TM: C2-2 illustrates cleft grafting and can be shown in class to further discuss and understand cleft grafting.

(PowerPoint Slide #69)

D. The **side graft** is adapted to a wide range of branch sizes (.64 to 1.9 centimeters diameter). Its use is generally restricted to branches that are too large for the whip graft yet not large enough for the cleft graft. As the name suggests, the scion is inserted into the side of the stock, which is generally larger in diameter than the scion.

(PowerPoint Slide #70)

1. Select a smooth place on the rootstock branch at least a foot from the trunk.
2. Make a slanting cut at a narrow angle almost to the pith (core of the branch).

(PowerPoint Slide #71)

3. Cut the scion to a short, sharp wedge (about 2.54 centimeters) with one side thicker than the other.
4. Bend the branch slightly to open the cut. Press the scion in so the cambium layers of the stock and scion meet at one side.

(PowerPoint Slide #72)

5. Tying is unnecessary if the stock binds well, but you may have to tie small materials if the scion is not held firmly. Cut surfaces should then be covered with grafting compound or tape.

(PowerPoint Slide #73)

6. In about two weeks, cut off the stock above the union using sharp shears in order to avoid disturbing the scion, then cover the cut surface with grafting compound.

TM: C2-3 illustrates side grafting and can be shown in class to further discuss and understand side grafting.

(PowerPoint Slide #74)

E. **Budding** is a form of grafting in which a single bud is used as the scion rather than a section of stem. It is the most commonly used method for fruit tree production in the nursery, but can also be used for topworking plum, cherry, apricots, and peach as well as young apple and pear trees. (Cherry, plum, apricot, and peach are not easily cleft grafted or whip grafted.)

(PowerPoint Slide #75)

1. Budding is done in when the bark of the stock slips easily and when there are well-grown buds.
2. The first step is to cut bud sticks of the desired cultivar from strong shoots of the present season's growth. These buds should be mature, as indicated by a slightly brownish color.
3. Clip off the leaves as soon as the bud sticks are cut, leaving about 1.27 centimeter of the leafstalk for a handle. Discard the soft tips of the bud sticks. Wrap the bud sticks in moist burlap, moss or paper to prevent drying out.

(PowerPoint Slide #76)

4. Branches from the size of a lead pencil up to 1.27 centimeter diameter may be worked by this method. The bark of larger branches is too thick for satisfactory budding.

(PowerPoint Slide #77)

5. On the branches of the stock, about 40 centimeters or more from the trunk, make a T cut just across the bark. Then, with a knife blade or bark separator, lift the corners and carefully loosen the bark.

(PowerPoint Slide #78)

6. Remove the bud from the scion by shallowly whittling it off leaving enough surrounding bark and cambium to fit into the T cut just made in the stock.
7. Use rubber strips, electrician's tape, or adhesive tape to tie the bud. Wrap and tie tightly, but be sure you do not cover the bud.

(PowerPoint Slide #79) *This slide illustrates taping a bud to a rootstock. Point out that the tape does not cover the bud.*

(PowerPoint Slide #80)

8. Cut the tie before it binds too tightly—that is, in two or three weeks. Cut on the side away from the bud. Rubber strips need not be cut. The bud should remain dormant until the following Spring. Cut off the stock above the bud as soon as the bud starts growing.
9. Do not permit any shoot growth.
10. After the second year remove any growth from the stock and leave only growth from the buds.

TM: C2-4 illustrates budding and can be shown in class to further discuss and understand whip and tongue grafting.

(PowerPoint Slide #81)

F. Grafts are not always successful and even a successful orchardist will rarely have 100 percent success. There are many reasons why a graft may fail.

(PowerPoint Slide #82)

1. The scion and stock were incompatible.
    a. The process of wound healing between the scion and stock is necessary.
    b. In the healing process new plant tissues form, including the cambium which allow the transport of water, nutrients and hormones to the scion.
    c. If the plant materials are rejected the scion will die so the correct genus and species must be chosen.
    d. For example peach cannot be grafted onto plum rootsocks but plum can be grafted to peach.
    e. There are many sources available which suggest the best scion rootstock combination but most times compatibility can only be discovered by testing.
    f. In general, plants of the same species are genetically more similar and more likely to be compatible.

(PowerPoint Slide #83)

2. The grafting was done at the wrong season.
3. The rootstock was not healthy.
4. The scions were not vigorous.
5. The scions were dry or injured by cold temperatures.
6. The scions were not dormant.
7. The cambium of scion and stock were not meeting properly.

(PowerPoint Slide #84)

8. The scions were upside down.
9. The graft was improperly covered with grafting compound.
10. The scions were displaced by wind, birds or storms.
11. The graft was shaded too much after growth began.
12. New growth was damaged by aphids or other insects.
13. The union girdled because the bindings or label were not released in time.

These grafts are covered in the Roots of Peace document on pages 17 through 31. It also covers other grafts which were not covered in this lesson as they are not commonly used but the students should still read about them. After a review has been completed of these grafting methods have the students read as a class page 34 "Taking Care of Grafted and Budded Plants".

Review/Summary: Use the student learning objectives to summarize the lesson. Have the students explain the response to the anticipated problem of each objective. Student responses can be used to determine which objectives need to be reviewed. Questions on PowerPoint Slide # 85 can be used as review.

Application: Have the students complete grafts in an orchard or on rootstock. Practicing grafts is the best way to learn and succeed. Grafts do not necessarily need to be done on actual fruit and nut rootstock as this can be expensive, but rather can be done on any woody shrub or tree. Allow the students to practice all types of grafting and budding. Observe them as they practice to ensure safety and proper technique. If fruit and nut trees and rootstock and scion material are available have students graft or bud some of the trees and see if their grafts take.

Evaluation: Evaluation should focus on student achievement of this lesson's objectives. A sample written test is attached.

Answers to Sample Test:

Matching:

1. A
2. C
3. E
4. G
5. F
6. D
7. H
8. B

Short Answer:

1. Students can have various answers from the following:
The scion and stock were incompatible; apple will not unite with plum, for example. The grafting was done at the wrong season.
The rootstock was not healthy.
The scions were not vigorous.
The scions were dry or injured by cold temperatures.
The scions were not dormant.
The cambium of scion and stock were not meeting properly.
The scions were upside down.
The graft was improperly covered with grafting compound.
The scions were displaced by wind, birds or storms.

The graft was shaded too much after growth began.
New growth was damaged by aphids or other insects.
The union girdled because the bindings or label were not released in time

True/False

1. False
2. True
3. False
4. True
5. True

Sample Test Name_____

Test

Unit C Lesson 2: Plant Propagation Techniques Utilized in Fruit and Nut Production

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

A. Cutting	C. Scion	E. Top working	G. Layering
B. Budding	D. Proximal end	F. Cambium layer	H. Grafting

_____ 1. Any vegetative plant part such as stem, leaves, or roots that, when detached from the parent plan is capable of reproducing a plant exactly like the parent.

_____ 2. The upper part of a plant used in cuttings.

_____ 3. Placing a new variety on older established trees.

_____ 4. a portion of an attached shoot is partially buried underground where roots develop. The new plant may then be separated from the parent plant

_____ 5. Thin layer of cells between the bark and the inner wood where the tree grows most actively and also where most of the nutrients are transported.

_____ 6. The end of a cutting that was closest to the roots

_____ 7. A shoot or scion is removed from the desired plant and placed on another plant (the stock)

_____ 8. A bud is removed from the desired plant and placed on the stock.

Part Two Short Answer

Instructions. Provide information to answer the following questions.

1. Name 3 reasons why grafting and budding might fail.

Part Three True/False.
If the statement is true write T, if it is false write F

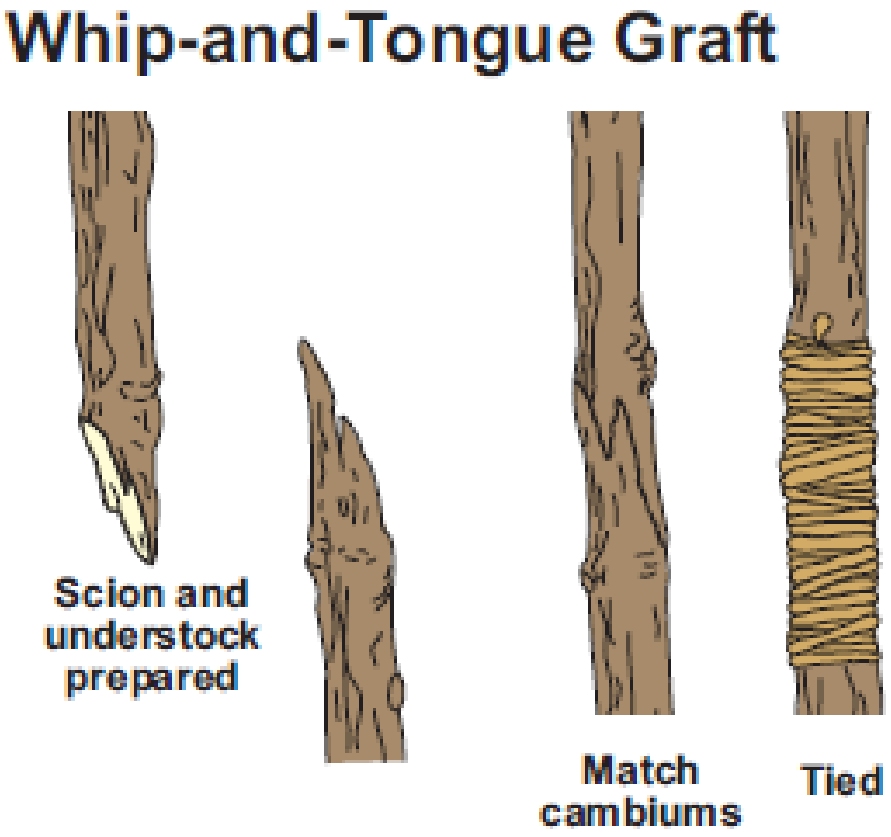
1. ____ Plants of the same genius are more likely to be compatible.

2. ____ It is important that the cambium layers of the stock and scion match up.

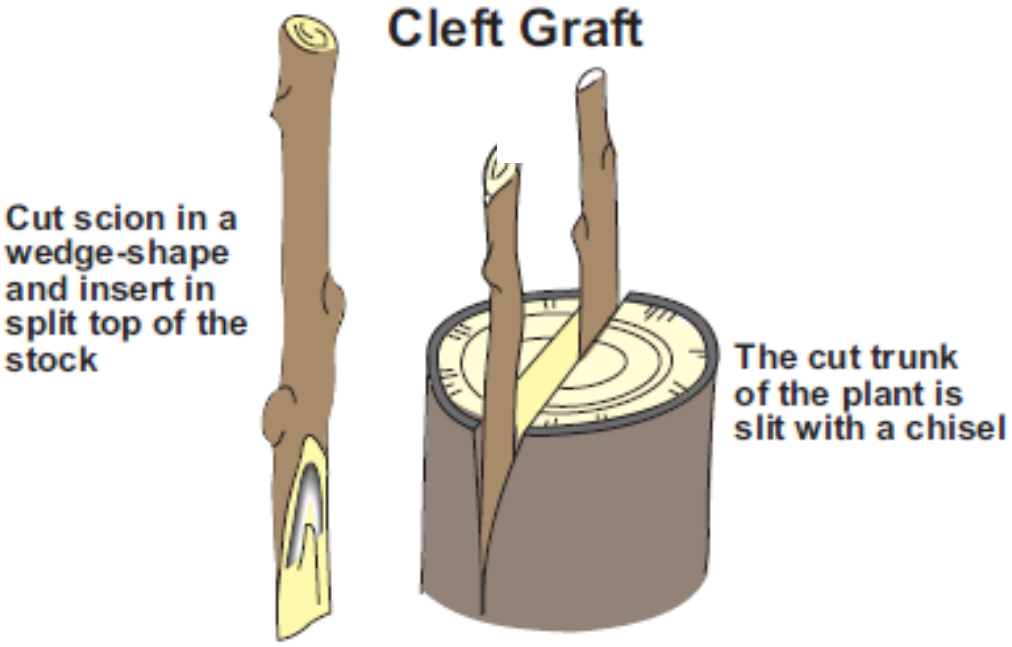
3. ____ When a seed is produced and planted, the resulting fruit will be exactly the same as the fruit the seed came from.
4. ____ The offspring of vegetative propagation are genetic clones of the parent.

5. ____ In general, the bark from the trees being grafted should be slipping.

TM: C2-1

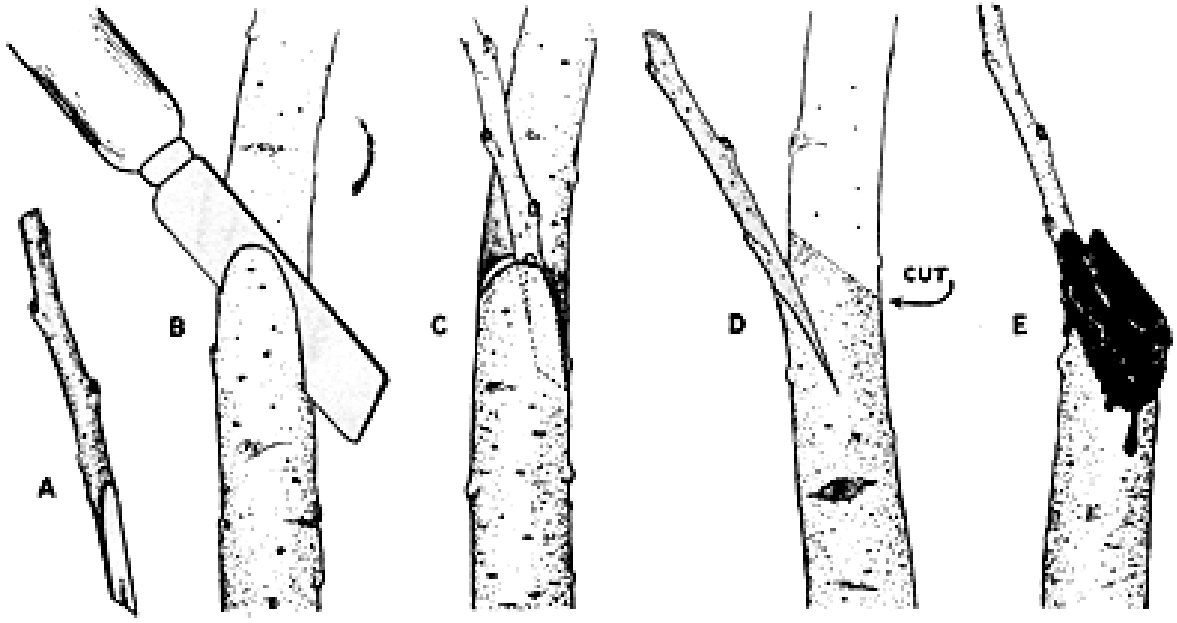

Whip-and-Tongue Graft
Scion and understock prepared
Match cambiums
Tied

TM: C2-2


Cleft Graft
Cut scion in a wedge-shape and insert in split top of the stock
The cut trunk of the plant is slit with a chisel

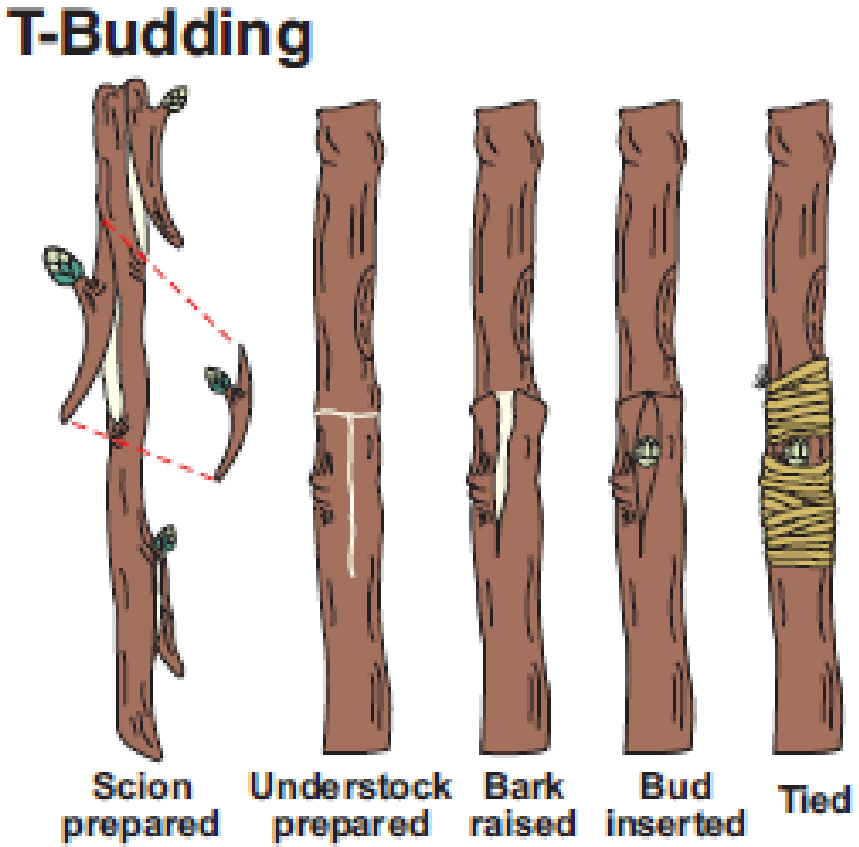
TM: C2-3

Side Graft



Illustrated here is the side graft. Notice how thin the wedge of the scion is cut. In the second picture a thin bladed saw is used to slice into the branch of a tree. The scion is inserted in the third picture so that the cambium layers matchup. The fourth picture shows a side view and where to cut the second year after the scion has been inserted. In the last picture the branch has been removed and covered with grafting compound.

TM: C2-4


T-Budding
Scion prepared
Understock prepared
Bark raised
Bud inserted
Tied

LS: C2-1

Propagation by Cuttings

Introduction: This lab will introduce the practice of propagating grapes. Grapes are rather easy to propagate by cuttings. The method of propagation used will be stem cuttings.

Objectives:
1. Correctly propagate a grape plant.
2. Understand the practice of stem cuttings as a propagation method.

Materials:
- Hardwood grape cuttings
- Sharp knife
- Rubbing alcohol or 1:9 bleach: water solution
- Potting media (vermiculite, coarse sand, or perlite and peat- use what is available as long as it holds moisture)
- Plastic to cover cuttings or a mist system

Procedure:
1. Find cuttings. Take cuttings from dormant vines which are at least one year old. The best time is at harvest or just prior to it. Be sure to select vines that are healthy and disease free. Selecting vines with a disease will spread the disease to the cutting and possible to other vines in the vineyard.

2. Take cuttings. The cuttings should be at least 15 centimeters long or contain five to 6 buds (nodes). Use a sharp knife to prevent damaging the cutting. Remember to cut the proximal end at an angle and the distal end flat so as not to confuse the orientation of the cutting when inserting it into the media.

3. Prepare cutting. Keep the cutting moist until it is ready to be placed in the growing media. Remove any flower buds from the cutting. If available, dip the cutting in rooting hormone.

4. Prepare growing media. A variety of growing medias can be used. Choose a media that will stay moist but not too wet. Avoid potting mixture as it tends to dry out quickly. Some suggestions include: coarse sand, vermiculite, or perlite and peat. Place about 8 to 12 centimeters of mixture into the flat or tub and moisten it.

5. Insert cuttings. Poke holes in the media about 8 to 12 centimeters apart. Use a pencil or other thin object to hollow out a hole deep enough to insert the cutting so that at least one node is covered by the media. Avoid using your finger as this will cause the bottom of the hole to become compacted and prevent the roots from spreading as easily. Hollowing out a hole will also prevent the rooting media from rubbing off.

LS: C2-1 (continued)

6. Firm the growing media around the cutting and keep in a moist area. The tub or tray can be covered in clear plastic or can be placed under a misting system. Place the tub in indirect sunlight and keep it moist but not soaking wet.

7. Observe the cuttings every other day over the next few days and take note of any root formation present and other observations.

Day	Observations
1	
3	
5	
7	
9	
11	
13	

LS: C2-2

Propagation by Layering

Introduction: This technique works best on plants that have a naturally trailing growth habit such as raspberries and blackberries. Simple layering is most effective on woody shrubs that produce numerous new shoots annually or on trees that tend to produce suckers. Deciduous plants are best layered in Fall or Winter whereas evergreens are best layered in Fall or Spring.

Objectives:
To become familiar with and practice various layering techniques

Materials:
Plants suitable for layering
Rooting hormone (optional)
Shovels
Small, sturdy stakes
Labels and marking pens
Stakes, bent nails or pins

Procedure:
1. Select a healthy, flexible, vigorous shoot that has grown in the current year.
2. Gradually and carefully bend it down until a point of the shoot about 22.5 to 30 cm from the growing tip reaches the ground.
3. Dig a hole about 7.5 to 10 cm deep at the point where the shoot touches the ground, then partly refill the hole.
4. Strip the leaves (if present) from the part of the branch that will be rooted.
5. Cut a shallow slit in the underside of the branch with a clean, sharp knife and dust the cut surface with rooting hormone using a paint brush.
6. Place the prepared stem section into the hole and carefully bend the shoot tip upward.
7. Secure the stem into the hole with a U-shaped wire around 15 to 20 cm long (this process is called "pegging").
8. Bend the tip of the shoot upright and if necessary support it with a sturdy stake.
9. Fill the hole with the remaining soil and cover the pegged area of the stem.
10. Thoroughly water the area and water as necessary during the rooting process.
11. Plants usually root within 12 to 15 months. You can check for rooting by gently pulling the soil away from the plant.
12. Once roots are visible and well-developed, sever the new plant from the parent plant using a clean, sharp knife or pruning shears.
13. Leave the newly-rooted plant in the site for a 2-3 week period of adjustment.
14. Dig and gently lift out the root ball and replant.
15. Make observations of the layerings every other day for the next few days.

LS: C2-2 (continued)

Day	Observations
1	
3	
5	
7	
9	
11	
13	