Unit 6. Propagation by Specialized Stems and Roots

Today's lab will deal with propagation by specialized vegetative structures (modified stems and modified roots). During this lab the specialized vegetative structures that we will be studying are bulbs, corms, tubers, tuberous roots, rhizomes, and pseudobulbs.

A. Specialized Reproductive Structures

B. Bulbs

C. Corms

D. Tubers

E. Tuberous roots

F. Rhizomes

G. Pseudobulbs

H. Laboratory Exercise Outline

I. Laboratory Questions

A. Specialized Reproductive Structures

Certain herbaceous perennial plants possess modified plant parts in which food storage tissue is coupled with protective tissue and meristematic tissues to produce a specialized reproductive "structure". The purpose of such specialized "structures" are to carry the plant over a dormant (environmentally unsuitable) period in a protected condition, and to provide a means of vegetative (asexual) reproduction. Vegetative propagation is a separation of detachable plant structures or by division of the plant into sections. The major types of specialized stems and roots utilized in asexual propagation are: bulbs, corms, tubers, tuberous roots, rhizomes, and pseudobulbs.

The specialized vegetative structures that we will be studying during this lab can be divided into specialized stems or specialized roots.

Specialized (modified) stems	Specialized (modified) roots
Bulbs (more than just a modified stem)	Tuberous roots
Corms	
Tubers (& tuberous stems)	
Rhizomes	
Pseudobulbs	

Plants producing these specialized vegetative structures can be propagated in two ways:

1. Sexual (seed) - except for a few cases of specific plants, sexual propagation is not widely used except by breeders.

    a. Cultivars of plants having specialized vegetative structures do not usually come true from seed.

    b. Time required to get plant to blooming or marketable size.

2. Asexual - for most species is of great importance commercially

    a. Separation - production of naturally detachable structures, e.g. bulb offsets.

    b. Division - cutting plant parts into sections (e.g. tuber - white or Irish potato)

B. Bulbs

1. Tunicate (laminate) bulb - e.g. onion, tulip, daffodil, amaryllis

    a. Tunic - Outer bulb scales: dry and membranous. The tunic provides protection from drying and mechanical injury.

    b. Bulb scales -the fleshy scales are in continuous, concentric layers or lamina so that the structure is more or less solid.

c. Cross section of the daffodil bulb.

1. Consists of bulb scales: morphologically are the continuous sheathing leaf bases.
2. The outer scales are generally fleshy and contain reserve food materials.
3. Scales toward the center function less as storage organs and are more leaf-like.

d. Longitudinal section of the daffodil bulb.

2. Non-tunicate (scaly) bulbs - e.g. lily

a. These bulbs do not posses the enveloping dry covering.

b. The scales are separate and attached to the basal plate.

In general, the non-tunicate bulbs are easily damaged and must be handled more carefully than tunicate bulbs; they must be kept continually moist because they are injured by drying. Root primordia are present at the time of harvesting. They do not elongate until planted under proper conditions.

Thickened contractile roots are produced in many species of scaly bulbs that shorten to pull the bulb to a given level in the soil. This is a very important mechanism for survival.

3. Propagation of bulbous species -

a. Sexual (seed) - as mentioned earlier except for a few cases where used primarily by breeders.

b. Asexual (vegetative) methods

1. Offsets (lateral) bulblets - daffodil, tulip
2. Bulblet formation on intact stems.

a. Underground stems bulblets - lily
b. Aerial stem bulblets (bulbils) - tiger lily

c. Cuttings- Instead of roots and shoots forming on the cuttings as would occur in other plants, bulblets form in the leaf axils and then produce roots and small shoots while still attached to the cutting.

1. Stem cuttings – lilies
2. Leaf-bud cuttings – lilies
3. Leaf cuttings - grape hyacinths

d. Bulblet formation on scales (scaling) - lily

1. Propagation of Easter lily by scaling

Easter lilies can be propagated by a procedure known as scaling in which individual bulb scales are separated from the mother bulb and placed in growing conditions so that bulblets form at the base of each scale. One to three bulblets will development from each scale. This method is particularly useful for rapidly building up stocks of a new cultivar or to establish pathogen-free stock. Almost any lily species can be propagated by scaling.

2. Twin-scaling bulbs

Twin-scaling is a method for rapid multiplication of certain bulbous plants. The procedure involves cutting a bulb into many pieces, each with a portion of the basal plate attached.

3. Basal cuttage

The hyacinth bulb continues to increase in size each year, but because the number of offsets produced is small, scooping or scoring is used.

a. Scooping

The entire basal plate is scooped out using a special curve-bladed scalpel, a round bowled spoon, or a small-bladed knife. Adventitious bulblets develop from the base of the exposed bulb scales (actually bulblets develop from callus which forms at the bases of the exposed scales). Depth of cutting should be deep enough to destroy the main shoot.

b. Scoring

Two or three straight knife cuts are made across the base of the bulb each deep enough to go through the basal plate and the growing point. Growing points in the axils of the bulb scales begin growing into bulblets.

The depth of each cut should be sufficient to kill the main flower bud at the apex of the basal plate and if done properly the cuts should reach into the bulb at its widest point.

4. Tissue culture - lilies, hyacinth, etc.

C. Corms

1. Dry leaf bases which persist at each of the nodes and enclose the corm are known as the tunic. The tunic protects it against injury and water loss.

2. At the apex of the corm is a terminal shoot which will develop into the leaves and flowering shoot.

3. Two types of root systems are produced by the corm:

   a. A fibrous system developing from the base of the mother corm.

   b. Enlarged, fleshy contractile roots developing from the base of the new corm - these roots maintain the corm at a particular depth in the soil, they are very important for survival.

D. Tubers

Examples:	Irish (white) potato	*Solanum tuberosum*
	Jerusalem artichoke	*Helianthus tuberosus*
	Caladium	*Caladium hortulanum*

1. A tuber has all the parts of a typical stem:

   a. The "eyes" are present in regular order over the surface and represent nodes, each consisting of one more small axillary buds subtended by a leaf scar.

   b. The arrangement of the nodes is a spiral, beginning with the terminal bud on the end opposite the scar resulting from the point of attachment to the stolon.

   c. The terminal bud is located at the apical end of the tuber oriented farthest (distally) from the crown of the plant.

2. Propagation of tuberous species

   a. Sexual (seed) - except for a few species sexual propagation is used primarily by plant breeders

   b. Asexual (vegetative)

      1. Plant whole tuber (separation)

      2. Division - cut tuber into pieces - each containing one or more buds "eyes" - the pieces of the tuber used for propagation are commonly referred to as seed. Also, the large tubers used for this purpose are also referred to as seed.

E. Tuberous Roots

1. Certain species of herbaceous perennials produce thickened underground structures which contain large amounts of stored food.

2. In certain plants such as sweet potatoes (Ipomoea batatas) and Dahlia sp. these thickened structures are true tuberous roots with external and internal structures of roots.

3. Comparison of tubers and tuberous roots

   a. Tuberous roots lack nodes and internodes.

   b. Buds are present only on the crown or stem (proximal) end of tuberous roots.

   c. Fibrous roots are commonly produced only on the opposite (distal) end of tuberous roots.

   d. Polarity of a tuberous root is the reverse of that of the true tuber.

Note: Root cuttings form roots at the distal and shoots at the proximal end.

4. Propagation of plants producing tuberous roots

   a. Sexual (seed) - as mentioned earlier, except for a few species is used primarily by breeders.
   Seed is widely used for propagation of dwarf (miniature) dahlias.

   b. Asexual (vegetative)

      1. Adventitious shoots - e.g. slips on sweet potatoes

      2. Division - used experimentally with the sweet potato and also used on dahlias.

         Dahlias - division is used; this involves dividing the crown so that each section bears a short bud.

      3. Stem, leaf or leaf-bud cuttings - cuttings develop tuberous roots at their bases.

      4. Tissue culture

F. Rhizomes

1. Rhizome - a specialized stem structure in which the main axis of the plant grows horizontally at or just below the ground level.
2. A number of economically important plants such as bamboo, sugar cane,

banana, and many grasses, as well as a number of ornamentals are rhizomatous in nature.

Rhizomatous ornamentals - Iris, Lily-of-the-valley, Sansevieria (snake plant) and the Canna.

Three general types of rhizomes are found:

a. Pachymorph - e.g. rhizomatous Iris and Ginger - the rhizome is fleshy, thick and shortened in relation to length. Plants of this nature grow in a clump.
It is determinate; each clump terminates in a flowering stalk, growth only continuing from lateral branches.

b. Leptomorph - e.g. Lily-of-the-valley - The rhizome is slender with long internodes. It is indeterminate; it grows continuously in length from the terminal apex and from lateral branch rhizomes. This type does not produce a clump but spreads extensively over an area.
Indeterminate plant - main axis vegetative, in which flowers form in axillary buds, e.g. cucumber.
Determinate plant - main axis terminates in a flower stalk, e.g. sweet corn.

c. Mesomorph - intermediate between 1 and 2. Some bamboo species.

3. Propagation of rhizomatous species

A. Sexual (seed)

B. Asexual (vegetative)

1. Division (clumps and rhizomes)

a. Clumps

Pachymorph - individual sections (or culms) are cut off at the point of attachment to the rhizome, the top is cut-back and the piece with the cut-back top is transplanted.

Leptomorph - individual offshoot is removed.

b. Rhizome - cut in sections, being sure each piece has at least one lateral bud or eye - is essentially a stem cutting.

c. Culm (pronounced kulm)- in large rhizome-bearing plants such as bamboos, the aerial shoot or culm may be used as a cutting.

These may be whole culm cuttings in which the entire shoot or culm is laid horizontally in a trench. New branches arise at the nodes. Or, a stem cutting of 3-4 node sections may be planted vertically in the ground.

C. Tissue culture

G. Pseudobulbs

1. Pseudobulb - a specialized storage structure, produced by many orchid species, consisting of an enlarged fleshy section of the stem made up of one to several nodes - In general, the appearance of the pseudobulb varies with the orchid species. The differences can sometimes be used to identify species. Pseudobulbs arise during the growing season on upright growth which develops laterally or terminally from the horizontal rhizome. Leaves and flowers from either at the terminal end or at the base of the pseudobulb depending on the species. During the growth period they accumulate stored food materials and water and assist in surviving dormant periods.

2. Propagation of orchids by pseudobulbs

   a. Offshoots - used in propagation of *Dendrobruim* species.

      The pseudobulb is long and jointed being made up of many nodes. Offshoots develop at these nodes and from the base of these offshoots roots can develop. The rooted offshoots are cut back from the parent plant and potted.

   b. Division - many important species of orchids, including *Cattleya, Laelia, Miltonia,* and *Odontoglossum* may be propagated by dividing the rhizome into sections.

      Division is accomplished during the dormant season, and preferably just before at the beginning of a new period of growth.

      The rhizome is divided into sections to include 4 to 5 pseudobulbs in the new section, leaving the old rhizome section with a number of old pseudobulbs or back bulbs from which the leaves have abscised.

      The section is potted when growth begins from the bases of the pseudobulbs, and at the nodes. Removal of the new section of rhizome from the old part stimulates new growth or "back breaks" to occur from the old part of the rhizome. These new growths grow for a season and can be removed the following spring.

   c. <u>Back bulbs and green bulbs</u>.
      Back bulbs - those without foliage.
      Green bulbs - those with foliage.

      Back bulbs are commercially used to propagate clones of *Cymbidium.*

      The back bulbs are removed from the plant, the cut surface is painted with a grafting compound and they are placed in a rooting medium for a new shoot to develop. When a rooted shoot has developed it is removed and potted. This back bulb can again be propagated and a second shoot developed from it. Green bulbs (those with foliage) can also be used in propagation. Treatment with IBA either by soaking or by painting with a paste has been shown to be beneficial.

H. Laboratory Exercise Outline - Unit 6

Exercise 1. **Practice scooping and scoring on the hyacinth bulbs provided by your lab instructor.**

a. Scooping:
The entire basal plate is scooped out using a special curve-bladed scalpel, a round bowled spoon, or a small-bladed knife. Adventitious bulblets develop from the base of the exposed bulb scales (actually bulblets develop from callus which forms at the bases of the exposed scales). Depth of cutting should be deep enough to destroy the main shoot.

b. Scoring
These straight knife cuts are made across the base of the bulb each deep enough to go through the basal plate and the growing point. Growing points in the axils of the bulb scales growing into bulblets.

The depth of each cut should be sufficient to kill the main flower bud at the apex of the basal plate and if done properly the cuts should reach into the bulb at its widest point.

AFTER TREATMENT:

a. dust bulbs with hydrated lime/fungicide mixture. Wear gloves and apply this mixture outdoors. Do not handle bulbs without gloves after treatment.

b. Callus bulbs at about 21°C (70°F) for a few days to a few weeks in dry sand or soil in open trays cut side down.

c. After callusing, the bulbs are incubated (up side down) in trays or flats in dark or diffuse light at 70°F which is increased to 85 to 90°F (29.5-32°C) over a 2 week period and held at high humidity (85% for 2 ½ to 3 months).

d. The mother bulbs are planted (right-side up) about 4 inches deep in nursery beds in the fall. The next spring bulblets produce leaves profusely. Normally, the mother bulb disintegrates during the summer. Annual digging and replanting of the graded bulbs is required until reach flowering size.

Exercise 2. **Propagation of Easter lily by scaling**

Easter lilies can be propagated by a procedure known as scaling in which individual bulb scales are separated from the mother bulb and placed in growing conditions so that bulblets form at the base of each scale. One to three bulblets will develop from each scale. This method is particularly useful for rapidly building up stocks of a new cultivar or to establish pathogen-free stock. Almost any lily species can be propagated by scaling. There are several modifications of this procedure. However, each student is instructed to do the following.

Treatment:

a. Carefully break off healthy outer scales from an Easter lily bulb.
b. Soak in fungicide (Benlate) for 30 min. (1 oz. per 1 ½ gallon water). Place scales in cheesecloth and wear gloves!
c. Space the scales well apart in slightly damp vermiculite in a plastic bag.
d. Seal the bag and store it at a constant temperature of 20 -22°C (68 -72°F) for 6-8 weeks.
e. After storage for 6-8 weeks, the scales will be removed and various data taken. These data will be recorded on the attached sheet and the sheet turned in.
f. After the bulblets develop on the scales, they may need at least 8 weeks of chilling at 2 -4°C (35 -40°F) to overcome dormancy. This can be accomplished by placing the bags in a refrigerator or potting the bulblets and storing them in a cold frame. After the chilling requirement has been satisfied, the bulblets are ready for planting outdoors.

Exercise 3. **Twin scaling (Easter Lilies or Daffodils)**

Treatment:

a. Cut off the "nose" of the bulb and then cut downwards through the bulb to make 4 or 6 segments. Placing each segment on its side, slice through the base plate to separate scales in pairs.
b. Benlate soak for 30 min. Place in cheesecloth and **wear gloves!**
c. Mix segments in moist vermiculite.
d. Store in sealed polyethylene bags.
e. Normal bulbs increase by a factor of 1.6 per year, so that it takes about 15 years to produce 1,000 bulbs from one individual, with twin-scaling on 2 occasions the period could be reduced to 8 years.

Exercise 4. **Division of Rhizomes**

Many rhizomatous species are propagated by division of the rhizomes. You will have an opportunity to divide several rhizomatous species and plant the propagules in 1 quart pots. The procedure involves cutting the rhizome into small pieces, each containing several buds and then planting these divisions.

I. Laboratory Questions - Unit 6

1. Outline the steps necessary for successful propagation of hyacinths by scooping or scoring (following the actual scooping or scoring operation) (5 points).

2. Why do daffodil and tulip bulbs generally cost less than hyacinth bulbs? (3 points)

3. With the exception of plant breeders why are tulip cultivars propagated commercially using asexual (vegetative) techniques? (3 points)

4. Describe how an individual could determine the proximal and distal ends of an Irish potato. (3 points)

5. When propagating orchids by pseudobulbs, how does one distinguish between a "back bulb" and a "green bulb"? (3 points)

6. Examine, sketch and label an external view and longitudinal section of a tunicate bulb (5 points) and a corm (5 points) using the plant material provided by your lab instructor. These sketches will be handed in with the lab questions and graded.