Propagation Techniques for Desert Plants

Part I
of a minisymposium with contributions from

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Recently the journal *Desert Plants* contacted a number of growers, both commercial and governmental, to see if enough interest existed to assemble a miniature journal symposium dealing with propagation techniques. A large number of persons with expertise in the field shared their knowledge through both written communication and oral discussion. The response was so large and enthusiastic that it seemed desirable to publish a sample of the contributions immediately as Part I and to continue the minisymposium in a future issue.

Under the term plant propagation we ordinarily include any technique by which mankind intentionally increases the number of individuals of a plant. On the other hand, the term *plant reproduction* is ordinarily used to refer to the natural increase in numbers of individuals. Many times man chooses to propagate a plant by taking advantage of natural reproductive mechanics inherent within the species. Although such propagation is quite common in animal breeding *(i.e. bringing two animals together to mate)*, it is less commonly practiced in propagating plants.

Successful plant growers customarily hire horticulturists adept and knowledgeable at artificial propagation techniques to produce seedlings, rooted cuttings or grafted material which will then be "grown on" to larger size. Within a company or governmental agency the person with the title **"Plant Propagator"** is typically greatly respected and may even be held in awe. This person holds the success of the enterprise in his or her hands. The propagator is knowledgable concerning theory, knows a good number of "trade secrets," has a green thumb, and may occasionally be accused of practicing black magic.

Although there may be a number of alternative procedures which would at first thought be capable of yielding similar results, one specific technique may actually prove to be greatly superior. For example, a hard impervious seed coat may be breached by scarifying with a file or sandpaper or grinding wheel, by treating with hot water, by soaking in concentrated sulfuric acid, or by other techniques. However, the treatment in sulfuric acid has the added advantage of cleansing the seed of any pulp or other material which might be present and of killing fungi and bacteria. Nevertheless, acid treatment may not give as good a result as a hot water soak, depending on the plant.

Seeds are by nature dormant structures. The embryonic plant is already present as well as a food reserve for the early stages of growth. When dormancy is broken and moisture gains entrance into the seed, dehydrated energy in the form of adenosine triphosphate (ATP) goes into solution and triggers rapid changes. Much of the time of the propagator is often devoted to discovering methods of artificially breaking dormancy and causing the ATP to become active. Techniques may be as different as the species are one to the other.

Vegetative reproduction (not involving seed germination) is a time-honored method of quickly obtaining duplicate material identical to the original. There are a great number of procedures varying from tissue culture to rooting cuttings under intermittent mist. Many types of succulent plants, particularly, are propagated vegetatively and there is a wide divergence in methods depending on the species in question.

The Ruby Ball Cactus, a somatic mutant of **Gymnocalycium mihanovichii** *var.* **frederickii,** *provides an excellent example of a plant which must be perpetuated by vegetative means (= cloning). It is propagated by grafting offsets onto a chlorophyll-bearing understock.*

This minisymposium brings together a number of previously unpublished findings. It does not take the place of textbooks on the subject and does not purport to be complete or encyclopedic. Books previously published which are quite useful are listed below.

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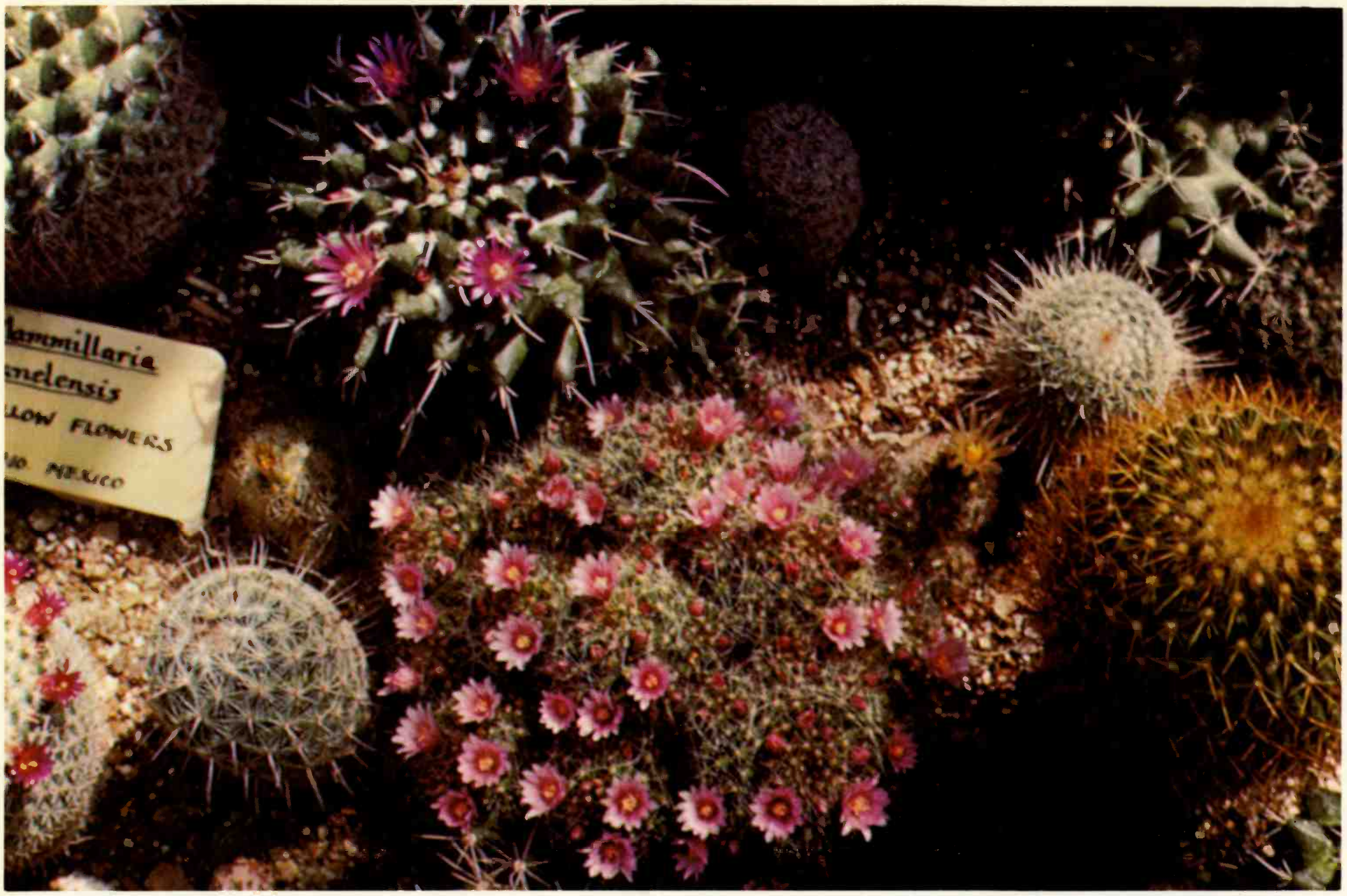
The *Baggie*™ *Method* of Cactus and Succulent Seed Germination (Information courtesy of Kent C. Newland, Boyce Thompson Southwestern Arboretum). Fill 2¾"-wide square plastic pots with growing medium of ⅓ commercial potting soil, ⅓ coarse sand and ⅓ pumice or perlite. Drench the soil with a solution of Captan™ fungicide in distilled water to prevent damping off of the young seedlings. Sow seed in the pots, labelling each with name of the plant, date of sowing and source. Enclose each pot in a plastic Baggie™ with a twist tie. This technique simulates greenhouse conditions of high humidity for maximum germination. Shading the pots also seems to benefit germination by simulating low light conditions as found in rock cracks where young cactus and succulent seedlings have been noted.

The seeds will germinate in about two weeks. After the seedlings have made two months of growth, the baggie can be removed. Continue to water. After four or five months the seedlings can be transplanted individually to 2"-wide



Pincushion Cacti of the genus **Mammillaria** *have become popular as flowering greenhouse ornamentals in Germany, the Netherlands, England, Japan, and elsewhere because they are propagated so readily from seed sent from Mexico and the Southwestern United States where they are native.*

pots and fertilized with Miracle Gro.™ The recommended sowing time for cacti is spring, for summer-growing succulents *(Euphorbia, Cissus, Adenium)* also spring, for winter-growing succulents (*Aloe,* Mesembryanthaceae, Crassulaceae) fall.

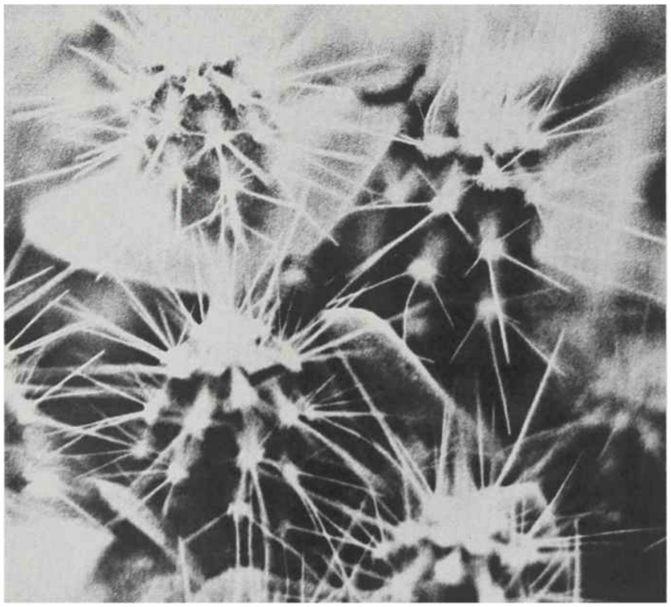
Growing Boojum Trees From Seed (Information courtesy of Sarah Ives, V & P Nurseries, Inc., Mesa, Arizona). To germinate *Idria columnaris,* collect fresh seed and begin the germination process in May when the older plants are beginning to become dormant. This allows the seedlings to attain a size and vigor sufficient to cope with the May through October dormancy period of the next year. Prepare a soil mix of ⅓ sand, ⅓ peat and ⅓ perlite. Place this into small seed flats or directly into 2¼"-diameter deep rose pots. Wet the soil and allow to drain. Use of a fungicide at this stage is optional. If moisture is dispensed to the developing seedlings properly the fungicide will not be needed and if the moisture conditions are not maintained properly the plants will die when the fungicide is leached away anyway.

Place the seed on the damp soil and cover with a layer of soil as thick as the seed. Although the flats or pots can be covered with plastic to keep the soil moist, this is not necessary and may in fact keep the soil too soggy. The seeds germinate within 24 hours and need good ventilation. As the seedlings grow they should be lightly watered but the soil surface should be allowed to dry out.

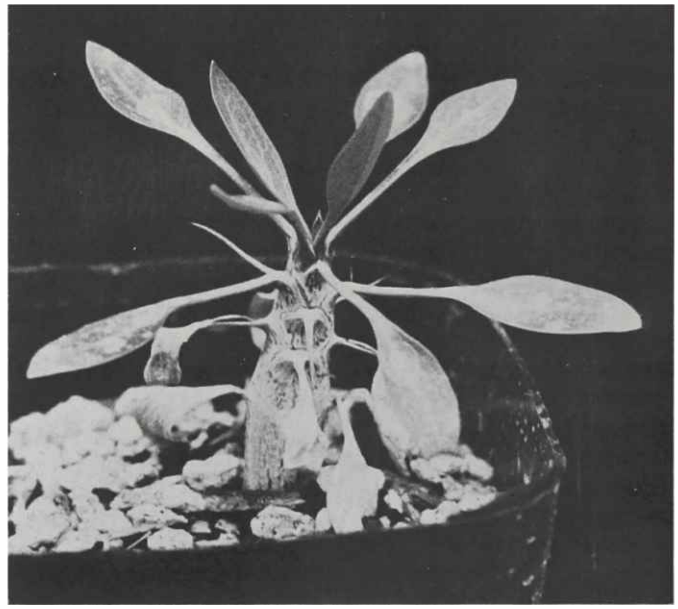
If the seedlings were started in a flat, once they become somewhat woody they can be separated and planted in individual 2¾"-diameter deep rose pots. During the May to October dormancy period watering should be greatly reduced. This is the most critical period when young seedlings in nature are apt to die. By carefully monitoring the moistness of the soil and by providing optimum greenhouse conditions, a high percentage of the plants will survive this critical period of the first year. During dormancy the seedlings lose their leaves. Those plants which remain hard and firm will leaf out in the fall but any which become soft and wrinkled should be disposed of.

When the young plants are leafy and growing they can be watered frequently as long as the soil is allowed to dry out between waterings. Use of a fertilizer such as Miracle Gro™ at ⅓ the strength recommended for house-plants can be used every third or fourth watering. The plants thrive on hard greenhouse light and good ventilation.

Home gardeners living where temperatures do not often go below 26°F should transplant seedlings into the soil when about one year old after they have leafed out from the first dormancy. Screening to protect from rabbits and



Young seedlings of cacti have large fleshy cotyledons under the short plump spiny plant body.



Seedling of Boojum Tree (**Idria columnaris**).

rodents may be necessary for three to five years. In coastal areas or other regions where fog, humidity and clouds temper the intensity of the sun, plants may be placed in 80% to nearly total sun. In areas with high intensities of light and heat, such as southern Arizona, filtered shade is necessary for young seedlings. When grown at home as a container plant, good filtered light of a patio should prove successful. If the plant must be grown indoors without a greenhouse, a position on the sunniest window-sill should be chosen.

Propagation of Certain Semi-succulent Shrubs of the Sonoran Desert (Information courtesy of Gene E. Joseph and Mark A. Dimmitt, Arizona-Sonora Desert Museum). Discussed below are procedures used for propagating the species of *Bursera, Fouquieria* and *Jatropha.* BURSERA SPP.: Burseras are easy to grow once they get past the early seedling stage. Problems are low seed viability and susceptibility of seedlings to fungus until the stems begin to harden a few weeks after germination. Plants grow rapidly if generously potted, but growth slows greatly as soon as the roots become potbound.

Seeds of *Bursera laxiflora* were collected from cultivated plants at the Arizona-Sonora Desert Museum. Seeds of three other species were collected in Baja California Sur in August of 1979. Seeds were sown in a greenhouse in 1:1 perlite:vermiculite on May 9, 1980. Germination was complete in less than two weeks. Approximate germination was 40% for *B. laxiflora,* 30% for *B. hindsiana,* 15% for *B. microphylla* and less than 5% for *B. odorata.* Examination of samples of the same seed collections revealed that most of the seeds were hollow. We surmise that most of the viable seeds germinated. A second collection of *B. microphylla* sown a few weeks later resulted in about 50% germination. Among seeds collected on the same day from the same plant, darker seeds had higher germination.

During their six weeks in the seed flats the seedlings were treated four times with Banrot™ or Captan™ fungicides and fertilized once with full-strength 20-20-20. About 30% of the seedlings succumbed to fungal diseases. At six weeks the plants were transplanted into 2¼"-diameter rose pots, with mortality negligible afterward. They were treated approximately weekly with Captan,™ Banrot™ or Terrachlor™ and fertilized bimonthly for the next seven weeks. In their fourteenth week they were potted up into 4"-diameter pots, at which time the plants averaged about 8"tall with basal stem diameters of about ⅜". These were grown in 50% shade. Two year old plants in 10"-diameter pots in full sun now are approaching 3 feet in height with ¾"-diameter stems.

FOUQUIERIA SPP.: The Fouquierias are also fairly easy once past the soft seedling stage, and again some seeds seem to be inviable. *Fouquieria splendens* grows very slowly even with copious watering and feeding. *Fouquieria macdougalii* and *F. digueti* respond to generous treatment. The former at least will flower in two years, at which time it can be a nicely branched plant 2 feet tall. When grown hard, stem growth is much reduced and the plants develop relatively larger caudexes.

Seeds were sown in flats of 1:1 perlite:vermiculite on June 8; germination was complete in less than a week. Approximate germination was 50% for *F. digueti* and *F. splendens,* but only 15% for *F. macdougalii.* (Seeds collected from cultivated plants of *F. macdougalii* have been found to have much greater viability.) The seedling flats were treated weekly with fungicides named above and fer-

A nursery flat full of **Fouquieria macdougallii** *seedlings at the Arizona-Sonora Desert Museum.*

tilized with 20-20-20 every other week. There was very little mortality. At 6 weeks the plants were moved into 2¼"-diameter rose pots in well-drained soil and kept in the greenhouse under 50% shade.

JATROPHA SPP.: The Jatrophas are very easy to grow. The only significant caution is to keep them quite dry during cool weather. In the heat of summer they will grow very fast with generous treatment, or remain as dwarfed bonsai-like specimens if grown hard and/or underpotted.

Seeds of 5 species were planted on June 8 in flats of 1:1 perlite:vermiculite in the greenhouse. Germination was complete within 10 days:

species	collection	number planted	number germinating
J. macrorhiza	Southeastern Ariz. 9/78	4	1
J. cuneata	Hermosillo, Sonora 9/79	11	5
J. cercifolium	A.S.D.M. (cult.) (10/79	20	0
J. vernicosa	La Paz, Baja Calif. 11/79	5	3
J. cinerea	Bahia de Los Angeles Baja California 11/79	76	71

All the seedlings were planted into 3"-diameter pots in well-drained soil at 3 weeks of age and moved outside under 50% shade 2 weeks later. Fungicides were used weekly until the plants were moved outside. Fertilization is done bimonthly with a balanced fertilizer. Survival has been essentially 100%. At 10 weeks the *J. cinerea* and *J. vernicosa* plants averaged a foot tall with a basal diameter of about one-half inch. The *J. cuneata* plants were about 8" tall and ½" thick. They probably would be larger if they were in larger pots. These plants have vigorous root systems.

Germination of Agave, Yucca, Nolina and Similar Plants (Information courtesy of Marc Mittleman, Desert Botanical Garden, Phoenix). The Desert Botanical Garden has concentrated much of its effort in growing those plants that are not represented in the garden, primarily leaf and stem succulents. We have also placed a large emphasis on growing plants for our plant sales and on growing species that have restricted ranges. *Agave arizonica* and *Agave toumeyana* var. *bella* are two plants in the latter category. These two *Agave* species were grown from seed planted in October of 1977 and were about ready to go into the ground at the end of 1980.

Yucca glauca, *Y. decipiens* and *Nolina longifolia* have also done well from seed. Seeds of these were collected in the summer of 1979 and planted the following January. Germination occurred anywhere from two to three weeks after sowing. All are now well established in deep 2¼-inch wide liners and are ready to be transplanted up to 1-gallon cans.

The garden has had great success in starting all of their seeds in a mixture of 50% vermiculite and 50% perlite. As these were started in winter they were set on a heating pad at a temperature of 78°F. They were watered daily with a fine mist until germination, at which time watering was reduced to every other day. Three weeks following germination, seedlings were thinned and transplanted up to deep 2¼-inch liners. At the end of 1980 they were ready to transplant up to 1-gallon cans. The mixture used for transplanting leaf succulents has been that of 2 parts decomposed granite to 1 part each of sand and compost. About a tablespoon of the 12–14 month formulation of Osmocote® fertilizer is added to each gallon can. Aloes, Dasylirions and many of the Crassulaceae have also responded favorably to these propagation methods.

A Radical Departure in Propagating Prickly Pear Cacti (Information courtesy of R. E. Foster, Department of Plant Sciences, University of Arizona). The University of Arizona's planning for an "Energy Ranch" prompted a number of proposals in the realm of renewable energy sources. One of these was the consideration of the Prickly Pear (*Opuntia* spp.) in a multiple use program. The plant is adapted to desert environments. It has been used for human food and for livestock feed. In some species the potential for rapid and massive growth makes the plant a prime desert candidate for biomass production with either methane or ethanol as an end product. The perennial characteristic suggests uses in erosion control especially in conjunction with land sculpturing for water management. Plantings could be made according to natural water availability. The establishment or renewal of Prickly Pear selections would call for rapid exponential vegetative reproduction.

Quick reproduction is not possible with the accepted methods. All information sources discovered called for the use of mature pads. All suggested that excised pads be allowed to air dry and form callus for about 1 month before being planted for adventitious root development. An extreme change in the time requirement and in other features seemed to call for radical changes in methods. The procedure developed for vegetative propagation of

When cuttings are taken from large mature cacti with white hair in the form of a cephalium or pseudocephalium, propagants may be induced to not revert to a more juvenile stage if the physiological balance of the piece severed is little disturbed, quickly rooted and given good sun. The plant of **Cephalocereus leucocephalus** *illustrated here is such a specimen which has continued to produce hairs over a period of several years while grown as a container plant at the Arboretum.*

muskmelons was adapted for *Opuntia* reproduction with surprising success. Various experiments were made.

Research demonstrated that juvenile pads (4–6 cm long, 3–4 cm wide, 5–10 g.) placed in an aerated balanced nutrient solution plus growth regulator would start producing roots in 2–3 days. These plants could be transplanted to soil in 15–20 days with over 90% success. The results were similar for all species tested. With a spineless ornamental form (used because it was available and easy to handle) the third "vegetative generation" produced roots 170 days after the first padlet was treated. As an interesting spin-off it was found that an *Opuntia* plant could be grown to large size with several mature pads in aerated water culture alone. Remember this is a desert-loving plant regarding which the admonition is often heard by gardeners not to overwater.

Linda Moore demonstrating the electric carving knife technique at Tanque Verde Greenhouses.

The Electric Carving Knife Technique for Commercial Cactus Propagation (Information courtesy of Carol Scannell, Tanque Verde Greenhouses). Tanque Verde Greenhouses in Tucson, Arizona grows and markets cacti and succulents in sufficient quantity to satisfy local retail demands and to fill wholesale requirements of various nurseries and chain stores. Although a large number of cacti are marketed as small plants grown from seedlings, some are grown from cuttings taken from stock plants. Some of these plants are ones which do not readily produce seeds or do not come true from seed.

When making a large number of cuttings at one time, several factors are important. 1) It is desirable not to have to move stock plants, but rather to cut them in place. 2) It is desirable that the cutting tool have a long blade and long handle. 3) It is good to avoid the "sawing action" of moving the hand back and forth because spines are more apt to pierce the flesh if the hand bumps into a plant. 4) A serrated or sharp edge on the cutting tool is necessary to insure that the vascular bundles are quickly and neatly severed. 5) If fatigue of the fingers develops, efficiency at which consistently good cuttings are produced may decrease.

Although horticultural supply houses market a variety of "cutting knives" or "propagating blades," we have found that an electric carving knife best fills our needs as a commercial grower. By using this device the cuttings are uniform and of consistently high quality. In conjunction with the device, a pair of kitchen tongs (such as are used for grasping hot vegetables from boiling water) is useful for holding the part of the cactus which is being cut away from the stock plant.

Germinating Seeds of Wildland Trees and Shrubs (Information courtesy of Department of Plant Sciences Faculty, University of Arizona). Many common crops which man has grown over the centuries tend to have seeds with simple germination requirements. Indeed, ease and constancy of germination under agricultural conditions have undoubtedly been selected for in plants which man has grown for a large number of generations. Wildland species, on the other hand, have seeds which often must endure extremely harsh environmental conditions. Such conditions are rarely as optimal for completion of the generalized plant life cycle as are those of the typical cultivated field. Such wildland or "native" plant species have become individually closely attuned to some set of specialized growing conditions.

Indeed, many wildland plants are so well adapted to specific environments that somewhat paradoxically they grow poorly or not at all under less harsh or more generalized conditions. Seeds of wildland plants may exhibit inhibitors or dormancy factors of complex biochemical derivation which are triggered by equally complex ecological sequences.

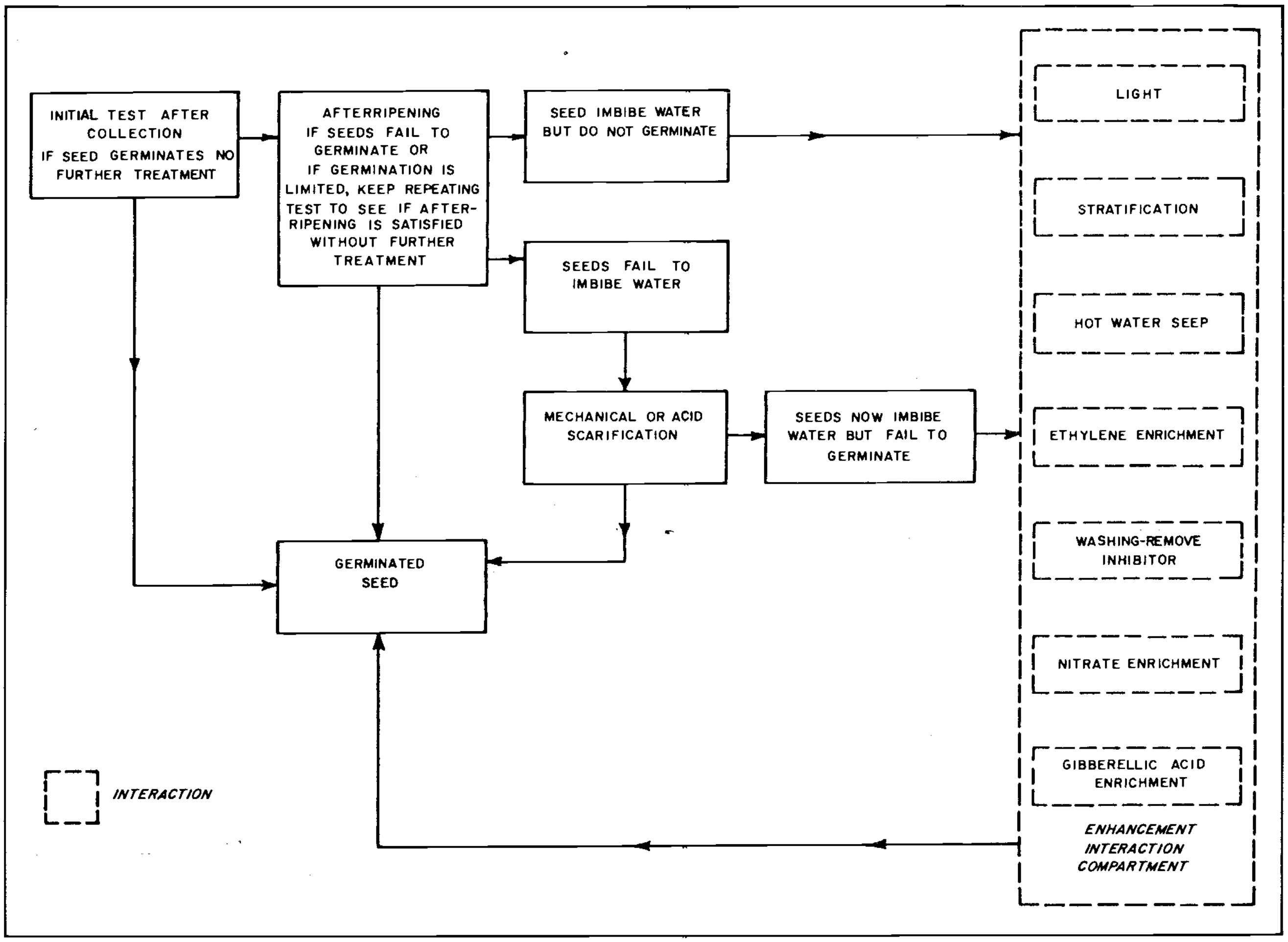
Seed testing laboratories mantained by governments or private companies are usually set up to deal with standard agricultural species. They will report germination percentages according to established national or international standards. Such testing laboratories often have little time or inclination to experiment with breaking dormancy in non-standard species. Seed testing and germination enhancement for wildland plants have been very capably treated recently in a U.S.D.A. (S.E.A.) publication by James A. Young, Raymond A. Evans, Burgess L. Kay, Richard E. Owen and Frank L. Jurak (1978). Previously, N. T. Mirov and C. J. Kraebel (1939) had published a useful booklet on collecting and handling seeds of wild plants under auspices of the former Civilian Conservation Corps. Dara Emery (1964) treated seed propagation of native California plants in a leaflet issued by the Santa Barbara Botanical Garden. Otherwise, information has been quite scarce.

AFTERRIPENING. Some seeds such as those of Saguaro *(Carnegiea gigantea)* or Palo Fierro Ironwood *(Olneya tesota)* germinate readily upon falling to the ground if other factors are favorable. A large number of species, however, may require an "afterripening" period. Often nothing more than holding the seed in a resting stage for six months is required for afterripening. In studies conducted within the Sonoran Desert, data tend to indicate that afterripening may be enhanced by the high ambient air temperatures characteristic of that desert. Investigators working further to the north have described a type of temperature-regulated afterripening whereby seeds of certain species germinate readily at low temperatures but not at medium or higher temperatures until afterripening has occurred. These investigators have found that low temperatures "are more likely to produce germination than higher incubation temperatures for seeds with afterripening requirements." They also point out that low temperatures also reduce growth of harmful microorganisms.

INHIBITORS. Seeds may contain chemical germination inhibitors which must either be washed away with water or leached with organic solvents. The presence of water-soluble inhibitors in the seeds of desert plants assures that germination will not occur in nature unless abundant rain has fallen which will allow the seedlings to become well established. When washing inhibitors from seed coats, cold water is usually used because warm water might trigger germination.

SCARIFICATION. Many desert plants have tough impermeable seed coats, sometimes waxy. In nature seeds of Palo Verde (*Cercidium* spp.) and several other species of the Legume Family do not ordinarily germinate until they have been washed by flash floods down normally dry washes. After the seeds have become abraded on the sand and gravel of the wash, they begin to imbibe water. If there was not enough rainfall to result in heavy run-off and the seeds travelled only a short distance, the abrasive action may not have been sufficient for water imbibition to occur. Here again an adaptation seems to exist to assure that germination occurs only when environmental conditions favor seedling establishment. To grow such plants under nursery conditions, it may be necessary to artificially scarify the seed coats. Most commercial growers soak the seeds in concentrated sulphuric acid, the length of time depending on the plant species. Other techniques which may prove to be effective but which may take more time and therefore be suitable for only small lots, include holding the seed with a pliars against a grindstone, rubbing the seed against sandpaper, or scratching the seed with a three-cornered file. Care must always be taken to avoid contacting the embryo. Soaking seeds in water which has just been brought to a boil may render the seed coat permeable and may also leach away some inhibitors.

STRATIFICATION. Classically, stratification refers to placing seeds in strata of moist sand outside or in a coldframe over the winter. As stratification is practiced today, seeds are usually placed with moist sand or vermiculite in plastic bags and stored in the refrigerator for one month or more. Growers of the many wild *Penstemon* species have found that length of time for stratification can be reduced



Flowsheet outlining steps for experimenting with germination of seeds of wildland plant species. Courtesy of James A. Young, Raymond A. Evans, Burgess L. Kay, Richard E. Owen and Frank L. Jurak, from USDA (SEA) ARM-W-3. By permission.

by placing the moistened seed directly into the freezing compartment of the refrigerator. Most plants of warm deserts do not have seeds which require stratification. Plants of cold deserts often do, however. Aside from the typical cool-moist stratification, some seeds respond to warm-moist treatments or a combination of warm-moist and cold-moist. Stratification seems to relate to the penetration of oxygen through the seed coat to the embryo. At colder temperatures oxygen-enriched water becomes available to the embryo and the colder temperatures reduce the oxygen demands of embryonic respiration, resulting in the oxygen-rich environment conducive to germination. Stratification therefor is essentially the same as oxygen enrichment.

CHEMICAL ENHANCEMENT. Chief among chemicals used to enhance germination are 1) **thiourea** and related sulphydryl compounds, 2) **ethephon,** 3) **nitrate,** generally in the form of potassium nitrate, and 4) the growth regulator **gibberellic acid.** Thiourea is frequently used in a standard three percent solution. [**This potentially dangerous chemical should not be used by persons lacking training in use of hazardous chemicals.**] Ethephon functions as an ethylene gas generator, being merely added to the solution or substrate in which the seeds are placed. Potassium nitrate is often used as an 0.2 percent solution. Gibberellic acid up to about 250 ppm can be used in conjunction with the nitrate treatment. The combination of the two is frequently more effective than either substance used alone.

HEAT AND LIGHT. Seeds of different species show different rates of germination at various temperatures. Although it is possible to determine the optimum germination temperature for a specific species by conducting a large number of separate experiments at different temperatures, a temperature-gradient plate can be used to more rapidly identify the best response. Such a device can be constructed to produce a constant change in temperature from one end to the other and this can be varied by means of manual controls. Seeds are then positioned regularly along the device for inducement of germination.

Some seeds, such as those of Saguaro *(Carnegiea gigantea)* require light for germination. They are customarily sowed on the surface of flats and a thin layer of chicken-grit broadcast over them. The grit must be widely spaced enough to allow some penetration of light to the seeds. As germination procedes, particles of grit are moved by the emerging seedlings and light penetrates to any individual seeds which previously had insufficient light. Generally fluorescent light is considered superior to that from incandescent bulbs. In a greenhouse situation, the light entering from outside is sufficient. In growth chambers without natural light, eight hours of artificial light per day is recommended.

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The Hammer Technique For Breaking Dormancy in Gourleia (Information courtesy of Sarah Ives, V & P Nurseries, Inc., Mesa, Arizona). The trees of Chilean Palo Verde *(Gourliea decorticans)* at the Boyce Thompson Southwestern Arboretum flower well but produce quite variable and undependable quantities of seed. Although the species is in the Legume Family, the structure of the fruit departs radically from the typical legume pod, being round and fleshy with a hard stone-like center. This modified fruit resembles the drupe characteristic of so many plants in the Rose Family. Some of the seeds produced at the Arboretum are aborted and not suitable for propagation. To identify good seed the fruit can be shaken. A rattle often signifies that a good seed is within. The seed seems not to be attached to the inner woody shell at maturity.

The woody shell is so hard and impervious to water that it must be physically cracked. A hammer can effectively be used to crack the shell. Care must be taken not to crush the seed itself. Sowing can be done in flats and the seedlings transplanted subsequently into rose pots or any other deep container which allows the deep root system to develop. When roots become visible at the drainage holes the plants are ready to transfer to 1-gallon nursery containers. About half of the seedlings grown from Arboretum seed are usually albino, coming up perfectly white.

Results of Germination Enhancement Trials With Certain Xerophytes (Information courtesy of W. R. Feldman, Department of Plant Sciences, University of Arizona). Seeds of arid-land plants were germinated as part of the laboratory portion of a class in nursery management taught in the Department of Plant Sciences. Various experimental treatments to enhance germination have been studied. Some of the data recorded for specific plants are given below. Treatments used in these studies included 1) mechanical scarification with sand paper (MS), 2) acid scarification (AS), 3) immersion in just-boiled water with soaking for 12 hours, or hot water soak (HWS), 4) placing in boiling water and soaking for 12 hours (BWS), 5) cold stratification of imbibed seeds at 35°F for 6 to 12 weeks (CS), and 6) no treatment (NT).

Seeds treated by stratification include *Ephedra viridis, Cupressus arizonica, Vitex agnus-castus* and *Prunus virginiana demissa.* Non-treated *Ephedra* seed had not emerged at 5 weeks, with 60% emergence for those stratified 6 weeks. *Vitex* seed emerged at the rate of 15% for NT seed and 100% for CS seed stratified for 3 months. Prunus seed stratified for 3 months had 90% emergence. Mountain Mahogany *(Cercocarpus)* had 60% emergence for fresh NT seed in 1977 but only 25% emergence for 1 year old NT seed in 1978. When the 1 year old seed was stratified, however, emergence was 50%. *Cupressus arizonica* had 50% emergence for CS seed in 1978. Seed of Cat's Claw Vine *(Macfadyena unguis-cati)* planted in early September, 1978, (NT) had very poor emergence until November when night-time temperatures had been in the 40s for 2 or 3 weeks, at which time most of the seed emerged, indicating that they perhaps need a period of cold stratification.

For experiments with scarification, results were as follows: *Dasylirion wheeleri,* NT = 0%, MS = 40%, BWS = 60%; *Cassia artemisioides,* MS = 100%; AS = 90%; BWS = 0%; *Pittosporum phillyreoides,* NT = 8%; MS = 90%; *Rhamnus californica,* NT = 15%, MS = 25%; *Rhamnus crocea* var. *illicifolia,* NT = 10% MS = 15%; *Dodonaea viscosa,* NT = 0%, BWS = 10%, MS = 100%; *Sophora secundiflora,* NT = 0%, BWS = 0%, MS = 100%. Stored seed of either *Rhamnus* studied may require cold stratification.

Mist-House Propagation of Succulent *Euphorbia* Species (Information courtesy of Frank S. Crosswhite, Boyce Thompson Southwestern Arboretum). J. E. Thompson, Jr., nephew of the founder of the Arboretum, together with scientists at the Boyce Thompson Institute for Plant Research in New York, pioneered studies of adventitious root formation in plants under intermittent mist using growth regulators. This type of propagation is now routine throughout the nursery industry for many woody shrubs and trees as well as herbaceous perennials such as *Penstemon.* A number of commercial rooting powders or liquids are now available which contain growth regulators in standard concentrations.

Although now a standard procedure for woody species, propagation under mist has not been recommended for succulent plants because of the tendency of cuttings of the latter to become quickly necrotic in a substrate which remains moist for any considerable period of time. During 1972 a large number of succulent *Euphorbia tirucalli* plants were propagated from cuttings placed into dry soil mix. As is frequently the case with *Euphorbia* cuttings, rooting was slow and a few cuttings dried up before rooting-out. As watering was slowly increased and the cuttings were presumably rooting, one particular plant stood out because of its turgidity, dark green, lush growth and generally robust appearance. When it was discovered that the container for this plant was "defective" in that it lacked a drainage hole, the idea was conceived of experimenting with radical departures in rooting *Euphorbia* cuttings, using the assumption that a moist relatively sterile environment would be desirable.

During 1973, when a large number of *Penstemon* cuttings were being rooted in the mist-house which remained after J. E. Thompson's studies previously alluded to, representative cuttings from all available *Euphorbia* species were subjected to experimentation using various mist-house routines and growth regulator treatments. One technique resulted essentially in 100% rooting in 2–4 weeks without necrosis of tissues. This procedure has been used effectively in mass-producing Euphorbias for annual Arboretum plant sales and is described below.

Take apical cuttings of *Euphorbia* 4–8 inches long using a heavy and sharp pruning shears. Avoid contact of the poisonous sap with eyes or face. Place each cutting into a pail of water as it is taken. When the pail is full, go to a water tap and thoroughly wash latex from the cut surface of each individual cutting. Shake each cutting to eliminate excess moisture and dip the cut end into any of the commercial rooting powders having napthalene acetic acid and/or indole-3 butyric acid. If the preparation does not already include a fungicide, this can be blended-in before use. Place the cuttings into rose pots and fill with clean horticultural grade perlite. Place the pots under intermittent mist.

During cool weather, heating cables or propagating mats may be used to maintain a bottom heat of 70°–80°F. The time clocks should be set to provide a one-second misting every three minutes during daylight hours and a few seconds of misting during widely separated intervals at night. This method has never failed over several years and has proven quite successful with other genera of the Euphorbiaceae family such as *Synadenium* and *Pedilanthus.* Once the cuttings are rooted they should be removed promptly from the mist-house to avoid hard water encrustations from forming on the stems.

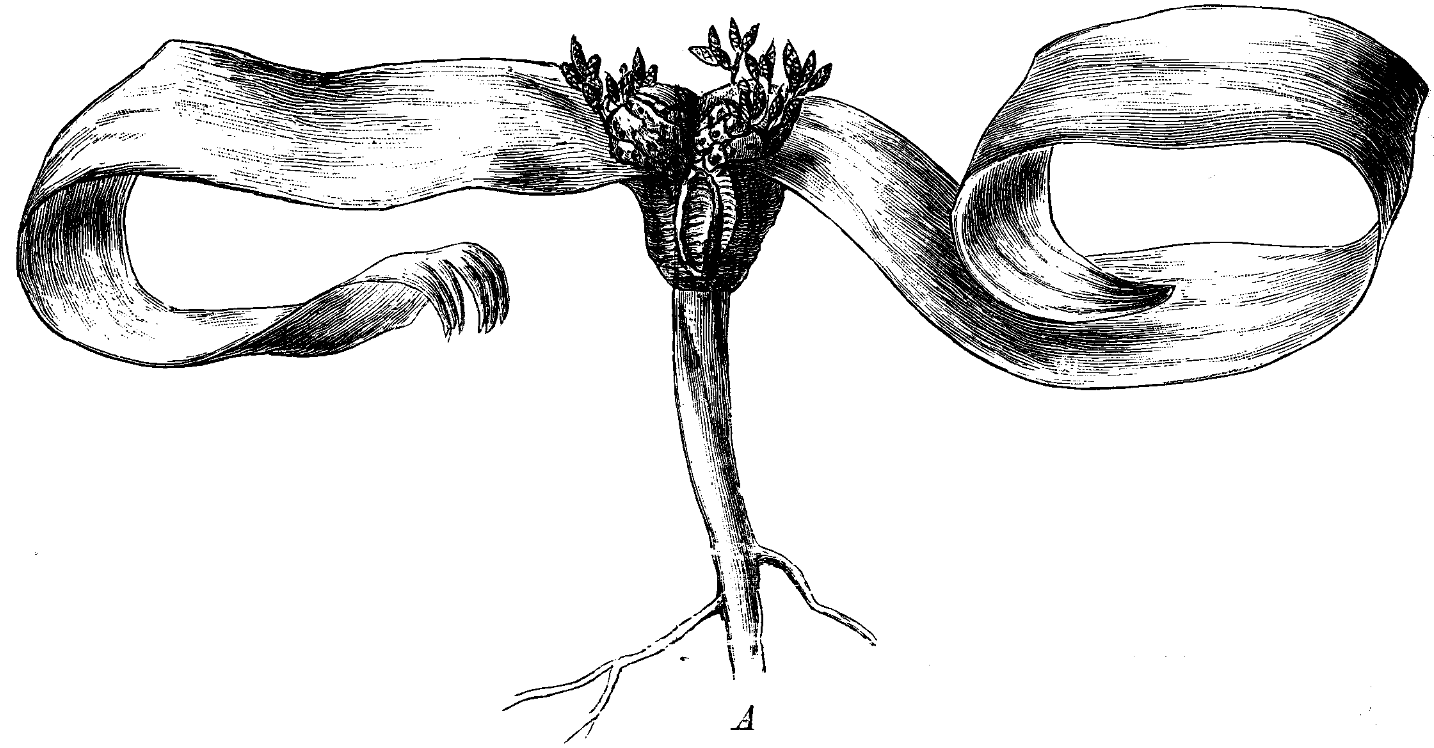
The Shaving Mug and Brush Procedure For Rooting Cuttings of Large Columnar Cacti (Information courtesy of Frank S. Crosswhite, Boyce Thompson Southwestern Arboretum). Prepare a mixture of equal parts of 1) powdered sulphur, 2) fungicide powder, and 3) commercial rooting powder. Place into a large mug, adding water to make a thin creamy paste. Take apical cuttings 1–2 feet long using a pruning saw. Hold each piece being severed with a loop of thick cotton rope. While the surface of the severed piece is still freshly cut, daub the sulphur-fungicide-rooting paste onto the surface using an old-fashioned shaving brush. As each cutting is treated, turn it on its side to air dry. After a few hours of drying, store each cutting in a vertical position in a plastic nursery container having a thin layer of vermiculite in the bottom. Large heavy cuttings will remain vertical if the cut at the base is perfectly at a right angle to the long axis and the nursery container is chosen to be so snug that the cutting touches on all sides. Cuttings should be stored vertically in 50% to 95% shade for one month before watering. When watering finally commences, it can be repeated first at weekly intervals, then every 2–3 days. When the vermiculite has been invaded by a large mass of roots, the cutting can usually safely be planted in a larger container with a good nursery soil mix.

If the cutting is stored horizontally the growing apex will tend to develop a disfiguring right-angle bend. If the cutting is placed directly into soil mix without the month-long callusing period, bacterial necrosis may develop. The sulphur in the paste dries out the cut surface rapidly and sterilizes the wound by forming sulphuric acid on the moist surface. The fungicide kills many of the organisms which might result in necrosis. The rooting powder provides hormonal growth regulators which induce rapid development of adventitious roots.

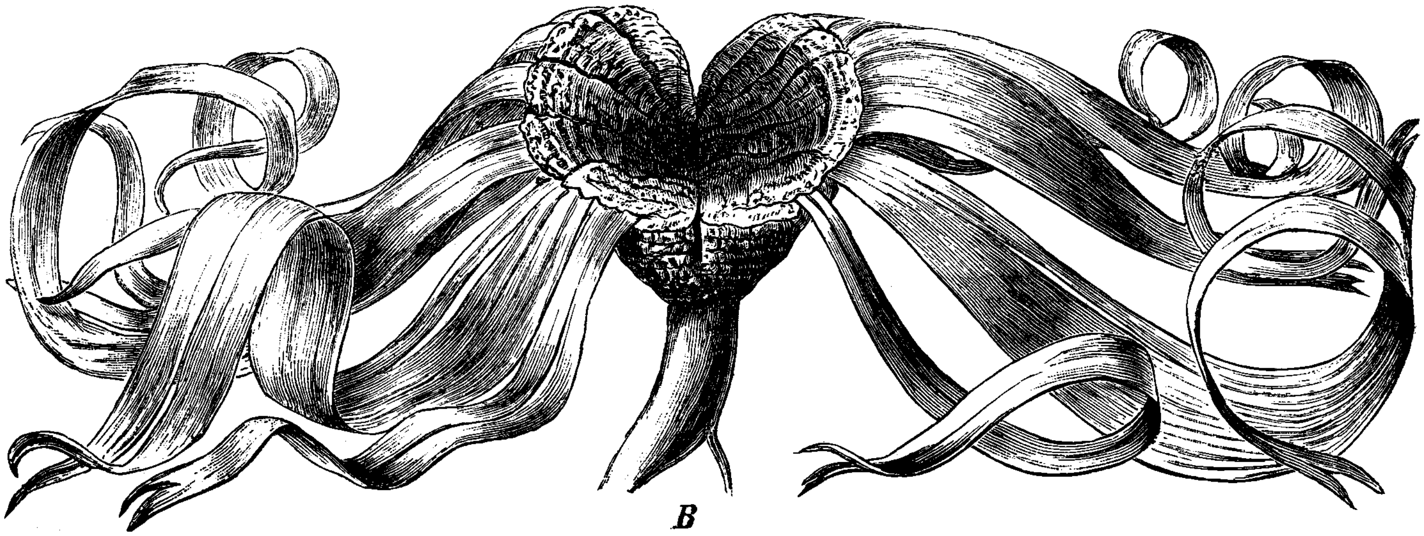
When cuttings are taken from large mature cacti, the rooted cuttings frequently flower the first year on the side which had faced the sun during the previous winter and spring, irregardless of the new orientation of the cutting (see illustration on cover of this issue). When a cutting of a mature columnar cephalium-bearing or pseudocephalium-bearing species is rooted, quite frequently hairs of the structure will continue to grow and flowering will occur if the physiological balance of the piece severed is little disturbed, and if the piece is quickly rooted and given good sun.

Propagation and Establishment of *Welwitschia mirabilis.* (Information courtesy of Chuck Hansen, Arid Land Plants, Tucson.) *Welwitschia* is an unusual desert plant of an extremely arid and restricted region of southwest Africa, the Namib. It has been much studied by plant morphologists, anatomists and taxonomists because of its unique structure and position in the plant kingdom. The plant forms two leaves during its lifetime and these lie on the surface of the desert sand with the reproductive structures between them. A plant is said to live one hundred years or more and the old leaves eventually become split into many segments. The plant is of great value in living collections of educational institutions and is a thought-provoking conversation piece in private collections. Unfortunately its use has been restricted by knowledge of propagation procedures being not well publicized. Taxonomically *Welwitschia* is a member of the Gymnospermae, the group which contains cycads, pines and *Ephedra,* seed plants which do not have true flowers.

To propagate *Welwitschia,* obtain a 6-inch diameter drainage tile (sewer pipe) of fired red clay to be used as a deep pot. For optimum results the drain-tile should be four feet deep but in any event at least two feet. Choose a clay flower pot that will just fit inside the tile and cement it in place in the bottom of the drain-tile. Place two inches of coarse material in the bottom of the pot and fill the tile with a mixture of ⅔ pumice and ⅓ commercial potting soil to a level two inches below the rim. Place a thin layer



A



B

The unusual gymnosperm **Welwitschia mirabilis** *of the Namib Desert of Africa, as illustrated in the monograph by A. W. Eichler in Engler and Prantl's* Die Naturlichen Pflanzenfamilien *(1889). A: young plant. B: old plant with split leaves. Successful propagation and growth can be achieved by planting in a tall drainage tile to accommodate the deep root.*

of pumice (⅛″–¼″) over the soil mix. Water well and let drain. Remove the membranous wing from the seed. Dust the seed with fungicide such as Thiram™ and place it directly on the pumice surface. Cover with a ½-inch layer of pumice and mist lightly. Cover the top of the drain-pipe with glass or saran wrap. If the seed is good, germination should occur by one week. Remove the cover when the seedling is well above ground and move the drain-tile into bright light. There is a danger that the rapidly growing root may push the plant out of the soil. If the soil compacts at all or if the seed shows a tendency to heave, cover with additional pumice. Do not fertilize the plant for the first four months. Then water with a good well-balanced house-plant fertilizer at one-fourth the recommended strength on the package. Do not fertilize more frequently than once a month during the growing season of spring, summer and fall. The plant does well in the hardest light of a greenhouse. When grown in a home or patio situation, move the drain-tile out-of-doors in the summer and back indoors before the first freeze.