



# Propagation of Plants from Specialized Structures

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## INTRODUCTION

Most plants reproduce sexually from seeds, but some can be reproduced (or multiplied) by vegetative parts such as stems, roots, and leaves. In addition, some plants produce modified stems and/or roots, referred to here as specialized structures that accumulate food reserves and therefore have built-in regeneration potential and are valuable as vegetative propagules. Plants with specialized structures are well-suited for asexual propagation. For example, potato tubers are modified stems that store starch; such swollen underground structures—known as tubers—serve as a seed for raising commercial potato crops. Other plants produce specialized structures to survive under unfavorable conditions and resume growth when conditions become favorable for their survival.

Some plants have growth habits that facilitate vegetative propagation. Such structures usually originate from stems, roots, and sometimes leaves. For example, strawberry and spider plants produce horizontal stems known as runners. Runners can produce roots and develop new plantlets at particular nodes on the runner. Rooted runners can be detached from the mother plant and grown as independent plants.

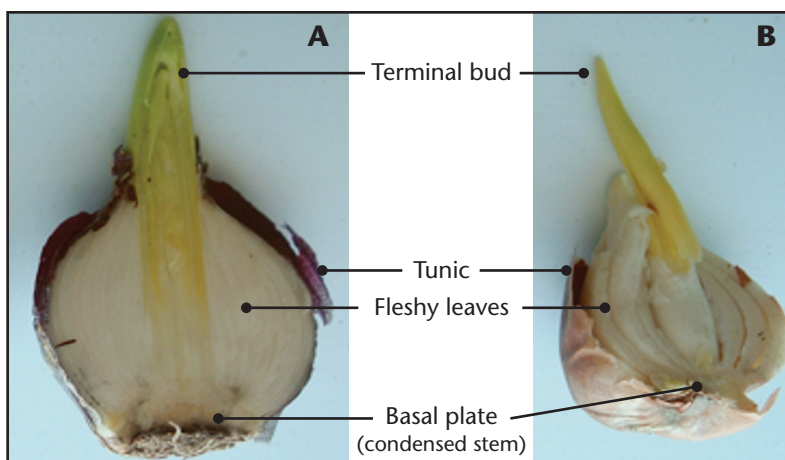
Plants produce a variety of specialized structures useful in plant multiplication or reproduction. This publication offers some basic information and guidelines that can increase the success of your experimentation with new ways of growing

plants. Refer to Table 1 (page 10) for a summary of specialized structures and the plant parts involved in their development.

## UNDERGROUND STEM MODIFICATIONS

### Bulbs

Bulbs consist of a growing point (stem or shoot tip) surrounded by layers of modified fleshy leaves designed to store food reserves. Both the growing point and the leaves are attached to a compact stem located at the base of the bulb called a basal plate. Thus, bulbs contain both stem and leaf tissue. See Fig. 1 (A and B) for a longitudinal section of a bulb.



**Fig. 1.** Longitudinal sections of hyacinth (A) and tulip bulbs (B). Bulbs are modified structures derived from a stem and leaves. The stem is compressed into a base plate carrying flowers or vegetative buds. Fleshy leaves with carbohydrate reserves surround the buds in a concentric manner. When planted, adventitious roots grow from the basal plate. The buds develop into flowers on the new plant.

There are two types of bulbs, known as either tunicate (Figs. 1 and 2A and B) or non-tunicate (scaly) bulbs (Fig. 2C), and either can be multiplied asexually. Onions, composed of concentric layers of fleshy leaves, are tunicate bulbs because the outer layers of leaves dry and form a protective tunic (covering). Lilies are non-tunicate bulbs because their leaves are fleshier and overlap each other, giving a scaly appearance. Since non-tunicate bulbs do not have a protective tunic, they are easily damaged and susceptible to desiccation. For best results, store non-tunicate bulbs in polyethylene bags containing moist sawdust or sphagnum moss.

Many fall-planted bulbs will flower outdoors. Some bulbs lack winter hardiness and must be stored over winter for spring planting. Table 2 (page 11) provides information about the hardiness of various types of bulbs.

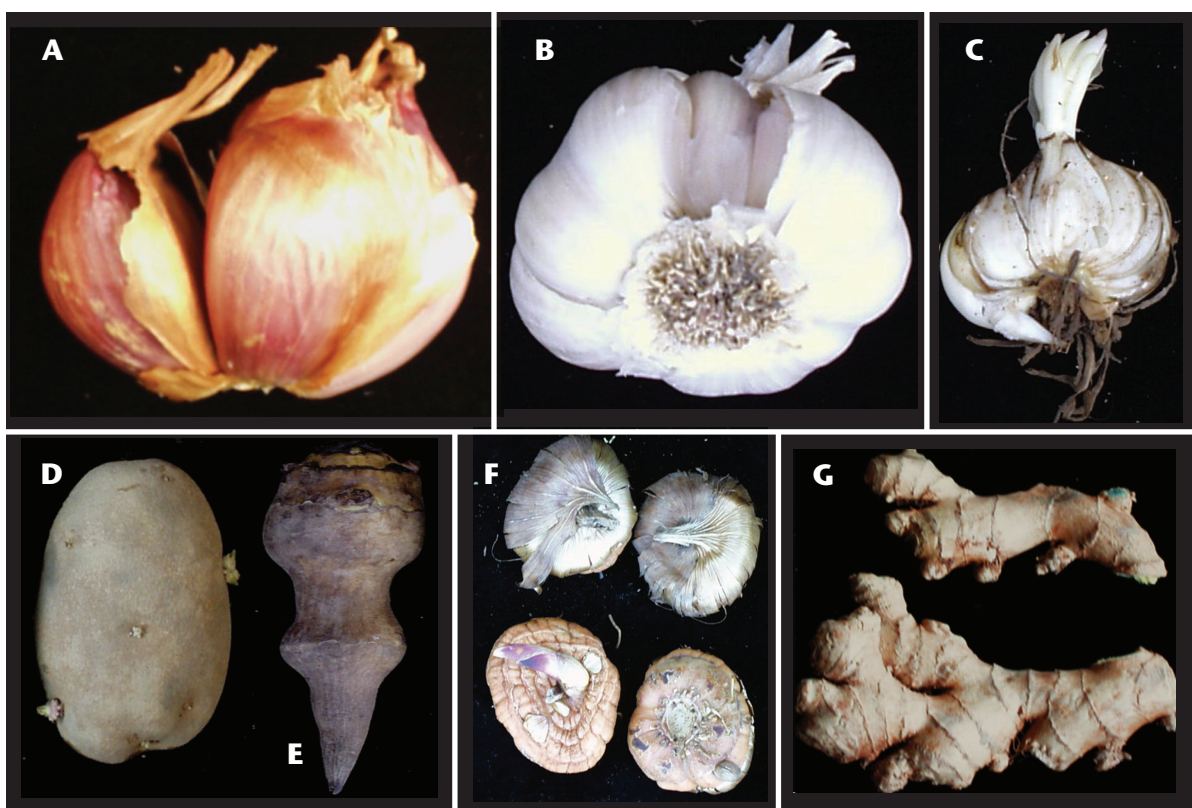
### ***Propagation of tunicate bulbs***

The most common approach is to simply leave tunicate bulbs in the soil between occasional diggings and replantings. The resulting plants may form dense colonies, but many prefer this as a natural look. Alternatively, digging annually prevents over-

crowding and produces better quality and larger bulbs. Dig tunicate bulbs, such as snowdrop and narcissus, after the leaves die back. Earlier digging reduces bulb size and subsequent flower quality.

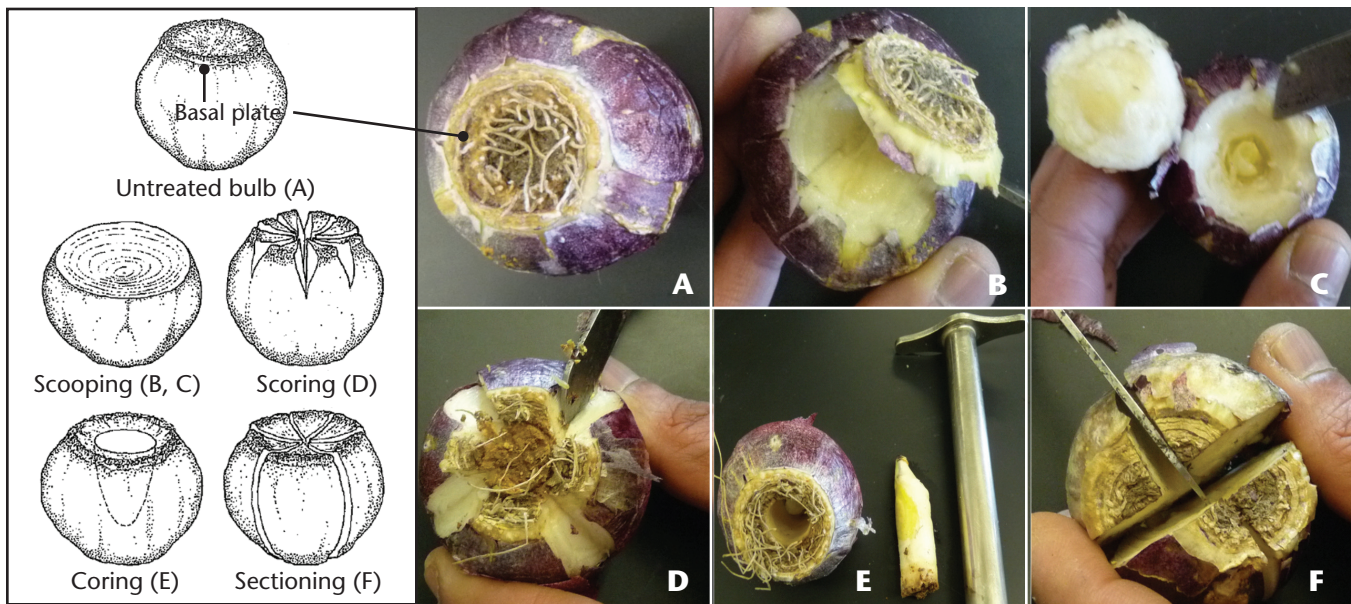
If you choose to dig and store tunicate bulbs annually, avoid drying them in the sun, as this can cause scalding. Clean them well after drying by brushing off dried roots and soil. Store tunicate bulbs in trays with wire mesh bottoms to provide adequate ventilation. To prevent root development and mold growth while in storage, maintain a humidity that will keep the bulbs dry, but not so dry as to shrivel—usually around 75 percent. Unless otherwise specified, store tunicate bulbs at about 80°F (27°C) for the first two weeks after digging to cure them, and then lower the temperature to around 48°F (9°C) until you plant them. If stored at higher temperatures, the bulbs may not flower properly. An underground cellar usually provides a good storage temperature after curing.

- *Offsets*: The simplest way to produce more plants from tunicate bulbs is to use offsets. Offsets are small bulbs that develop naturally from parent bulbs. You can enhance tunicate



**Fig. 2.** Examples of modified plant structures derived from stems and produced underground. Tunicate bulb of onion (A) and garlic (B), non-tunicate bulb of lily (C), tubers of potato (D) and Jerusalem artichoke (E), corms of gladiolus (F), and rhizomes of ginger (G).





**Fig. 3. Variously treated hyacinth bulbs for propagating (A-F). Note the development of bulblets from cored (a) and scooped (b) bulbs.**

bulb propagation by digging parent bulbs, separating, and planting. Small offsets will usually produce only leaves the first year; do not expect flowers until the second year or later. In Fig. 2A, the smaller bulb developing to the left of the larger bulb is an offset. Some plants, such as hyacinths, do not readily form offsets and therefore require artificial stimulation in the form of scooping, scoring, coring, or sectioning to induce new bulblets.

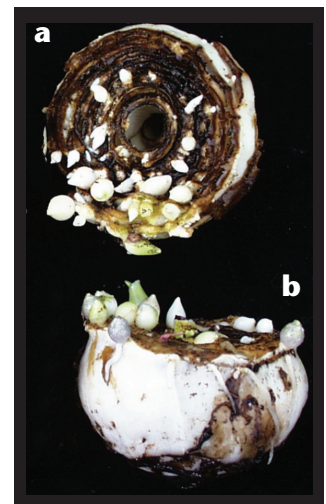
- **Scooping:** Scooping involves removing the entire basal plate of a bulb, which includes the main shoot and flower bud at the center of the bulb to expose the bases of the leaf rings (Fig. 3B and C).

Keep the bulbs in a warm (about 70°F or 21°C), dark place for about two weeks to dry and form wound tissue on the cut surface. A common storage method during this time is inverting the bulbs in a shallow box with a wire mesh bottom. When the scales begin to swell (by the third week), increase the temperature from 70°F (21°C) to about 85°F (29°C) and hold the relative humidity at about 85 percent. Small bulblets will then form at the base of these fleshy leaves (Fig. 3a and b).

Scooped bulblets are ready for planting when new roots begin to develop. The first year, plant them still attached to the mother bulb in loose soil, with the tip of the mother bulb about 1 inch deep. The bulblets will produce only foliage the first year. Dig

and separate when the foliage is yellow and dry. Although scooping produces 25 to 50 bulblets per mother bulb, these will be small and may require four or five years before flowering.

- **Scoring:** To score a bulb, make three V-shaped cuts through the basal plate so there are six pie-shaped sections (Fig. 3D). Make cuts deep enough to destroy the main growing shoot and reach just below the widest point of the bulb. Bury cut bulbs upside down in clean, dry sand about 2 inches below the surface. After the wounded tissue has healed, remove the bulbs from the sand and treat the same as scooped bulbs. Scoring produces about half as many bulbs as scooping, but they will be larger and should flower in three or four years.
- **Coring:** Coring removes the center portion of the basal plate and the main growing point of a bulb. Use a corer as shown in Fig. 3E or an apple corer for this purpose. Treat cored bulbs like scored bulbs. Cored bulbs produce still fewer bulblets than scored bulbs, but they will be larger and should flower in two or three years.



- **Sectioning:** If you cut bulbs into sections with a portion of the basal plate attached (Fig. 3F), bulblets will form from the basal plate of each cutting. These sections can be further divided by slipping a knife between each third or fourth pair of leaf-scale rings and cutting through the basal plate. Each bulb section should include a portion of the basal plate with segments of three or four leaf scales attached.

### **Propagation of non-tunicate bulbs**

Dig scaly bulbs like lily six to eight weeks after flowering (except as mentioned previously) or after the first light frost. Replant scaly bulbs immediately after digging. Drying of either the bulbs or roots will reduce the flower quality.

- **Scaling:** Propagate scaly bulbs by removing their outer scales and planting them one-half their length in a medium. Wait to dig these bulbs until after they flower. Plant the scales about an inch apart in rows 6 inches apart. New bulblets will form at the base of the scales (Fig. 4B) by fall, when they can be planted out. A replanted mother bulb will regenerate more scales in one or two years. If you cannot dig scaly bulbs until fall, store the scales in moist sand until spring, and then plant.
- **Bulblets:** Bulbs will also develop underground on the flower stalks of some lilies (Fig. 4A). Pull the stalk from the plant after flowering

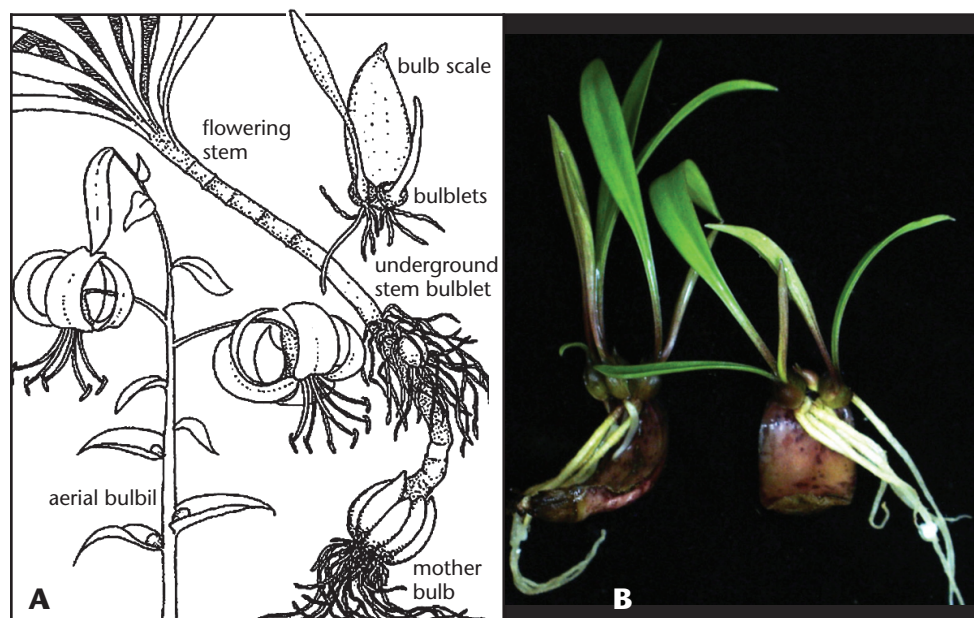
and cover the basal portion with moist rooting medium. Bulbs formed in this way can be separated and planted out to form new plants that should flower in one to two years.

### **Forcing bulbs**

Both tunicate and non-tunicate bulbs can be planted in pots and “forced” to flower indoors. Plant bulbs for forcing in the fall so that their tips are about one-half inch below the soil (or growing media) surface. Thoroughly water after potting and store in a cool, dark place such as a cellar or basement with temperatures between 40°F (4°C) and 45°F (7°C). If this type of storage is not available, bury the pots about 18 inches deep outdoors and cover with soil or straw mulch. After a good set of roots forms in three to ten weeks (depending upon storage conditions and type of bulb), bring the bulbs into your house and place in a sunny location. Care for them as with any other house plant, and they should produce flowers in the fall. Refer to Brown and Wilkins (2009) for detailed methods.

### **Corms**

Corms are often confused with bulbs, but the two differ substantially. Corms are the swollen bases of flowering stems; each corm is enclosed by a few thin leaves. Solid cores of enlarged stem tissue form beneath these leaves (Fig. 2F). Bulbs, on the other hand, are made up almost entirely of fleshy leaves.



**Fig. 4.** Lily plants develop underground (mother) bulbs and bulblets, and aerial bulbils suitable for propagation (A). Detached scaly leaves also produce bulblets, which eventually produce new plants (B).

If you want to propagate or replant from corms, dig then in the fall while the leaves are still somewhat green or after a light frost. Dry rapidly either outdoors or indoors. Only after the corms and leaves have thoroughly dried should the corms be cleaned and the cormels (described below) separated.

Store in perforated plastic or paper bags, below 60°F (15°C), with about 70 percent relative humidity. If corm diseases are a problem, reduce the temperature to less than 40°F (4°C). Plant hardy corms such as spring-flowering



crocus in the fall, and tender corms such as gladiolus in the spring.

Plants which grow from corms produce a new corm at the base of each shoot every year. The old corm is used up producing the plant. More than one flowering shoot may grow from a large corm. As a result, two (usually more) corms of smaller size will form from the original corm.

### Cormels

Small corms called cormels form at the base of new corms. Shallow planting of corms encourages their formation. Separated and planted cormels will flower in one to three years. Plant cormels only about 1 inch deep because of their small size.

### Tubers

Tubers are stem tissue which has been modified to become an underground storage organ (Fig. 2D and E). A well-known example of a tuber is the potato (Fig. 2D). The “eyes” of a potato are actually vegetative buds (meristems). When planted, the potato tuber sprouts from the meristems and develops a new shoot system. Roots then form from these new stems.

Propagate tubers by cutting them into sections, making sure that each section has a bud. Allow the cut surface to dry and slightly harden (wound heal) for several days prior to planting. Use fungicides as per the manufacturer’s instructions. Wear gloves to protect yourself from the chemicals.

### Rhizomes

A rhizome is a swollen modified stem that runs horizontally just under or partially under the ground (Fig. 2G). Rhizomes are the main axis of a plant and contain vegetative buds. Rhizomes can be used for propagation by cutting into sections that each have at least one bud. Plant the sections horizontally, the same way they were growing in the parent plant. Plants suitable for propagation by rhizomes include bearded iris, ginger, and canna.

### Tuberous Stems

Some plants, such as the tuberous begonia and gloxinia, have enlarged stems between the regular stem and roots. This area of a plant is known as the hypocotyl region, which means

tuberous stems are modified hypocotyls (Fig. 5C). These enlarged stems grow annually, and can be propagated by cutting into sections with at least one bud. Dry each section for several days after cutting before planting. Use fungicides as per the manufacturer’s instructions. Wear gloves to protect yourself from the chemicals.

### Suckers, Slips, and Crowns

Plants such as bananas, pineapples, raspberries, and blackberries produce adventitious shoots known as suckers that originate from roots. Propagate suckers by digging, separating from the mother plant, and growing as individual plants. In addition to suckers, pineapple plants produce slips that originate on the fruit stem (Fig. 6). Slips are separated from the mother plant and used for

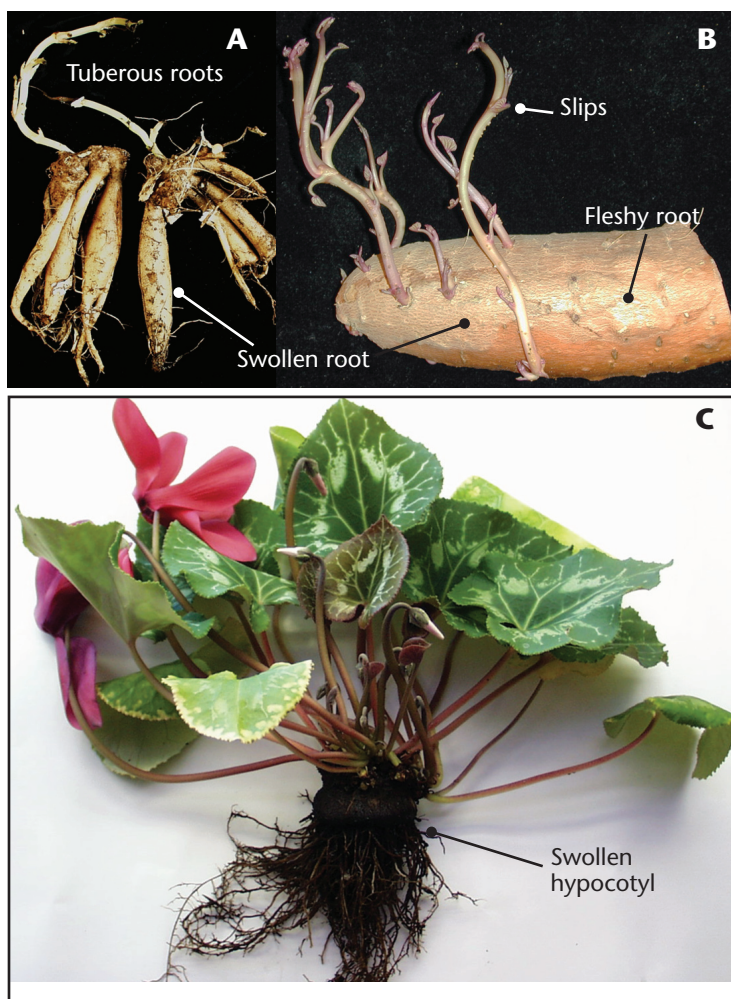
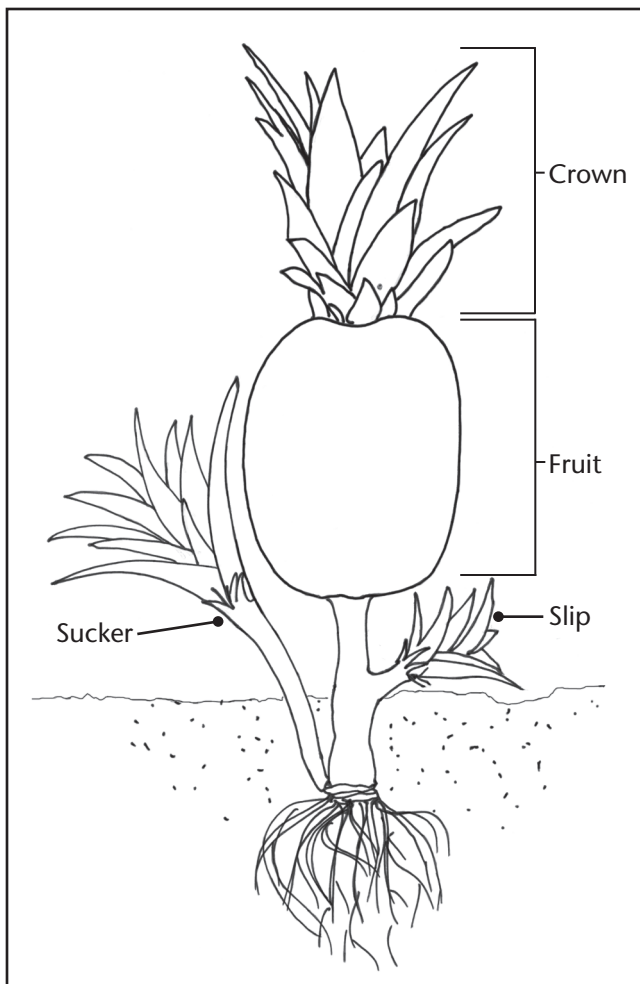


Fig. 5. Tuberous roots of dahlia (A), fleshy roots of sweet potato (B), and tuberous stems of cyclamen (C). The absence of vegetative buds on tuberous and fleshy roots distinguishes them from tuberous stems. With cyclamen, tissue joining the stem and root (hypocotyl) enlarge to form a swollen structure known as a tuberous stem.



**Fig. 6.** Various parts of pineapple suitable for asexual propagation. In commercial cultivation, pineapple is propagated from slips that develop on the fruit stem. Pineapple can also be propagated from suckers that develop from the underground stem. Pineapple sold in grocery stores carry an intact crown that can be separated from the fruit and grown as an independent plant.

commercial propagation of pineapples. Crowns that develop on the top of pineapple fruit can also be used for propagation by simply detaching and planting in a moist growing medium.

## UNDERGROUND ROOT MODIFICATIONS

### Tuberous Roots

Tuberous roots are sometimes confused with tubers. Tuberous roots, however, are actually root tissue and don't have "eyes" or buds (meristems) on them as tubers do (Fig. 5A). When propagating with tuberous roots, include a section of the crown or stem with a bud (Fig. 5A) on it. Tuberous roots such as dahlia are usually divided so that each root has one bud from the crown of the plant with it. Divide the clumps before the buds begin to grow in Febru-

ary or March just before planting. Sweet potatoes are fleshy roots that produce adventitious shoots directly from their root tissue (Fig. 5B), and these shoots then form roots. Such young plants, often called slips, can then be separated and planted. Tuberous and fleshy roots dug in the fall can be stored on shelves in a cellar where temperatures range from 40°F to 50°F (4°C–10°C). If the storage area is dry, pack the roots in dry peat or dry sand. When loss from drying is expected to be severe, dip the roots in molten paraffin wax floated on hot water to reduce desiccation.

## SUB-AERIAL (SURFACE) STEM MODIFICATIONS

### Runners, Stolons, and Offsets

Plants such as strawberries produce specialized stems that originate from a leaf axle and grow horizontally on the ground. Runners produce roots at certain nodal regions of horizontally-growing stems and form new plants. Runners are also considered stolons. When separated from the mother plant with intact roots, runners serve as units of propagation. Spider plants produce runners with plantlets at their ends (Fig. 7B). To propagate spider plants, sever the plantlets (daughter plants) from the mother plant and plant in a rooting medium. These plantlets contain pre-formed root initials and root easily when placed in contact with rooting media.

Some plants such as mint produce specialized stems known as stolons that form an extensive mat on the ground (Fig. 7D). Such plants generally root at every node and can be separated from the parent plant for propagation. The term "offset" refers to plant structures that develop by the side of mother plants. In fact, slips on pineapple can be considered offsets or offshoots. Fig. 7E shows offset formation in *Sansevieria*, and Fig. 2A shows offset formation in onion bulb. Offsets are desirable for propagation of *Sansevieria* plants with yellow margins to produce true-to-type plants.

## AERIAL STEM MODIFICATIONS

### Aerial Bulbs (Bulbils)

Some lilies produce tiny aerial bulbs (Fig. 4A) called bulbils at leaves joining the stem (leaf axils). Similar to bulblets, bulbils can be used to produce new plants after separating and planting. They take two or three years to reach flowering size. Remove flower buds from the plant to encourage aerial bulb formation.



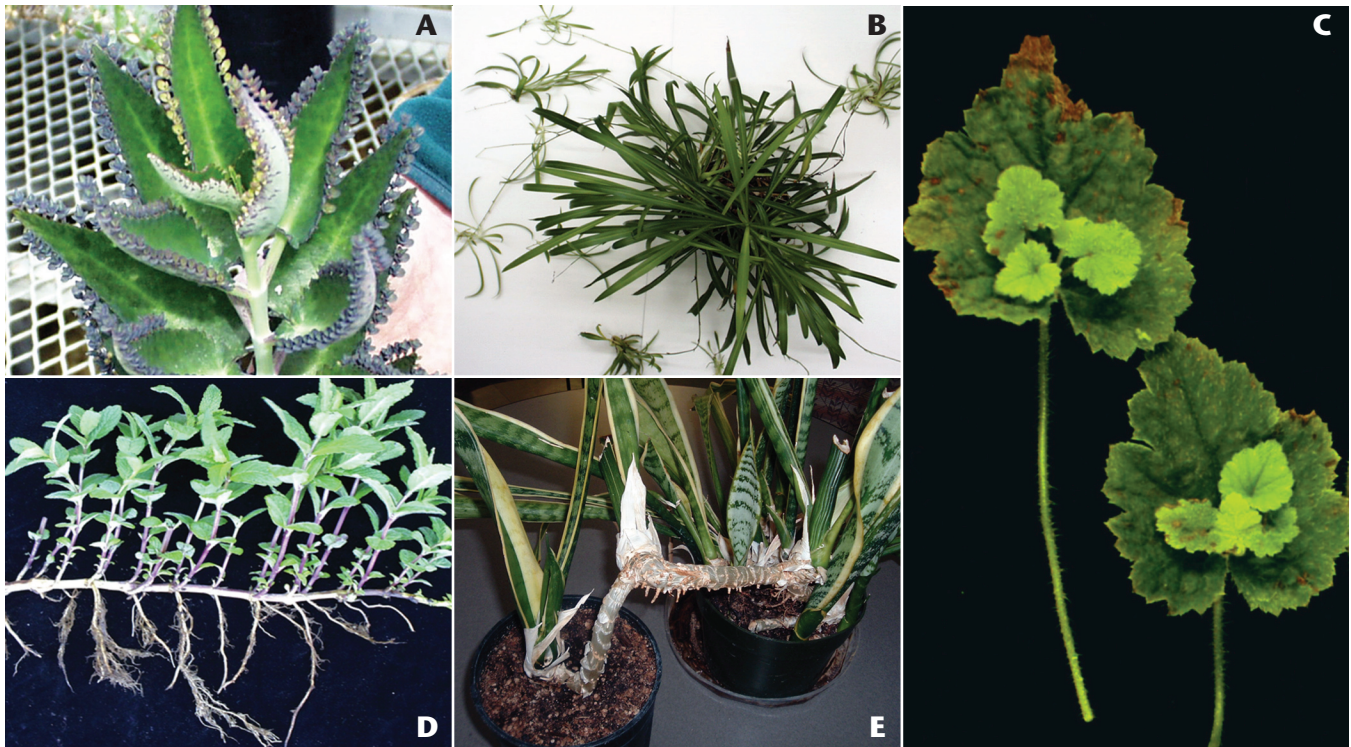


Fig. 7. Foliar embryos of bryophyllum and piggyback plant (A, C), runners of spider plant (B), stolons of mint (D), and offsets of sansevieria (E). Foliar embryos either attached or detached from a leaf can be placed on a moist rooting media and grown as individual plants. Similarly, runners of spider plant and stolons of mint can be separated from their mother plants and used as vegetative propagules. Offsets are desirable for the propagation of sansevieria plants with yellow margins to reproduce true-to-type plants. Leaf-blade cutting, a commonly employed method for propagation of sansevieria, fails to reproduce the yellow-margin in the offspring.

## Pseudobulbs

Some orchids produce rhizomes and while others produce a type of modified stem called a pseudobulb (Fig. 8). The exact structure of these organs varies among different species of orchids.



Fig. 8. Pseudobulbs of orchid. Pseudobulbs can be detached from a mother plant along with the leaves. To facilitate rooting, treat the basal end of the pseudobulb with rooting hormone prior to planting in a medium.

The pseudobulb itself can sometimes be used for propagation. Either back bulbs (those without leaves) or green bulbs (those with leaves) can be used to propagate the species *Cymbidium*. Treating pseudobulbs with the rooting hormone IBA (indolebutyric acid, available as a formulation in talc or powder at most garden centers) helps in rooting. Place the pseudobulb in a rooting medium to about half its depth. When one new shoot forms, separate it with its roots from the pseudobulb, which should then produce additional shoots.

## AERIAL LEAF MODIFICATIONS

### Foliar Embryos

Production of plantlets at the leaf margin is a common occurrence in plants such as *Bryophyllum* (Fig. 7A) and *Kalanchoe pinnata*. These plantlets are known as foliar embryos, which have pre-formed roots. To propagate such plants, either 1) place a whole leaf-bearing foliar embryo on a moist rooting medium, wait for roots to develop, and then



transfer the resulting plantlets into containers, or 2) separate individual plantlets from the leaf and plant in containers.

In piggyback plant (*Tolmiea menziesii*) new plantlets originating from the upper surface of the leaves can be excised from the mother plant as shown in the Fig. 7C. Place the excised leaf in a rooting media with its petiole buried. The plantlets strike roots, resume growth and develop into a new plant.

## AERIAL INFLORESCENCE MODIFICATIONS

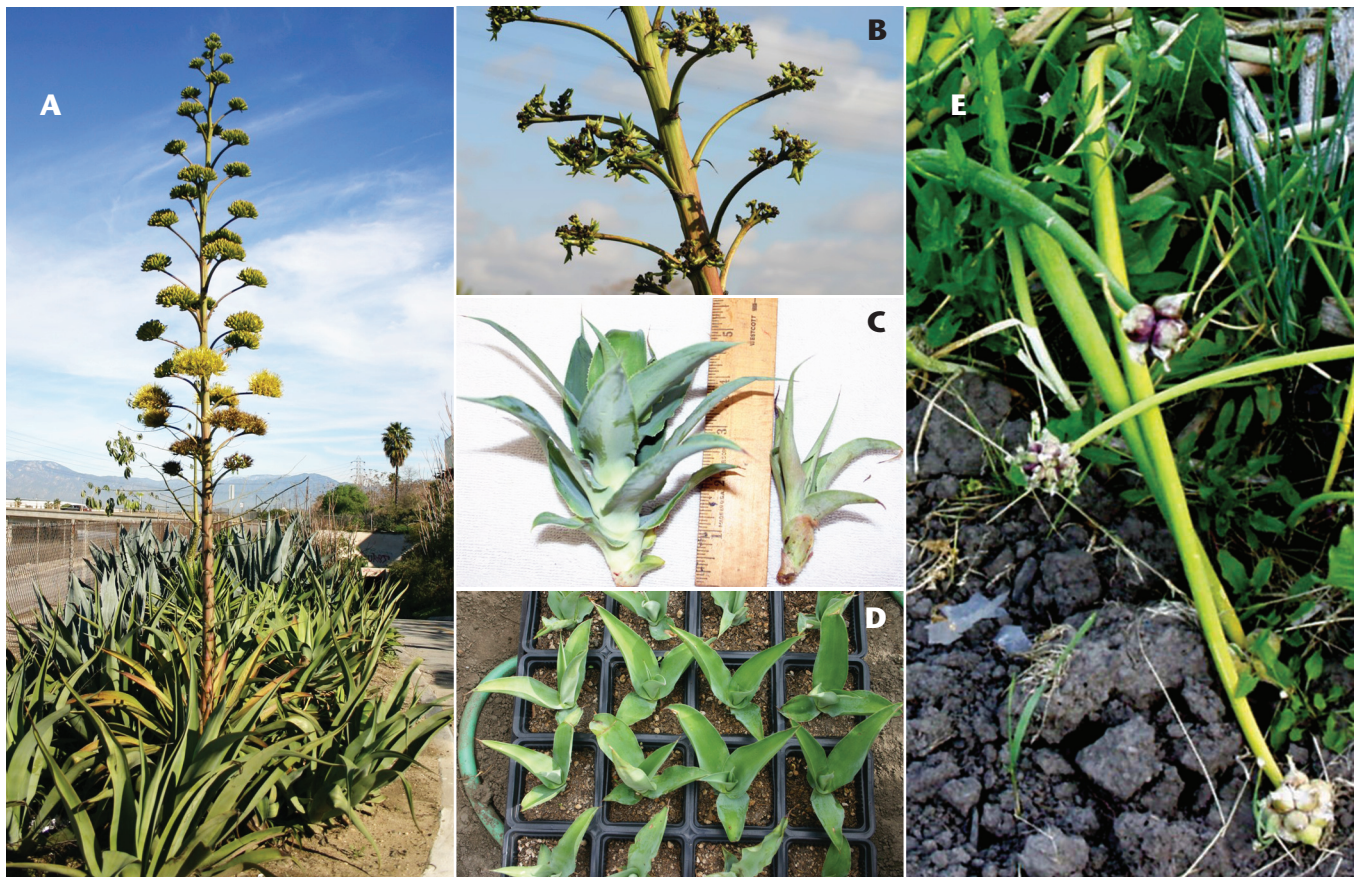
### Bulbils

Plants such as agave produce vegetative buds (bulbils) in the inflorescence instead of flowers (Fig. 9A–D). These bulbils readily form roots and grow into independent plants when planted in soil or a rooting medium. Egyptian walking onions

(top/top-set onions) produce a cluster of aerial bulbs in place of inflorescence that are also known as bulbils (Fig. 9E). The stem carrying the aerial bulbils of Egyptian onion are eventually weighted toward the ground. Once the bulbils make contact with soil, they root and develop into a new plant. Egyptian walking onions can also be propagated by separating bulbils from the mother plant and growing in soil. Wild garlic plants are also known to produce bulbils.

## CONCLUSION

Multiplication of plants using specialized structures that are unique to certain plants can be accomplished with ease in most cases. Do not get discouraged if your attempts fail initially. Instead, experiment with other plants and/or method adjustments. You can gather additional information to increase your success and enjoyment from the publications listed below.



**Fig. 9.** Examples of inflorescence modifications into bulbils. Agave with a large number of bulbils appearing like an inflorescence (A), bulbils in clusters (B), bulbils detached from the inflorescence (C), bulbils planted in a rooting media (D), and aerial bulbils of Egyptian walking onion (E). When fully developed, onion bulbils bend toward the ground from their own weight, form roots, and grow into independent plants. Detached bulbils can be used as vegetative propagules. Photographs of agave (A–D) are courtesy of Scott Bunnell, Socal Guerrilla Gardening, California (<http://socalguerrillagardening.org>).



## FURTHER READING

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**Table 1. Plant parts involved in the development of various modified structures with potential for vegetative propagation.**

Location of Growth	Specialized Plant Structure	Associated Plant Part					Example
		Stem	Hypocotyl	Root	Leaf	Inflorescence	
<b>Underground</b>	Bulb	+			+		Onion
	Corm	+					Gladiolus
	Cormel	+					Gladiolus
	Offset	+					Onion
	Tuber	+					Potato
	Tuberous root			+			Dahlia
	Tuberous stem		+				Cyclamen
	Rhizome	+					Ginger
	Slip (offshoot)		+				Pineapple
	Sucker			+			Banana
<b>Sub-aerial (surface)</b>	Offset	+					Sansevieria
	Runner	+					Spider plant
	Stolon	+					Mint
<b>Aerial</b>	Bulbil	+				+	Agave, Lily
	Crown	+					Daylily
	Foliar embryo				+		Bryophyllum
	Pseudobulb	+					Orchid



Table 2. Characteristics of common flowering plants propagated from specialized structures. Numerals in shaded areas refer to approximate planting depth in inches. Shaded areas indicate hardiness, planting, and flowering time.

Modified Part	Plant Name		Hardiness			Planting		Flowering		
	Common Name	Botanical Name	Hardy	Semi-hardy	Tender*	Spring	Fall	Spring	Summer	Fall
<b>Bulb***</b>	Amazon lily**	<i>Eucharis grandiflora</i>								
	Belladonna lily	<i>Amaryllis belladonna</i>				4				
	Daffodil	<i>Narcissus</i> spp.					8-9			
	Glory-of-the-snow	<i>Chionodoxa luciliae</i>					3-4			
	Grape hyacinth	<i>Muscari comosum</i>					3-4			
	Hardy amaryllis	<i>Lycoris</i> spp.					5			
	Hippeastrum**	<i>Hippeastrum</i> spp.								
	Hyacinth	<i>Hyacinthus</i> spp.					6			
	Iris (bulbous)	<i>Iris</i> spp.					4-5			
	Lily	<i>Lilium</i> spp.					6-8			
	Oxalis (bulbous)**	<i>Oxalis</i> spp.								
	Snowdrop	<i>Galanthus</i> spp.					3-4			
	Summer hyacinth	<i>Galtonia candicans</i>				6-7				
	Squill	<i>Scilla</i> spp.					3-4			
	Tuberose	<i>Polyantha tuberosa</i>				3-4				
	Tulip	<i>Tulipa</i> spp.					8-9			
	Autumn crocus	<i>Colchicum autumnale</i>					3-4			
	Crocus	<i>Crocus</i> spp.					3-4			
<b>Corm</b>	Freesia	<i>Freesia</i> spp.				3-4				
	Gladiolus	<i>Gladiolus</i> spp.				4-5				
	Begonia (aerial)	<i>Begonia evansiana</i>								
	Caladium	<i>Caladium</i> spp.				1-2				
	Black calla**	<i>Arum palaestinum</i>				1-2				
	Bleeding heart	<i>Dicentra</i> spp.								
	Cyclamen**	<i>Cyclamen</i> spp.				1-2				
	Dahlia	<i>Dahlia</i> spp.				6-7				
	Elephant's ear**	<i>Colocasia</i> spp.				8-10				
	Gloxinia**	<i>Sinningia speciosa</i>				1				
<b>Tuberous root &amp; stem</b>	Jack-in-the-pulpit	<i>Arisaema triphyllum</i>				2				
	Ranunculus**	<i>Ranunculus</i> spp.					2			
	Tuberous begonia	<i>Begonia</i> spp.				1-2				
	Wind flower	<i>Anemone nemorosa</i>					1			
	Achimenes**	<i>Achimenes</i> spp.								
	Bearded iris	<i>Iris</i> spp.					1-2			
	Calla lily**	<i>Zantedeschia</i> spp.				1-2				
	Canna	<i>Canna</i> spp.				4-6				
	Lily-of-the-valley	<i>Convallaria majalis</i>					3-4			
<b>Rhizome</b>										

\*Tender bulbs should be dug and stored indoors during winter.  
 \*\*Suitable as greenhouse or house plants only; indicated planting depth refers to container planting.  
 \*\*\*All bulbs listed are tunicate except the Amazon lily and lily.  
 Modified from Hartmann, H.T. and D.E. Kester. 1975. *Plant Propagation: Principles and Practices*, 3rd edition.

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