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Teo's small book of grafting cacti

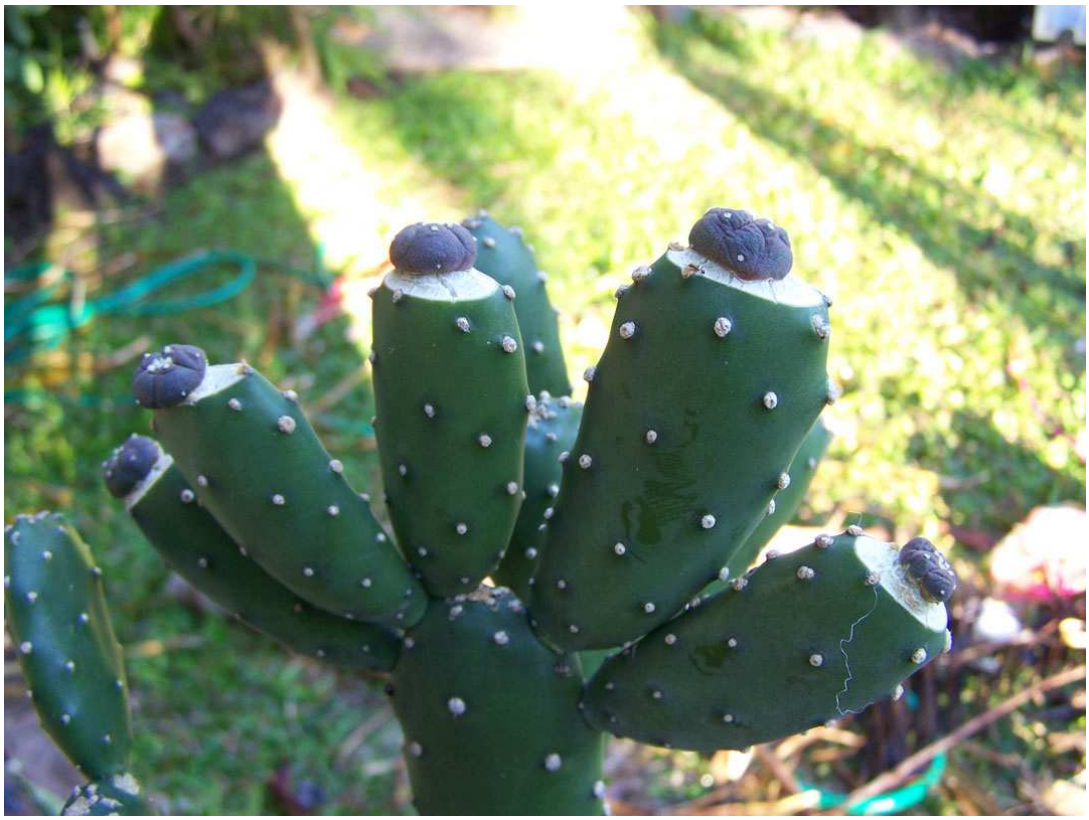

Figure 1: Work in progress, *Lophophora* to O*puntia* graft .

This is a small book containing what I believe to be the keys to grafting cacti. My experience is generally with *Lophophora sp* as the scions and so unless otherwise stated this is what I am referring to. There is no 'correct' way of grafting just a way that works for you, what is mentioned here is what works for me in my climate. I live in Tropical North Queensland, Australia, where the weather is generally hot and humid. My setup is explained further into the book but I will start now by saying that I grow under lights. So the key to grafting as far as I'm concerned is practise and experimentation, there are few boundaries on what can be done and I suggest people just do it rather then sit around discussing it all day, more can be learned through experimentation than I can share in this book. Using the methods I describe here and those obtained through your own experimentation, you will hopefully have a near endless supply of *Lophophora* plants.

This book is free to distribute to all. All photos in this book are my own unless stated, please ask my permission before using them elsewhere. Throughout this book I have used the old nomenclature *Trichocereus*, this genus is now included in *Echinopsis*.

The sections covered in this book are:

Why Graft?

The reasons for grafting are personal and can widely vary, here are some reasons why one might decide to graft:

1) Increased seed production
2) Vegetative propagation
3) To make plant more hardy to particular conditions
4) Preservation of albino or other mutations
5) Because one likes the look of grafted plants
6) Because you can

Some people graft in order to shorten the length of time required from seed to ingestion of psychoactive plants such as peyote and san pedro, this I believe is not a good reason as there is no evidence to suggest that increased growth correlates with increased alkaloid content, that said there is no evidence to suggest the opposite is true, just popular opinion. Many people also like to graft seedlings of fast growing species such as Trichocereus sp, this to me seems pointless as they are so fast anyway, as before grafting these for increased alkaloid content seems silly to me. I do however see value in grafting a few to see what the younger seedlings will look like when older, thus allowing one a better identification earlier, likewise they could be used for practise grafts or grafted for the hell of it. If one wants to grow mescaline containing *Trichocereus* for ingestion my advice is find a clone of already known high potency and buy as many cuttings as you can afford and propagate ruthlessly, in no time 10 cuttings can be turned into 50+ plants.

Figure 2: *Lophophora williamsii* solitary form pupping like crazy

Figure 3: Caespitose *Lophophora williamsii* pupping like crazy (Photo from Gerbil)

Now that that has been cleared up I will discuss how reasons 1,2,3 and 4 above could be of use to you. By grafting plants the time between germination and flowering is drastically reduced, therefore giving increased seed production and concurrently increased propagation by seed, your very own seed factories. Grafting also initiates a lot of pupping even in plants normally of solitary nature. The reason for the pupping is that that scion is slower growing then the stock, this causes a build up of hormones responsible for shoot production (similar to when you pinch the tip of a plant and it produces axillary buds). This excessive pupping can be put to good use as it provides excellent material for further grafts or for cuttings to be rooted, this allows for an increase in vegetative propagation.

The cultivation requirements of grafted plants are mostly those of the stocks, therefore it is possible to tune plants to your own growing requirements by selecting the appropriate grafting stock.

Some cacti are albino, meaning they lack chlorophyll, and will die after all their food reserves have been consumed as they are unable to photosynthesise. Such plants can be kept alive by grafting as the stock photosynthesises and nutrients are passed onto the albino scion. Like the albino plants, variegated plants lack chlorophyll but only in certain areas leading to a speckled appearance. Some plants are so highly variegated that they cannot survive on their own and like albino plants require grafting. A note on cristate plants, I had a cristate *Trichocereus pachanoi* which reverted to normal growth under lights so its possible that the light spectrum was the culprit.

Figure 4: Variegated *Trichocereus cuzcoensis*

Whilst some people do not like the look of grafted plants I still highly recommend that people graft as it allows one to become self sufficient in seed production. It also adds an element of forgiveness to the plants and even the most experienced growers lose plants to rot.

Grafting Basics

Grafting in horticulture is defined as the joining of two separate structures so that tissue regeneration occurs forming a union and the united pieces grows as one plant.

Some common terminologies encountered include:

Scion: The material taken from one plant and placed on top of the rootstock.
Rootstock: The base of the graft upon which the scion is placed. Sometimes shortened to stock.
Vascular tissue: The tissue responsible for conduction of water and nutrients in plants. In cacti this tissue takes the form of rings.
Cambium: Meristematic tissue in the stems of plants which divides to produces xylem on the inside and phloem on the outside, responsible for increase in girth. Is situated inside vascular tissue.

The process of grafting involved cutting the rootstock and the scion in a way that they fit together like pieces of a jigsaw puzzle. The cambium layer of each component must overlap as it is this layer that is capable of healing the connecting wounds and forming conductive vascular tissue. As the cambium is inside the vascular tissue overlap of the vascular rings is sufficient enough to provide a union.

Figure 5: Schematic of overlapping vascular tissue

Figure 6: Left is the cut stock, note the circular vascular tissue near the centre of the cactus. Middle shows the cut scion with vascular tissue. Right shows the subsequent union.

The scion may experience significant water loss as the vascular tissue is not yet conductive therefore it is advisable to place the graft into an area of high humidity. Pressure may have to be exerted on the graft in order for the surfaces to stay in contact as the plants dehydrate. As it is the scion you wish to grow, any shoots produced from the rootstock should be removed as soon as possible as these shoots decrease the available nutrients for the scion.

Figure 7 shows a number of ways that the scion and rootstock can be cut and arranged. The possibilities are only limited by the presence of vascular tissue and the imagination of the grafter.

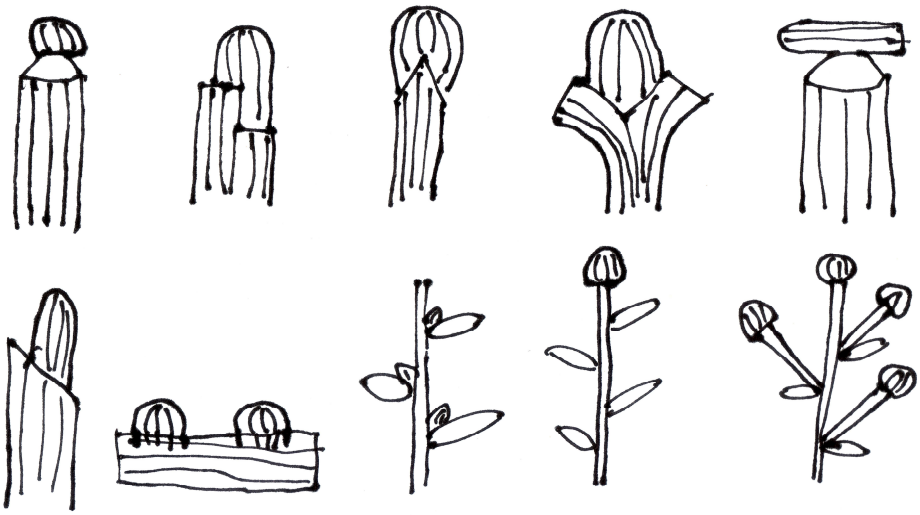

Figure 7: Possible grafting arrangements.

Choice of Stock[1]

Figure 8: Some *Trichocereus sp* to be used as stock plants

Practically any other cactus can be used as a stock for grafting, some common types will be listed with their properties below, but I would like to outline a few parameters that I believe are important to consider in choosing stock:

1) Growth rate
2) Cultivation requirements
3) Life time
4) Availability
5) Other

The first one is obvious, why graft a plant onto a slower growing plant apart from doing it for the hell of it, or for some sort of gene transfer from stock to scion. The growth rate of the stock should be fast to maximise to growth of the scion. Factors that affect growth rate of scion include the size and type of the scion. Unlike grafting woody vascular plants with leaves cacti are essentially large photosynthetic columns or blobs. When grafting with normal plants all branches produced by the stock are removed therefore the stock only plays a sequestering role where as the scions role is completely photosynthetic. As cacti have photosynthetic bodies the stocks act as the roots but also photosynthesise therefore providing added benefits not found in other plants. The larger the cactus the larger the photosynthetic area therefore the more growth could be expected from the scion. Many people say that it is the size of the root ball that counts - and they are not wrong - as size of root ball will correlate to the amount of photosynthetic area it is providing for.

The cultivation requirements of the stock must be considered, no point using a cold susceptible stock plant in a cold climate. Some stocks also require a lot of water to be kept at grafting prime and therefore would not do well in a drought.

The different stock plants have different lifetimes, by lifetimes I mean the length of time the stock is able to support the scion before it goes woody.

[1] Note I use the word stock in two contexts, one as was defined above; as the bottom part of a graft or root stock; and the other refers to stock plants; which are generally large plants from which cuttings or seed are taken to maintain plant numbers.

Availability is more important than you think, if you have 1000000 plants to graft (could I be so lucky) then the last thing you want to do is have to pay the excessive prices charged for *Trichocereus* in order to obtain enough stocks. Around this area we have a lot of *Opuntia* and *Cereus* growing wild, both of these are great stocks and as they are readily available and free they quickly become a contender when I choose my stocks. Another thing contributing to availability is how fast can they be propagated, the faster they can be propagated the easier it is to maintain numbers yourself.

What other factors would affect choice of stock you ask? Well some *Opuntia* and *Pereskiopsis* have horrible small spikes called glochids which are fine as hairs and can be really nasty, other plants such as *Trichocereus peruvianus* have huge spikes which can do a lot of damage if handled wrong. The other reasons are varied.

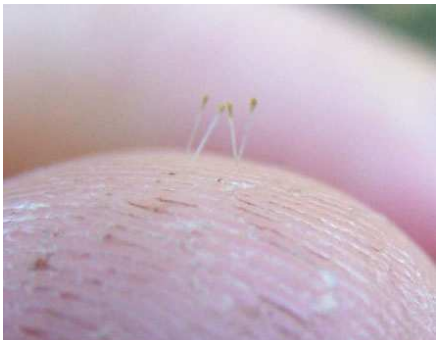

Figure 9: Glochids in my finger

Figure 10: *Pereskiopsis* glochids

Some common stock plants[2]:

Figure 11: *Pereskiopsis* plants

***Pereskiopsis sp*:** These plants have photosynthetic stems and leaves and the areoles are full of tiny hairlike glochids and when older some quite nasty spines. Due to their small diameter and fast but short term growth these plants are great for grafting of seedlings and small plants. The lifetime of the graft is <2 years. They are available from some people in the cacti community for quite cheap and are readily propagated to give large quantities. They can handle a lot of water. Stocks over 30cm become hard to handle.

[2] As I live in a tropical environment I cannot really comment on how the stock plants handle the cold so this information has been left out.

***Trichocereus sp*:** Large columner cacti which have plants with small to no spines, *T. pachanoi* and *T. scopulicola*, to plants with large fierce spines, *T. peruvianus* and *T. bridgesii*. The diameter ranges with age and growing conditions but *T. scopulicola* is renound for its large diameter. The entirety of my original seedling grafts onto *Trichocereus* failed and none have been attempted since, there are people that graft seedlings onto these plants with success. These plants do not mind water. They are reasonable quick to propagate and growth up to 1cm a week when watered and fertilised regularly is common. These stocks seem to have an unlimited lifetime as I have yet to hear of anyone whose plants went corky and have not experience this myself. There is essentially unlimited stock height.

Figure 12: *Trichocereus pachanoi* plant

Figure 14: *Opuntia* plant

***Opuntia sp*:** The pad like structures of opuntia can be covered in glochids making them hard to handle and the vascular tissue in these pads is located quite close to the edge of the pad meaning a good overlap on a large scion would be hard to get. Seedlings have taken ok to grafting onto *Opuntia*. They don't mind water at all. Stock height is essentially unlimited but generally only one pad is removed therefore limiting height to the size of the pads. They are fast growers and as they use to be a nasty weed in Australia they are readily found in the wild. I'm unsure of the lifetime of these grafts as I do not frequently use them.

Figure 13: *Opuntia* with grafted *Trichocereus* seedlings

Figure 15: *Hylocereus* plant

***Hylocereus sp*:** Triangular stems with small manageable spines, the plant has a vine like habit. Commonly encountered as the stocks on the novelty lollipop cactus with the albino *Gymnocalycium sp* scions. Easy to grow and propagate and can handle lots of water. Supposedly good for grafting seedlings, results so far are not good. Lifetime of the graft is not long term. As the plants grow their girth increases and decreases and so the size of the stocks is limited to the length between sections of small girth.

***Cereus*:** Similar to *Trichocereus* except that the diameter is much less. Very common garden cactus.

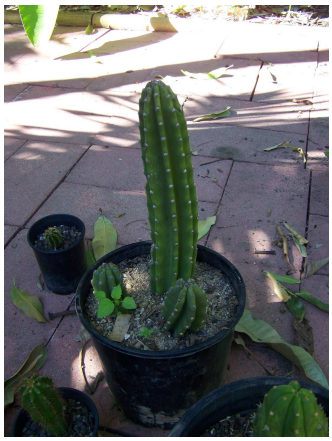

Figure 16: *Cereus* plant

In my opinion Pereskiopsis represents the best choice for seedling grafts as it provides rapid seedling growth on par or better then the others but the plants are much more easily propagated and grow a lot faster therefore its easy to be self sufficient.

Growing *Pereskiopsis*

Figure 17: Pereskiopsis stock plants

With any grafted plant you should treat the graft as you would the stock plant, therefore it becomes vital to know the how to cultivate the stocks. This section is purely on *Pereskiopsis* as much has been written about growing the other stocks. This is only what I myself has found works well under my conditions and I cannot stress how important it is for you to experiment rather then taking what I say as gospel.

Pereskiopsis are easily propagated by cuttings, they do grow from seed but I have never seen seed offered and as I already said they grow so easily from cuttings. There are two methods of vegetative propagation that I have used for *Pereskiopsis* and the change from the first to the second was only due to my laziness of not wanting to double handle the plants, once for rooting then again for re-potting. In both methods and anytime when taking cuttings of any plant use a sharp blade to make the cuts, the sharper it is the less tissue damage.

Figure 18: Razor blade for small plants

The first method I use requires a container filled with clean coarse sand and water into which the fresh cuttings were placed, sometimes I did not even use the sand just placed the cuttings in the water. I would use enough water to cover the sand and it is important that the water be replaced frequently. During the first day mucilaginous material was exuded from the cuts so I would replace this water with fresh water two times during the first day if I were not lazy.

For the second method I would just place the cuttings into some premium potting mix in the pots I wanted them in (5cm tubes) and then watered from the bottom.

In both cases I rooted them under cool white fluoro lights but both techniques would work equally well outside under shade cloth. Roots took less then a week to form and the temperature was between 25-45°C. Remember EXPERIMENT!!!!!
A method that I used to increase my plant numbers involved cutting above and below every node whilst leaving the leaf attached, these tiny stumps were placed in the soil with only the leaf showing and then kept moist. It takes a while be eventually the node roots and pups producing a new shoot.

Figure 19: Left, single node cutting note areole. Right, single node cutting planted with leaf exposed.

Now down to cultivation requirements, probably the main point (other then temperature which is always hot here) is that these plants love water. I use bottom watering as its easier for lots of plants and I never let it dry out. I also grow them in shady environment or under lights. Plants grown with little water and in sunny position will have super mega spines and are very nasty to deal with, as well as that the nodes are close together and leaves are small and thick. Therefore by growing them with lots of water and in shady/under lights environment they are much easier to handle and it makes the whole experience much more pleasant. After they hit about 15 cm there is a distinct preference to lean so to overcome this I plant them close together thereby providing each other with support.

So lets put this all together as I explain to you my process from before cutting to ready to graft.
The first thing is building up a collection of stock plants, the job these plants play is to provide the vegetative material for cuttings. The number of stock plants you need will correlate with how many cuttings you wish to take at a time. Unused stock plants will get really crappy after a while so throw them out or place them elsewhere to grow really big, or even give them away.

So I like to pick straight vertical growth about 10-20cm long, remember use sharp blade for cuttings. I then remove about 10cm worth of leaves and place this treat this section as per cuttings above burying the cutting up to where the leaves start. The reason for removing so much leaf material is to provide a deep rooted cutting with lots of stability, this is more important than you think.

Figure 20: Left, straight 15cm cutting. Middle, leaves removed. Right, plant cutting up to leaves.

I grow the cuttings out under lights where they grow nice and supple and non spiky. I think it is important to grow the cuttings out under the conditions where you are going to have them after grafting as leaves are produced adapted to particular environmental factors and when you change conditions there is only some degree to which the leaves can adapt, any new leaves grown under the new conditions will be adapted to these conditions but the stock plant of a graft is not expected to produce any new leaves. I like to keep my stocks to 20cm, I have tried bigger and they were too unstable to be worth it.

My light setup for grafts consists of 60cm X 150cm shelves with 4x36watt cool white fluoro lights, the outside is covered with panda film to reflect the light. I run 18:6 day: night cycles. See Figure 21 on following page.

Figure 21: My light setup

Sowing seed

Figure 22: Seedlings in sand inside takeaway container

There are many different methods to sow seeds but I thought it worthwhile to mention two here as they have been found to be very effective under lights. The first is the bag method in which the seed raising soil is placed inside a zip seal bag and sterilised in a microwave for several minutes then allowed to cool, see here http://www.cactus-mall.com/ccc/index.html for more info. The second is a derivative of the above process where sand is placed in take away containers and moistened, then sterilised in microwave. In both cases the seeds are sown quickly to avoid contamination and sprayed with a fungicide such as copper oxychloride or mancozeb. In both cases the seedlings can be left in humidity for up to one year.

I like my seedlings to etiolate a little, this has many added advantages such as:

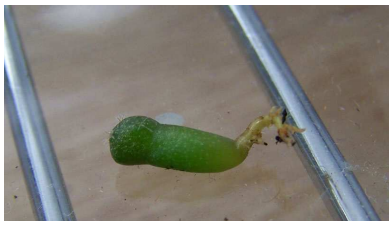

Figure 23: Etoliated *Lophophora* seedling, note how it started to fatten at top

- You can add a layer of sand around the plants to stabilise them without covering them if you're not grafting them.
- If you cut in half you can graft top and bottom as both have areoles.
- You can cut in half and graft only top and let bottom pup then graft pup.

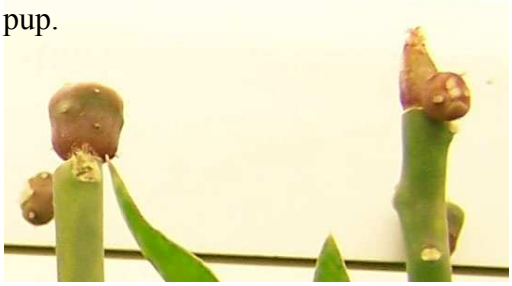

Figure 24: Left graft is seedling top, right graft is seedling bottom, note roots.

For seedlings I run 2x 36watt cool white fluros on a 18:6 day: night cycle.

Grafting to Pereskiopsis

Figure 25: Some 6 month old Lophophora williamsii grafts

Pereskiopsis have found a niche in the area of seedling grafting. These plants allow for very rapid growth of seedlings and encourage early flowering and profuse pupping. So by now you should be aware of how to grow *Pereskiopsis* successfully and how to sow seeds. If you have not yet grown and propagated any *Pereskiopsis* then I suggest you read no further and master the cultivation of *Pereskiopsis* before moving on.

The process of grafting is simple and one only requires five things, a sharp blade (I prefer a fresh razor blade), a humid low light place to allow the grafts to take, some stock *Pereskiopsis*, some seedlings (preferably healthy and less then 8mm) and a reasonably steady hand.

Figure 26: The five things needed for grafting

In my experience humidity is more important when dealing with seedlings then with older scions as the seedlings have never experienced low humidity conditions and so dehydration is rapid. My humidity setup involves a large foam box covered with plastic, the plants are placed inside with a dish of water and misted when ever I feel like it. The container is not in any direct light but receives some very diffuse light.

In my opinion the health of the seedlings is more important than their age. A small note on sterility, feel free to sterilise the instruments before and during the session but I don't and have any problems. The only time I sterilise a blade is when it has been in direct contact with rotting tissue and I plan on taking more cuttings with the same blade, I normally wash with clean water and soap. Be careful when using alcohol or swabs to sterilise equipment, especially blades or cutting tools, as un-evaporated residue will damage plant tissue.

There is much discussion about whether to water or not to water before grafting, I do not find there is any direct correlation and I have not had any grafts pushed off because I have watered. Feel free to experiment as it may be something to do with the environment.

First step is to cut the stock plant, where you cut is a matter of experience so experiment and practise as much as you can. I like to cut so that the scion is a little smaller then the diameter of the stock and I always cut just below an areole, this means when the *Pereskiopsis* form shoots these shoots will be far enough away from the scion that they wont interfere with it and can be easily removed.

I then remove the top few leaves as this allows easy access to the top areoles for shoot removal when required. The seedling is then cut, this cut must be clean and straight so I do it by drawing the blade back towards me whilst applying downward pressure on the seedling. Pluck the bit to be grafted off the top of the razor blade and place it on top of the stock and apply a gentle downward force to expel and air. Some people say you must slide the scion off the razor onto the stock with one movement so as to not allow air to get caught, I say this really does not may a difference and is a lot harder than what I do.

Now stand back and admire your work, too easy yeah? Yes that's all there is to it! Now go and place it in some humidity for about a week to allow the graft to take, during this time leave it and do not poke, prod, take out, or stare at it in an inappropriate way or the graft may fail. Take the graft out of the humidity and place it into the growing conditions, treat like a *Pereskiopsis* and growth of the scions should be noticeable within 2 weeks. The initial growth is likely just a bloating or swelling of the scion, after about 4 weeks the graft will start to grow.

Housekeeping of your grafts is simple, every so often remove the shoots that the *Pereskiopsis* produces, initially a lot of shoots will be produced but as the scions starts to grow more rapidly the frequency will decrease. This is because the initially there is a build up of hormones as the scion is not growing as fast as the stock would like, these hormones cause the stock to pup, as the scion starts to get bigger and grow faster it uses more of the hormones and so less re-shooting occurs. I advise that you wait for a shoot to be fully developed ie. having a visible stem before you remove the shoot, as before this it is possible to just damage the meristem and many more shoots can appear.

Figure 27: Grafted stock re-shooting

If your grafts did not take then you have just obtained a new stock plant that you can use in the future to obtain more plants for grafting. If they do fail do not be disheartened just keep trying and keep experimenting until you find what works for you. You may find grafting at midnight after five days sleep deprivation, naked, with a monkey may increase your success rate, though it may not as well.

For seedlings above 8mm it is still possible to graft onto *Pereskiopsis* albeit a little trickier. The process I use is that of wedge grafting. The first step in doing a wedge graft is cutting the stock at an appropriate height, I cut mine lower then when doing seedlings as the scions are much heavier and prone to falling off if the stock wobbles, shall we say 10cm high. Two cuts are then made to the stock to form a point, the angle of the cuts should be such that they are about 1-1.5cm long. The scion is then chosen and the bottom most section of root is removed and a cut is made along the vascular tissue (perpendicular to initial cut). The scion is then pushed down onto the stock with the stock causing the scion to flare out as the pieces of the puzzle fit together. Remember to overlap the vascular tissue, I do this by tilting the scion to the right or left a little. A weight can be placed on top of the scion or it can be left as is. Humidity is not required but may be advisable if the growing conditions are harsh.

Figure 28: Wedge graft

These grafts take longer to show signs of taking, again look for bloating.

Pollination

Figure 29: *Lophophora williamsii* flowering, note style in the middle and anthers around it.

As grafted plants flower prolifically I think it is important to touch on this subject. Pollination is the transfer of mature pollen onto a receptive stigma, in nature this can be done by animals, wind and even water. In the home garden pollination will continue to occur by these mechanisms but can also be achieved by the hand of man. Cross-pollination in Lophophora sp results in a larger production of seeds then does self pollination.

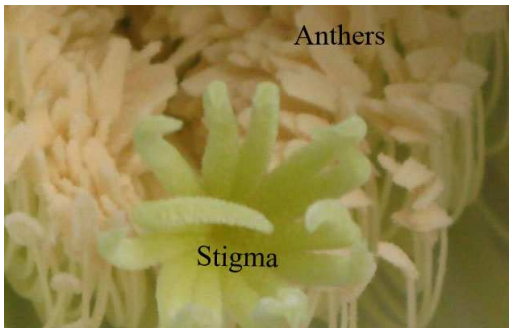

Figure 30: Trichocereus flower with stigma and anthers labelled (Picture from FB)

Pollination is achieved by brushing the stamen of one flower with a cotton bud or small paint brush then subsequent brushing of a receptive stigma of another plant. It can also be done by removal of the stamens from one plant and then brushing these onto the stigma of another. I utilise the second method and store pollen from my plants in aluminium foil in the fridge, this allows cross pollination when only one plant is flowering.

Many people will want to preserve the genetics of the location cultivars that can be purchased these days, this can be done by ensuring the brush or pollen used is from another plant of the same location. Other people will find more enjoyment in hybrids in which case they could be random or controlled again as above. I urge people to try all forms of hybridisation including intergeneric hybrids, cross between Lophophora and a different genus where Lophophora plant can be father or mother.

If pollination was successful after a period of time ranging from three weeks to several months a seed pod will be produced. I generally give the seeds a few days to finish developing but advise that you watch for birds or ants as they love to steal the fruits and seeds. Ants will put a hole in the fruit and take all the seeds, this does not take long so be ever vigilant. To remove the fruit I find tweezers useful, I grasp as far down the fruit as I can see and pull it off. To remove the seeds just squeeze them out then place them on a surface to dry out a little or sow immediately, a brushing with fungicide might be advantageous.

Re-grafting to other stock

As I mentioned in the grafting stocks section different stocks have different properties, perhaps the most important long-term property is that of lifetime. *Pereskiopsis* grafts have a short lifetime before the graft becomes corky and the scion is deprived of nutrients. That is why I recommend re-grafting from the *Pereskiopsis* to a more suitable stock such as *Trichocereus* after an appropriate time.

Figure 31: *Lophophora* graft

Step 1: Get plant to be regrafted and cut Pereskiopsis just below the scion.

Figure 32: Bottom of ex-graft showing P*ereskiopsis* join

Figure 33: Pups removed

Step 2: Remove large pups and regraft these onto some stock. You do not need to do this. Graft the pups then cut the main button in half and graft the top and bottom onto different stocks.

Figure 34: Ex-graft cut into two, bottom and top.

Figure 35: Some re-grafted *Lophophora*

Step 3: Secure scions to stocks, I use grafting tape, and place them in a cool shaded location to heal.

Degrafting/ Taking Cuttings

Figure 36: Top, freshly cut rootstock. Bottom, showing how much rootstock is left after taking a cutting.

Buttons or whole grafts can be removed from their grafting stock or own roots and rooted. If taking cuttings of plants on their own roots make sure to leave some areoles for the plant to pup from and let the rooted area dry out a little before watering.

Cuttings are taken with a sharp knife and the resulting button is left in a cool dry shaded place to callus. Once callused it can be placed in/on sand to root.

Figure 37: Top, rootstock has healed and pupped. Bottom, cutting showing root development.

Rooting is a reasonably slow process, so employ some patience.

Coco coir as a rooting medium has been used with success by some people struggling with pathogens in sand, I have not tried it.

Final thoughts:
For a long time now in Australia *Lophophora* plants and seeds prices have been excessive, though of late the prices have come down a little. Grafting allows mass seed and plant production and provides good plants for the trial of hybridisation, both intra and intergeneric, and general experimentation. Through the sharing of pollen, seed and plant material the price of these plants will hopefully become more reasonable, and as the price becomes reasonable and the number of plants in peoples collections increase so to will the ability to use this sacrament as it was intended. If we work together with grafting and generosity I believe this dream could become a reality in the near future.

I would like to thank those crazy fellows at the nook who brought *Pereskiopsis* grafting to my attention and Phillistine for doing all the *Opuntia* seedling grafts and stuff and Indy for guarding my laboratory from pirates and aliens.

Figure 38: Indy aka K. Cactus (Keeper of the Cactus)

Remember EXPERIMENT!!!

Teonanacatl
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PICTURES to TAKE

Step by step

- Stock plant tip
- Cut tip below areole
- Remove leaves
- Seedling
- Seedling cutting
- Seedling cut
- Placing on stock
- Push to expel air
- Done graft

Wedge grafting step by step

- Larger seedling
- Cutting stock
- Cutting seedling
- Push on
- Finished.

Seedpod