

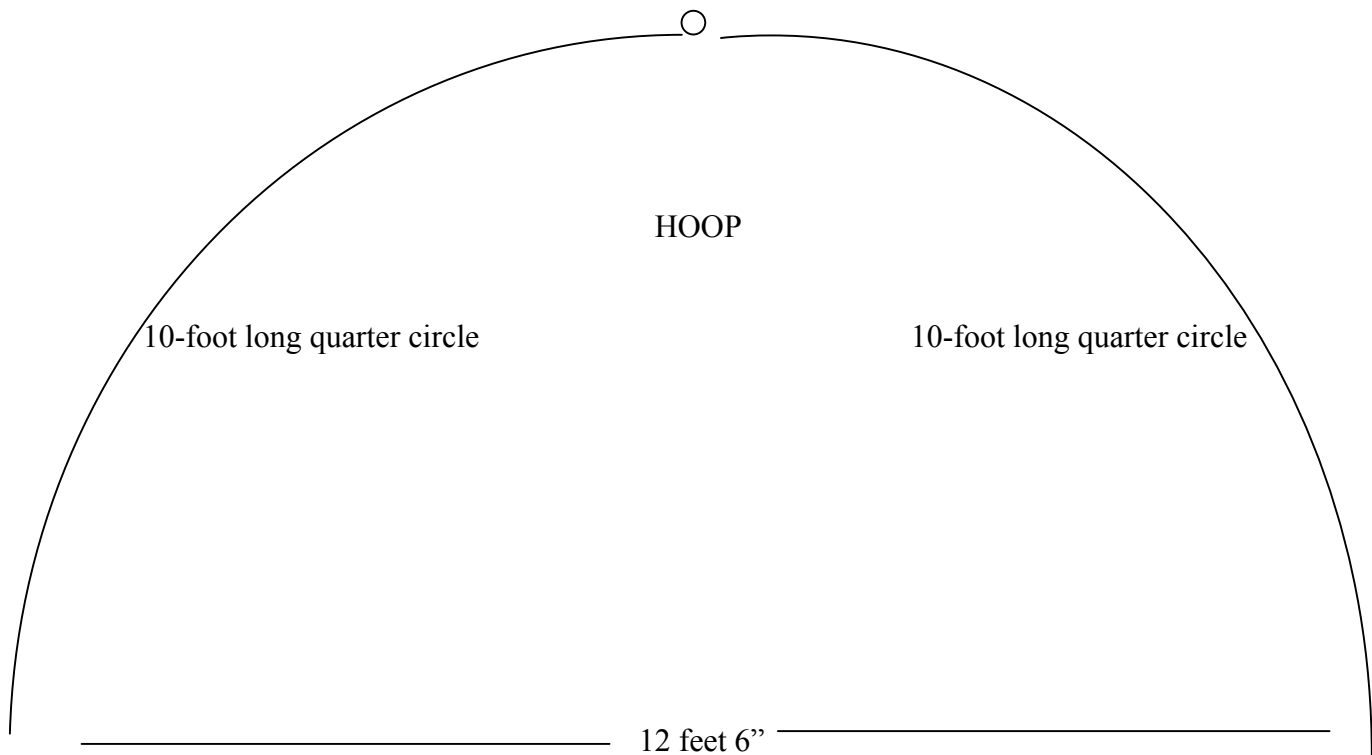
**Building The Modular Moveable Greenhouse described
in “The Four Season Farm Gardener’s Cookbook”
By Barbara Damrosch and Eliot Coleman**



This modular greenhouse is designed so home gardeners can easily build their own greenhouse. All of the major parts in the list following are available at your local home projects store. We have conducted workshops to build these modular greenhouses with groups of gardeners and the quick and simple process always delights everyone. All of a sudden, there it is, a greenhouse.

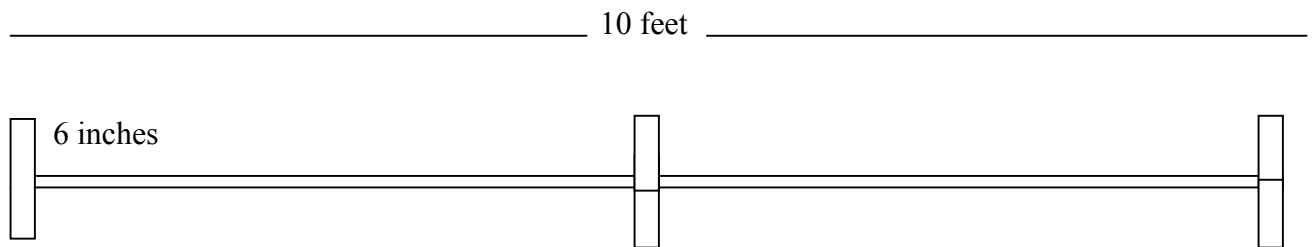
First, here is an overview of the project. Specific instructions will follow. The modular greenhouse has five major components – the hoops, the connectors, the plastic, the anchors, and the doors.

1. Each **hoop** is made from two 10-foot long by 1-inch diameter lengths of Electrical Metal Tubing (EMT.) Since there are three hoops in this greenhouse you will need six lengths of EMT for the hoops. Each length is bent into a $\frac{1}{4}$ circle using a # 7000 curved bending form from the Johnny’s Selected Seeds catalog. Two quarter-circles together make a half-circle. The bending forms are sold with detailed instructions on how to use them.



2. There are three **connectors**. They each consist of a straight 10-foot length of EMT with three 6-inch lengths of chain link fence top-rail pipe bolted on – one at each end and one in the middle. Two of them, the base connectors, lie on the ground, one on either side of the greenhouse, to secure the bottoms of the hoops. The third, the top connector, secures the upper ends of the hoops at the apex of the greenhouse. These are all placed with the long length of EMT to the outside of the greenhouse.

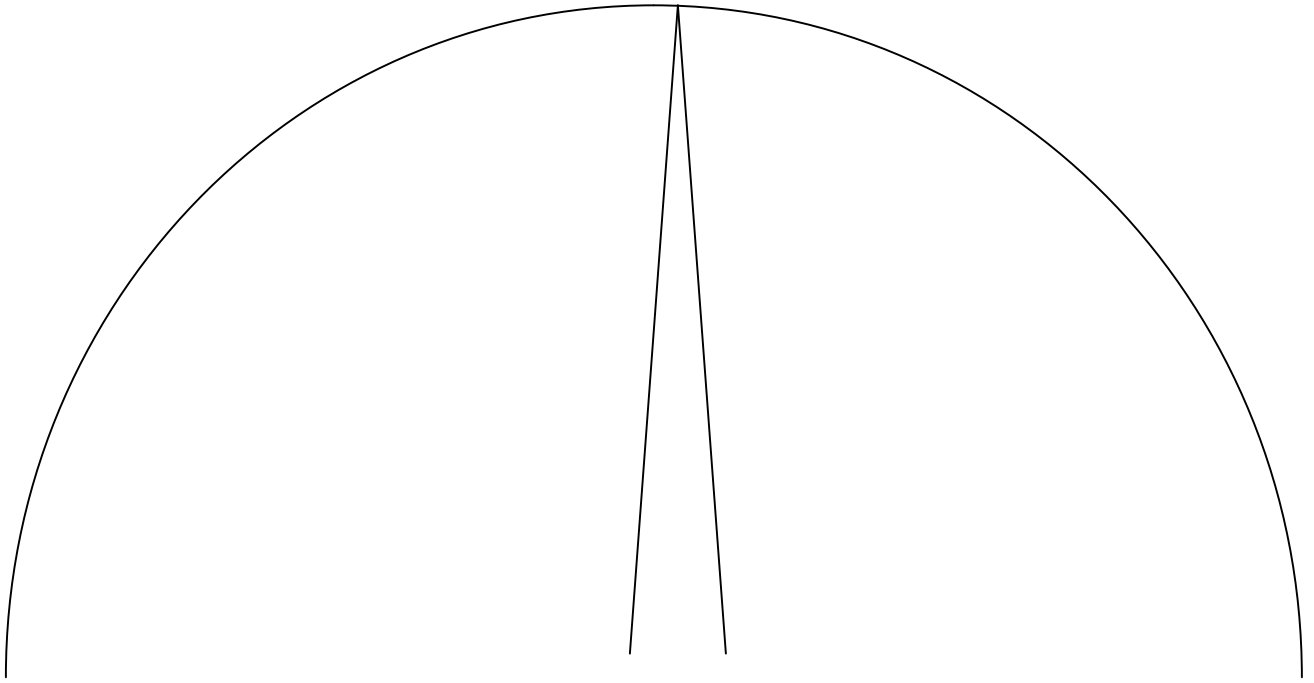
CONNECTOR



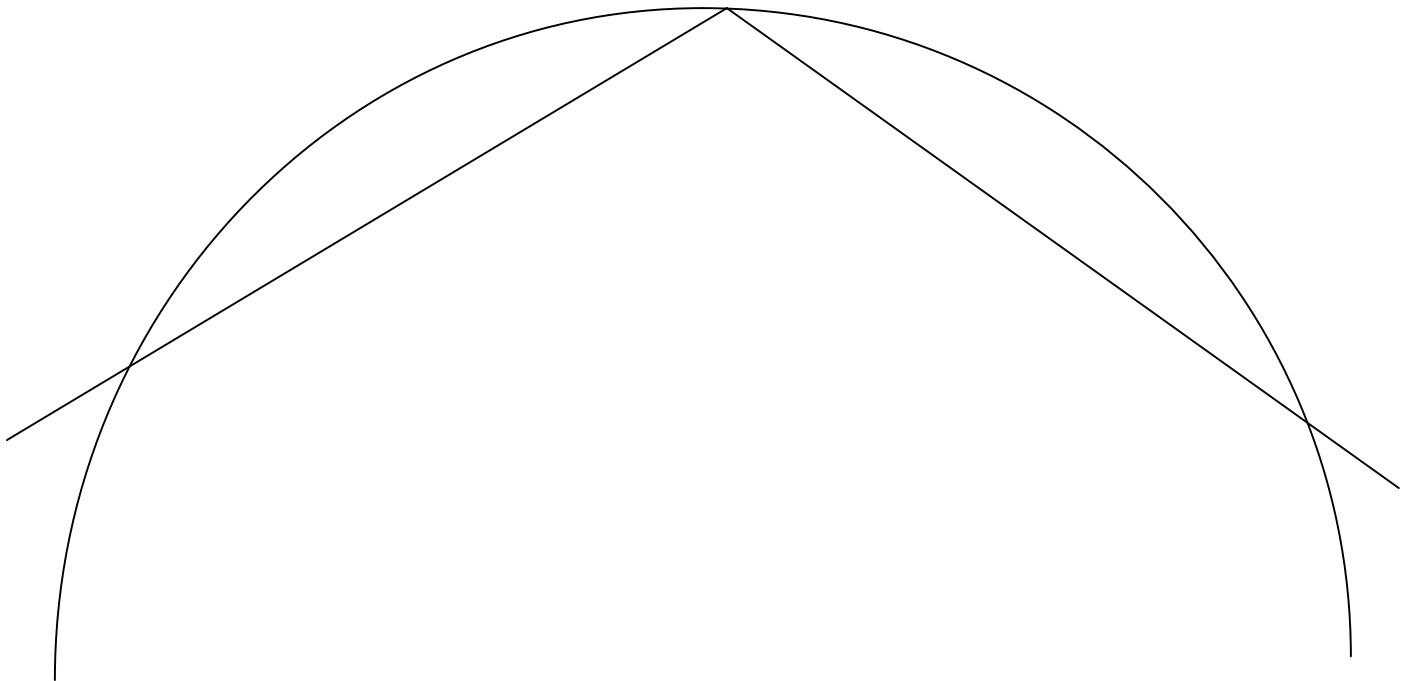
3. The **plastic** covering is what creates the greenhouse climate. It lets in light but keeps out the cold dry winds that kill plants in winter. We highly recommend a commercial grade, ultra-violet resistant greenhouse plastic over the hardware store variety, which, since it is not manufactured to resist sunlight degradation, will break down in less than a year. The plastic is used both for covering the greenhouse and for making the doors and is attached to the pipe frame with form-fitting plastic snap-clamps. (Both the greenhouse plastic and the snap clamps are available from the Johnny's Selected Seeds catalog.)

4. The corner **anchors** consist of four lengths of top-rail pipe, each 2½ feet long. One is driven in at each corner of the greenhouse and each is attached to a U-bolt that secures to the base connectors. Drive each anchor pipe into the ground to its full length, if possible, leaving just 3” protruding. The scissor door anchors consist of two lengths of top bar pipe, each 2 1/2 feet long. One is driven in at the base of each door and holes in the door tubes slip over a bolt in the anchor pipe.

5. The **doors** cover both ends of the greenhouse and make up the whole end-wall. The end wall consists of two lengths of EMT hanging side by side with plastic attached. We call them “scissor doors” because the two lengths are held to the top of the greenhouse by a bolt through their upper ends but the bottom ends swing free and can be opened to either side like a pair of scissors. Just swinging one of them allows entry and exit from the greenhouse. Or one or both of them can be set slightly open for partial ventilation. When both are swung out completely to their respective sides of the greenhouse and tied off, the whole of each end of the greenhouse is open giving as complete summer ventilation as is possible.



SCISSOR DOORS AJAR



SCISSOR DOORS FULLY OPEN

PARTS LIST

All items are available either off the shelf at your local home projects store or from the Johnny's Selected Seeds catalog.

1. 15 lengths of 1" by 10' Electrical Metallic Tubing (EMT.) EMT is also known as metal electrical conduit. It is made of zinc-coated steel. In the instructions to follow these are referred to as "tubes."
2. 2 lengths of 1-3/8" by 10' Chain-Link-Fence Top-Rail pipe. In the instructions to follow these are referred to as "pipes."
3. 20 bolts @ 3" by 5/16" hex-head with nuts.
4. 4 bolts @ 5" by 5/16" hex head with nuts.
5. 1 box of 1" self-tapping screws (tech screws.)
6. 4 U-bolts @ 5/16" by 1-3/8" by 3-3/4".
7. 1 sheet of 20' by 32' greenhouse plastic.
8. 1 box of 100 Snap-Clamps for 1" EMT.

TOOLS LIST

1. A corded or cordless electric drill.
2. An 11/32" drill bit. This bit is slightly larger than the 5/16th bolts. The larger hole makes assembly easier.
3. A couple of 1/2" wrenches for tightening bolts.

4. A hand hacksaw or electric reciprocating saw for cutting metal tubing.
5. A chalk line.
6. A carpenter's square.
7. A drill bit for driving self-tapping screws.
8. One large bolt (6" by 1") to use when driving the anchor pipes.
9. A four to six pound sledge hammer.
10. One model # 7000 Quick Hoops Moveable Caterpillar Tunnel Bender from the Johnny's Selected Seeds Catalog.

SETTING UP THE BENDER

The tubing bender may be mounted to any solid surface, such as a workbench, a picnic table, hay wagon, etc. It may be lag-screwed or thru-bolted into place. 5/16" mounting holes are provided on benders. Screws, bolts, etc. are included. By securing the bender in a fixed position, and pulling the tubing around the bender, the operator can maintain precise control of the tubing being bent.

Wherever mounted, it is important to have enough room to accommodate both the in-feed and out-feed of tubing, as well as some type of support at the out-feed end about 3/4" above the mounting surface. This will prevent 'corkscrewing' and ensure that the modular greenhouse hoops created are in a single plane. This is accomplished

most easily with something similar to 1 x 4" slats (actually 3/4" thick); 3/4" plywood or a similar material would also be adequate.

The bender comes with a lever bar that fits over the end of the tubing you are bending to give you extra leverage for completing the bend (see below.)

BENDING THE HOOPS

1. Mark one end of each of the six lengths of tubing for the hoops with a magic marker. This is the end that will be inserted into the base connector when the greenhouse is assembled.
2. Insert the marked end of tubing into the holding strap at the end of the bender.
3. Keeping the tubing in the channel created by the two sandwiched curved pipes of the bender, and with a smooth motion, pull back as if on a long oar (do not push), bending the tubing all the way around until it just touches the end of the bender closest to you. Stop. Do not bend past the end or the arc you create will not be smooth.
4. Release tension until the tubing is loose in the holding strap and slide it through the holding strap about one third the length of the bender itself. It is important to keep the newly curved section flat against the supports at the out-feed end (see above) throughout the bending process.

5. Repeat steps 3 and 4 until about three feet of unbent tubing remain beyond the closest end of the bender or if bending becomes too difficult.
6. Slide the lever bar over the unbent end. This effectively gives you more leverage for bending the rest of the pipe.
7. Repeat steps 3 and 4 until the point where the lever bar meets the pipe is even with the closest end of the bender.
8. Pull the now bent pipe out of the bender and repeat for all other unbent pipes, always inserting the marked end of the pipe into the bender first.

MAKING THE CONNECTORS

Start by cutting nine pieces, each six inches long, off of one of the lengths of top-rail pipe. Drill a hole through the middle of each. These are the pipe sections into which the hoops will be inserted when the greenhouse is assembled. (1 3/8th inch chain-link-fence top-rail has an interior diameter into which 1-inch EMT fits neatly.) They are attached at right angles with 3-inch bolts to a straight ten-foot long length of EMT. First you have to drill 5 holes in each of the EMT tubes used as base connectors. Before drilling holes snap a chalk line lengthwise along the centerline of a ten-foot length of EMT. That line will help to keep the holes you drill lined up down the very center of the tube. Make marks across at 3/4 inch in from each end, at 3'8" in from each end, and in the

middle. With a punch, make a dimple at each mark to prevent the drill bit from “walking”. Drill a straight and true hole with an 11/32nd bit at each mark. For the top connector you follow the same process but only drill three holes, one 3/4 inch in from each end and one in the middle.

Using 3” by 5/16” galvanized bolts attach three of the 6” long top bar pipes to each of the ten-foot long drilled EMT tubes at right angles to the tube. Attach one at each end and one in the middle. Insert the bolt first through the tube and then through the pipe section. Twist on a nut and a lock washer and tighten securely with the 1/2” wrenches.

The two holes in the base connectors, 3’ 6” in from each end, will be used for attaching the diagonal braces later in the construction process. To make the diagonal braces cut two lengths of EMT in half. That gives you four lengths each 5 feet long. Snap a chalk line lengthwise and make a mark 3/4” in from each end on all four lengths. Make a dimple at each mark with a punch and drill a straight and true hole at each mark with an 11/32nd drill bit.

ASSEMBLING THE MODULAR GREENHOUSE

One person can do this alone but the process will be easier with two people. Lay one of the base connectors on the ground. Take three of the curved lengths of EMT and insert the marked end of each into one end of each right-angle pipe on the base connector. Insert them so the curve of the hoop will place the straight length of the base connector to the outside of the greenhouse. Insert the other ends into the pipes attached to the top connector, again placing the straight length of the connector to the outside of the greenhouse. Then lift up the top connector and the one-half greenhouse frame and insert a hoop into the center pipe to hold it in position. Insert the other two hoops. Finally lay the second base connector on the ground next to the three recently inserted hoops and, one by one, insert the bottom of the hoops into the base connector pipes. If you are working alone and do this right the hoops you haven't secured yet will not fall out while you are securing the others. If they do fall out, go back to step one and find a friend to help with the whole process.

Once you have the structure upright make sure all the hoops are fully inserted into the pipes. Depending on how consistently you bent the hoops the greenhouse will be about 13 feet wide. Make sure it is sitting on a reasonably flat piece of ground and then square the structure. To do

that first make sure both ends are the same width. Then measure the two diagonals from corner to corner. If the ends are the same distance apart the structure will be square when the diagonals are each the same. Rearrange the sides of the structure until you have a perfect square. Once you have the structure squared up secure each hoop in the connector pipes with a 1" self-tapping screw. Insert the screws so their heads are on the inside of the greenhouse.

Next, starting at one corner, bolt one end of a diagonal brace to the adjacent empty hole in the base connector (3' 6" from the end) with a 3" bolt. Swing the other end of the brace up against the hoop and using a square to make sure you have a right angle, and using the hole in the end of the brace as a guide, drill a corresponding hole through the hoop and insert another bolt to secure the diagonal. In both cases the brace, and the nut holding the bolt, should be on the inside of the greenhouse. Repeat those steps at the other corners.

COVERING WITH PLASTIC

You need a 20' by 32.5' sheet of plastic to cover this greenhouse. If you purchase a 20" by 65' sheet of greenhouse plastic (sold by the Johnny's Selected Seeds catalog) you will have enough to cover the

greenhouse two times. The plastic has a guaranteed four-year life span but we find we can stretch it to five years before the plastic begins to deteriorate. If you store the second half of the sheet under cover out of the sun it will not deteriorate. Thus, one plastic purchase will protect your greenhouse crops for up to ten years.

The plastic will be attached to the greenhouse with plastic snap-clamps that fit snugly around 1" EMT. To guarantee that they will not pop off under stress we pre-drill a ¼ inch hole through the center of each clamp so that we can secure them with tech-screws.

Putting on the plastic is easiest with two people and should be done on a day with no wind. Cut a 12' by 22' piece of plastic for the greenhouse cover from the roll (see plastic cutting pattern). With one person on each side stretch it up and over the greenhouse. Lift up one edge of the greenhouse, fold the plastic around the base connector, and anchor the plastic to the base connector with 10 evenly spaced snap-clamps and tech-screws. (Cut a slit where the plastic encounters the center pipe on the base connector.) Go to the other side of the greenhouse, lift it up, pull the plastic taut and again anchor it with snap-clamps and tech-screws. Then with one person on each side of the greenhouse pulling the plastic taut against each other put on snap-clamps to attach the plastic to the hoops. Secure them with tech-screws.

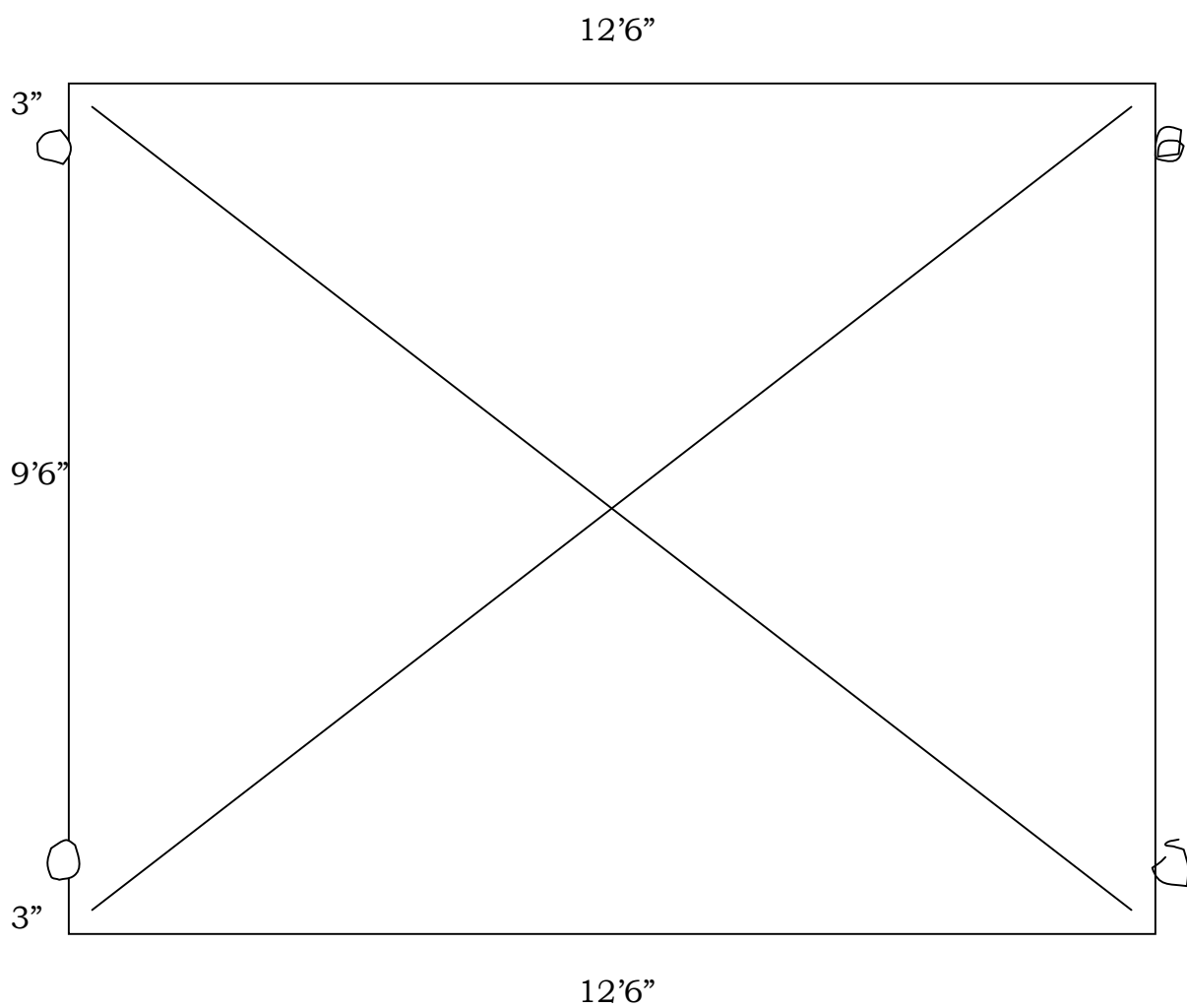
Using a pair of sharp scissors trim the excess plastic to about a three-inch length around the four edges of the greenhouse.

THE ANCHORS

We plan on the eventual width of our greenhouse to be 12'6". That distance accommodates the width of the four beds and three paths (see pages 87 – 101 in *The Four Season Farm Gardener's Cookbook*) with a little extra along each edge. When setting the greenhouse in place you push the edges in to that distance to put the greenhouse base connectors inside the anchor pipes. So the first step is to put the anchor pipes in place.

To make the anchors you will need four 30" lengths of top-rail. Cut off the swaged end on the remaining length of top-rail and cut it into four equal length pieces. Drill a hole with the 1 1/32nd drill bit one inch from one end of each anchor pipe. The end with the hole will be the top end when you drive the anchor pipe into the ground.

Lay out a square site for your greenhouse. Again make sure you carefully measure the distances apart of the sides. Then make sure the diagonals are equal. Two anchor pipes are placed on each edge of the greenhouse.



They should each be set 3” in from the corner with the hole in the top perpendicular to the side on the greenhouse. Drive them into the ground with a sledgehammer using the driving bolt to protect the top end from deforming. Stop driving when there is still about 3” remaining above the soil.

When the greenhouse is placed on the site, push the bottom ends of the base connector pipes into the soil so the base connector tube sits flat on the ground. The next step is to anchor the greenhouse to the ground pipes with the U-bolts. First, you need to modify each U-bolt by cutting off the threaded leg on one side to give you a cane-shaped part. Discard the cross plate. The remaining threaded leg will be poked through the plastic just above the base connector, and through the hole in a ground anchor pipe. Before doing that you will want to drive the anchor pipe in slightly deeper so the drilled hole sits just above the base connector tube. The cane-shaped end goes around the base connector tube. Put on a washer and a nut and tighten each one.

ADDING THE SCISSOR DOORS

At each end of the greenhouse drill an $1\frac{1}{32}$ hole through the end pipe of the top connector, just to the right of the bolt connecting the pipe to the tubing. Slip a 5-inch by $\frac{3}{8}$ bolt through that hole with the bolt head on the inside of the greenhouse. Add a nut on the outside to secure it in place. That bolt supports the top end of the scissor doors and serves as their hinge.

Each scissor door consists of a pair of tubes hanging from that bolt. They sit side-by-side, one in front of the other. The bottom of the tubes should sit 3" above the ground so cut them to length accordingly. Snap a chalk line down each tube and drill two holes with the $1\frac{1}{32}$ drill bit. The first is one inch from one end of each door tube and the second is TK from that end. The end with the hole will be the top end and that hole is slipped over the bolt.

The bottom ends of the scissor doors are secured in place, when closed, by a similar bolt on the scissor door anchor pipe. The anchor pipes are made by cutting in half the 5-foot long section of top-rail pipe left over from cutting the six-inch connector pipes. Drill a hole at one end of each of those 3" down from the end.

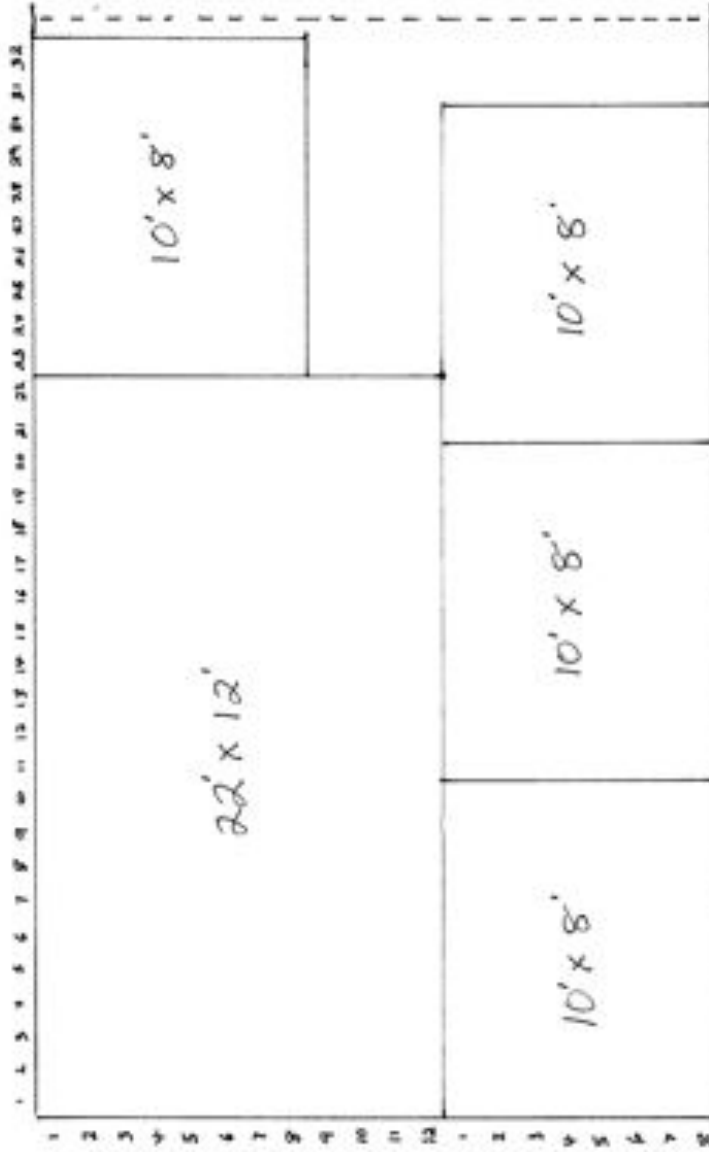
With both tubes in place and hanging down make a mark on the soil just to the greenhouse side of them. With the hole at the upper end drive an anchor pipe at that spot with the driving head. Twist the anchor pipe so the hole is perpendicular to the scissor door tubes and drive it deep enough so its hole lines up with the holes towards the bottom of the scissor door tubes. Place a 5-inch bolt through the hole in the anchor pipe and hold it with a nut on the other side. The bottom ends of the scissor door pipes are secured, when the doors are closed, by slipping their holes over that bolt. (Some people have found it easier to slip the holes over the bolt if they increase the size of the hole in the scissor door tubes by using a larger drill bit, up to ½ inch.)

Each door tube is attached to separate piece of plastic that also attaches to the greenhouse. Each door sheet is 8' by 10' (see pattern). Swing open the outside tube and secure it to one side. Leaving a 12" flap of plastic to lie on the soil at the bottom attach one of the 10' sides of the door plastic to the inside tube with snap-clamps, flip it over the top of the greenhouse and, pulling the plastic reasonably taut, attach it to the curve of the greenhouse with snap-clamps. Place the snap-clamps in between those holding the top plastic on. Close the outside tube and repeat that process placing the snap-clamps on the outside tube in between those on the inside tube. Trim the excess plastic with a sharp pair of scissors, leaving a 3-inch flap. Repeat that process on the other

end of the greenhouse. When the doors are closed we add a wing nut on the end of the anchor pipe bolt to keep the scissor doors closed. A few sand bags set on the 12” flap of plastic at the bottom will keep the doors extra secure against wind. (See The Four Season Farm Gardener’s Cookbook page 454.)

For ventilation the doors are held open by short lengths of rope. Place a piece of heavy-duty clear plastic tape over the cover plastic just above the top of each corner brace. Make a hole through that reinforced plastic area and stick one end of a 3-foot length of rope through the hole. The two ends of that rope can then be tied around the swung out scissor door to secure it in the open position. When we need just a little ventilation, early and late in the season, we open the door slightly and hold it open with a garden fork stuck in the ground.

PLASTIC CUTTING PATTERN





The modular moveable greenhouse frame.



Base connector with diagonal braces.



The completed greenhouse with one scissor door open.