

Hobby Greenhouses

How to Design and Build Growing Rooms

BY STEVE KLITZING



CHARLES MARDEN FITCH

ABOVE When designing a greenhouse, consider if you will want to have different temperature zones. One way to achieve this is to divide the greenhouse into two or more rooms, separating them with permanent walls.

OPPOSITE Tiered benches combined with horizontal pipes on which to hang orchids maximizes space in a greenhouse. A collection can be devoted to a single group of orchids, such as phalaenopsis and dorianopsis, or expanded to embrace a diversity of genera.

FOR YEARS I GREW ORCHIDS ON the windowsill, behind sheer curtains and pieces of frosted plastic. But there came a time when I needed more space. Although I live in an area where I can grow cymbidiums and bletillas outdoors, I kept feeling the pull of tropical epiphytes that grow here only indoors. I had three choices: build bigger windowsill shelves, install an attached plant window in place of the regular window or construct a greenhouse. My wife liked the look of our home inside and out, so the first two choices were out of the question. Besides, there's nothing — and I mean nothing — like having your own greenhouse. In addition to growing orchids, it's the one place where you can find refuge from a bustling city, a dreary winter or a tedious workday. But, more than that, it gives you the opportunity to bloom truly exotic, wonderful and fragrant tropical flowers.

There are many types of hobby greenhouses available through mail order or even local dealers. The frames are constructed from four basic materials: aluminum, wood, galvanized steel and PVC. Most greenhouses will fall into the first category, with wood and galvanized steel frames making up a smaller portion, and PVC trailing the rest. Some have a more elegant design than others. The question you must ask yourself is: What style of greenhouse is right for me? The answer is location, location, location.

WHERE TO SHOP The style of your greenhouse is completely up to you. Find one you like, do some research, browse the Web and order catalogs. Then, when you find one you want, order it and build it. Greenhouse kits are easy to assemble after you get the foundation ready. You basically just bolt the pieces together. Glass greenhouses take the longest to build and require a lot of diligence and caution during construction. For mail-

order catalogs showing greenhouses and greenhouse supplies, you can go on line, see advertisements in orchid periodicals and check out the commercial section of the Society's Web site (www.aos.org). Each Web site lists a phone number or a mailing address. For more greenhouse dealers and suppliers, just Google "greenhouse," "greenhouse kit" or "greenhouse supplies."

LOCATION If you are part of a couple and live in a residential neighborhood, the main factor in deciding the location of your greenhouse is your spouse, who may want it in a place where it is out of view. Another factor is the local zoning code that may influence the placement of a greenhouse on your property as well as place restrictions on its size and height.

Unless you are growing low-light orchids such as paphiopedilums, a north location is a poor choice, as it will be cold in the winter and receive little light, especially if that light is obstructed by your house, a building or evergreen trees. A south location usually receives full sun. This is ideal. However, summer temperatures will require greater cooling and misting in the greenhouse. The better exposure is a western one.

The next important decision faced in greenhouse construction is determining how to align the structure. That depends on a number of factors (see page 294). Many commercial growers have their greenhouse aligned north to south, and place the buildings side by side. But, still others align theirs east to west. And, some align theirs southeast to northwest. All such alignments are acceptable and should be based on the type of bench system (page 296) that you plan to install.

FRAME The frame is the skeleton of the greenhouse that holds everything together. Greenhouse frames come in four basic types:

Aluminum Holds up well against



weather and requires little maintenance or protection and uses glass or polycarbonate glazing. Aluminum greenhouses lose more heat in the winter because the outside frame elements are exposed to the open air and dissipate heat more than a greenhouse that is covered with cladding (fiberglass, Lexan® or polycarbonate) instead of glazing (glass or polycarbonate). This can mostly be remedied by lining the interior with bubble wrap for the winter. If water or fertilizer runoff stands on the base of the frame for an extended period of time, the aluminum can corrode into a pasty oatmeal.

Wood A wood frame has the advantage of looking natural and homey, especially if you live in the

country or forest, or if you own a wood-shingled house. Because it is subject to water damage and weathering, it requires a yearly application of water seal. On the down side, wood frames can attract termites and catch fire, and can be subject to sagging over a long period. When selecting a redwood greenhouse, choose wood that is dark in color. Lighter-colored redwood lacks the tannins that hold up to weathering and insects. Having once built a custom redwood greenhouse from scratch, I can say that, in the winter, it kept its heat better than the aluminum kit greenhouse I now own. Much of that has to do with the type of cladding or glazing you use. On a custom wood greenhouse, the rafters are usually beneath the cladding (fiberglass or

Lexan®), and so are not exposed to the outer air and weathering. This means less temperature loss through the roof, where heat naturally rises.

Galvanized Steel Galvanized steel greenhouses are cheaper than aluminum greenhouses simply because steel costs less than aluminum. Despite the galvanization, an electrically applied protective coating, the steel can be subject to slow rust, particularly from interior humidity and misting systems. Galvanized metal may require repainting every few years to maintain its protective coat. It is more resistant to corrosion than aluminum, but has two advantages over wood — it holds up better to the elements and it keeps its shape with age. Steel lasts virtually forever, provided you keep painting it to

protect it from rust. Well-manufactured galvanization can allow you to avoid painting the steel altogether. Galvanized steel greenhouses are usually covered with plastic tarp or corrugated fiberglass, and are usually used for commercial greenhouse operations. Many of these greenhouses are made of quick-to-assemble tube steel that compares comparably in weight to the lightness of aluminum.

PVC PVC pipe greenhouse frames are easy to construct and can be glued together, but always have a temporary appearance. They are the least attractive of all greenhouses, and they are usually covered with plastic tarp. However, if you are waiting to build a more standard greenhouse, a PVC greenhouse can provide your orchids with a temporary home until your hobby greenhouse is finished and operating. PVC frames provide an inexpensive place to shelter outdoor cymbidiums if the temperatures dip below 20 F (-6 C) and can also be reused as a structure in which to start outdoor bedding plants and flowers for the spring. Also, if you are moving from one location to another, a PVC greenhouse can be assembled in half a day to provide a temporary home for your orchids.

SIZE Get the biggest greenhouse you can afford and that municipal codes and restrictions allow. A small greenhouse will quickly fill with orchids and divisions. This is one case where bigger is always better in the long run. A large greenhouse allows for more orchid diversity and the possibility of a wider range of orchid microclimates within.

GLAZING AND CLADDING This is translucent material that diffuses sunlight into the greenhouse. Glazing is made of glass or polycarbonate panels that integrate with the frame of the greenhouse. What you use to cover your greenhouse depends on the type you are building. Glazing is usually used with aluminum greenhouses, but is also used with well-crafted wood greenhouses. Cladding is made of panels or materials that are secured to the outside of the greenhouse frame such as fiberglass (commercially called Filon®), Lexan® or plastic tarp. Cladding is usually used with basic wood or galvanized steel greenhouses and is more often found in commercial settings.

Glass Glass has the worst thermal efficiency, but is not subject to UV or other deterioration. It is vulnerable to breakage from rocks, baseballs, large hailstones and other hard flying objects. Double-strength glass is best and can be easily and cheaply replaced if damaged. For orchids, glass must be whitewashed or shielded by shade cloth. It does not catch fire and holds up well to temperature fluctuations. It is also heavy and a little dangerous to install.

Polycarbonate This plastic cladding is subject to slow UV deterioration which, over a long period of time, turns it yellow brown. Filled with air tubes between the outer and inner surfaces, it has a high thermal efficiency for keeping a greenhouse warm during the winter. It comes with twin- or triple-wall construction, depending on how much you want to save in heating costs. It costs more

than glass, but, if several people are building greenhouses, you can pool your orders and buy in bulk to reduce expenses. Although polycarbonate comes in clear and semifrosted translucencies, you will probably need to use an external shade cloth to cut down on late spring and summer sunlight. Most people do not whitewash polycarbonate, as it detracts from the clean look. If you need to cut polycarbonate, use a band saw.

Fiberglass Filon® is a type of fiberglass plastic that is a tough, durable and inexpensive cladding that has been used on greenhouses since the 1950s. It has rounded corrugated strakes along the length, is rigid and comes in semiclear, white and green. Because it is thick and stiff, you usually cut Filon® with a band or coping saw. It is cheap, easy to install, and found in most home and hardware centers. Filon® is subject to deterioration, but holds up better and longer than Lexan®. It doesn't hold its heat well in winter, so you need to install a plastic tarp as a thermal barrier on the interior side of the greenhouse frame to cut down on energy costs. It holds up to blows and flying objects much better than glass or Lexan®, but can become brittle over its long life span.

Lexan® Lexan® is a durable plastic, first appearing commercially in the 1960s and 1970s, that is thinner and more flexible than fiberglass, though the panels have a similar look and shape with boxier strakes. Its stronger cousin is called polycarbonate (twin wall). Lexan® usually comes in sheets and, when produced for greenhouse cladding, is corrugated like Filon®. It comes in clear, smoked, white and green. It also has UV resistance built in. You can cut Lexan® with scissors. It is also cheap and easy to install, and is readily available at home centers. Even Lexan® can deteriorate from UV radiation, and non-UV resistant grades show signs of aging after four to five years. Because it has no air tubes sandwiched inside it like polycarbonate, you can reduce heat loss by installing plastic tarp or bubble wrap on the interior of the greenhouse frame. Unlike fiberglass, Lexan® gives the option of several premade translucencies that allow the most appropriate diffusion of sunlight for your climate and orchid collection. If selected correctly, Lexan® needs no shade cloth. It resists flying objects better than glass, but can still be punctured by a hard sharp blow.

Alignment Pros and Cons

North-South This is fine if you are using a single-tier or triple-tier stepped bench system. If you are using a double-tier bench system, where the top bench is directly over the bottom bench, this doesn't work as well.

East-West This is better for the hobbyist, particularly if you have a double-tier bench system. Place the benches next to the south wall to get high light. Other benches placed next to the north wall can run in a north-south alignment so that the top bench will gain full light, and the bottom bench will gain full morning and evening light. The bottom bench in such an arrangement is better for lower light orchids and bromeliads.

Southeast-Northwest This is great for optimizing solar radiation, especially in the winter months, as the sun tends to track this way. This alignment is seldom used as most housing tracts are aligned to the four major points of the compass, and having an angled greenhouse in your back yard disturbs the aesthetic feng-shui lines of your house and yard.

Tip Do not locate your greenhouse where the midday sun will be blocked by other buildings or trees. Do not place your greenhouse on the north side of your home. This makes for a cold greenhouse in the winter, and poor photosynthesis for orchids. — *Steve Klitzing*.

Plastic Tarp Plastic tarp, or PT, can be stapled, draped or glued over a greenhouse frame easily. It seldom lasts more than a year or two, requiring frequent replacement. If you can obtain plastic tarp that has UV protection in its composition, it may last longer; this depends on the climate, sunlight and weathering. PT is subject to rips, tears and puncturing from heavy winds and small flying objects. It comes in clear or frosted translucencies. If you need to get your greenhouse operating quickly, you can cover it with a plastic tarp in a matter of minutes. A major windstorm may wreck it. It is also a serious fire hazard and can be ignited with a match or a spark. Always buy frosted or white plastic tarp as you cannot whitewash clear tarp. Make sure you are using at least 4–6 mils in thickness for durability.

ELECTRICAL SYSTEMS For any greenhouse, you will need the following electrical items:

- ◆ Underground conduit
- ◆ Underground 12- or 14-gauge Romex wire
- ◆ An exterior junction box with a kill switch in case of fire
- ◆ An interior power conduit
- ◆ A junction box with waterproof covers for power outlets
- ◆ An exhaust fan
- ◆ A thermostat
- ◆ A humidistat
- ◆ Timers for water valves, misting systems, irrigation, heating units or foggers
- ◆ A speed control for the fan
- ◆ A portable oscillating fan inside to move air around the interior

If you are not electrically inclined, have an electrician set this up. Or, order those controls and systems that can simply be plugged into the electrical sockets. That costs more, but makes setup quick and headache free. Electrical systems must be grounded by connecting a ground wire to an exterior copper rod that must descend a minimum of 4 feet (1.4 m) into the soil and must use a weatherproof cable housing a thick electrical wire. This is not just for an electrical short, but also if lightning should strike the metal frame. You want the energy conducted safely and directly into the ground. Electrical power to the greenhouse should be run from your house via an underground PVC conduit that emerges inside the greenhouse's foundation. Use 12- or 14-gauge



LEFT A two-tier bench constructed from wood is both practical and attractive. Edging a bench with siding helps to keep containers from falling to the floor. Here, orchids grow on the top bench while aechmeas thrive in the light below.



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LEFT Plastic-coated wire shelving, available at hardware stores, can be used to increase growing space in a greenhouse to accommodate more plants, such as the soft-leaved bromeliads shown here in the author's greenhouse.

outdoor Romex wire as a power line within the buried conduit. Outdoor Romex is waterproof. Moisture leaks in the conduit will not cause it to short. The best place to locate your junction box is next to the main entry door, about four feet high. This provides easy access to the controls and outlets. Electrically opened vents should be

near the bottom on one end of the greenhouse, while the exhaust fan should be at the top on the other side of the greenhouse.

POWER BACKUP SYSTEMS A power outage during the winter or a fan failure on a hot day can quickly kill an orchid collection. Make sure you purchase a quality long-lasting exhaust

fan. In my first greenhouse, I installed a cheap exhaust fan that rusted and burned out after a year, causing overheating that nearly wiped out my orchid collection. You may also need to install an alarm that sounds when there is a power outage.

There are two choices for power backup. You can install a rack of car batteries whose power is turned on by

Types of Benches

THE following are some general guidelines for benches and bench systems. You can purchase ready made benches, or you can build them yourself.



Single-Tier Bench A single-tier bench holds orchids on top but nothing below. You can always cram some plants, such as bromeliads, at the floor level below the bench. However, you invite slugs and snails to those pots, and cleanup is more difficult. The positive side of this bench system is that it's simple, easy and inexpensive to buy or construct, and it keeps all of your orchids at waist level where they're easy to access and inspect.



Two-Tier Bench A two-tier bench can hold orchids on top and bromeliads on the bottom. Bromeliads are not susceptible to orchid diseases and viruses and benefit from excess fertilizer runoff from the orchid pots above them. If you place an angled water deflector plate (a piece of corrugated Lexan®) just beneath the top tier, angled downward toward the front of the bench, the bottom tier can also hold orchids without danger of passing viruses from dripping orchids on the top tier. This doubles the number of plants you can safely grow in the same floor space. Orchids requiring less light, such as paphiopedilums and phalaenopsis, can be grown on the bottom tier. This unit should be constructed of treated 2 x 4 boards, nailed or screwed together, using plastic-covered hardware cloth or galvanized concrete wire for the racking. Length: 6 to 8 feet (1.8 to 2.4 m). Height: 4 feet (1.2 m). Width: About 26 inches (65 cm). Total Do-it-yourself cost: Around \$55. Time to construct: 1 hour per bench.



Triple-Tier Stepped Bench A triple-tier stepped bench can provide placement for orchids on three different levels without the worry of passing viruses among orchids because of runoff. No splash plate is required. A triple-tier stepped bench uses more floor space and holds fewer orchids, but accessibility is easier, and there are no light limitations on any of the orchids. You can construct them yourself, or purchase ones with a similar design. The shallower the individual benches, the less stretching and straining you'll have to do to reach the plants in back.



Fogger and Mister Bench One of the best ways to provide humidity for a hobby greenhouse is by using a mister or hydrofogger. You need a small bench, like a nightstand, that will raise the fogger-mister unit above the level of the highest orchid bench. Place the unit on top of the fogger-mister bench, and, if you want, grow something else on the bottom tier. The bottom tier is added to prevent the bench from wobbling and to give it added strength for the weight of the humidity unit.
— Steve Klitzing.

STEVE KLITZING

a relay that is activated upon loss of main power or you can choose to purchase a photovoltaic solar-electric panel, a fan and a thermostat that all work together. The solar panel will provide power for 30 years and will keep the fan operating during daylight hours. Photovoltaic power does not fail during daytime, which is the only time a warm-weather power failure can harm an orchid collection. This is a no-brainer backup, and will save you energy costs over the long haul. With a photovoltaic power source, you will never lose your collection to overheating caused by a power failure. And, any excess power generated by the solar panel can be used to reverse your electrical meter.

HEATING SYSTEMS The best heating comes from the bottom up. Some large greenhouse operations use water tubes embedded in the concrete slab that heat and recirculate hot water through the slab, making the concrete a bottom-up radiator. In a smaller greenhouse, you can use an electric oil-filled heater that provides radiant heat. You can also use an electric coil heater that uses a small fan to blow air across red hot coils. This is more energy intensive and tends to dry out the air. Whatever heating device you use, it should have its own thermostat that you can set, or should be regulated by a greenhouse thermostat. My oil-filled radiant heater has a knob with six settings, low to high (1 to 6), which I not-so-humorously call “cold” to “expensive.” Passive solar heating, such as black water-filled barrels, can also be used as bench supports.

WATER SYSTEMS There are two main watering concerns for your greenhouse. The first is irrigation and the second is misting and humidity. You must run a water pipe into your greenhouse. I would suggest installing a PVC pipe underground and have it come up on one side of your main entry door. There, you should provide a spigot and at least two 9- or 12-volt electrically actuated valves. And, if you are using a fogger or humidity unit, you will need to run a vinyl water feed line (the same kind that feeds the water supply to refrigerators) from a manual valve to the unit. That line stays on all the time. Electrical sprinkler timers can be used for activating misting or watering lines. You can run mister lines on the ceiling of your greenhouse. And, for watering while you are away on vacation, you



LEFT In the author's California greenhouse, schomburgkias in clear plastic pots are suspended from cross beams.



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LEFT When developing a design, consider natural disasters that can harm a greenhouse. Here, an L-beam helps safeguard a greenhouse against earthquakes.

can run a PVC water pipe on the ceiling with a handful of small hanging sprinklers, turned upside down, that activate for about one minute a week during winter, or one minute every other day during summer depending on how often you need to water. Depending on your water quality, you may need to install a filter on the water pipe before the water gets to the spigot and valves.

FOUNDATION Many municipalities require a concrete foundation. If your community has no requirements,

you can bolt your greenhouse to a 4 × 4 wood frame (treated) and fill in the interior of the frame with gravel. Otherwise, you must have one poured. Some concrete foundations can be rim only, filled with gravel in the center. Usually, though, you are required to pour a solid slab. In the center of the greenhouse slab, provide a screened plastic drain that connects to an underground drain pipe. Concrete foundations require steel cage reinforcement and must be of a certain

depth and width, about a foot wider and longer than the greenhouse. Unless you are building a wooden greenhouse, do not sink greenhouse attachment bolts into the slab until after it is dry. Place the frame over the slab, mark your holes, and then drill the holes using a hammer drill. Then, place the greenhouse frame over the holes and insert and tighten Red Dog anchor bolts that expand and grip inside the drilled holes. As you are finishing work on the cement slab, take a stiff push broom and add a lightly brushed texture. When it dries, it will provide a nonslip surface so nobody falls down when the floor is damp. If you do not like a concrete surface, you can dump gravel or small lava rock on top of it when the greenhouse is finished. Or, you can build it up by mortaring saltillo tiles to the floor and grouting them in. These rough-faced Mexican tiles are inexpensive, provide an elegant look and are not slippery if kept clean.

Plant Hanger Options



STEVE KLITZING

BENCH space fills up rapidly. If you need additional space for growing orchids, look up. Potted orchids can be hung on the horizontal cross beams of your greenhouse. For additional hanger capacity, you can hang plants on ¾-inch (2-cm) PVC pipes, of schedule 40 thickness, that run the length of the greenhouse (above). These PVC pipes can be placed on top of the horizontal cross beams and secured in place with inexpensive plastic band clamp ties. They can also serve a dual purpose if you use the PVC pipes for overhead misting or watering as well. If there are no beams, then you can mount eyebolts into the ceiling joists and rafters and hang the PVC pipes or plants from those. High-light orchids, such as vandas, cattleyas and schomburgkias, benefit greatly from being hung up above where diffused light intensity is higher.
— Steve Klitzing.



ABOVE In the author's greenhouse, Scruffles guards the hydrofogger.

BELOW Casters make it easy to move a space heater around the greenhouse.

FRAME REINFORCEMENTS In some areas, where there can be earthquakes or high winds, local building codes may require you to provide stress calculations or reinforcing for the greenhouse frame. Make sure your greenhouse comes with these calculations as part of the package. Otherwise, stress and wind shear calculations must be provided by a structural or mechanical engineer who will require a set of greenhouse diagrams that include an overhead view, a side view, and an end view. This work can cost \$500 or more. If reinforcements are required, you can get the materials at your local home and hardware store. If your greenhouse has a metal frame, you can acquire thin steel L-beams that can be cut to size using a hacksaw, or 2 × 4 reinforcing studs if your greenhouse is made of wood. Usually, these reinforcements are placed at a diagonal, pressing flat along the interior side walls of the greenhouse. Reinforcements are not ugly and they do not get in the way of your benches.

FIRE CODES With a wooden greenhouse, you may have to provide some kind of smoke alarm or sprinkler system. When I built my greenhouse, the city planner sent me to visit the fire chief, who demanded that I install a sprinkler system and a smoke detector. I then pointed out that the greenhouse was made of aluminum and glass, it would sit on a concrete slab and that it sprinkled and misted itself automatically at least once a day. Moreover, it would be filled with green plants, not dry tinder. I was met by a short period of silence, a flush of red on the chief's face, chased by an amused smirk

whereupon he remarked "Hmmm. Sounds like these requirements are a little bit unreasonable. I'll call the city planner and have him waive the fire permits." However, it is wise to check with local code officials to find out what requirements are necessary.

FINAL THOUGHTS My first kit greenhouse took me, alone, about two weeks to assemble in my spare time. Once the frame is assembled, put the roof on first, because that's the hardest area on which to install your glazing. If you are not constructively inclined, hire someone to assemble it for you.

Remember, a greenhouse is a miniature rainforest and a refuge of beauty and peace. And, during those cold winter months, where nothing outside is blooming, a greenhouse can provide you with dozens of cheerful blooming orchids to brighten up a gloomy day.

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