THE UNIVERSITY OF ARIZONA
Cooperative Extension

az2050 May 2023

The Terrarium – An Oasis of Humidity for Plants

Michael Chamberland

A terrarium (plural: terraria or terrariums) is an enclosed or mostly-enclosed growing environment for plants. A terrarium encloses an environment with high humidity and moist soil. Terraria are useful in Arizona's arid environment where the air is dry indoors and outdoors. Using terraria, it is possible to grow plants with high moisture needs without using a lot of water. This is useful for growing and exhibiting moisture-loving plants. Water-cycling, a microcosm of the Earth's hydrologic cycle, can be demonstrated in closed terraria. The moist environment is maintained with limited water input, a real advantage in a region concerned with water conservation. Terraria can be designed as attractive displays for unusual specimens, promoting an interest in the diversity of plants.

What is a Terrarium?

Almost any sort of clear container with plants growing inside might be called a terrarium (Figure 1). A terrarium is typically closed or sealed, maintaining humid air within and allowing water-cycling to occur. Terraria are often made from a watertight container with a removable lid. Larger and more complex growing environments may be called growth chambers, Wardian cases or greenhouses (Martin, 2009). Terraria are usually moderate-sized enclosures too small for people to enter.

In the popular literature, a wide range of planted open containers are presented as terraria (Elzer-Peters, 2014), however a terrarium kept with a wide-open top is not capable of water-cycling. An open top allows water vapor to escape into the environment. A container with a wide open top is more like a dish garden (PennState Extension, 2019). In a dry climate an open container or dish garden will not maintain a humid environment and will require regular watering to prevent drying out completely (Trinklein, 2017). This eliminates the most useful function of a terrarium, maintaining humidity and preventing water loss. A terrarium achieving its potential will be entirely or nearly closed, in the manner of the original Wardian cases used for growing and transporting plants in the 19th Century (Trinklein, 2017).

Figure 1. A variety of improvised terrarium containers.

The utility of terraria is for growing plants. If animals are included, the system may be called a vivarium. The animals are confined to a smaller area than in the wild. No rain washes away leftover food and excrement. Nutrients and salts may build up to levels detrimental to plant health (Rice, 2006). Such an enclosure can be pursued as an attractive way to display animals. But the plants may become a perishable backdrop, requiring periodic replacement.

An enclosed humid environment for germinating seeds may be called a germination chamber. Seeds are typically started in pots placed in the chamber. After germination the pots of seedlings are transferred to a different environment for their next stages of growth. Terraria have the potential for longer-term low-maintenance growing of plants. This is the utility of terraria which will be discussed here.

Water-Cycling

The cycling of water, also called a rain cycle or hydrologic cycle, can be observed in a sealed terrarium. Within the enclosed container, water evaporates from the moist soil and transpires from the leaves of plants. The enclosed atmosphere becomes moisture-saturated. Evaporation and transpiration

Figure 2. Condensation on the inside glass of a terrarium obscures viewing through the glass.

decrease until a balanced equilibrium is achieved (DelPrince, 2018). Liquid water slowly condenses on the inner walls of the terrarium (Figure 2) and gradually trickles back down to the soil, maintaining soil moisture and water for uptake by plant roots. This completes the cycle, which may continue indefinitely unless water vapor is lost from the system.

Closed or Sealed Terraria

A terrarium with an airtight seal (hermetically sealed) will cycle water continuously and will need no further watering. An airtight seal may be achieved with a gasket or sealant around the lid. A non-sealed lid or cover placed over the top of a terrarium will usually not achieve an airtight seal but may come close. A non-sealed lid is convenient as it is easy to open for terrarium maintenance. This cover will allow some water vapor to escape gradually into the external environment, when that is much drier than the interior of the terrarium. A terrarium which is closed but not sealed will dry slowly and require infrequent watering.

Partially Open Terraria

A terrarium can be maintained with a slight opening to allow the intentional loss of water vapor (Schnelle et al. 2017). Such a terrarium must be monitored and watered before it dries out. There are advantages to keeping a partially open terrarium. Water will stop condensing on the inner walls, which is desirable for visibility into the terrarium (Figure 2). Without condensation, the water cycle is broken. Water no longer drips back to the soil. Water is lost to evaporation and escapes from the terrarium. However, until the soil dries out, a humid atmosphere is kept within the terrarium.

A partially open terrarium with a humid interior will suit a wide variety of plants which might not tolerate the saturated atmosphere in a sealed terrarium. Most plants require transpiration as a force to pull water from roots to higher parts of the plant. In a perpetually saturated atmosphere transpiration is limited. This can lead to the death of many kinds of plants, even plants which thrive in a partially open terrarium. Maintenance of a partially open terrarium involves finding a balance between the humidity requirements and humidity tolerance of plants. The terrarium must be monitored and watered before it dries out. In Arizona's dry air, the size of the opening of the terrarium is critical. Even a small gap in the cover will break the water cycle and begin the process of gradual moisture loss. A partially open terrarium for Arizona is open just a crack. Terraria should never be left open. They can be opened to work on the interior but must be returned to their prior state, sealed or partially open, immediately after the work.

Terrarium Containers

Terraria are almost always clear-walled allowing light to enter from an outside source. The material may be clear glass, plastic or acrylic (Martin, 2009). Tinted or cloudy glass will reduce light entry and hinder plant growth (Shaughnessy and Pertuit, 1999; PennState Extension, 2019). Designer terraria may be made of blown glass, formed glass, or constructed of small panes like a tiny greenhouse (Martin, 2009).

An empty aquarium or fish tank is ideal for use as a terrarium. Aquariums are watertight and available in a variety of sizes (Figure 3). Fish tanks may be sold with hoods or covers manufactured to fit snugly over the top of the tank. The hood may include an electric light, access doors and ports for heaters and aerators used for keeping fish. The seams and gaps in an aquarium hood can allow a lot of water vapor to escape, making them less than ideal as terrarium covers. Instead, cover the aquarium top with a pane of clear glass or plastic. For a low-budget approach, cover the aquarium with a sheet of plastic wrap and secure it with tape.

Repurposed clear containers such as pickle jars or mason jars make good starter terraria. Clear plastic beverage containers may be cut open, planted with small plants, and taped back together again. These budget-conscious terraria are ideal for individual classroom projects.

Size matters when choosing containers for terraria. Larger terraria have the capacity for bigger plants and more plants. The space allows room to grow. Larger terraria support a greater volume of air and soil which can buffer against changes in the environment, such as the rate of drying out or overheating if exposed to sunlight.

Terraria do not usually have drain holes in the bottom, as plant pots do. Drain holes would create a different dynamic

for a terrarium, since water would be lost out of the bottom. This would have some potential benefits, such as preventing waterlogging from overwatering. Drain holes could allow excess salts to be flushed from the growing medium. There is no rule saying terraria cannot be provided with drain holes. Most terrarium containers are not well suited for drilling.

Preparing a Terrarium

A terrarium may be used as a humid chamber for growing plants in pots. Keeping plants separate in pots is preferred by plant collectors managing a collection (Rice, 2006). Alternately, a terrarium can be filled with a layer of growing media (soil) for plants. This kind of "planted out" terrarium can be designed as a miniature landscape (Figure 3). Many creative and attractive possibilities can be achieved (Martin, 2009). Before planting into a terrarium, ensure the growing medium and the plants have been watered. Remove extra growing media from the plants to be added, so they are largely bare-root. Trim off roots which are circling or pot-bound (Trinklein, 2017). Quickly plant into the terrarium's growing medium before plants can wilt or dry out. This is critical in Arizona where humid-adapted plants can wilt and dry incredibly fast. If possible, plan to do the planting during a rainy day or during the humid monsoon season. Do not over-plant with too many plants. Give plants room to grow and avoid planting plants so they touch the inside walls. Add any top material that might be used over the top of the growing medium. It is often necessary to mist the insides of the terrarium after planting, to wash down any media stuck to the inside walls (Trinklein, 2017). A newly planted terrarium should be watered immediately to improve contact between roots and the growing medium. Take care not to flood the interior with too much water. It is difficult to remove water from a flooded terrarium.

Figure 3. An aquarium planted as a terrarium and outfitted with a fluorescent light on top. A printed jungle scene serves as a backdrop.

Growing Media

Use a sterile soilless growing medium with low fertility (PennState Extension, 2019). Be careful not to introduce pathogens, seeds, or insects. Do not use garden soil or compost. Bagged growing media should come sterilized (PennState Extension, 2019). A blend of peat moss, vermiculite and perlite is an excellent choice (Trinklein, 2017). Activated charcoal is frequently added to a terrarium media mix, as is sphagnum moss (Trinklein, 2017).

Water and Fertilizer

Water only exits a terrarium as water vapor. Any dissolved salts in the water or growing medium will stay and cannot be removed, short of replacing the medium or flushing the medium if the terrarium is equipped with drain holes. Arizona tap water is high in dissolved salts and should not be used. Instead, water a terrarium with rain water, distilled water or reverse osmosis (RO) water. Do not use softened water, which has undergone a mineral exchange, not mineral removal. Keeping animals in a terrarium will cause buildup of minerals and nutrients over time. This will become detrimental to many terrarium plants and lethal to sensitive kinds such as carnivorous plants (Rice, 2006).

Terraria may be popularly viewed as a microcosm where water, minerals and resources all recirculate as a balanced system. This might be achievable in some large designs, but that is a project beyond what can be adequately addressed here. Keeping a terrarium purposed for plant growth is more achievable without extra variables.

Adding fertilizer to the growing medium is usually not necessary because plants in a terrarium should not grow rapidly (Trinklein, 2017). Fast-growing plants will outgrow the terrarium space. Good plants for terraria are small-stature plants and slow growers. Many of the best plants for terraria come from bogs or wetlands which are low in soil fertility. Fertilizer, if used at all, should be half the recommended rate and frequency (Schnelle et al. 2017). Do not plan to fertilize until at least a year after planting (Shaughnessy and Pertuit, 1999).

One of the advantages of keeping potted plants in a terrarium is they can be easily moved in and out. Their growing media can be replaced, and the empty terrarium can be washed clean. Even with this arrangement, pure water should be used.

Light and Heat

Terraria are typically kept indoors. Their temperature matches the indoor temperature. Plants chosen for terraria should be adapted to indoor temperatures. Some plants require a seasonal change in temperature and may not thrive long-term without it.

Figure 4. Outdoor terraria in Tucson Arizona, growing Venus' flytraps and pitcher plants, maintained with partially open tops.

A terrarium needs light. The typical light level indoors is too low. An indoor terrarium must be situated near a window, or provided with artificial light (Martin, 2009; Trinklein, 2017). Using a window for a terrarium is risky. Direct sunlight can overheat a terrarium's interior (Martin, 2009). The amount and direction of sunlight coming through a window changes through the year. An increase can cause unexpected heating. The best placement is where the terrarium is exposed to indirect light. Sealed terraria are most vulnerable to overheating. A partly open terrarium can vent out heated air but may still overheat.

Artificial light is best for terraria (Martin, 2009). A timer can be set to turn the lights on and off to create a steady day/night cycle (Rice, 2006). Specialized grow lights are not required, though they can be more efficient at converting electricity to the light wavelengths used by plants. Standard white-light fluorescent and LED lamps are sufficient for terraria. LED lamps are more efficient, generate less heat, and are available in more sizes and spectra than incandescent or fluorescent lights. It is important to provide plants with adequate light. Lights should be placed as close to the plants as possible, usually directly above the terrarium. For a rectangular terrarium, choose a light fixture the same length as the top of the terrarium for full light coverage. Aquarium hoods often have a built-in lamp intended to illuminate the aquarium. This may be effective for illuminating fish, but these lamps often provide too little light for good plant growth.

It is possible to maintain a terrarium outdoors in Arizona, but the prospect will require experimentation. Start with a position in the shade or limited direct sun. Be aware of the changing direction of the sun through the seasons. Large glass enclosures, kept partially open to vent heat, can be a starting point (Figure 4). It may be necessary to move the terrarium to a new location with the seasons to avoid overheating.

Choosing Plants for a Terrarium

Terraria achieve their potential for conserving water by water-cycling or by slowing the loss of water. This produces either a saturated atmosphere or a very humid atmosphere within the terrarium. These conditions are typical of bogs, wetlands, springs and seeps, or moist forest floors. Poorly suited plants will not thrive or even survive in a terrarium. Terraria offer a growing environment optimized for plants which are small, shade-loving, and tolerant of high humidity (Martin, 2009).

Good Terrarium Plants – Mosses and Bryophytes

Mosses and bryophytes (liverworts and hornworts) are ideal plants for terraria (Figure 5). They are particularly suited for small terraria (Fourwords, 2018). Many will tolerate the saturated atmosphere of a sealed terrarium. The interior of a terrarium is almost always mossy, or becomes so over time. The introduction of mosses is nearly unavoidable as tiny moss fragments or moss spores are introduced with the growing plants or their media when planted into the terrarium. Sphagnum moss, or its breakdown product peat moss, is common in growing media. Live sphagnum moss is

Figure 5. Mosses and bryophytes. Left, live sphagnum moss; center and right, unidentified moss and bryophyte which emerged unintentionally in a terrarium.

an excellent terrarium plant especially for bog plantings, as this is the predominant moss in bogs. Mosses are sometimes regarded as weeds in terraria, as their appearance is unavoidable and they can overgrow small desirable plants.

Good Terrarium Plants – Ferns and Fern Allies

Ferns and "fern allies" such as selaginella, are naturals for terrarium cultivation (Fourwords, 2018; Schnelle et al. 2017). Ferns are among the easiest terrarium plants. Many will tolerate the saturated atmosphere of a sealed terrarium. Ferns are larger than mosses and bryophytes, and will need a larger terrarium. Ferns may release spores within a terrarium and increase their numbers. Some ferns may take over a terrarium (Shaughnessy and Pertuit, 1999).

Good Terrarium Plants – Carnivorous Plants

Carnivorous plants are some of the best plants for terrarium cultivation. A terrarium is the preferred way to keep them outside of their humid native environment or a greenhouse. Many carnivorous plants grow in bogs and wetlands, particularly sphagnum bogs on mats of sphagnum moss (Rice, 2006). Some will tolerate the saturated atmosphere of a sealed terrarium, but most do better in a partially open terrarium. Carnivorous plants are very sensitive to dissolved salts in the media or the water. Their growing media should be made from peat moss, sphagnum moss, perlite or clean sand. Do not use any kind of potting soil. Water them only with pure water. Carnivorous plants do best when provided bright light. Unfortunately the most famous carnivorous plant, the Venus' flytrap, is difficult to grow. Rice (2006) points out that even Charles Darwin couldn't grow flytraps! Better success can be found with many kinds of sundews, butterworts, and the smaller pitcher plants (Figure 6). Do not grow carnivorous plants expecting them to rid the house of flies and other insects. In the dry Arizona climate, these plants must be maintained in an enclosed terrarium. The plants do not have the power to lure in pests from about the house. It is not necessary to feed these plants regularly, if at all.

Good Terrarium Plants – Small Tropical Ornamentals

This category of plants is a generalization. Small tropical ornamentals originate from the forest floor in tropical forests. They are adapted to low light, slow growth, and the moderate temperatures kept indoors. They include plants such as aluminum plant, nerve plant, pickaback plant, polka dot plant and prayer plant (Schnelle et al. 2017). Many have attractive patterned leaves and some produce colorful flowers (Figure 7). The many species and their attributes are too numerous to list here. These plants may have limited availability in Arizona. They will be found in sales greenhouses where high humidity is maintained.

Figure 6. Many small carnivorous plants make excellent and colorful plants for terraria. Pictured: Mexican *Pinguicula* (pink flowers) and *Sarracenia psittacena* (reddish leaves).

Figure 7. A terrarium with various gesneriads. These tropical plants are good terrarium subjects but they will not tolerate the saturated humidity in a sealed terrarium. Note there is no moisture condensed on the inside of the glass.

Plants Unsuited for Cultivation in Terraria

A properly maintained terrarium provides light, water, humidity and growing media. This might seem like a great home for any plant. But a terrarium is really only ideal for certain plants like those listed above. Some kinds of plants are unsuited for growth in terraria. Confusion is caused when popular publications show unsuitable plants planted

in terraria, or when open-topped containers are identified as terraria. Some plants such as cacti, succulents and air plants may persist a long time in an unsuitable terrarium environment, because these plants are tough and slow to die. Plant stress caused by excessive humidity and poor air circulation is hard to recognize. Some terrarium plants which thrive in a partially open terrarium will die if the terrarium is sealed. In the natural environment most plants experience the passage of air and water through the soil, often with conspicuous wet and dry cycles. Many plants require air circulation or seasonal changes. Conditions within a terrarium can be too constant.

Plants to avoid using in terraria include:

- Cacti and succulents
- Large growing plants such as palms, bananas, and most woody plants
- Vegetables and herbs
- Epiphytes such as air plants (*Tillandsia*)

Poor Terrarium Plants – Cacti and Succulents

Most cacti and succulents come from environments with dry air and soil that dries quickly. This is the opposite of conditions in a terrarium. Unfortunately, a lot of popular literature depicts containers planted with succulents being called terraria (Fourwords, 2018). Usually these are shallow open vessels, similar to dish gardens. A dish garden is a reasonable way to grow cacti and succulents, but it is confusing when it is called a terrarium. Terraria are usually not provided with drain holes, which are critical for proving good drainage for cacti and succulents. A few succulents and semi-succulent plants originate from tropical habitats. These could be tried in partially open terraria, such as various peperomias, which are somewhat succulent (Martin, 2009). While they may survive, they are vulnerable to rotting under excessive humidity and poor air circulation. Cactus and succulent seeds require abundant moisture and humidity for germination (Kelly, 2009). A germination chamber similar to a terrarium serves them well for germination and growth during their first few months. They should then be transitioned to drier surroundings.

Poor Terrarium Plants – Large-Growing Plants

A terrarium is a moderately-sized enclosed space. Many plants will grow too large for a terrarium. Agaves, bananas, corn and palms are too large, although some could fit as seedlings. Terraria are best for plants which are small and shade-loving (Martin, 2009). A plant should not have to be pruned regularly to maintain its fit within a terrarium. Trees and shrubs mature at sizes far beyond the capacity of terraria. Dwarfed or bonsai woody plants are questionable for terrariums. Large plants are difficult to illuminate adequately from a lamp overhead, as the top of the plant shades the lower portions. This is not an issue outdoors as sunshine illuminates different sides of a plant over the course of the day.

Poor Terrarium Plants – Herbs and Vegetables

Herbs and vegetables, with a few exceptions, are unsuited for terraria. The plants are usually intolerant of constant high humidity and limited growing space. People seek to harvest edible parts of these plants. Plants yielding harvestable parts are resource-demanding. They require fertile soil and high light conditions (Martin, 2009). Some herbs, such as mints, may be adapted for terrarium cultivation especially if they are grown as ornamentals or harvested in limited amounts. Cranberry is a creeping bog plant which is suited for growing in a terrarium. Do not expect to harvest berries unless the flowers are hand-pollinated, as pollinators are not present in the terrarium.

Poor Terrarium Plants – Tillandsia and Epiphytes

Epiphytes are plants which grow perched on tree branches or other aerial supports. Epiphytes are mostly tropical. They experience regular rainfall, often daily, followed by drying out. They have adapted to a regular wet/dry cycle and free air circulation. This is very different from the environment in an enclosed terrarium. Epiphytes such as *Tillandsia* or air plants are commonly depicted as terrarium plants. They are prone to rot in an enclosed humid environment lacking air circulation, especially if they are planted into wet media. A large enclosure could be equipped with misters and fans for air circulation. This could suit the cultivation of *Tillandsia*, other epiphytes, as well as other plants generally unsuited to terraria. This would be a custom project, and would function unlike a regular terrarium.

Most commonly available orchids are epiphytes. Their expected lifestyle may not be suited for terraria. But orchids are a diverse family of plants with many lifestyles. Some could be suited for a partially open terrarium. Look for suitable orchids among the terrestrial kinds such as the jewel orchids, rather than among epiphytic orchids.

Pests and Problems

Algae and fungi can thrive in terraria. Using sterile media and cleaning the media off roots of plants as they are planted are measures to minimize introduction of algae, fungi and pests. Insect pests in terraria are usually greenhouse pests which came into the terrarium with the plants. The high

humidity will be unsuited for some pests such as spider mites. Insects which can tolerate the humidity include fungus gnats and scale insects. While not true insects, isopods such as sowbugs and pillbugs can be detrimental inside terraria, as are snails and slugs. Do not use chemical pesticides in a terrarium as the fumes will linger inside the enclosure. Terrarium plants tend to be sensitive and exposure to contained fumes probably won't be tolerated. Pest issues may require removing all the effected plants and media and replanting the terrarium. An established terrarium with healthy plants is unlikely to develop pest problems except through contamination during addition of new material.

Mosses and ferns can become weeds in terraria. A commonly used growing medium for terraria is sphagnum moss. This is commercially available in dried bundles (sometimes sold as "orchid moss"). The moss may be contaminated with seeds, particularly sedges. Unfortunately, dried sphagnum is unlikely to contain live spores that would sprout live sphagnum moss. Live sphagnum is a desirable growing medium but it can be difficult to obtain in Arizona.

Terraria in the Classroom

Terraria are good tools for instruction. They are easy to make from clear plastic containers. Potentially every student can make their own. Terraria require little maintenance. They can be kept in a classroom under lights. Terraria facilitate observation of plant growth through the course of the semester. The ease of replicating small terraria creates possibilities for comparative experiments.

The teacher may prepare a terrarium for displaying ferns, carnivorous plants and interesting tropicals. A display terrarium makes an attractive conversation piece. Water-cycling can be interpreted as a microcosm of the Earth's hydrologic cycle.

For biology classes terraria can maintain fresh specimens of mosses, bryophytes, and ferns for examination under the microscope. Both the sporophyte and gametophyte phases can be available to assist teaching about the alternation of generations. The leaves of delicate moisture-loving plants provide opportunities to view stomata and cytoplasmic streaming. These are hard to view on leaves of arid-adapted plants. The wet media from a terrarium can harbor microorganisms to be explored under the microscope.

Resources:

DelPrince, J. M. 2018. *How to Design a Closed-System Terrarium.* Mississippi State University Extension. Publication 3253. http://extension.msstate.edu/sites/default/files/publications/publications/P3253_Terrarium.pdf Accessed 4 July 2021.

Elzer-Peters, K. 2014. *Miniature Gardens*. Cool Springs Press.

Shaughnessy, D. and A. Pertuit. 1999. *Clemson Cooperative Extension. Indoor Plants – Terrariums.* https://hgic.clemson.edu/factsheet/indoor-plants-terrariums/ Accessed 4 July 2021.

Fourwords. 2018. Miniature Terrariums. Tuttle Publishing.

Kelly, J. 2009. *How to Propagate Agaves and Cacti from Cuttings and Seed.* Publication az1483. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1483.pdf Accessed 4 July 2021.

Martin, T. 2009. *The New Terrarium*. Clarkson Potter/Publishers.

PennState Extension. 2019. *Creating a Closed Terrarium.* https://extension.psu.edu/creating-a-closed-terrarium. Accessed 4 July 2021.

Rice, B. 2006. *Growing Carnivorous Plants*. Timber Press.

Schnelle, M., Hillock, D. and L. Payne. 2017. *Terrariums.* Oklahoma Cooperative Extension Service HLA-6438. https://extension.okstate.edu/fact-sheets/print-publications/hla/terrariums-hla-6438.pdf Accessed 4 July 2021.

Trinklein, D. H. 2017. *Terrariums.* University of Missouri Extension. Publication 6520. https://extension.missouri.edu/publications/g6520 Accessed 4 July 2021.

THE UNIVERSITY OF ARIZONA
Cooperative Extension

AUTHORS

Michael Chamberland
Assistant Agent, Urban Horticulture, Maricopa County Cooperative Extension

CONTACT

Michael Chamberland
mchamb@arizona.edu

This information has been reviewed by University faculty.
extension.arizona.edu/pubs/az2050-2023.pdf

Other titles from Arizona Cooperative Extension can be found at:
extension.arizona.edu/pubs

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Edward C. Martin, Associate Vice President and Director of the Arizona Cooperative Extension System , The University of Arizona.