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## CACTUS and SUCCULENT SOCIETY of NEW MEXICO

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### ARTIFICIAL SOIL

The following recipe was developed by Cornell University ("Cornell Mix"):

1 gallon sphagnum peat moss, 1 gallon vermiculite, 2 level tablespoons of finely ground (or powdered) calcium carbonate, 1 level tablespoon of triple-superphosphate fertilizer (0-45-0), and 1 cup composted cow manure.

Thoroughly mix these ingredients in a plastic container (a five-gallon bucket is convenient). Add enough water after mixing such that the "soil" can be handled to your satisfaction.

I've grown all sorts of plants in Cornell Mix for many years. All my garden vegetables were and are started in this stuff, and I once grew Chinese peas, tomatoes, and pole beans to harvest in it. All of our houseplants, including some eventually very large benjaminii and fiddle-leaf figs, were grown for years in Cornell Mix. Even my early cacti were grown in this mix. Some of these plants are still with me today, but they're no longer in straight Cornell Mix. Managing cacti and other succulents in this very water-retentive medium requires constant vigilance and care, and I eventually ran out of time and patience, so I modified this mix for cacti. This modification is described in Note 8. below.

I've made some minor modifications to the basic mix:

- a) I use dolomite in place of the calcium carbonate. See Note 4, below, for the explanation. If you don't use dolomite you'll have to buy some Epsom Salts (magnesium sulfate 7-hydrate) at the drugstore and occasionally add a bit of this to the water you use on the plants.
- b) If I intend to use the soil as a permanent home for a plant, I add more than one level tablespoon of triple-superphosphate, maybe up to five. Lots of phosphate will not injure your plants and it is a critical macronutrient. For bedding plants and vegetable starts, I stick with the original level tablespoon. I can't think of any harm that would be caused by increasing the phosphate here also. I just haven't done so.

With these minor modifications, I am now using or have recently used this soil to grow large fruiting fig trees (pruned to bushes), a banana tree, tomatoes, peas, spinach, bush apricots, gooseberries, kiwis, grapes, African Daisies (*Dimorphotheca* sp.), Living Stone Daisies (*Mesembryanthemum criniflorum*), ice plants (*Delosperma cooperii*), dwarf citrus trees, and bamboo. There is nothing which is happy in a pH=6.5 or so soil that you can't grow in Cornell Mix. In my opinion, stuff grows much faster in Cornell Mix.

(The University of California [Davis? "Ucal Mix"] also developed an artificial soil which is essentially the above with sand [large particles, 12 or 14 grit, I think] in place of the vermiculite. I don't think the UCal Mix is as good as the Cornell mix. I never warmed up to it. I haven't seen any reference to UCal Mix in many years. It also weighs very much more per unit volume than Cornell Mix because of the sand, maybe a factor of four. I prefer my relatively weightless Cornell Mix.)

Notes:

1. Do not substitute for the sphagnum peat moss (\$12 for a 5.5 cubic foot bag at WalMart in 2006). I've tried other supposedly equivalent media with disastrous results. More advice--if you're tempted to buy potting soil, beware of any which is based on ground bark ("Black Magic", etc.). The label disguises the bark by calling it "forest products." This stuff is worthless and it stunts plants. Don't buy anything not based on sphagnum peat moss. Don't use any other kind of peat moss, ever. I had bad results when I did so.

2. Vermiculite used to be quite cheap at lumber yards or other builder's supply stores. It was called "Zonolite," which is a brand name. Apparently vermiculite can't compete with other insulation materials today, because I haven't been able to get it as Zonolite for many years. This leaves you with having to buy a "horticultural grade" of vermiculite at a garden shop. These big bags come marked "coarse, medium, or fine." The markings and the size of the stuff in the bag have nothing whatsoever to do with another. Look at the stuff before you buy it. The size should be 1/8-inch cubes or larger (what should be marked "medium"). Don't buy the fine stuff unless you have to. It'll work, but I found plants do better in the coarser medium. I think it has to do with the fact that plant roots need air and the coarse stuff ensures a goodly air supply. The really fine stuff combines with the peat when wet to make a relatively impervious (to air) mixture. Luckily, you can get a six-cubic-foot bag (this is almost 50 gallons, folks!!) at Greenhouse and Garden Supply, 3820 Midway Place, NE, in Albuquerque, for about \$18, and it's certified "asbestos free." I've used two bags of this stuff and it's quite satisfactory. Look out. Some garden shops have small bags of vermiculite the price of which will drive the unit cost for this soil up by a factor of 25 or more!

Another cheap (actually, free) source of vermiculite is packing material from chemical shipments. This is another of the many perks of being a chemist. I bet you wish you were one too!

3. Some people, or even some bad books, might tell you that you can use perlite in place of vermiculite. This is not true. Perlite and vermiculite are very different in structure, and in how they behave. The perlite soil is much less water retentive and the perlite has no nutritional value at all. Vermiculite actually does have a small amount of accessible micronutrients in it. Perlite also makes a hard-to-manage soil in that the perlite is constantly separating from the soil and tends to float around and off as you water. Perlite does have its horticultural uses, though. See Note 8. below.

4. The dolomite (\$2 - \$3 for a 40-pound bag in the Northwest [acidic soil], hard to find in New Mexico [basic soil]; I've seen five-pound bags at garden shops) should be very fine or powdered. It's function is both a source of calcium and magnesium, and it gets the pH of the soil up to where most plants can effectively assimilate micronutrients. Most plants MUST have the dolomite (or calcium carbonate) in the Cornell Mix. Some plants, such as orchids, epiphytic cacti and blueberries must have a very acidic soil. For acid-loving plants, skip the dolomite and add magnesium and calcium some other way. If you try to grow epiphytes in straight Cornell Mix, they will not grow and will eventually die, maybe out of boredom. Leave the dolomite out for epiphytes. I am now growing blueberries. They require an amazingly acidic soil which is unknown in New Mexico. I made up Cornell Mix, leaving out the carbonates, and instead adding two heaping tablespoons of elemental powdered sulfur, available in garden shops. Soil bacteria metabolize the sulfur to make some acid, so the pH is probably close to four in my blueberry boxes. Other plants (the not-blueberries, not-epiphytes, not rhododendrons or azaleas, not orchids) can't live in this mix.

5. The manure (in one-cubic-foot bags) can be bought at any garden shop for \$2 -\$4. It can be any kind. Chicken is fine; cow is fine. Manure is a source of trace elements. You can skip adding manure if you add a half-teaspoon of a black powdery substance called "fritted trace elements" ("FTE"), also available at garden shops. I'm considering leaving out the manure altogether in the near future for cacti. See Note 7 below.

6. Buy some calcium sulfate ("gypsum") at a garden shop and add about one level tablespoon to this mixture. Gypsum is a source of necessary sulfur, and calcium. Usually the complete fertilizer (10-20-20, etc.) which you use when you water will have sulfur in it, even though the bag doesn't say so explicitly. If there are four numbers on the bag, as is true sometimes, the fourth number is a measure of the sulfur content. This should let you realize how important sulfur is. The gypsum is a way to make sure of the sulfur, and too much can't hurt your plants. It has absolutely no effect on the pH of the soil. (Some books claim there is an effect, but the authors are completely wrong. We well-trained chemists know that calcium sulfate is a neutral salt.) Gypsum is relatively insoluble so you shouldn't have sulfur problems for a long time, if ever. My cactus mix ALWAYS has gypsum in it, including soil for epiphytes. Gypsum has no effect on pH! To feed magnesium to your plants if you haven't added dolomite, buy some Epsom Salts (magnesium sulfate 7-hydrate) in the drug store. A few dollars buys several pounds, and this should be enough magnesium for your use for the rest of your life. I add about a half teaspoon to a gallon of water occasionally when I water. Incidentally, magnesium sulfate is also a neutral salt. It has no effect on soil pH whatsoever. I'm a well trained chemist and I know it's true.

(Incidentally, there is a school of chemists called soil chemists and something happened to them in the 19th century. They split off from us mainstream chemists and practice a form of chemistry today which the rest of us hold to be complete nonsense. For instance, you will find the sentence "There are no basic cations." in every modern general chemistry book. Soil chemists believe and teach their students to believe that sodium, potassium, calcium, and probably magnesium and others are "basic cations." It turns out that they are consistently wrong in all their reasoning, so in the end, they get the correct answer to soil chemical problems for completely the wrong reasons. It happens that this is a case of two wrongs making a right. I've tried to do my part to get them to change, but they won't because they don't care that their understanding of chemistry is completely wrong. As long as they only talk to soil chemists, it doesn't matter, they think. They truly don't care that the rest of chemistry thinks that they are completely crazy.)

7. Plants will be happy in Cornell Mix for one-to-two months. After two months, water regularly with dilute fertilizer having trace elements. You're essentially hydroponically gardening. I use any of the Peters Peat-Lite mixes. These have an especially heavy dose of trace elements. I'm still working on a bag of 20-20-20 I bought about 10 years ago. I've seen Peters Peat-Lite 20-20-20 for about \$10 for five pounds at a Lowe's garden shop. I recently bought a 25-pound bag of 20-10-20 for about \$25 at Greenhouse Garden and Supply in Albuquerque. They were out of stock of my preferred 20-20-20, but I didn't much care since I've been making up Cornell Mix with much more phosphate than the original recipe. As with all fertilizer, the manufacturers want you to use as much as possible so they tell you to use it just short of immediately killing your plants with fertilizer burn. Use any fertilizer at about one-tenth strength or even less. I use about one tablespoon in 10 gallons (or more) of the Peters.

Be sure to leach your plants thoroughly every six months to a year or so to get rid of unavoidable salt build-up due to the fact that your plants are confined to a pot. Unfortunately, the best way to water potted plants is with copious amounts of water. Most people find this an inconvenience in the house and they pride themselves on being able to add just enough water so that just one drop comes out the drain-hole. These people are slowly killing their plants. This makes leaching mandatory if you want to hang on to your plants. Put them in a bathtub or outside and run water through the rootball like crazy. Ten or more volumes. Then re-charge with very dilute fertilizer having trace elements.

My cacti are either outside or in my greenhouse, and I water them thoroughly when I water. Lots of runthrough. My vegetable plants are in containers outside, so they too get thoroughly watered often. My wife has a few houseplants which she leaches occasionally as specified above.

8. For cacti and other plants that like drainy soil: to the Cornell Mix, modified with dolomite and more superphosphate, add one gallon of perlite. This really allows the water to run through and gets air to the roots of the plants. You can't water-log a soil which is 1/3 (or more!) perlite. This material is available at Greenhouse Garden and Supply for about \$25 for six cubic feet. This is again almost 50 gallons. You can really pay a lot for perlite in small bags at garden shops.

9. Cornell Mix and its variants is notorious for being very hard to re-wet once it's allowed to dry, as after a winter dormancy. The cure is simple: add some liquid Ivory (or any other detergent) to the water. This will collapse the surface tension of the soil and the water will wick in. The detergent residue on the soil will help to re-wet the soil if it dries out thoroughly again. Soil bacteria will eventually metabolize the detergent. Don't overdo the Ivory; start with a few drops. Too much and there'll be foam everywhere. Although I think that bottom-watering generally is completely crazy (it will kill your plants!), I've found it convenient sometimes to soak a bunch of very dry pots in a flat filled with detergent-treated water. Once the root ball is wet, I then water from the top to get the waste flowing in the right direction.

10. I never throw any artificial soil away, unless I suspect there is some disease or infestation in the soil. This stuff never wears out or deteriorates. I re-use it as much as possible. I don't care what someone says on the internet about how peat-based soils deteriorate, I've used them for over 30 years and I've never seen anything I would call deterioration. Some of my cacti have been in the same pot with the same soil for more than 15 years. The only occasion in which my plants get fresh soil is when I re-pot to a bigger pot. I actually use the pot size to keep my plant size under control, so re-potting is something I try not to do very often. Cacti in small pots are easier to manage because the plant sucks the water out of the soil rapidly.

11. I now live on the side of a dormant (??) volcano, and pumice is very available. I can go steal pumice from the State at innumerable road cuts in the Jemez Mountains, which is where I live. My neighbor remodeled his house recently and gave me about four cubic yards of pumice which had been on his old roof, so I'm starting to experiment with using pumice in my synthetic soil. Pumice is a lot like perlite, only much heavier. It may not float in water. I knew some cactus freaks in the Northwest (many volcanos!) who grew their plants in straight pumice. It's impossible to have a too-wet condition in pumice. I'll report on my pumice experiments in the future.)

Good luck.

Note added 9-30-2007: The pumice is a fine substitute for perlite. I'm using lots of pumice in my cactus mix and my plants appear to be doing well in this mix.