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Don't tell me, show me: the importance of maintaining data in cultivated plants

Introduction

Cacti and succulents have been in cultivation for several centuries. At least in part because of this, many published studies on cacti and other succulents have long relied upon cultivated plants for data; these studies include taxonomic, historical, and conservation-focused research (e.g., Janeba 2017, Starr and Davis 2021).

Historically, significant confusion has muddied the taxonomic waters for these plants because many of the older collections were stored with incorrect, invalid, or missing information; some **species** (see glossary) have even been described without known provenance. For example, the immensely popular peanut cactus, *Chamaecereus silvestrii* Britton & Rose was collected from Argentina in the early 20th century (Spegazzini 1905), but because of poor recordkeeping still has not been found in the wild. In 2018, its closest known relative, *Chamaecereus luisramirezii* Lodé & Carlier (Fig. 1) was described from Bolivia near the border with Argentina (Lodé and Carlier 2018).

Unlike many fields of science, scientific advances in the botanical world for cacti and succulents have largely depended on non-technically trained collectors and cultivators. For this reason, succulent collections with accurate data are especially useful for a myriad of important studies in the fields of taxonomy and conservation. Knowing where a plant came from is therefore of paramount importance.

In our travels and discussions with fellow cacti and succulent enthusiasts, we often hear a variety of excuses for not storing data on each plant owned. Even basic data like the plant's name are often considered too much of a burden. While this philosophy is acceptable for those that want to grow their plants for purely aesthetic reasons, this practice becomes an issue when these same collectors start desiring unusual or rare species to add to their collection. We feel strongly—especially in today's world where habitat destruction, poaching, and climate change are impacting wild populations at alarming rates (Goettsch et al. 2015, Pillet et al. 2022)—that those who own rare or unusual species should feel a sense of responsibility towards obtaining and storing as many data on those plants as possible.

In this article, we hope to make the process of storing data as easy as possible and illustrate how little effort is really involved.

Types of data

The first challenge—and often the one that concerns people the most when getting started—is to decide what types of data should be documented. In reality, the most basic data are also the most important data. Here we list the types of data that we feel are crucial to store, from most important to least important. Each entry or accession in your spreadsheet or database should have these data.

1. Genus and specific epithet. Although the most basic information, it is also the most important. But because of its importance, collectors are often reluctant to write names on their plants because of their fear of change; the gut reaction is to blame taxonomists. "Those darn lumpers/splitters just change names to make my life difficult!" But, in reality, it doesn't matter which name you apply to your plants as long as it is accurate! Taxonomy—as with any science—is a constantly changing

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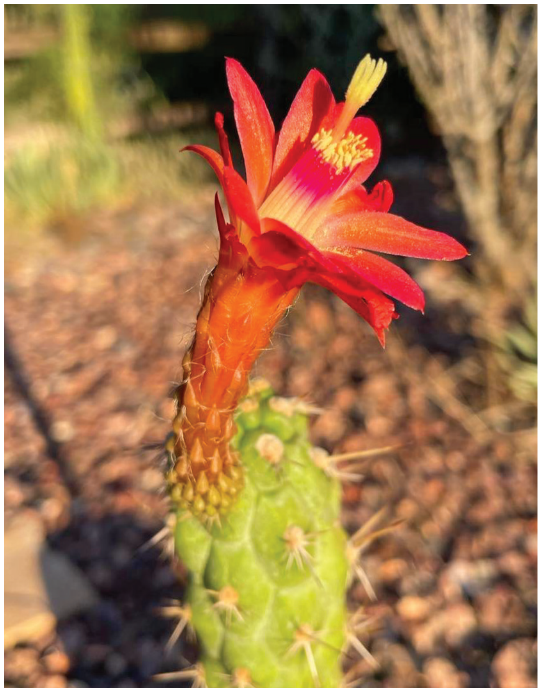
Photographs by Tristan Davis unless otherwise indicated.

1: *Chamaecereus luisramirezii* Photo: Kemper Ruth

environment; however, you do not need to fret about using the latest taxonomy or changing your names every time a paper proposes a new name. Why? Because the science of taxonomy includes the documentation of the change. As long as you have an appropriate name on your plants, someone can interpret what the name is at any one point in time. Some of us like to update our databases and tags with every solid taxonomic change. But that is certainly not a necessity. So, don't worry about what taxonomy you follow—just document an accurate name! Also important is keeping track of the original name that came with the plant, especially if you update your taxonomy regularly. For example, *Tacinga subcylindrica* M. Machado & N.P. Taylor (Fig. 2) was initially considered a form of *Tacinga inamoena* (K. Schum.) N.P. Taylor & Stuppy (first as a subspecies, but also called 'Marlon's Dwarf'), but was later described as a distinct species. You can inadvertently lose information if you don't record the original name. The next question people ask though is, "Well that's hunky dory, but what if I don't know the name of my plant?" Well, that's where the next few fields come into play.

2. Locality data. These data are grossly underplayed and under-documented in the majority of collections,

2: *Tacinga subcylindrica*



3: *Loxanthocereus parvitesselatus*

yet these can sometimes represent data that are actually more important than documenting the name of your plant! With locality data, you can ascertain not only probable species (if your plant is unidentified), but also often variations in populations such as **subspecies**. We make it a point *whenever* we obtain a plant to ask if there are any locality data associated with it, whether the plant is from a local nursery or eBay. You will be very surprised to find out how many sellers actually *do* have that information to share! And, when you know the locality, sometimes that informs you that your plant is actually not what you thought it was the entire time (despite where you got it). A good example is a collection of Karel Kníže of which we've obtained several specimens: KK 1601 from Samne, Peru. This seed collection has always been distributed as *Borzicactus samnensis* F. Ritter—a beautiful **taxon** with stout branches and purple flowers. However, we noticed as our plants were growing out that they did not fit the description of that species; they were thinner, with **tessellate** ribs, **decumbent**, and had larger, felted areoles than one would expect for a *Borzicactus* Riccob. When we finally got a plant to flower, it was confirmed: they were not *Borzicactus* at all (which has fairly straight, **actinomorphic** flowers that have only the petal tips barely reflexed), and instead had typical *Loxanthocereus* Backeb. flowers (**zygomorphic**, curved flowers that reflex significantly); plus, the flowers were a red-orange. So, what in the heck was it? Well, because we had the locality data, it didn't take long for us to discover that there is indeed a *Loxanthocereus* also found at Samne in Peru: *Loxanthocereus parvitesselatus* F. Ritter (Fig. 3)! Kníže likely mixed up his collection either in the field or prior to distribution with another plant he collected from the same area.

Also important is not pulling locality data out of thin air, i.e., looking up where a species comes from in the wild, and then pretending these are the data from where your plant originated. This mistake endangers the data integrity of not only your own collection, but also those of collectors with whom you trade.

With all of that said, what exactly are the locality data you need to store? The best answer is "anything

EXAMPLE A

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sequ	Genus	Species			Fi	Family	Purchase n	Source	cquisition da	So	S	I		Count (all)
2197	*Melocactus*	*andinus* ssp. *andinus*				Cactaceae		Tristan Davis, Chandler, AZ (from	Apr-22				Gu	9

EXAMPLE B

Genus	Species	Common Nam	Locality	Coll # / C	Obtain	First Bloom	Source	Comments	Family
Mammillaria	*densispina (1)*	Mammillaria sp.	MEXICO: Aguas Calientes; La Ciénega to Terrero del Refugio, 2250m-2350m	ML 312	2022	2023	eBay (shoalcreeksuc culents)	- AUG 1, 2022: Obtained 3" dia plant. - MAR 9, 2023: Several flowers started opening today.	Cactaceae
Mammillaria	*densispina (2)*	Mammillaria sp.			2023		Home Depot (Chandler)	- JUN 11, 2023: Obtained 2" dia plant with one mature fruit.	Cactaceae

4: Example accessions in Microsoft Excel. Note that not all columns are completed.

you have"! For example, if you don't have GPS coordinates, just leave that out. But we like to store all of our locality data in a consistent format that is easily understood by researchers. We recommend sticking to a specific format and suggest the following standard:

COUNTRY: State/province/department; specific locality, elevation; GPS coordinates

Example:

PERU: Arequipa; east of Camana, 710–1020m; -16.628284, -72.651030

3. Collection information. Most plants with locality data also come with a collector (or collection) number, usually represented by initials of the collector and a number that represents their personal collection number from their catalog. Sometimes having this information on hand can be very helpful. We have had instances of doubt about the identification of a collection we've obtained, but if we can figure out who the original collector was from their initials, we are often able to contact them and get clarifying information. More than once we have determined it was not the species we thought we had! Don't know what the heck "HU 1161" is or who the collector was? Well, you're in luck. There are great online resources that can translate most collector numbers for you. The following two websites are particularly useful: https://www.fieldnos.bcss.org.uk and https://www.cl-cactus.com.

4. Source. This is probably the least appreciated of the data folks tend to store, if at all, and the easiest one to know. Basically, where the heck did you get that plant from? If you know where you got a plant from, you can often go back to that source for more information or clarification. If you have determined what you got is something other than what the source thought, then why not let them know? Information is useless unless shared, right? Source can be an eBay seller, a local nursery, or a specific person.

Those are the most basic and most important data you can store on your plants. So, that's four things to store! How tough is that? If everyone stored just those pieces of information, the impact on the scientific and hobbyist communities would be enormous.

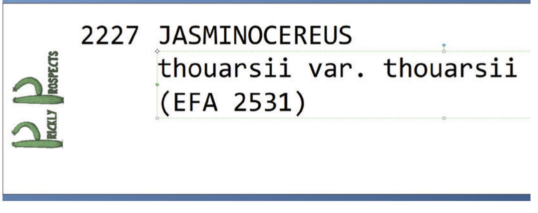
So, now that we have you excited about storing data—and how it is so easy—let's discuss what other data you could potentially store that would make your collection even more valuable. If you have the inclination, there are hordes of other data that you

Table 1: Non-exhaustive list of additional data elements that can be tracked

Field	Description	Example
Accession code	A unique identifier for each accession	2426
Acquisition date	The date you obtained the plant	September 7, 2021
Clone	Identifier for multiple clones	Clone 1
Flowering history	Any information about flowers	3 flowers in May 2021, 4 in April 2022
Health status	Any information about health of plant	Died in June 2021, potentially from rot
Location	Where the plant is located	On the bedside table to stare at each morning
Notes	Miscellaneous notes (e.g., information about identification or the history of the clone)	While received as *Huernia blyderiverensis* (L.C. Leach) Bruyns, the number of ribs suggests this is *H. quinta* (Phillips) A.C. White & B. Sloane
Original specimen type	The type of specimen as received	Seed, seedling, rooted plant, cutting, graft
Parentage	The source of the seed that produced the plant	Hand-pollinated, hybrid (female parent x male parent), open-pollinated, or seeds from accession 137 and hand-pollinated with accession 143
Prior collection number	Many sources will sell plants with a unique identifier	ISI 2007-7, HBG 95203
Share status	Names of people you've shared the accession with	Gave Michiel Pillet a cutting in January 2020
Size	Plant or pot size	4″ tall in a 2″ pot
Source history	Where your source got their plants from	CSSA Seed Depot, ex ISI

5: *Melocactus concinnus* Buining & Brederoo

7: *Matucana tuberculata*



6: Label generated using the software program BarTender by connecting to a collection spreadsheet.

can store—some easier than others to determine—but, once you get the hang of it, it is very easy to add these data to your data management system. Table 1 includes additional data elements that we try to keep track of for all of our plants.

How to store data

There are many different formats in which you can store your data. While some older collectors still keep paper records, we suggest maintaining a digital copy to facilitate data sharing, safety, and usability. Electronic storage formats vary from spreadsheets to advanced relational databases. The latter take quite a bit of effort to plan and implement, but allow for complex data retrieval. However, for most collectors, a simple spreadsheet approach is sufficient. A variety of different software programs can be used for maintaining your collection spreadsheet, but a common one is Microsoft Excel. For relational databases, programs such as Microsoft Access are available, but these can be a bit more challenging or expensive for beginners.

Regardless of your data management approach, each accession in a database should be a single record, with fields representing the different data (e.g., locality data) you are tracking (Fig. 4). Internal consistency is important as well. Come up with a standard format for entering data in each column (e.g., dates structured as year-month-day).

Using a digital system of this sort for managing your data has several advantages. First, you can search and filter your accessions easily. For example, you may want to know how many different species of *Melocactus* Link & Otto (Fig. 5) you have, which can be easily done by filtering a single column in a spreadsheet. Second, sharing a digital copy of your collection is simple. Maybe someone wants to trade with you, but is only interested in stapeliads. Just email them a copy of your collection after filtering by genus or family. Third, if you properly backup your collection records, you'll never have to worry about losing data. Finally, an electronic format can also simplify other tasks collectors have. Don't want to rewrite your labels now that *Corynopuntia* F.M. Knuth is *Grusonia* F. Rchb. again? Just change the genus in your database. If you have a label printer, you can even automate tag printing with only the data elements you want (Fig. 6).

Importance of data

As mentioned, once you have a spreadsheet or database up and running, it makes it a lot easier to ask questions about your own collection. If you often trade plants, partners will be grateful to get a simple copy of what you have available and are more likely to take you seriously. And should you own a nursery, a data management system becomes absolutely indispensable to your daily operations, even if just used to keep track of inventory.

Scientific studies

If you only maintain a plant's name, unfortunately, those plants are often of little use to scientific studies. One of the main reasons that a name may not be enough is the fact that plants are often distributed under the incorrect name—often even a made-up name. Ever heard of the term "*nomen nudum*" (abbreviated as n.n. following a name)? This is Latin for "naked name"—that is, a name that was not formally or properly published, thus not valid. For example, *Matucana mammillaris* (a name frequently used in cultivation) is properly written as *Matucana mammillaris* n.n., and the correct name is likely *Matucana tuberculata* (Donald) Bregmann, Meerst., Melis & A.B. Pullen (Fig. 7). And, I'm sure we've all visited our local box stores and found diamonds-in-the-rough. We've personally found the following rarely encountered species amongst the hordes of common species under completely incorrect names: *Siccobaccatus estevesii* (Buining & Brederoo) P. J. Braun & Esteves, *Pilosocereus chrysostele* (Vaupel) Byles & G.D. Rowley (Fig. 8), *Stephanocereus leucostele* A. Berger, *Browningia hertlingiana* (Backeb.) Buxb., and *Oroya peruviana* Britton & Rose, to name just a few.

Additionally, even though a plant looks like the right species, there may be other species that have almost identical traits; quite often, the only distinguishing character is the flower. So, unless your plant has flowered, can you really be sure it was identified properly? What a plant looks like in cultivation can also be confusing because rarely do we grow the plants in the same climate, **substrate**, or **exposure** that is "natural" for the plant. And often distinguishing characters on a plant from habitat

8: *Pilosocereus chrysostele*

look very different than when that same plant is grown in cultivation (e.g., Menezes and Iracema 2015). Online sources of identification are often replete with inaccuracies, opinions, and misunderstanding of taxonomic concepts and are therefore often of little help and only serve to confuse. In online groups, always be suspect of identifications of unusual plants or similar species without explanation of what was used to make the identification. Some people that are often considered "experts" in online communities stick like glue to old names, concepts, or disproven identifications without valid justification.

Thus, when a scientist is scouring collections for a plant to include in their studies, they are forced to exclude potential candidate plants for lack of data—even if there is relative certainty of a proper identification. What the plant looks like in a collection is often irrelevant for modern studies that use **molecular data**, so if your plant at least has locality information, it suddenly becomes extremely useful. We've both donated plants to scientists across the country to include in their analyses (e.g., to build an evolutionary tree for the genus *Grusonia*) (Fig. 9) specifically because we have the data associated with that plant. Other types of data can be useful too. For example, information about flowering time can help researchers plan their fieldwork.

9: *Grusonia halophila* (D. Donati) Majure, M.A. Baker, & Cloud-H.

10: In-ground collection of T. Davis; data for each plant are maintained without tags; data about where the plant is located in the garden are stored in a database.

Conservation

Maintaining data is even more crucial for conservation purposes. Plants with accurate data are valuable for living collections at botanical gardens, and seeds with known provenance can be stored in a seedbank. Plants with proper locality data can be used to reduce inbreeding in genetic management programs and to choose parentage for reintroduction efforts. Data on the lifespan of plants and coordinates of source populations can be integrated into conservation assessments, i.e., analyses of how species are doing in the wild, and how they may respond to threats such as climate change. For example, Michiel has recently used locality data from a private grower to assess how *Copiapoa* Britton & Rose species may respond to changes in climate, and the results are being integrated in a new conservation action plan.

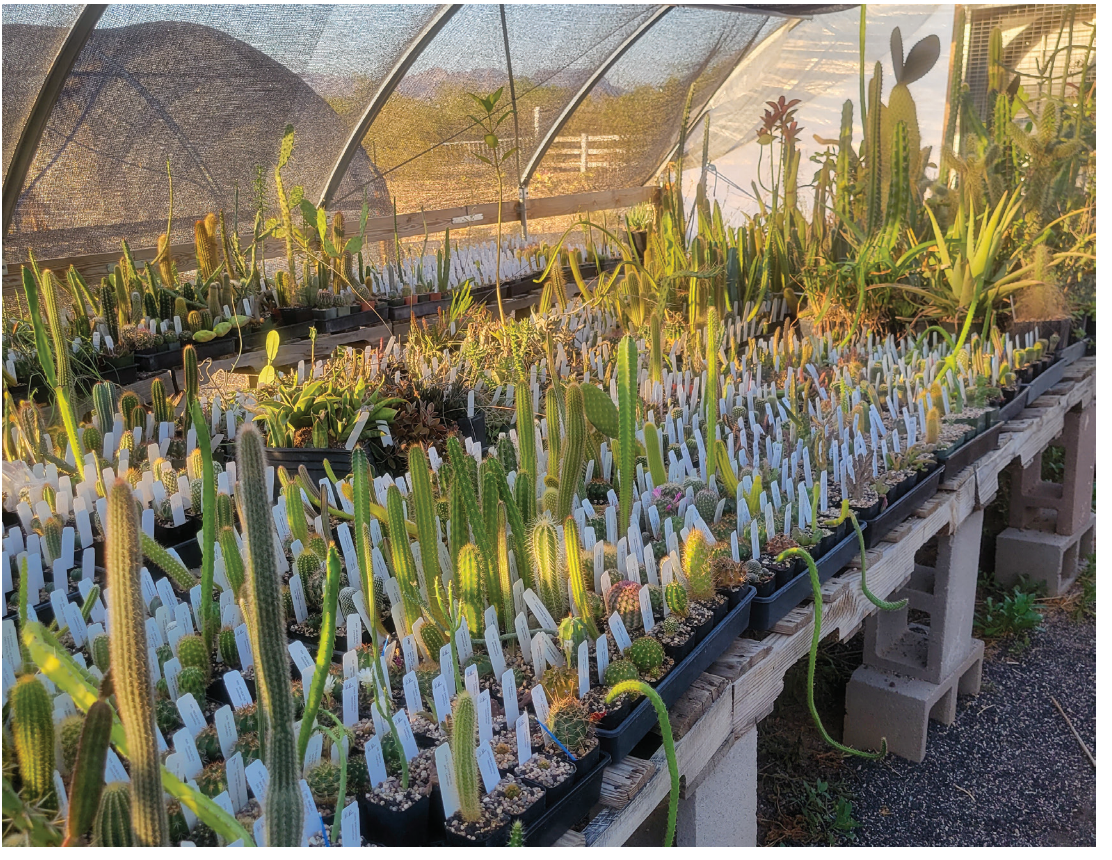
Storing data is clearly of paramount importance for plants that are rare in cultivation or threatened in the wild; it is also a great cost-saving mechanism for scientists who are always extremely under-funded. With the future of the majority of cactus species in grave danger from climate change (Pillet et al. 2022), habitat destruction, and poaching (Goettsch et al. 2015), can we afford *not* to make an effort to maintain data?

Communication

One of the important advantages of retaining data on plants in your collection is that these data help facilitate communication across a wider audience. By tracking data, one becomes more sensitive to the complexity and importance of those data; consequently, people that store data have an enhanced understanding of the challenges of growers, scientists, and conservationists. This improved understanding aids our communication of those data and concepts to others in the field. Additionally, with this understanding, we can more easily educate others with similar interests.

Looking to the future

Only a few decades ago, few could have imagined how besieged our succulent friends would be in the wild today. Careful tracking of data by pioneer growers and explorers continues to contribute to research and conservation efforts that are urgently needed. Data that may have seemed pointless to collect in the past can



11: Part of the collection of M. Pillet; each species is tagged with a clear reference to an accession number from the database where other data are stored. Photo: Michiel Pillet

become useful as technology develops and new scientific questions are posed—we don't yet know what we don't know.

Botanical gardens are starting to make information about their collections publicly available. For example, the Desert Botanical Garden in Phoenix, Arizona publishes their database online at https://livingcollections.org/dbg/Home.aspx. Furthermore, conservation organizations like Botanic Gardens Conservation International (BGCI) increasingly support efforts to manage collections at botanical gardens in a concerted manner. BGCI PlantSearch (https://www.bgci.org/resources/bgci-databases/plantsearch/) is a system that links databases of member institutions and facilitates exchanges between these institutions. This facilitates the pooled management of plants in cultivation as a "metacollection" (Griffith et al. 2020), which supports conservation efforts.

Like the rest of society, growers of cacti and other succulents are becoming increasingly connected through the internet. It's becoming exponentially easier to find people with an interest in similar taxa, making trading and learning more accessible to us all. We hope that soon a standardized data sharing system becomes available for private growers, similar to the aforementioned PlantSearch. If more growers maintain accurate data, such a system has the potential to bridge the gap between private growers, businesses, conservation organizations, and researchers, therefore building a stronger community and benefiting the plants we all love.

Acknowledgements

We would like to thank the multitude of individuals and organizations—past, present, and future—who have painstakingly curated data associated with their collections. Their efforts will continue to contribute to the future of succulent plants.

Glossary

Accession – An entry or row in your spreadsheet or database. This may represent a single plant, or a group of plants that share the same basic data (e.g., species, locality and collection info, and source).

Actinomorphic – A flower that is radially symmetric; i.e., when looking directly at the front of the flower, all sides look identical.

Decumbent – A plant that lies horizontally on the ground, usually with the tip curved upward.

Exposure – Typically refers to the amount of sun that a plant is exposed to (for example, full sun).

Genus – One of the principal components of a species name; all species within a genus should be more closely related to each other than they are to species in other genera. In combination with the **specific epithet**, this constitutes the official name of an organism (the binomial name); the genus and specific epithet are always italicized. Thus, the binomial name of the Silver Torch Cactus is *Cleistocactus strausii* Backeb.; "*Cleistocactus*" is the genus, and "*strausii*" is the specific epithet.

Graft – A method of increasing the rate of growth, survival, and/or flowering of slow-growing species by cutting two plants (one a fast-grower or stock, the other the slow-grower or scion) and joining them together so that the slow-grower takes on the fast-grower's rate of growth.

Hand-pollinated – A process of controlled pollination where a human manually collects pollen from one plant and transfers it to the stigma of another plant.

Hybrid – A genetic cross—whether man-made or natural—between two plants of different taxa; hybrids between plants of different genera are often assigned a **nothogenus** represented by a blending of the two generic names preceded by an '×'.

Molecular data – Data derived from the genetic information of a plant.

Nothogenus – A type of **genus** used for plants that are offspring of species from two separate genera; the nothogenus is preceded by an "×". For example, × *Cylindronia robertsii* (Rebman) M.A. Baker, Majure, Cloud-H., & Rebman is the scientific name for the plant resulting from a cross of *Cylindropuntia alcahes* subsp. *alcahes (*F.A.C. Weber) F.M. Knuth and *Grusonia invicta* (Brandegee) E.F. Anderson, where × *Cylindronia* M.A. Baker, Majure, Cloud-H. & Rebman is the nothogenus representing the hybrids between the genera *Cylindropuntia* (Engelm.) F.M. Knuth and *Grusonia*.

Open-pollinated – A plant that sets seed without human intervention or control.

Species – While many definitions exist, the most common one refers to a group of organisms consisting of similar individuals that can produce fertile offspring.

Specific epithet – The second component of a species name (the first being the **genus**).

Subspecies – A rank below species that typically denotes a geographically isolated group of individuals of a single species with distinct traits.

Substrate – The type of medium in which a plant grows (e.g., sand, loam, gypsum).

Taxon – A named and recognizable grouping of plants. Different levels of a taxon have different names; e.g., order, family, genus, species.

Taxonomy – The branch of science that involves naming and classification of organisms.

Tessellate – Refers to patterns of areoles or ribs that show a repeated shape (like a hexagon).

Zygomorphic – Bilaterally symmetrical; i.e., when looking at the front of a flower, there is a clear left and right side.

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