

Build a Gel Electrophoresis Chamber

Step- by- step instructions for building a gel electrophoresis chamber using inexpensive materials that are easily obtained from local hardware and electronics stores.

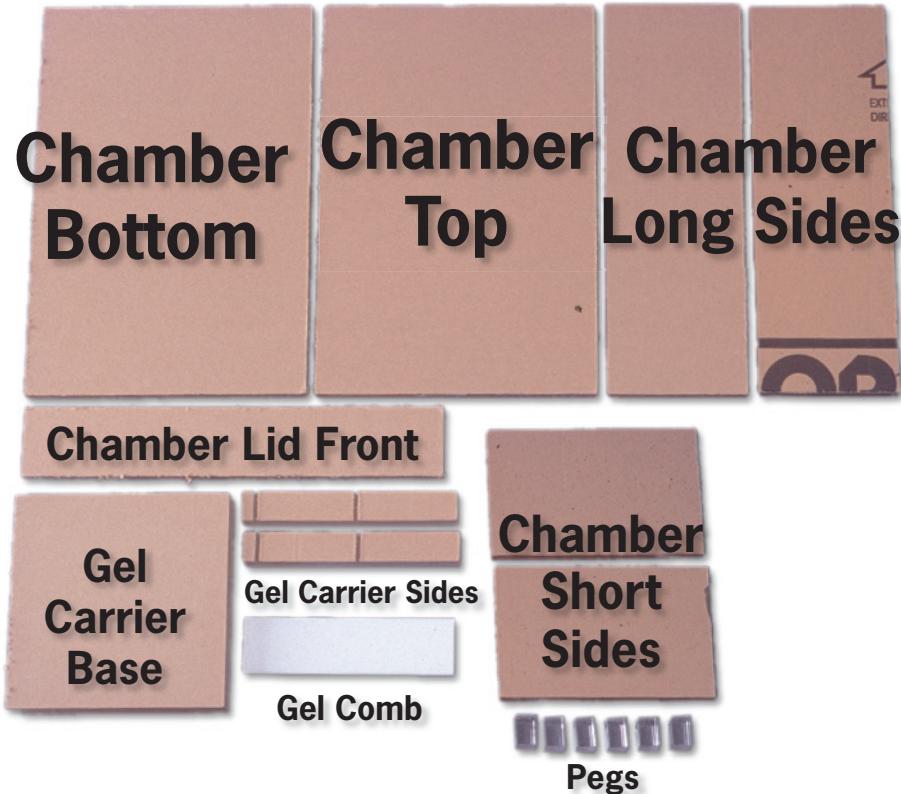
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Materials

A. Chamber Parts



Plexiglas® and Teflon®

To find a supplier, look in the Yellow Pages of your local telephone directory under the heading "Plastics - Rods, Tubes, Sheets, Etc.". Have them cut the pieces of Plexiglas® and Teflon® to size and the slots in the Gel Carrier Sides (see step 2 under "Construct the Gel Carrier"). The distributor will also be able to provide the Teflon for the Gel Comb.

- 2 pieces: 3 $\frac{3}{4}$ " by $\frac{1}{2}$ " by $\frac{1}{2}$ " thick - for Gel Carrier Sides
- 1 piece: 3 $\frac{3}{4}$ " by 3 $\frac{3}{4}$ " by $\frac{3}{4}$ " thick - for Gel Carrier Base
- 2 pieces: 7 $\frac{1}{2}$ " by 2 $\frac{1}{2}$ " by $\frac{1}{4}$ " thick - for Chamber Long Sides
- 2 pieces: 3 $\frac{7}{8}$ " by 2 $\frac{1}{2}$ " by $\frac{1}{4}$ " thick - for Chamber Short Sides
- 2 pieces: 7 $\frac{1}{2}$ " by 5" by $\frac{1}{4}$ " thick - for Chamber Lid and Chamber Bottom
- 1 piece: 7 $\frac{1}{2}$ " by 1 $\frac{1}{4}$ " by $\frac{1}{4}$ " thick - for Chamber Lid Front
- 6 pieces: $\frac{1}{2}$ " long pieces of $\frac{3}{8}$ " dowel or square rod - for pegs
- Teflon® - 3 $\frac{5}{8}$ " by 1" by $\frac{1}{16}$ " thick - for Gel Comb

Module

Do It Yourself Genetic Research

Instruction Guide

<http://gslc.genetics.utah.edu>



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Electrical Supplies

These can be purchased at hardware stores, electronics stores such as RadioShack, or ordered from an electronics supplier. All products listed below are available to order from Allied Electronics (<http://www.alliedelec.com>) as of the date of this publication.



Stackable Banana Plugs



Hex Nuts



Insulated Banana Jacks



Standard Banana Plug



Heat Shrink Tubing



Test Lead Wire

Quantity	Item	Manufacturer and Number	Description
2 feet	Black test lead wire	Pomona Electronics 6734-0	insulated, rated to at least 200 volts, black
2 feet	Red test lead wire	Pomona Electronics 6734-2	insulated, rated to at least 200 volts, red
2	Insulated Banana Jack, Black	Emerson Network Power 108-0903-001 BLACK	fits $\frac{5}{16}$ " holes
2	Insulated Banana Jack, Red	Emerson Network Power 108-0902-001 RED	fits $\frac{5}{16}$ " holes
2	Standard Banana Plug	Pomona Electronics 3263	Standard banana plug with threaded stud and solder lug, fits $\frac{9}{64}$ " holes
2	Hex Nuts	Keystone Electronics 4701	6-32, fits Standard Banana Plug
1	Stackable Banana Plug/Jack, black	Pomona Electronics 1825-0	solderless, stackable, black
1	Stackable Banana Plug/Jack, red	Pomona Electronics 1825-2	solderless, stackable, red
2 pieces	Heat Shrink Tubing, black	Alpha Wire FIT221 1/2 4' BLACK	$\frac{1}{2}$ " diameter, black, 1" pieces
2 pieces	Heat Shrink Tubing, red	Alpha Wire FIT221 1/2 4' RED	$\frac{1}{2}$ " diameter, red, 1" pieces

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Monel Seizing Wire

Other Parts

- Monel Seizing Wire or 20-gauge copper wire - 16" long piece cut in 1/2. This type of wire can be purchased at a marine (sailing) supply store.
- 15W AC-DC [24V/0.63A] Universal Power Supply. Available as of the date of this publication from www.circuitspecialists.com.



Power Supply

B. General Tools and Supplies Needed

- Weld-On 3®, Plastruct Plastic Weld®, or Methylene chloride - acrylic bonding agent for Plexiglas®
- Monoject® plastic syringe with curved tip, a 5cc syringe with a 21 gauge needle, or a glass Pasteur pipette and bulb - to apply acrylic bonding agent
- Drill Bits
 - » 9/64" - for drilling guide holes
 - » 5/16" - for drilling holes for banana jacks
- Drill press (works best) or electric drill
- X-acto® knife and pointed blade - to cut Teflon® comb
- Hammer
- Large Nail
- C clamp
- Needle-nose pliers
- Small adjustable wrench
- Wire cutters
- Wire strippers
- 1/8" wide flat-head screw driver - to unscrew stackable banana plugs
- 150 grit sandpaper - small piece
- Safety glasses
- Permanent marking pen, such as Sharpie®
- Ruler
- Forceps or tweezers
- Electric hair dryer (blowdrier) or alcohol lamp and matches - to "melt" heat shrink tubing
- Masking tape and electrical tape (optional)



Weld-On #4 Plexiglass Glue
acrylic bonding agent

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- Glass beaker (100-150 ml) - to hold acrylic bonding agent for bonding pegs
- Two 7" rubber bands (size 117B)
- Scrap lumber to drill on
- Hack saw (optional) - use for cutting slots in gel carrier sides, if needed

Directions

Plexiglass Bonding Basics

Bonding pieces of Plexiglas® together is most easily accomplished with two people working together. One person holds the pieces in position, and the other person uses a syringe or Pasteur pipette to apply a thin line of acrylic bonding agent along both sides of the seam where the two pieces of Plexiglas® meet.

The liquid should wick between the two pieces of Plexiglas® at the seam and bond them together within 2 minutes (hold them firmly together until bonded). It is very important to hold the pieces together firmly while bonding so that a leak-proof seal is made.

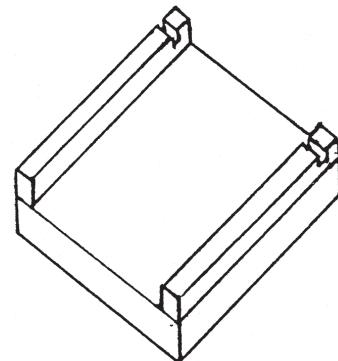
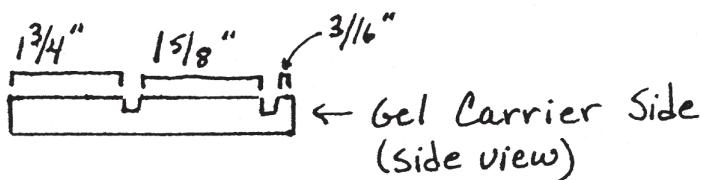
Pieces will bond best if you hold them so that the seam is horizontal. It is also better to hold the pieces so that the seam is not close to the table or surface you are working on. This allows any excess liquid to evaporate quickly. If the seam is close to or on a table or surface, the liquid may wick underneath and smear the Plexiglas®.

If a mistake is made in gluing pieces together and you discover it before the bond has fully set, the pieces can be snapped apart and re-bonded.

A. Construct the Gel Carrier

You will need the following pieces of Plexiglas®:

- 2 Gel Carrier Sides - $3\frac{3}{4}$ " by $\frac{1}{2}$ " by $\frac{1}{2}$ " thick
- 1 Gel Carrier Base - $3\frac{3}{4}$ " by $3\frac{3}{4}$ " by $\frac{3}{4}$ " thick



1. Cut a slot $\frac{3}{16}$ " from one end of each Gel Carrier Side. The slot should be $\frac{1}{16}$ " wide x $\frac{1}{8}$ " deep; the Teflon® should fit easily into the slot. If desired, cut a second slot $1\frac{5}{8}$ " from the first slot. This allows two combs to be used in the gel, providing more wells per gel. It also allows you to electrophorese

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molecules of unknown charge.

2. Remove the paper from the Gel Carrier Sides and the Gel Carrier Base.
3. Lay the Gel Carrier Base on a flat surface. Lay the Gel Carrier Sides on top, on opposite edges, along the sides.

TIP: Make sure that the slots in the Gel Carrier Sides line up.

4. Turn the Gel Carrier Base on its edge, and bond the top Gel Carrier Side to it. Turning the Gel Carrier Base on its edge while bonding prevents the bonding agent from flowing underneath and smearing the Plexiglas®.



5. Turn the Gel Carrier Base on the other edge, and bond the other Gel Carrier Side to it.

B. Cut the Gel Comb

You will need the $3\frac{5}{8}$ " by 1" by $\frac{1}{16}$ " thick Teflon® piece.

1. Copy the comb pattern onto paper or paperboard and cut it out.



2. Place the pattern in the gel carrier slots and check to make sure that the bottom edges of the comb teeth will be at least $\frac{1}{16}$ " (2 mm) above the Gel Carrier Base. It is very important that the wells in the gel formed by the teeth not go all of the way through the gel. Modify the pattern if needed.
3. Use a permanent marker to trace the pattern on the Teflon® or tape the pattern down on the Teflon®.
4. Place the Teflon® on a piece of scrap lumber or cardboard and cut out the comb using an X-acto™ knife.
5. Use fine sandpaper (150 grit) to smooth the edges of the Comb teeth so that they will not rip the wells in the gel when the Comb is removed.
6. Place the comb in the slots in the Gel Carrier sides. If it does not slide in and out of the slots easily, sand the flat surface of the Teflon® so that it slides easily.
7. Again place the comb in the slots in the Gel Carrier sides. Check that the bottom edge of each comb tooth is at least $\frac{1}{16}$ " (2mm) above the Gel Carrier



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Base. If any are not, sand them down.

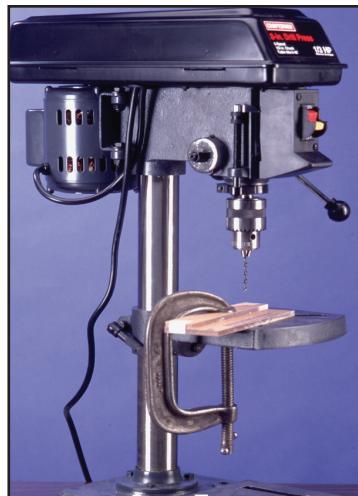
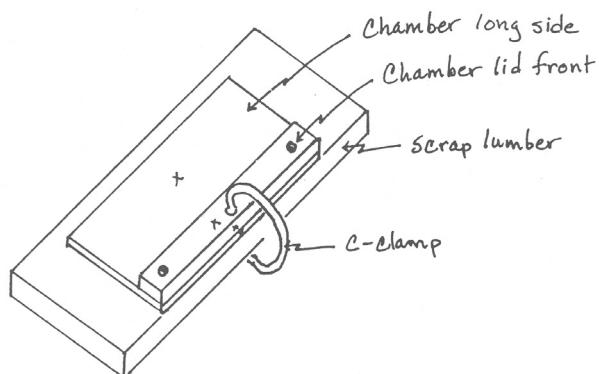
C. Drill Holes for the Leads to the Power Supply

You will need the following pieces of Plexiglas®:

- Chamber Long Side - one of the 7 $\frac{1}{2}$ " by 2 $\frac{1}{2}$ " by 1/4" thick pieces
- Chamber Lid Front - 7 $\frac{1}{2}$ " by 1 $\frac{1}{4}$ " by 1/4" thick

TIP: Do not remove the paper from these pieces until you are ready to bond them together

1. Lay the Chamber Lid Front on top of the Chamber Long Side, matching the two pieces along one long edge and the two sides. Tape the two pieces together with masking tape so that they do not slip while drilling.
2. Mark "X's" on the matched long edges and "X's" on the paper of the sides facing you. This will assist you in bonding the pieces together in the correct orientation later.
3. On the Chamber Lid Front, measure in 1" from each short end and make a pencil mark. Measure down $5\frac{1}{8}$ " from the long edge and make cross marks in the centers of the first marks; you should have a "+" mark at each end of the Lid Front.
4. Place the point of a nail at the center of each "+" mark and tap the head of the nail with a hammer to make a guide hole for the drill bit.
5. If you are using a drill press, clamp the Plexiglas® pieces to the drill platform using a C clamp or other clamp. If you are using an electric hand drill, place the Plexiglas® pieces on top of a piece of scrap lumber. Place a C clamp in the center of the long edges of the Plexiglas® and clamp the Plexiglas®/wood sandwich onto a table top in preparation for drilling.
6. Use a $\frac{9}{64}$ " drill bit to drill holes through both pieces of Plexiglas® in the places you made the guide holes (in the center of the "+" marks).



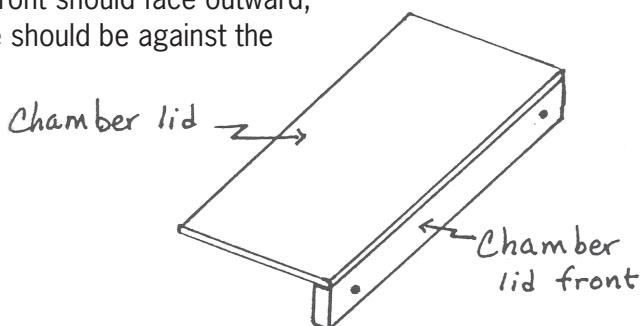
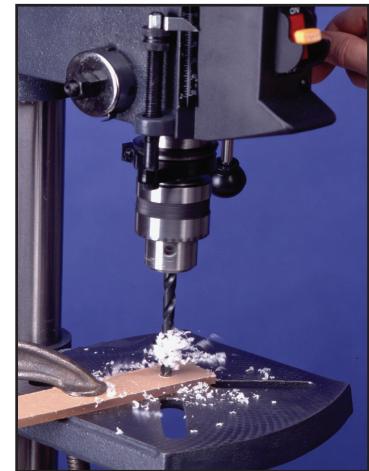
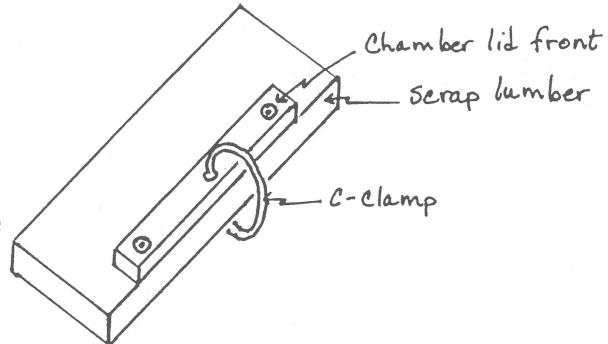
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7. Unclamp the Plexiglas® and remove the masking tape holding the two pieces together.
8. Clamp the Chamber Lid Front down for drilling with the side opposite the "X" up. Remember the piece of scrap lumber if you are using an electric hand drill.
9. Use the $5/16"$ bit to drill through the entire thickness of the Lid Front, centering the tip of the drill in the $9/64"$ holes

D. Construct the Chamber Lid

You will need the following pieces of Plexiglas®:

- Chamber Lid Front - $7\frac{1}{2}$ " by $1\frac{1}{4}$ " by $\frac{1}{4}$ " thick piece with holes drilled
 - Chamber Lid - one of the $7\frac{1}{2}$ " by 5" by $\frac{1}{4}$ " pieces
1. Remove only the paper marked with an "X" from the Chamber Lid Front. Use a marker to place an "X" on the Plexiglas®. Now remove the paper from the other side.
 2. Remove the paper from the Chamber Lid.
 3. Bond the Chamber Lid Front to the Chamber Lid. The "X" on the face of the Chamber Lid Front should face outward; the "X" on its edge should be against the Chamber Lid.



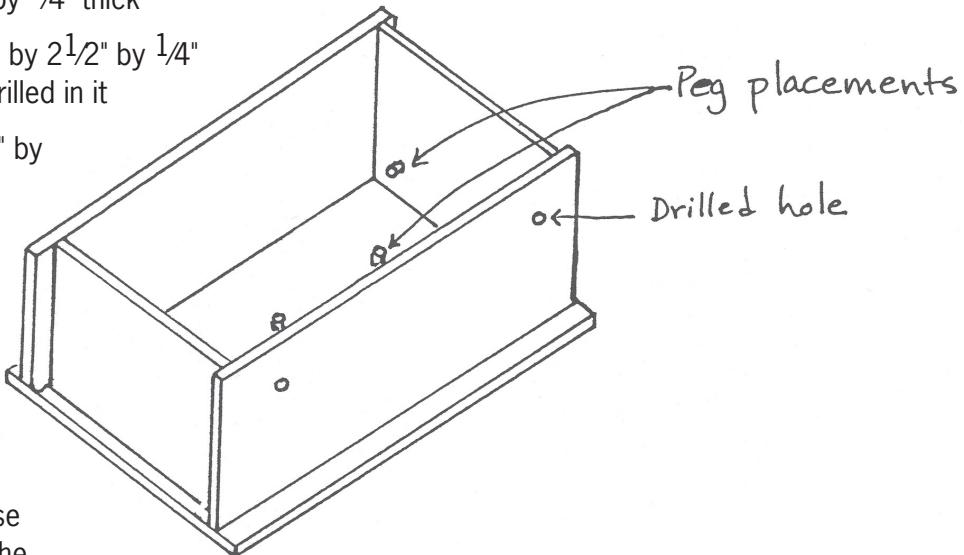
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E. Construct the Electrophoresis Chamber

You will need the following pieces of Plexiglas®:

- Chamber Bottom - 7½" by 5" by ¼" thick
- Chamber Long Sides (2) - 7½" by 2½" by ¼" thick, one of which has holes drilled in it
- Chamber Short Sides (2) - 3¾" by 2½" by ¼" thick

1. Remove the paper from the Chamber Bottom and lay the bottom on a flat surface.
2. Remove only the paper marked with an "X" from the Chamber Long Side that has holes drilled in it. Use a marker to place an "X" on the Plexiglas®. Now remove the paper from the other side.
3. Remove the paper from the other pieces of Plexiglas®.



TIP: The following bonding steps require two people working together and/or the use of large rubber bands.

4. Use the Chamber Long Sides and the Chamber Short Sides to form a box on top of the Chamber Bottom; the 2½" sides are perpendicular to the base. The Chamber Short Sides should be between the Chamber Long Sides. Hold the pieces in place, making sure that there are no gaps. The Chamber Long Side that has "X's" marked on it should be oriented as follows: the X on the surface should be on the outside; the X on the edge should be on the top.

TIP: Slightly inset the Chamber Short Sides from the edge of the base. This will keep the bonding agent from flowing under the Chamber Bottom and smearing it.

TIP: Use two large rubber bands to hold the sides in position while you are bonding them.



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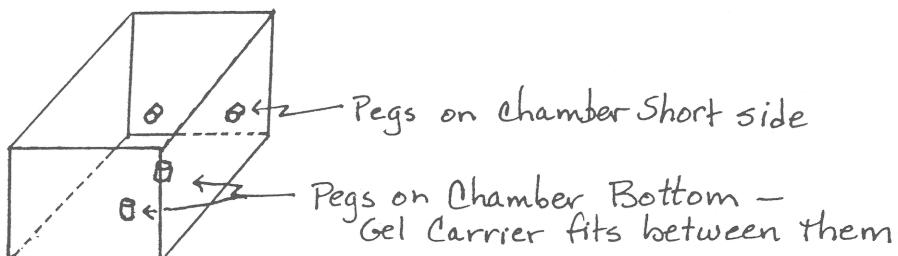
5. First bond the bottom edges of the square to the Chamber Bottom. Then turn the chamber on successive sides so that the seams you are bonding are horizontal. Remember to place bonding liquid on both the inside and outside edges of each seam.
6. Fill the chamber with water to test for leaks. Re-seal seams with the bonding agent if you find any leaks.



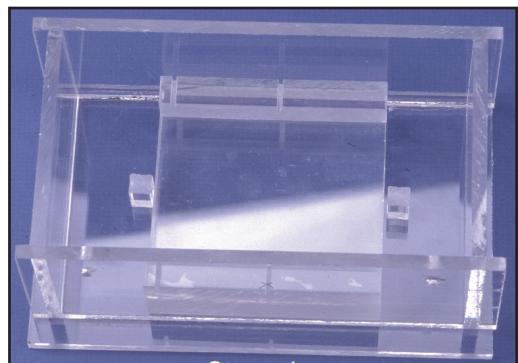
F. Place the Pegs in the Electrophoresis Chamber

You will need the following pieces of Plexiglas®:

- Electrophoresis Chamber (from previous step)
- Gel Carrier (already constructed)
- 6 Pegs - 1/2" long pieces of 3/8" dowel or rod



1. Sand the bottoms of the pegs to remove any burrs; they must be smooth to bond well.
2. Place the Gel Carrier in the center of the Electrophoresis Chamber with the Gel Carrier Sides parallel to the long sides of the Chamber.



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- Bond a peg on the bottom of the Chamber on either side of the Carrier; the pegs are centered along the two edges of the Carrier and are not tight against it.

TIP: To bond the pegs, grasp one end with forceps/tweezers. Dip the other end into the acrylic bonding agent and then place the peg in the chamber.

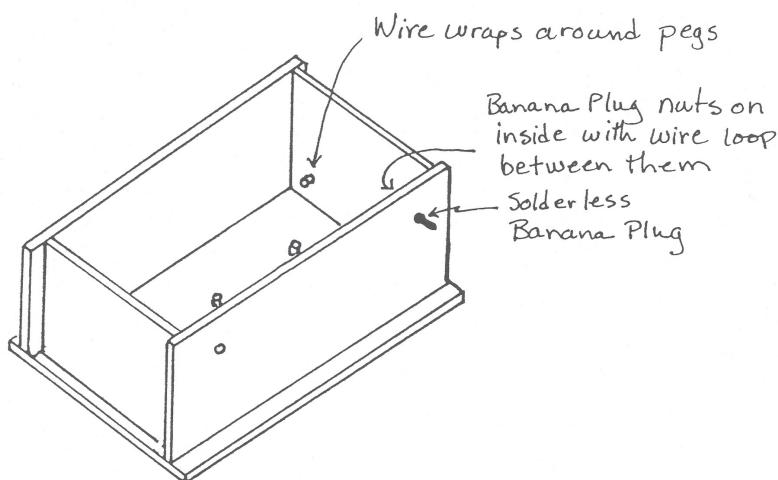
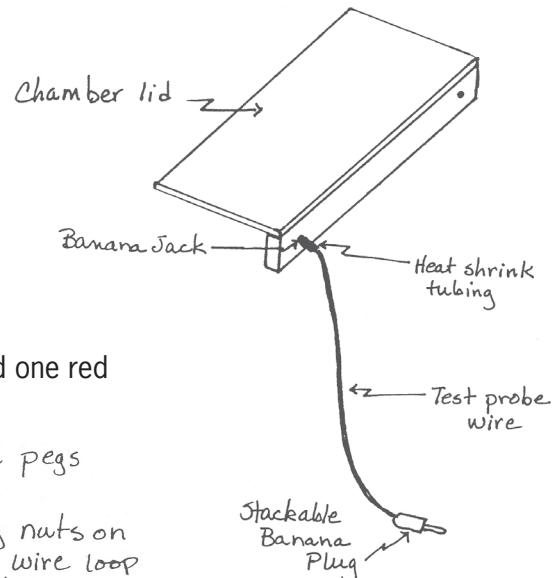
- Remove the Gel Carrier from the Electrophoresis Chamber.
- Place the chamber on one short side. Bond 2 pegs on this side, approximately $\frac{3}{8}$ " up from the bottom of the chamber and $\frac{1}{2}$ " in from the sides.
- Remember to turn the chamber so that the surface on which you are placing the peg is horizontal.
- Place the chamber on its other short side and repeat the process



G. Wire the Electrophoresis Chamber

You will need:

- 2 Insulated Banana Jacks
- 2 Standard Banana Plugs
- 2 nuts to fit Standard Banana Plugs
- 2 Stackable Banana Plugs
- 2 feet each of black and red Test Lead Wire
- Monel Seizing Wire or 20-gauge copper wire
- 2 - 1" pieces of $\frac{1}{4}$ " diameter Heat shrinking tubing, one black and one red

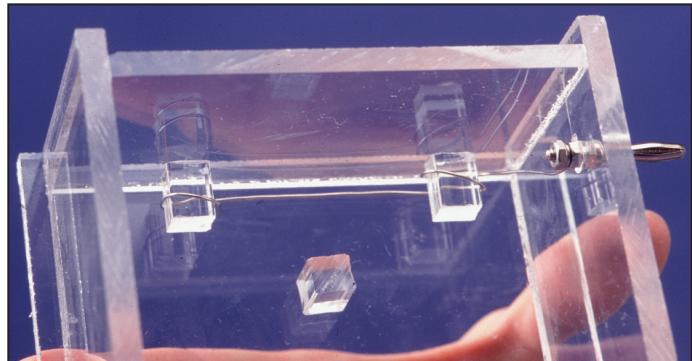


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1. Install a Standard Banana Plug in each of the two holes you drilled in the Electrophoresis Chamber Long Side. The Plug ends should face outward, with a nut on the inside of the chamber. Use a small adjustable wrench to help tighten the Plugs in place.
2. Place the second nut on the threaded side of the Plug but do not tighten it.

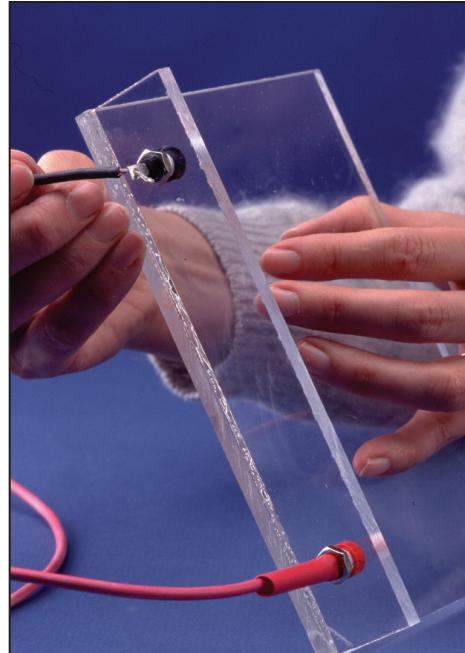


3. Use one piece of Monel or copper wire to form the electrode on the right side of the Electrophoresis Chamber. Form a small loop in one end of the wire. Place the loop between the two nuts on the Standard Banana Plug. Tighten the nuts on the wire to form a good electrical connection.
4. Loop the wire once around the peg closest to the Jack, then loop it around the other peg. Cut off any excess wire. Do not solder this wire into place since you will need to change it when it wears out. If you use copper wire, it will react with the electrophoresis buffer, turning the buffer blue. Use new buffer for each gel run.
5. Repeat Steps 3-4 on the left side of the Electrophoresis Chamber.

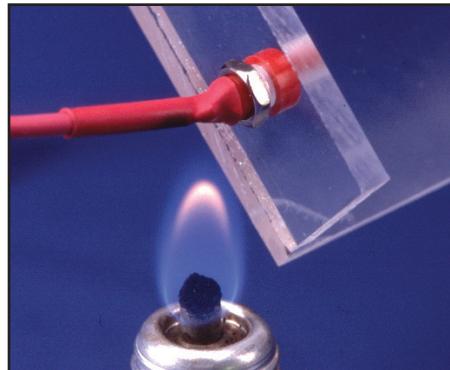


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6. Install the Banana Jacks in the two holes you drilled in the Electrophoresis Chamber Lid Front. Place the black Jack in the right hole and the red Jack in the left hole; the terminal ends and nuts face outward. Use a wrench to tighten the nuts.
7. Use wire strippers to strip off about $\frac{3}{4}$ " of insulation from the end of the black Test Lead Wire.
8. Thread the stripped Wire end through the hole in the metal part of the Jack and twist the stripped wire back on itself. Make sure it feels tight.
9. Thread the piece of black heat shrinking tubing over the Test Lead Wire. Make sure to cover the metal piece on the back of the Jack.



10. Use an alcohol lamp or hair dryer (high heat setting) to heat the tubing to shrink it around the pieces. Do not place the tubing directly in the flame. Rotate the pieces in the heat to shrink the tubing evenly.
11. Repeat Steps 6 - 10 with the red Banana Jack, red Wire, and red heat shrinking tubing.



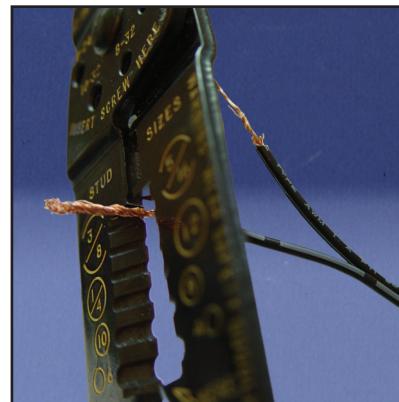
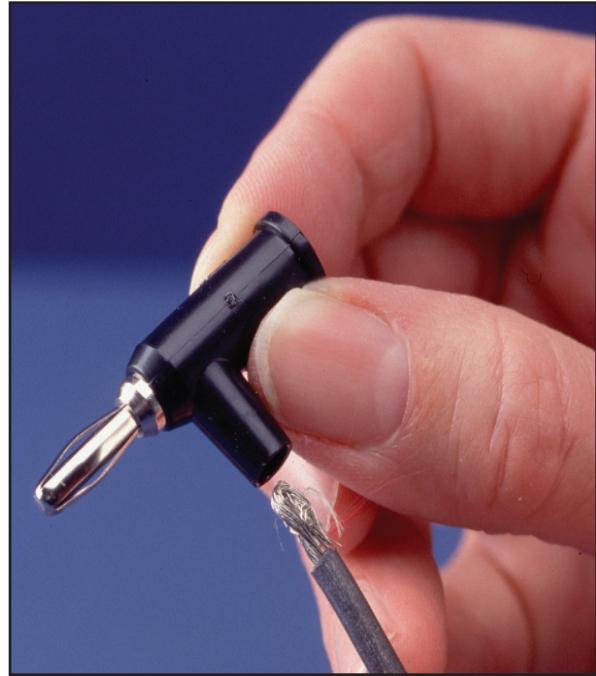
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12. Strip about $1/2"$ of insulation off of the end of the black Wire (there is a Banana Jack at the other end).
13. Take a small screwdriver and unscrew the screw inside the black Stackable Banana Plug. Do not completely remove the screw.
14. Double the stripped end of Wire on itself and thread it through the opening of the Plug. Then tighten the screw to keep the Wire in place.
15. Repeat Steps 12-14 with the red Wire and red Stackable Banana Plug. Your gel chamber is now complete!

Optional: Place a thin strip of black electrical tape across the bottom of the Gel Carrier under the comb. The black surface makes it easier to visualize the wells when loading the gel. The black surface will make it difficult to visualize food color or dye separation in the black area; place the electrical tape so that it does not extend past the wells toward the long end of the gel.

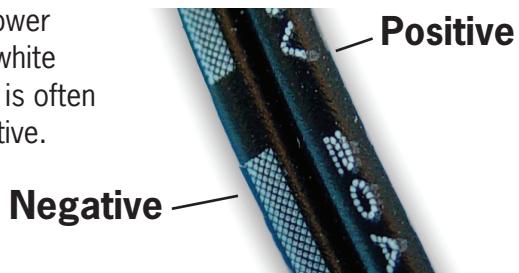
H. Build the Power Supply

1. Use wire cutters to cut off the plug end of the power supply.
2. Separate the strands and strip the insulation off the ends.

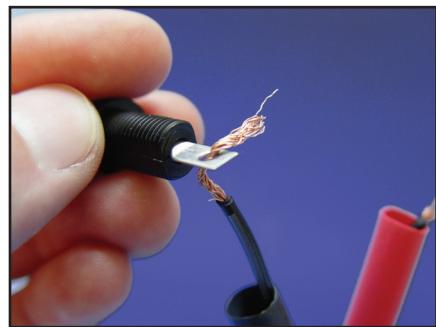


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3. Determine which wire is positive and which is negative. On most power supplies, such as the one used here, the negative wire will have a white stripe on the insulation. Also, the wire with writing on the insulation is often positive. You can use a voltmeter to distinguish positive from negative.



4. Slide the black heat shrink tubing over the negative terminal and the red heat shrink tubing over the positive terminal.



5. Attach the black banana jack to the negative terminal and the red banana jack to the positive terminal.
 6. Slide the heat shrink tubing up over the jack and shrink into place.
 7. You can now plug the banana plugs from your gel electrophoresis box into the power supply when you wish to run a gel.



Credits

The initial plans for constructing a Plexiglas® electrophoresis chamber were obtained from Rob Wheeler, Rampart High School, Colorado Springs, CO.

These plans were modified by Lisa Romero de Mendoza, Program Coordinator, and the instructions were written by Louisa A. Stark, Ph.D., Senior Scientist, both with the Hughes Undergraduate Biological Sciences Education Initiative, University of Colorado at Boulder.

The plans were further modified by Dr. Stark, currently Director of the University of Utah Genetic Science Learning Center.

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