

The "Down and Dirty" Guides to Making Biodiesel at Home

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Making  
Algae  
**Photobioreactors**

# Making Algae **Photobioreactors** At Home



By David Sieg

By David Sieg

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# Making Algae Photo Bioreactors at Home

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## About the Authors



**David Sieg**, teacher/consultant/biofuels entrepreneur/writer and author of the Series "Down and Dirty Guides to..." Covering all aspects of biodiesel, biofuels, and alternative energy. He is also the Managing Director of International Biofuel Solutions, LTD. Thailand and President of Information Specialists, Corp., USA He lives in Des Moines, Iowa USA with his wife, Tram and Son, Lennon.



**Paul Hendee** ...was brought up in Webster, N.Y., outside of Rochester, N.Y.. Rochester is, in some circles, known as the Graphic Arts Capital of the U.S.A. After doing a two year term in Viet Nam (1968 & 1969), he returned home and followed in his father's footsteps to work in the Research Dept. of Eastman Kodak. After five years at Kodak, Paul attended St John Fisher College. Attaining a degree in Mass Media Communications and Anthropology, he entered the Graphic Communications Industry in Rochester where, as an innovator of the graphic process he was entered into the Marquis Who's Who in Advertising.

Innovation and training has been the standard of Paul's career. Today he is working developing new, cost effective processes in Algae Development that will move our globe into a healthier planet of people.



**Howard Bankston**, Consultant, Certified ISO Auditor & Six Sigma Coach, a native Floridian. His higher education was at Carnage Institute of Technology in Pittsburgh, Penn. and the University of Miami, in Florida, a major in Business Management & Marketing.

Complementing his technical and marketing knowledge in the production of both printed and digital communications his most valuable skill is understanding the Customers wants and needs then providing the right marketing tools that match products and prospects. His favorite Lean Statement is . . ."If it Doesn't Add Value to the Customer, Get Rid of It"

## Making Algae Photo Bioreactors at Home

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These guides were written with the intent of providing “Down and Dirty” realistic, no BS, info on all aspects of the biodiesel process. If you liked this EBook, we’d like to hear about it.

If you didn’t like it, **WE’D REALLY LIKE TO HEAR ABOUT IT.** Your comments will help make future editions of this eBook even better. Don’t hesitate to sound off.

Send all comments, complaints, criticisms, and compliments to [dsieg@making-biodiesel-books.com](mailto:dsieg@making-biodiesel-books.com)

### Other Books in the “Down and Dirty” Biodiesel Series <sup>TM</sup>:

- [Making Algae Biodiesel at Home](#) <sup>TM</sup> (New 2010 Edition coming Dec. 2009)
- [Making Algae Photo Bioreactors at Home](#) <sup>TM</sup> (in production)
- [The Encyclopedia of Making Biodiesel at home](#)
- [Biodiesel Recipes](#)
- [Biodiesel Processors](#)
- [Washing and Quality Testing Biodiesel](#)



## Acknowledgements

First and foremost, I'd like to thank the co-authors of this work,

Howard Bankston, and

Paul Hendee.

Both for the time taken and the excellent advice freely given.

Designing the PBR's took place over the spring, summer, and fall of 2009. When I moved back to the USA from Asia, I didn't have a house, a shop, or tools. I left everything behind. I took one year to find a suitable location and Howard and Paul suffered through most of it. We had to do this eBook on the fly, and build everything from scratch. Their patience with me, when I was moving, when everything was going wrong, means more than you know. A HUGE thank you to both of you. This work simply couldn't have happened without you.

My steady, long term, (and new) customers come next. As always, I greatly appreciate your encouragement and criticism. Every single email I try to answer. (The exception is people with an ax to grind) And I get a lot of email. I enjoy hearing from all of you. Please keep the comments coming. You don't know how much all the comments help create a better source of learning for everyone.

Lastly, my wife Tram and my son Lennon. *Man*, they put up with a lot of crap when I'm writing. Lennon is turning 4 now and it seems his basic vocabulary is "Be quiet...Daddy is working." As I've said before, a simple thank you seems so inadequate.

## Introduction

Don't be fooled by the price...The manuscript you hold in your hands is valuable.

I know of no other like it. ANYWHERE. When I went looking for a lab unit, I saw similar PBR's selling for \$10,000 - \$20,000 USD or more. This is a full scale, working, patent-pending lab unit. The reason I'm giving it away for free is because this is a first generation design. It doesn't have all the bells and whistles. The designs that came after, and in the (upcoming) eBook, are much better, and more refined.

It is, however, better than anything you can find anywhere on the internet.

The PBR's presented here all met various criteria. Among other things they...

- All are scalable and can be built in different sizes
- All are made easily, from materials at hand.
- All are made using basic hand tools.
- All are inexpensive to reproduce.
- All are functional, work, and perform the job they are built for.

This is one small part, of a much larger work called ["Making Algae Photo Bioreactors at Home."](#) The complete manuscript will have many different sized PBR's, from small scale algae "incubators," to lab units, to full sized, scalable, PBR's to "continuous" PBR's for just about any algal application. These designs are patent-pending and will be ISO 9000 certified as well.

**In short, they are the real deal.**

This design presented in this "Sneak Preview" is a 10 cell "batch" Photo bioreactor. This was developed to test different strains of algae and/or 10 different variables, at the same time, when testing algae.

One of the big drawbacks of testing algae is you make one change, stop, wait for sometimes days, to see if it has the desired reaction. More times than not, it doesn't, and it is back to the drawing board. It is slow, tedious, pain-staking, work. This PBR is designed to solve that problem.

With this PBR you're able to test 10 different strains and/or variables at once.

## Making Algae Photo Bioreactors at Home

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The best part is, you **can build it yourself for less than \$400 USD.**

### **Advantages:**

- Easily built using readily available parts.
- Easily test 10 different algal strains to determine which one is best for your situation.
- Easily test 10 different variables at once, to see which one works best.
- Easy to take apart and clean.
- Can be built with normal household tools.
- Can be built in 2-3 days.
- Easy to maintain and repair

### **Disadvantages:**

- Harvesting is “clunky” and not fully developed.
- Many of the systems could be automated.
- In order to keep the cost down, compromises were made in quality materials, after all, this is a prototype.

Also available are [DIY PBR kits](#): These kits contain everything necessary, all parts, and materials cut to length. All you have to do is follow the full color instructions and put it together. You can be up and going in less than an afternoon. These kits are less expensive than ANYTHING available, anywhere.

We also will [custom build a PBR](#) for you. Contact us and we'll see what we can do.

In both cases, simply click on the link above, and send us an email.

I hope you enjoy this “sneak preview”

All the best

David Sieg

30 June, 2009

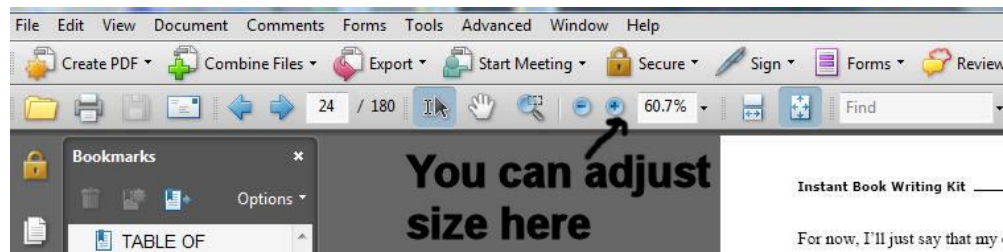
Des Moines, Iowa, USA

# Making Algae Photo Bioreactors at Home

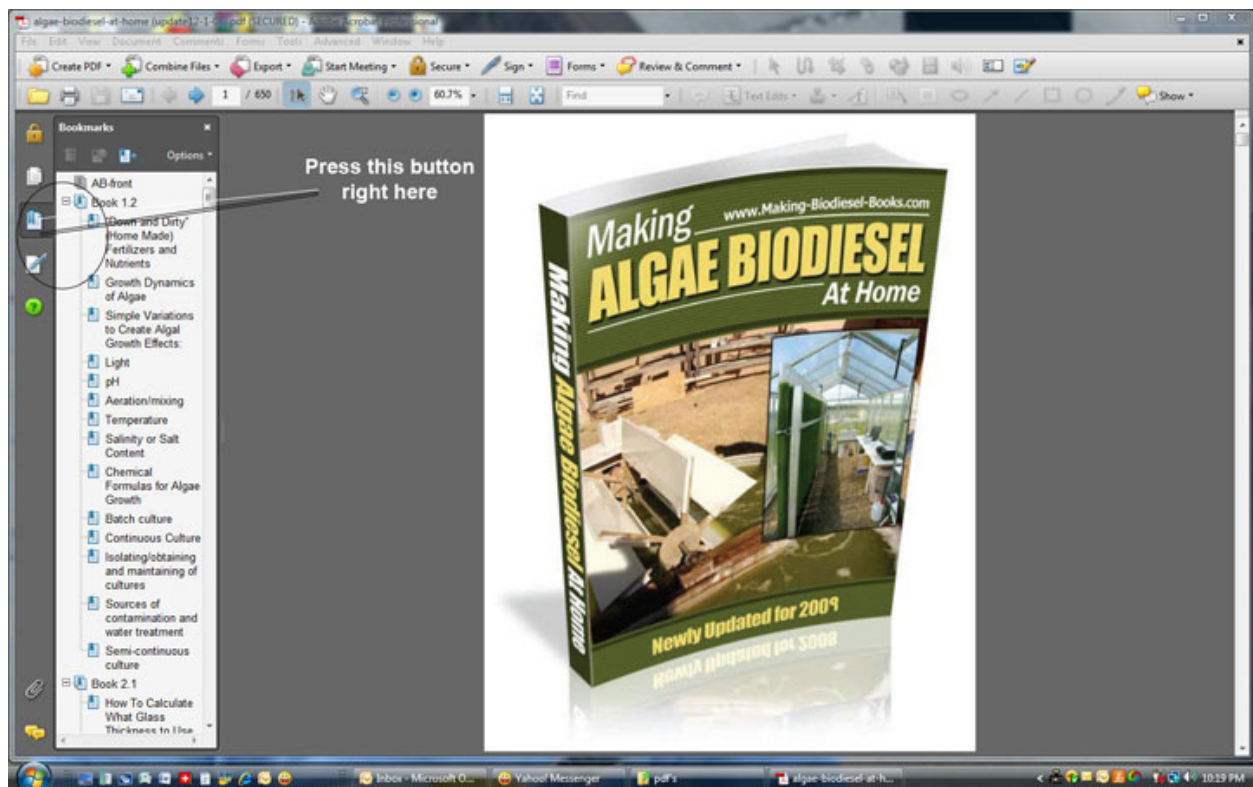
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## How to Use this eBook

Adobe eBooks are extremely easy to use. For example, unlike a regular book, you can adjust the size of the font to any size you want. This is very helpful for vision impaired readers.



You can also go to any section of the book, easily and quickly. Press the button indicated and you'll find a full Table of Contents.

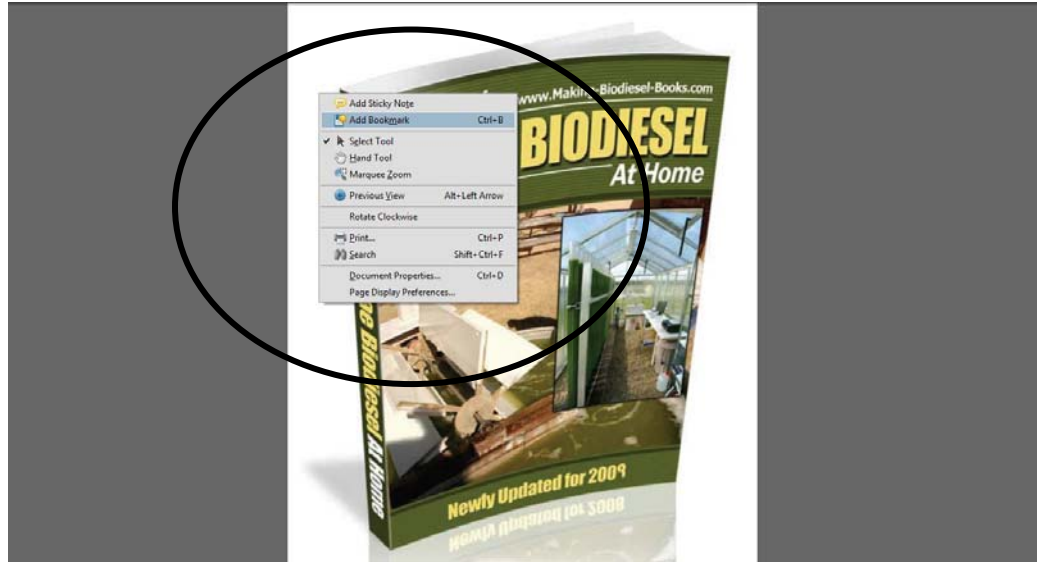


You can also “Bookmark” your place so you don’t lose where you’re at.

Simply “right click” your mouse and a menu will appear. Click “add bookmark” and your page choice will be added to the menu on the left.

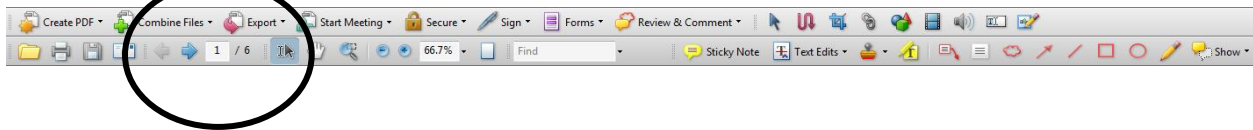
# Making Algae Photo Bioreactors at Home

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You'll need to click on the "untitled" section and add a name for your bookmark.

You can also jump to any page, easily and quickly by typing the page number in right here:



This is a very quick overview of some of the features of Adobe reader. There are many more and you can find out many more by reading the "help" section on the top tool bar.

Making an

# Algae Photo Bioreactor

At Home





## Design Notes

What I like most about this design...well, there are A LOT of things I like about this design. But if I had to pick one it would be the ease of building, and how easy it is to take apart and put back together. It is a real pleasure working with this unit.

I didn't design this unit to be "pretty." It is designed to be functional, inexpensive to build, easy to work with, and do what it is supposed to do. If you want pretty, you need to [buy the eBook](#).

This is a "first generation" design. A prototype. Our goal was to build cheap, and see if our ideas worked. (They did) So there isn't a lot of bells and whistles, there is no automation. Once again, those came later and can be found in the eBook.

I've made this build manual as simple as I can. I'm assuming you've never done this before, and have very little building experience.

Other thoughts:

- The use of adhesives: Don't get married to the ones I choose. Silicones work well too. The nice thing about silicone is if you screw up, you just peel it off and start over.
- The parts list is as complete as I could make it. In some places you might find small things missing, (mostly things you would find in any shop) but everything major is accounted for.
- Harvesting is accomplished simply by taking the bio-cell from the cradle and pouring the culture from the top. Nothing fancy.
- About the only maintenance required is occasionally replacing an air stone, or cleaning the tubes. This is done by removing the plug from the bottom. If you're cheap (Like me) all you have to do is scrape the air stone where the algae builds up on it.
- Cleaning the tubes can be done with a small, long handle, brush. Only of those small toilet brushes work pretty good. : +)

# Making Algae Photo Bioreactors at Home

## Detailed Parts List

### Parts Needed:

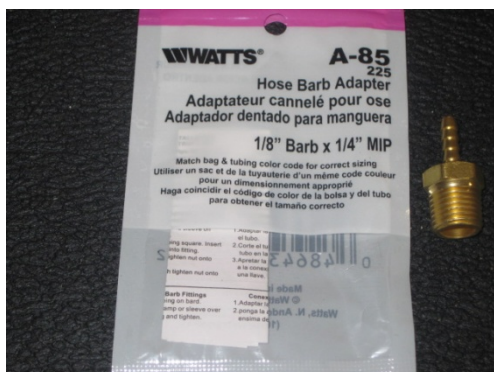
(10) 1.25" PVC threaded plugs



(10) Bulk Air stones



(20) 1/8" x 1/4" MIP Hose Barb Adapter



(1) Aquarium Silicone air hose



(10) 1/4" FIP Elbow Adaptors



(1) Tube 3M 5200 Marine Adhesive



# Making Algae Photo Bioreactors at Home

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(10) Check Valves



(10) 1.25" PVC Slip and Thread adapters



(10) 2" inch PVC "repair" Couplings



(10) 1.5" PVC "repair" Couplings



(2) Aquarium Grow Lights



(1) can PVC Cement





# Making Algae Photo Bioreactors at Home

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(1) 17" inch plant caddy



(2) 18"x24" plexiglass sheets



(4) 2"x4" inch steel brackets (10) T-12 36" inch fluorescent tube protectors



(2) XP60 air pumps



(2) 4-way Air-Valves



# Making Algae Photo Bioreactors at Home

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(3) 2-way Air Valves



(1) roll Velcro





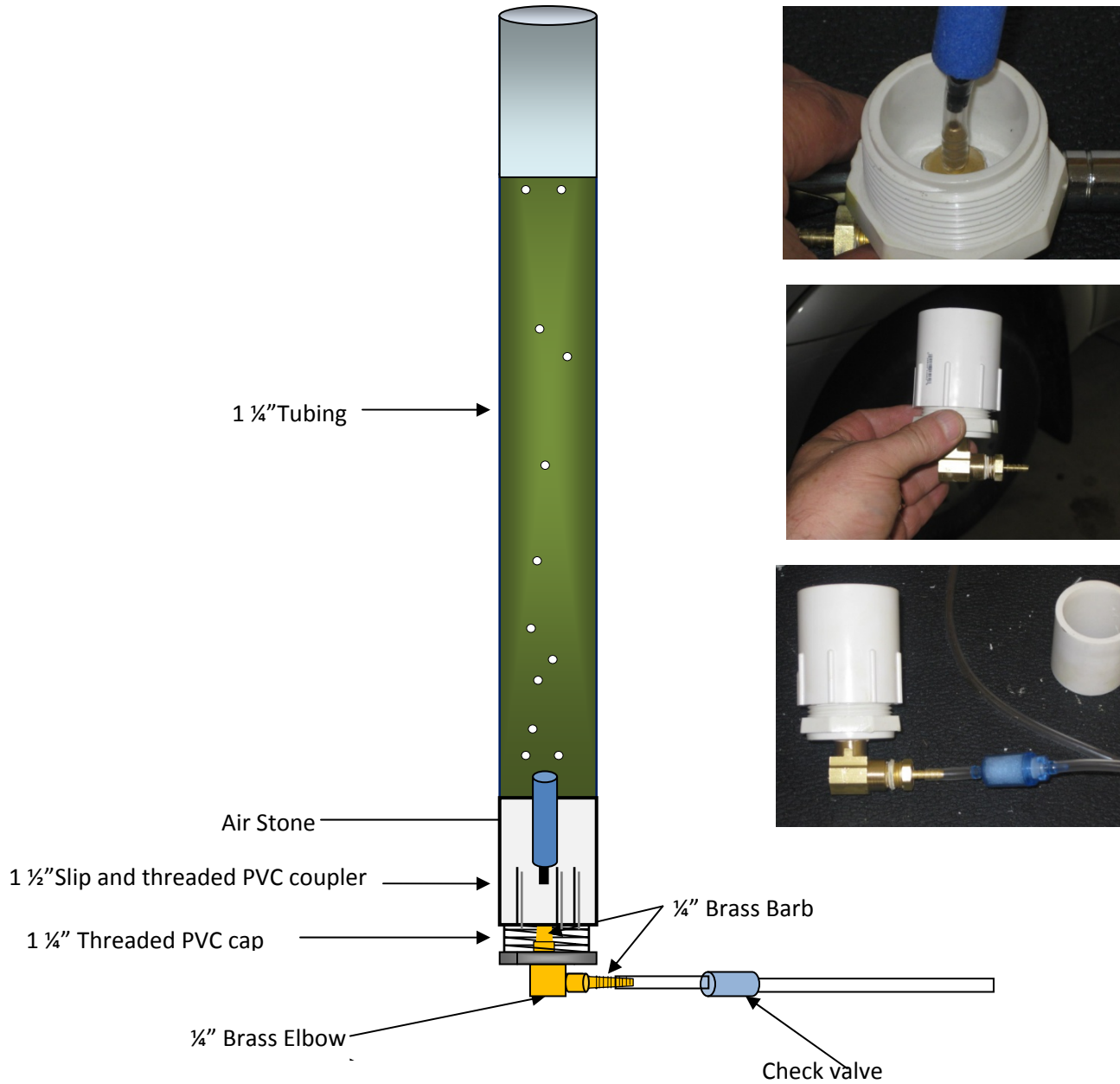
**\*Note:** PVC Post & Fittings can be used if desired Order On-Line From - [http://www.discountfence.com/vinyl\\_fence/postrail\\_vinyl\\_fence.htm](http://www.discountfence.com/vinyl_fence/postrail_vinyl_fence.htm)

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# Making Algae Photo Bioreactors at Home

## Cap Assembly Detail



# Making Algae Photo Bioreactors at Home

## Cap Assembly

### Parts Needed:

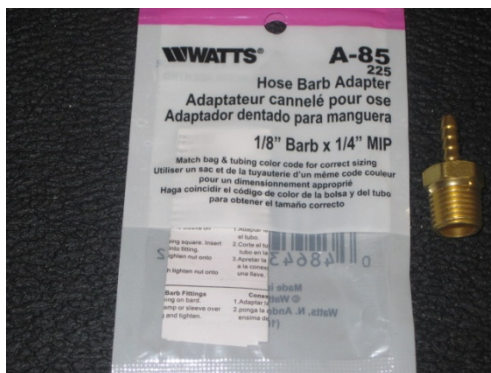
(10) 1.25" PVC threaded plugs



(10) Bulk Air stones



(20) 1/8" x 1/4" MIP Hose Barb Adapter



(1) Aquarium Silicone air hose



(10) 1/4" FIP Elbow Adaptors



(1) Tube 3M 5200 Marine Adhesive



# Making Algae Photo Bioreactors at Home

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(10) Check Valves



(10) 1.25" PVC Slip and Thread adapters



## Tools Needed:

- Drill press or power drill.
- 1/2" drill bit
- 9/16" deep socket
- Socket wrench
- Utility knife
- 3M 5200 Marine adhesive

**Assemble all the parts and tools necessary before beginning:**





# Making Algae Photo Bioreactors at Home

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## Fabrication:

- 1.) Start by drilling a ½" hole in the center of the PVC end plug.

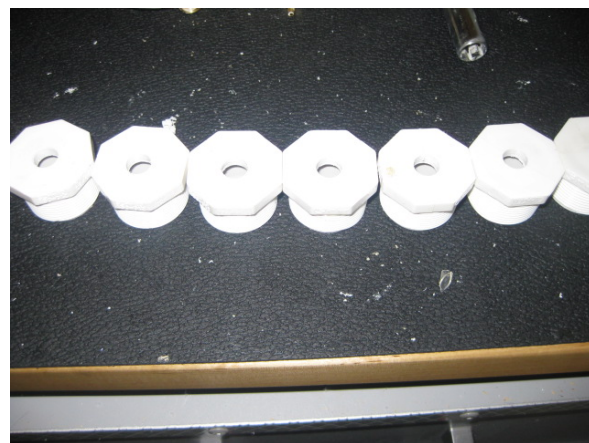
A drill press works best of this as you can make extremely exact holes.

A regular hand drill will also work. Keep in mind if you're using a hand drill the caps will have a tendency to spin away from the drill. You'll need some sort of clamp or vice to keep the plug and drill bit steady.

Working in plastic and PVC, using a wood drill bit at medium speed and steady pressure seem to work best.



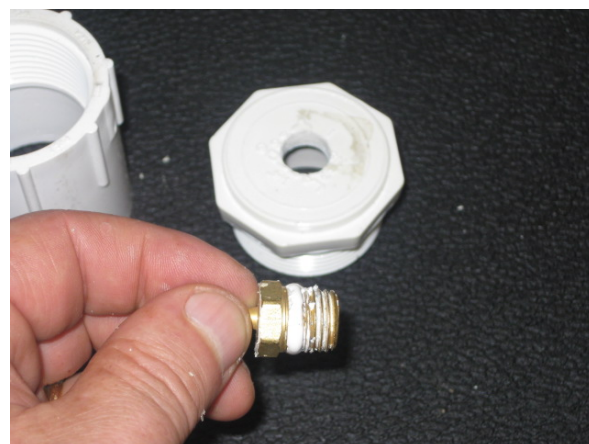
- 2.) Drill 10 caps.



- 3.) Carefully apply a small bead of the 3M adhesive directly under the barb nut.



- 4.) From inside the PVC cap, thread the barb into the PVC cap turning the hose barb adapter clockwise.



## Making Algae Photo Bioreactors at Home

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Seat the hose barb firmly into place using a 9/16" deep socket and extender. Carefully tighten, but DO NOT over-tighten.

- 5.) The hose barb should have approx. 3/8" of an inch extending from the bottom of the PVC cap. Put a small bead of adhesive around the threads.



Thread the right angle elbow onto the barb thread. Use your socket and extender to tighten as needed.



- 6.) Apply a bead of adhesive around the BOTTOM half of the hose adaptor.





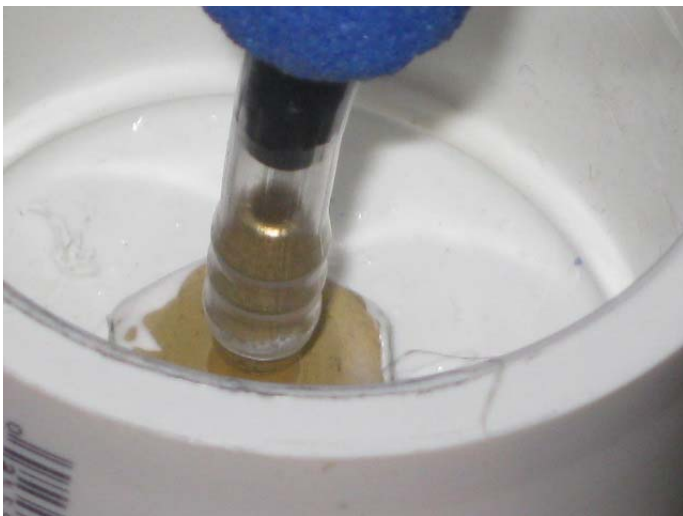
## Making Algae Photo Bioreactors at Home

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7.) Carefully thread the barb onto the right angle. You may need to use a pair of pliers or the socket to seat the hose barb firmly. DO NOT over tighten.

8.) Cut a piece of tubing about 1.25" and connect to the air stone.



9.) Press the air tube with the air stone connected to it over the barb located inside the PVC cap.

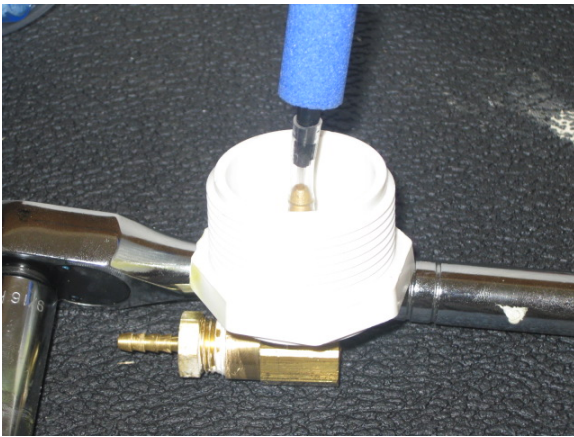
a. If pressing the air tube becomes difficult or kinks, place the end of the air tube into hot water for about a minute. This will soften the air tube and make it more malleable.



## Making Algae Photo Bioreactors at Home

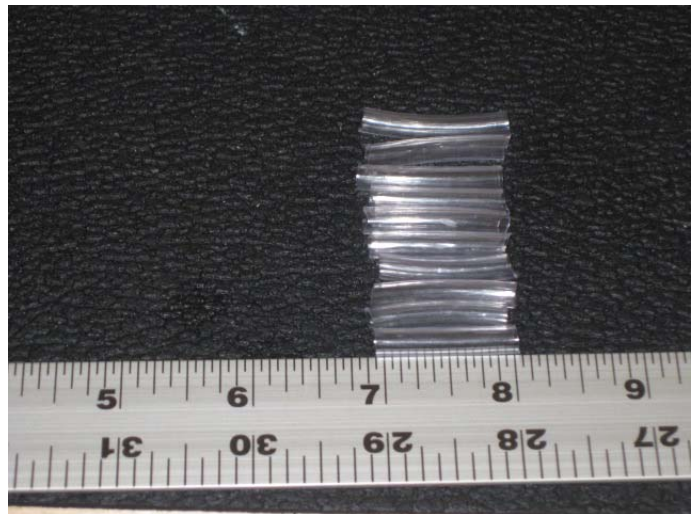
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Your cap assembly should now look like this:



10.) Now do 9 more cap unit assemblies.

11.) Cut 10- 1" inch pieces of tubing.



12.) It is a good idea to have a cup of hot water handy in your work area. Place the tip of the tubing in the water BEFORE connecting. This will allow the tubing to expand, then contract, for a better fit.

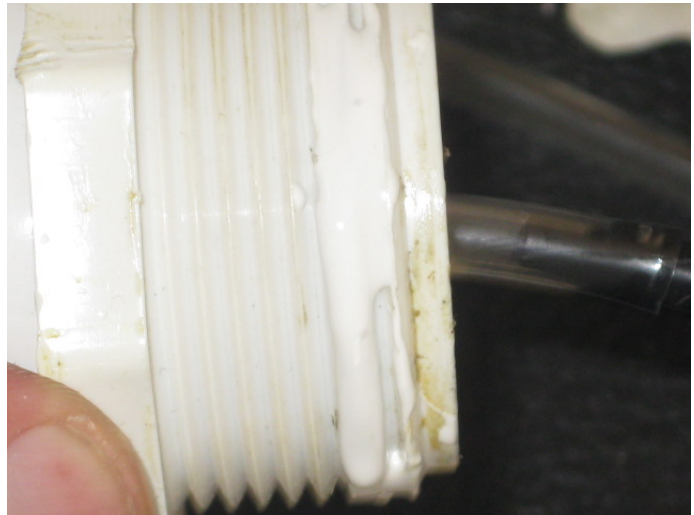
## Making Algae Photo Bioreactors at Home

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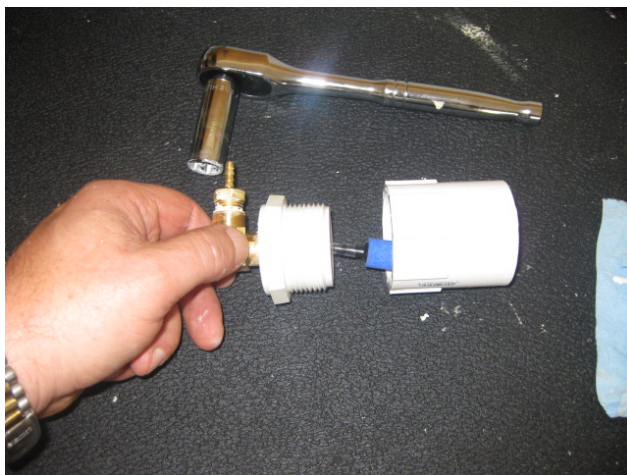


13.) Connect the one inch tubing to the barb extending from the cap.

14.) Spread a bead of adhesive on the threaded coupler.



15.) Screw the plug into the coupler.

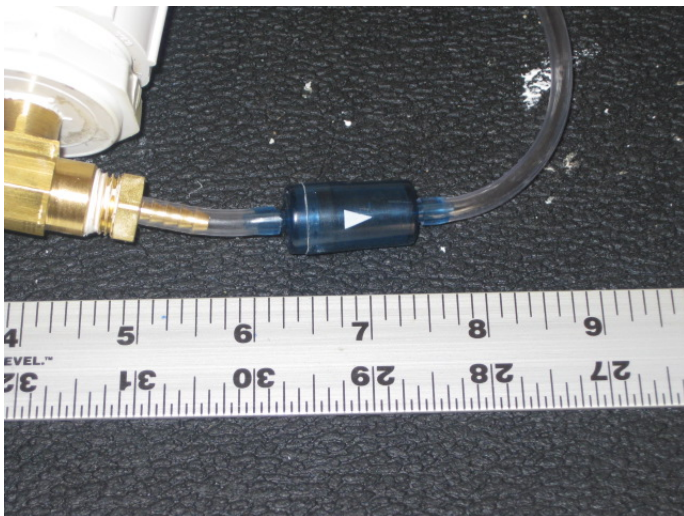




## Making Algae Photo Bioreactors at Home

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- 16.) Connect a check valve to the other end of the tubing making sure the arrow points TOWARD from the cap assembly.



- 17.) Now cut a piece of tubing approx. 4' foot long, and connect the tubing to the other end of the check valve. The completed check valve assembly should look like this, except arrow should point TOWARD cap:

**TIP:** Try blowing into the tube. You should be able to blow air all the way through. If obstruction, turn check valve around.



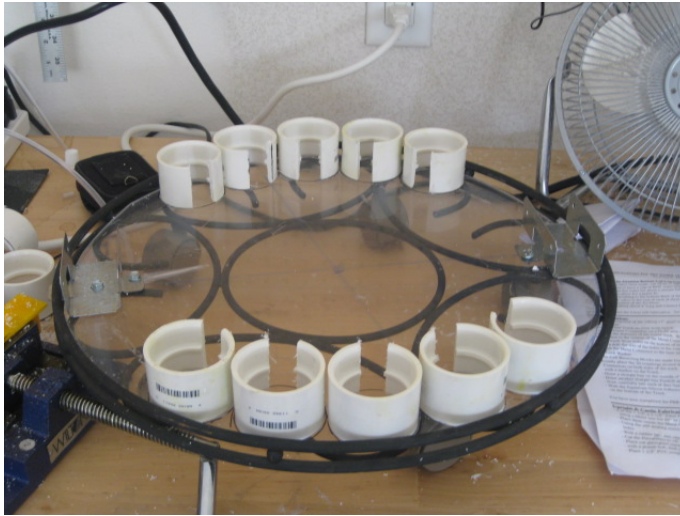
- 18.) Now complete a check valve assembly for each of the other 9 cap assemblies. Put them all in a box and set them aside for later use.

Your cap assembly and one of the most difficult parts of your PBR construction is now complete.

# Making Algae Photo Bioreactors at Home

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## Base Fabrication



### Materials needed:

- 17" Plant (saucer) caddy
- (10) 2" couplings
- 28" x 48" x plexi-glass
- (2) 2"x4" rail ties
- Aquarium sealant
- Wood screws and washers



### Tools Needed:

- Power drill
- Jig saw
- Straight edge
- Marker
- Vice





# Making Algae Photo Bioreactors at Home

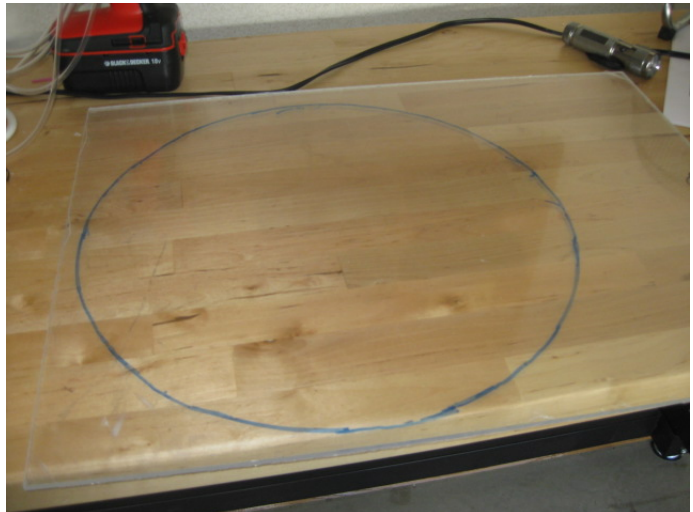
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## Base Fabrication:

- 1.) Take out the plastic insert in the plant caddy and set aside. Place the plant caddy upside down on the wood panel



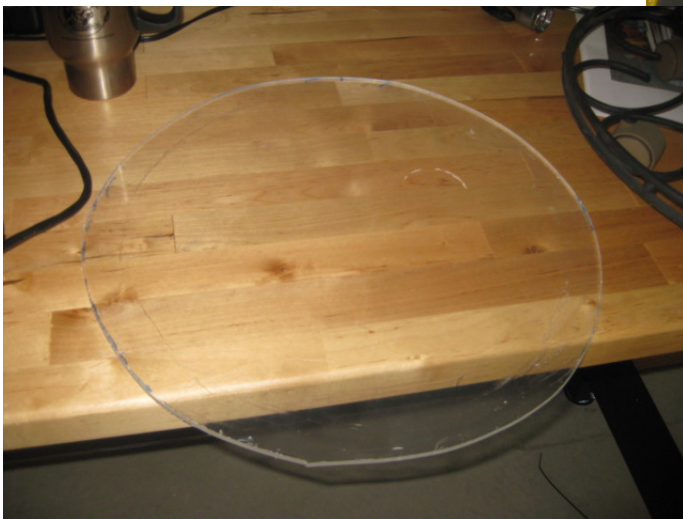
- 2.) Draw a circle on the INSIDE edge of the plant caddy.



## Making Algae Photo Bioreactors at Home

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- 3.) Take the jigsaw and cut along the circumference of the circle. You may want to cut along the inside of your pencil mark to make sure your wood panel fits into the plant caddy easily.



- 4.) Take your round piece and gently tap into the plant caddy.



- 5.) Using your straight edge, mark a straight line down the center. The line across, creating "quarter pieces." Mark the exact center with a dot.



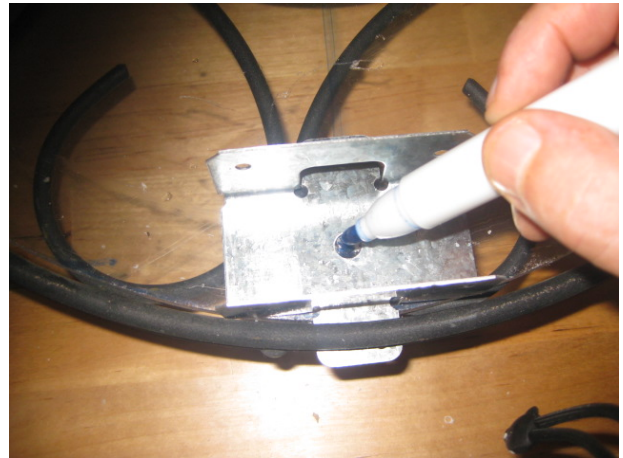
## Making Algae Photo Bioreactors at Home

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6.) Set your tie rails on the center and draw an outline around each.

7.) Using wood screws and washers, anchor the tie rails in place. Be sure to pre-drill the screw hole or the plexi-glass may crack



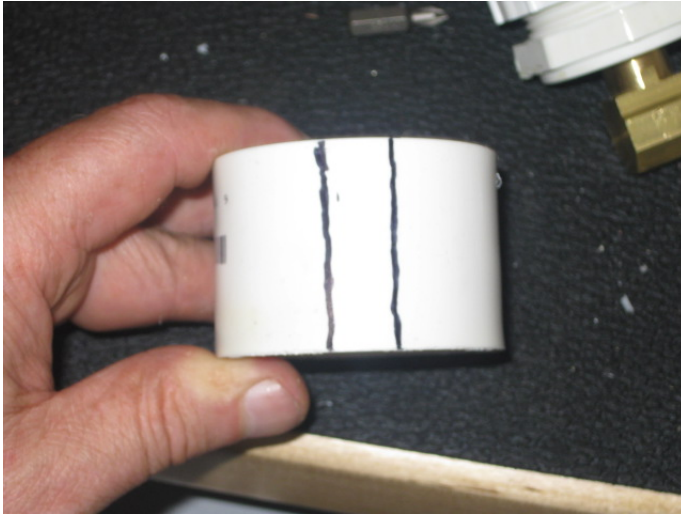
8.) Evenly place 10 of the coupling around the outer edge of the plant caddy, 5 to each side. Leave 3.5" space on each side of the metal tie rails.

9.) With the marker, draw outlines around each fitting.



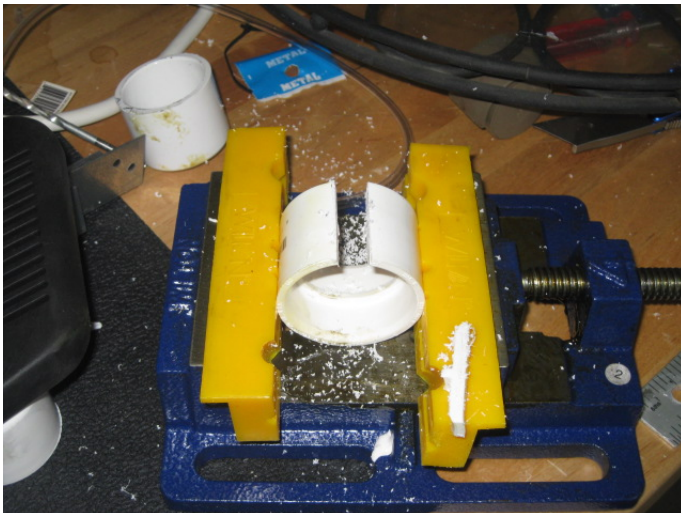
## Making Algae Photo Bioreactors at Home

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9.) Carefully draw 2 Lines next to each other going from opening to opening on the 2" inch coupling.

10.) Using a vice, carefully saw through both lines with a hacksaw.





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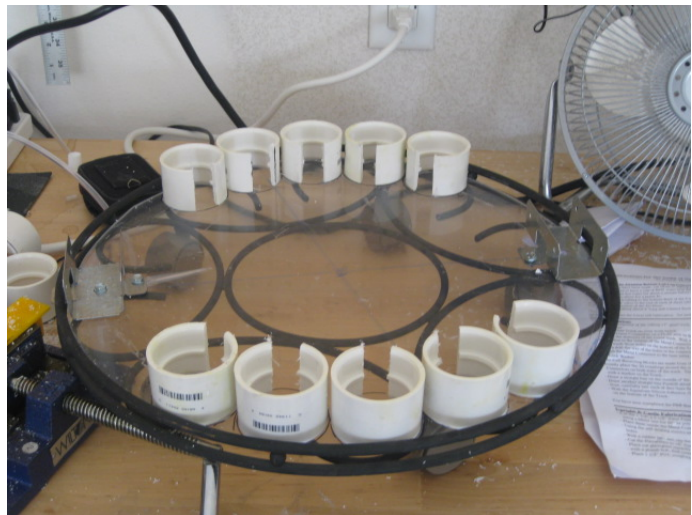
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11.) Using the aquarium sealant spread a bead around the bottom edge of the coupler.

12.) Glue the couplers onto the spots previously marked with the cut edges facing AWAY from the edge of the plant caddy.

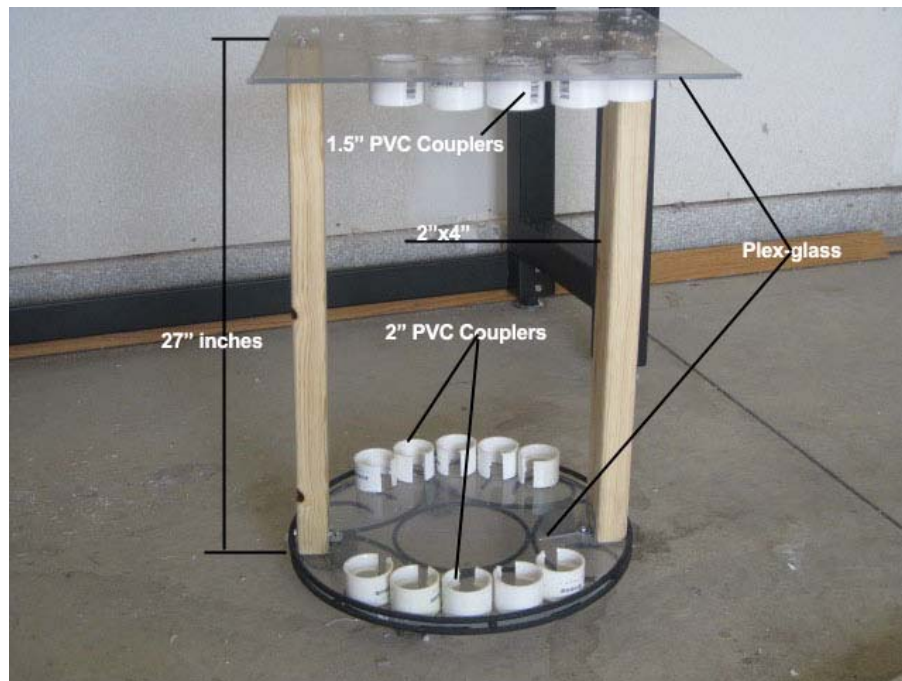
The base is completed.



# Making Algae Photo Bioreactors at Home

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## Upright and Castle Fabrication



### Materials needed:

- (1) 2"x4"x 8' stud
- (10) 1.5" couplers
- 28" x 48" x plexiglass
- (2) 2"x4" rail ties
- PVC Cement
- Wood screws and washers



### Tools Needed:

- Power drill (or drill press)
- 2" hole drill
- 1.5" drill bit
- Carpenter's square
- Plumb bob
- Jig saw
- Straight edge
- Marker



## Making Algae Photo Bioreactors at Home

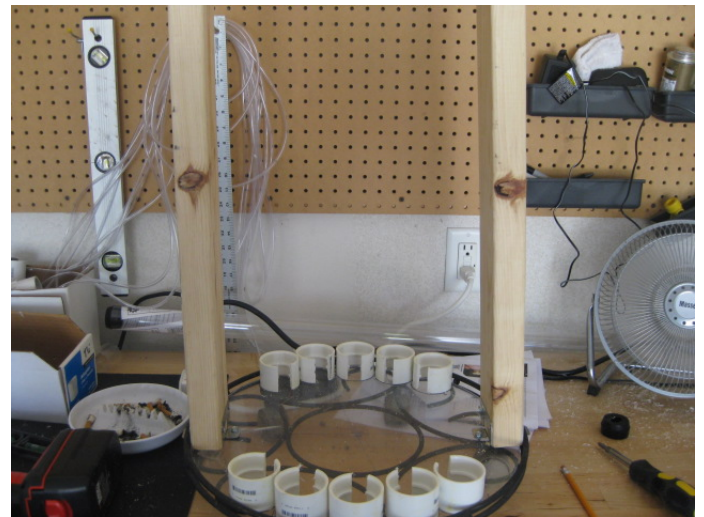
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- 1.) Cut the 2"x4" at 27" inches. Use a miter saw for this as you need a square cut.



- 2.) Place the plant caddy on your work bench. Place the cut 2"x4"'s inside the metal connectors and screw together with wood screws.

The unit should now look like this:



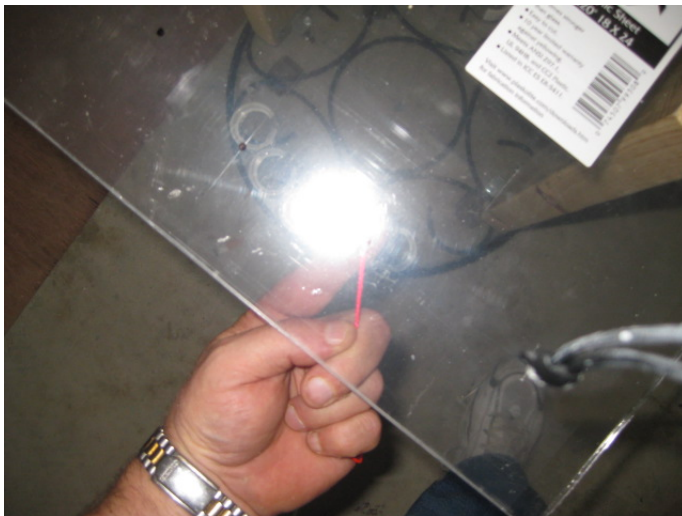
## Making Algae Photo Bioreactors at Home

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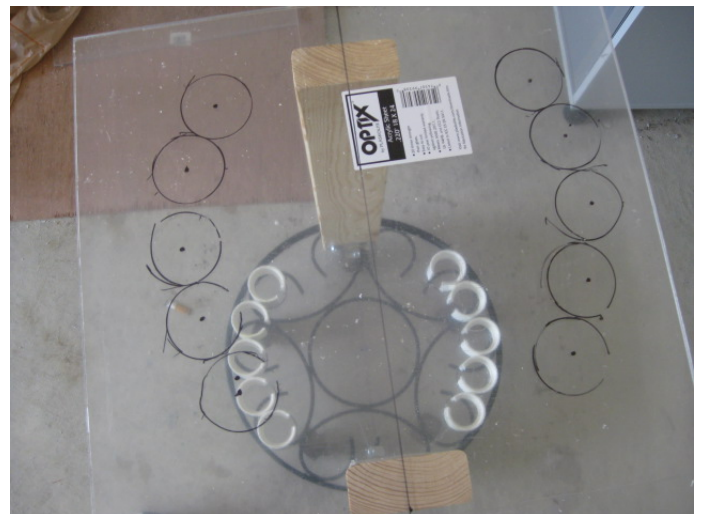
- 3.) Measure and cut the second piece of plexiglass to 18" inches square. Cut plexiglass along marked edge.



- 4.) Place the plexiglass on top of making sure the posts are squarely up and down.



- 5.) With a plumb bob, find the center of the cell receivers on the caddy below. Place on a dot on the plexiglass for the center of each cell.



- 6.) Place the 1.5" coupler on top of the plexiglass with the dot in the center and outline the outside of each coupler.



## Making Algae Photo Bioreactors at Home

- 7.) Place the plexiglass on the drill press and CAREFULLY drill out each marked hole with an 1 3/4" drill.



- 8.) Measure 9" from the edge and mark another across the middle. This should give you the exact center. With the 2" drill bit, drill a hole in the exact center of the plexiglass.

Clean the burrs off with a rounded file.



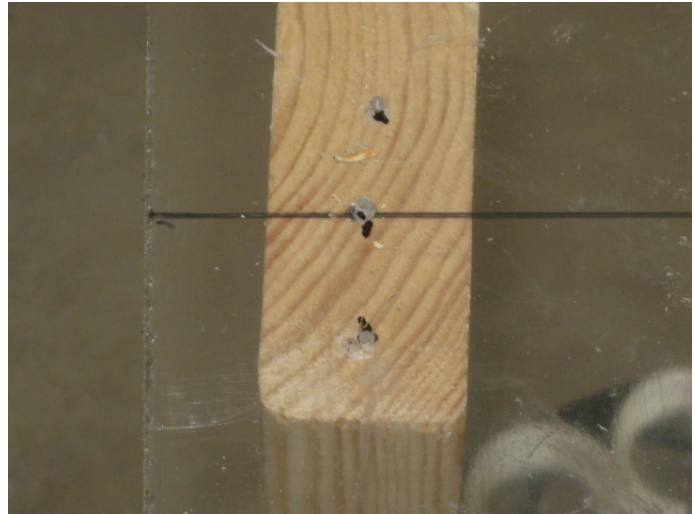
- 9.) Turn the plexiglass upside down on the work bench and using the PVC Cement, place a bead of glue around the edge of the 1.5" couplers and mount on the plexiglass.
- 10.) Repeat for all 10 holes. Allow the Cement to dry for a couple of hours.



## Making Algae Photo Bioreactors at Home

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- 11.) Flip the plexiglass over so that the couplers are facing down. Mark 3 evenly spaced dots on the plexiglass, directly where the 2"x4" is centered. Drill pilot holes in the plexiglass, then secure to the 2"x4"s.

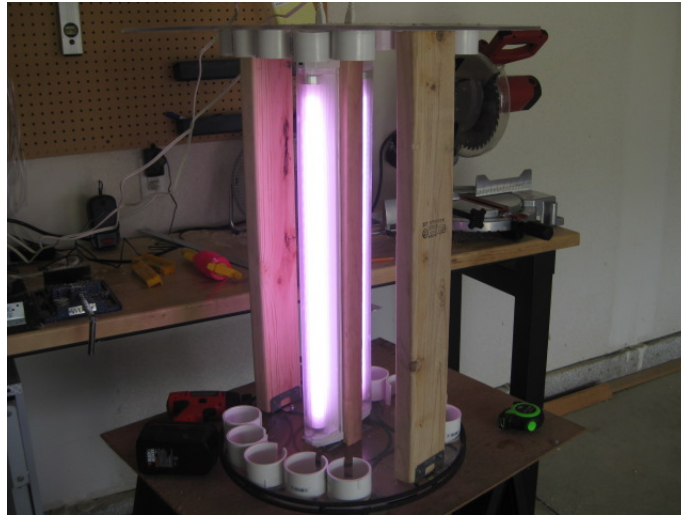


The completed castle and uprights should look like this:





## Bio Light Array Fabrication



### Materials needed:

- Left over 2"x4" stud
- (2) steels braces
- (2) Aquarium Grow lights
- Wood screws and washers



### Tools Needed:

- Power drill
- Miter saw
- Carpenter's Square
- Marker
- Vice



# Making Algae Photo Bioreactors at Home

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## Fabrication

- 1.) Unscrew the top castle from the last assembly.
- 2.) Cut the remaining length of 2"x4" at  $27 \frac{5}{16}$ th. (Never mind the photo...I screwed it up the first time...Yeah, I know, measure twice, cut once : +) Use the miter saw and get a straight, square, cut.



- 3.) Center the 2"x4" on the plant caddy. You have already made quarters and a center dot, so this is easy.

- 4.) Put your steel braces against each side and make a dot where the holes will be and pre-drill.



## Making Algae Photo Bioreactors at Home

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- 5.) Mark also the bottom holes as well.



- 6.) Pre-drill holes in the plant caddy.

- 7.) Attach the steel braces to the plant caddy and screw down.





## Making Algae Photo Bioreactors at Home

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8.) Pre-drill the holes in the 2"x4".

9.) "Dry" fit the 2"x4" into the braces. DO NOT screw the 2"x4" in place. Check to make sure height is correct.



10.) Take the 2"x4" out of the braces and lay it on your work bench. Get the Aquarium Grow light and lay the back side against the 2"x4" . Mark where the holes on the back of the light will go.

Make sure both switches are at the top.



## Making Algae Photo Bioreactors at Home

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11.) Mark the holes, and fit with screws. Do both sides of the 2"x4".

12.) Fit both lights to the 2"x4"



13.) "Dry fit" the light array into the plant caddy. It should fit snug and tight.

14.) If all looks good, take the lights off, and screw the 2"x4" into the plant caddy.



## Making Algae Photo Bioreactors at Home

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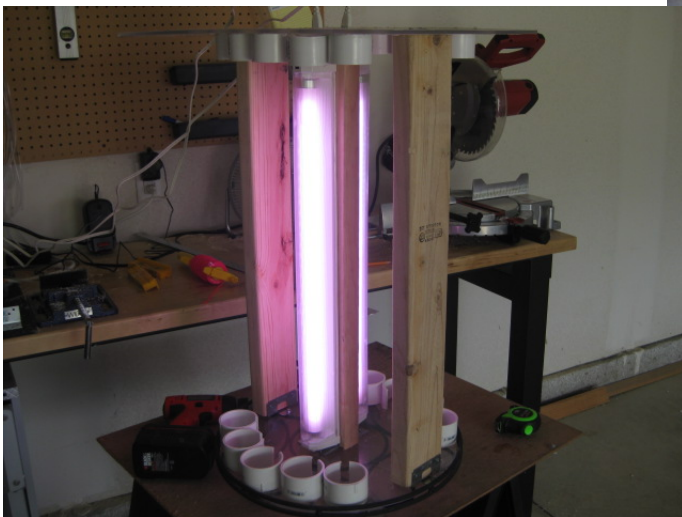


15.) Replace the top castle and make sure there is a tight fit. Mark where the cord plug receptacles are, and drill 1" inch holes on each side of the center hole to accommodate the power cords. Use a jigsaw to even out the cuts.

16.) Pre-drill two holes to either side of the large hole on the centerline to secure the 2"x4"

17.) Set the top castle in place and screw down.

18.) Line up Aquarium lights, and screw down top castle assembly.



19.) Hook up power cords to top of castle, switch on lights, and dry test to make sure all work correctly.

You have finished the Bio Light Array.

## Bio Cell Fabrication



### Materials needed:

- Cap Assembly
- (10) T-12 protector tubes

### Tools Needed:

- Miter saw
- Marker
- Adhesive



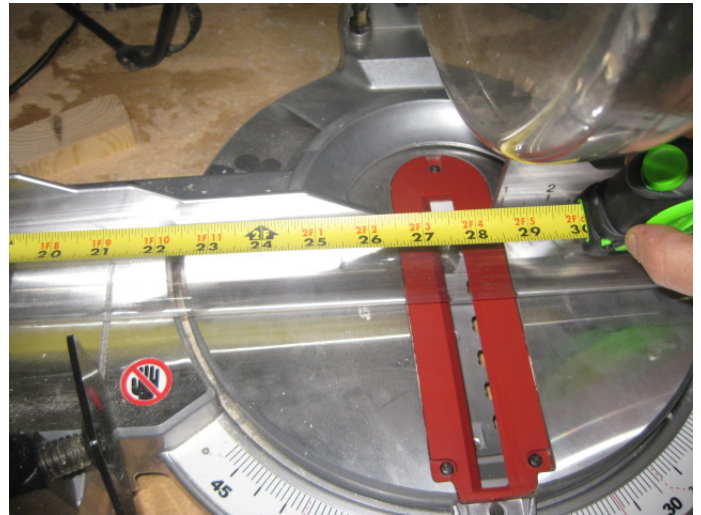


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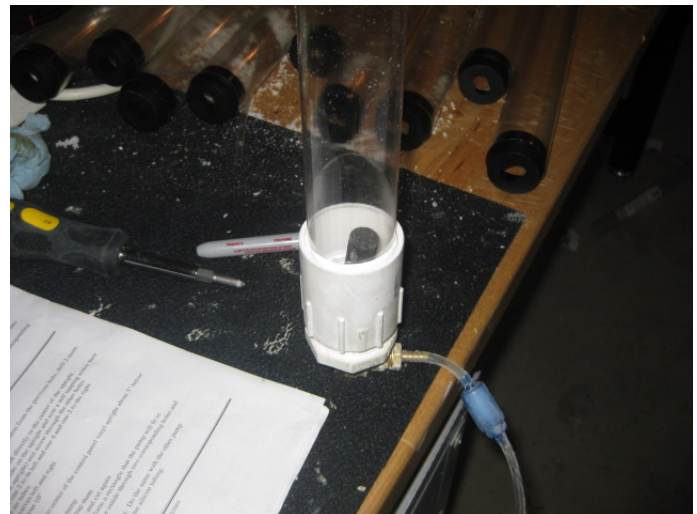
## Fabrication

- 1.) Measure and cut your T-12 tube protectors at 25 ½ " inches. Cut all ten.



- 2.) With the 3M Marine adhesive, add a bead of adhesive around the of the cut tube.

- 3.) Locate the 10 cap assemblies you fabricated earlier. Fit the tube into the cap assembly and push to the bottom snugly.



## Making Algae Photo Bioreactors at Home

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- 4.) Fit bio cells into the bottom of the base, by sliding the cell into the top first, then down into the base so that the hose barbs exit through the cuts in the coupler made previously.



- 5.) Fit bio cells into top castle

- 6.) Continue until all ten bio cells are in place.



You have completed the bio cell assembly.



## Air System Fabrication



### Materials needed:

- Left over plexiglass
- Plastic tubing
- (2) 4-way valves
- (2) 2-way valves
- (2) XP-60 air pumps
- Velcro
- Left over plastic tubing

### Tools Needed:

- Utility knife
- Drill and bit



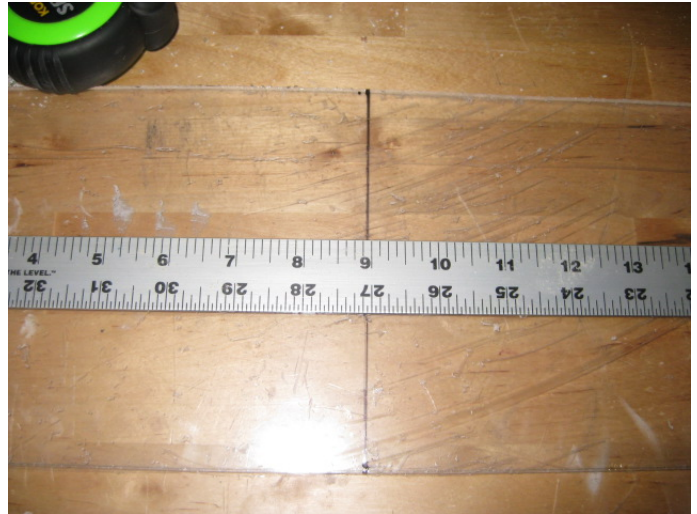


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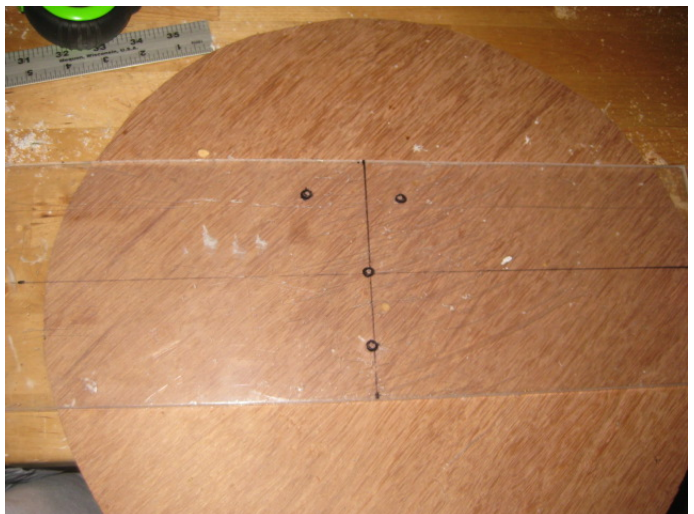
## Air System Fabrication

- 1.) Take a piece of left over plexi-glass and cut it 6" inches by 18" inches. Measure and mark directly in the middle at 9" inches. Draw a line directly down the middle.



- 2.) Measure again cross-wise at 3" inches, and make another line across so that you have the exactly middle of the plexiglass.

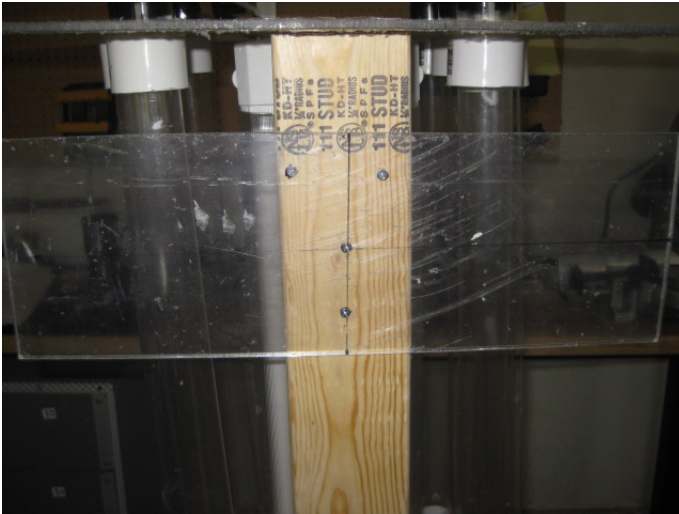
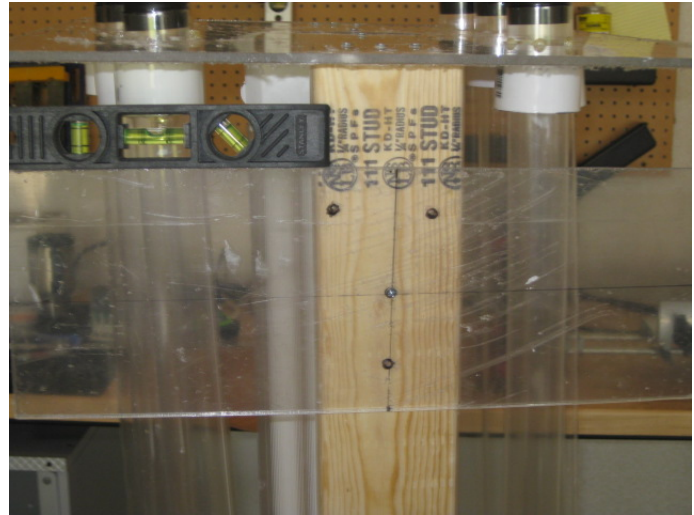
- 3.) Mark a spot directly in the middle, 2 more at the top, and one at the bottom of the centerline. Pre-drill each marked spot.



## Making Algae Photo Bioreactors at Home

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- 4.) Mount the control panel cross piece directly under the top castle, leaving 3"-4" inches of space between the top castle and the control panel. Screw in the middle screw, level, and screw in the rest of the screws.



- 5.) The mounted plexiglass should look like this.

- 6.) Mount the valves on the control panel...there is no need at the point in securing them. Simply hang them from the top.

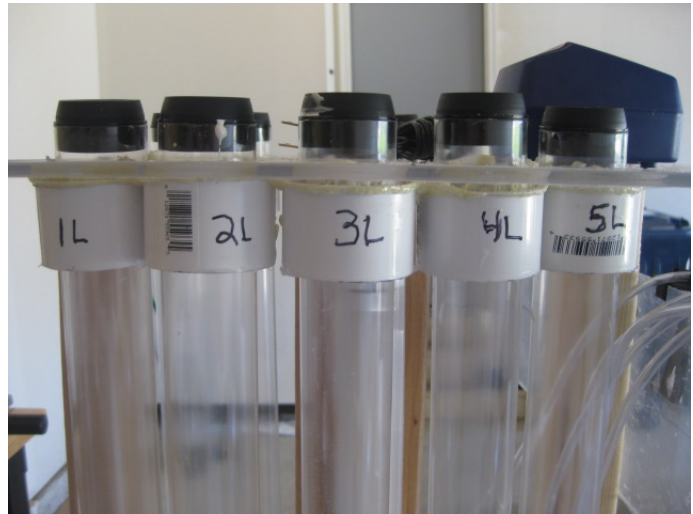




## Making Algae Photo Bioreactors at Home

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Label your bio cells at this point. Label each 1-5, L (left) and 1-5 (Right)



7.) Hook up each air line from the bio-cell to the corresponding outlet on the valve. Do this for both left and right sides. All 10 bio cells should be hooked up now.



8.) Mount the 2 air pumps, side by side, on top of the castle. Make 2 marks directly in front of each pump.

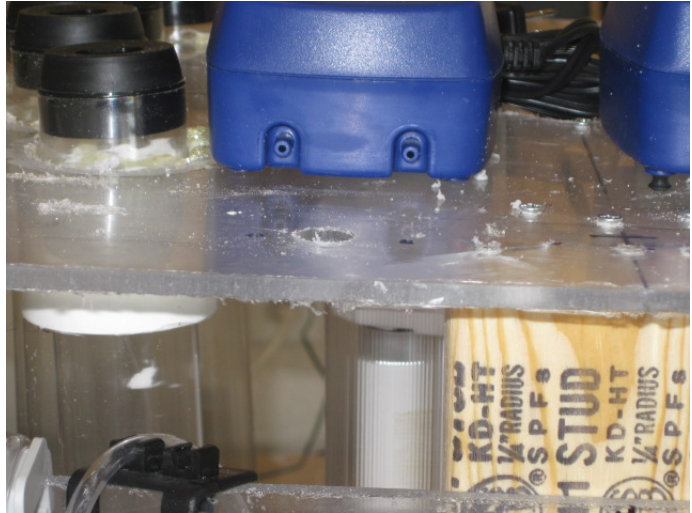




## Making Algae Photo Bioreactors at Home

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9.) Drill a 1/2" inch hole in the marked spots.



10.) Cut 4 pieces of tubing 18" inches.

10.) Hook up the tubing to the air pumps, run the tubing through the holes you just made, then hook up to the valves.



## Making Algae Photo Bioreactors at Home

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- 11.) Cut the Velcro into 3" inch pieces. Apply to one side of the air pump, and the other piece to the top castle.
- 12.) Fix air pump to the top castle.



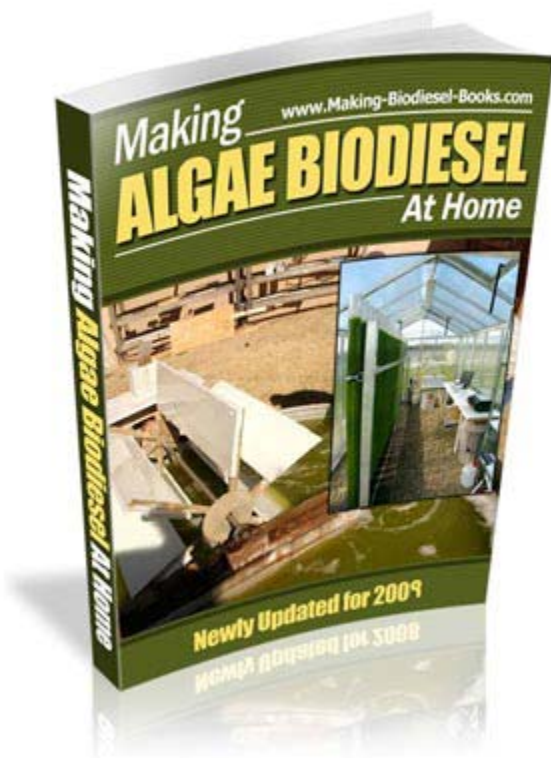
- 13.) Add some water to each cell, just enough to cover the air stones. Plug in the air pumps. Each cell should come alive with bubbling air.

You have completed the air system assembly.

Congratulations!! You have a algae photo bioreactor !



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At Home

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