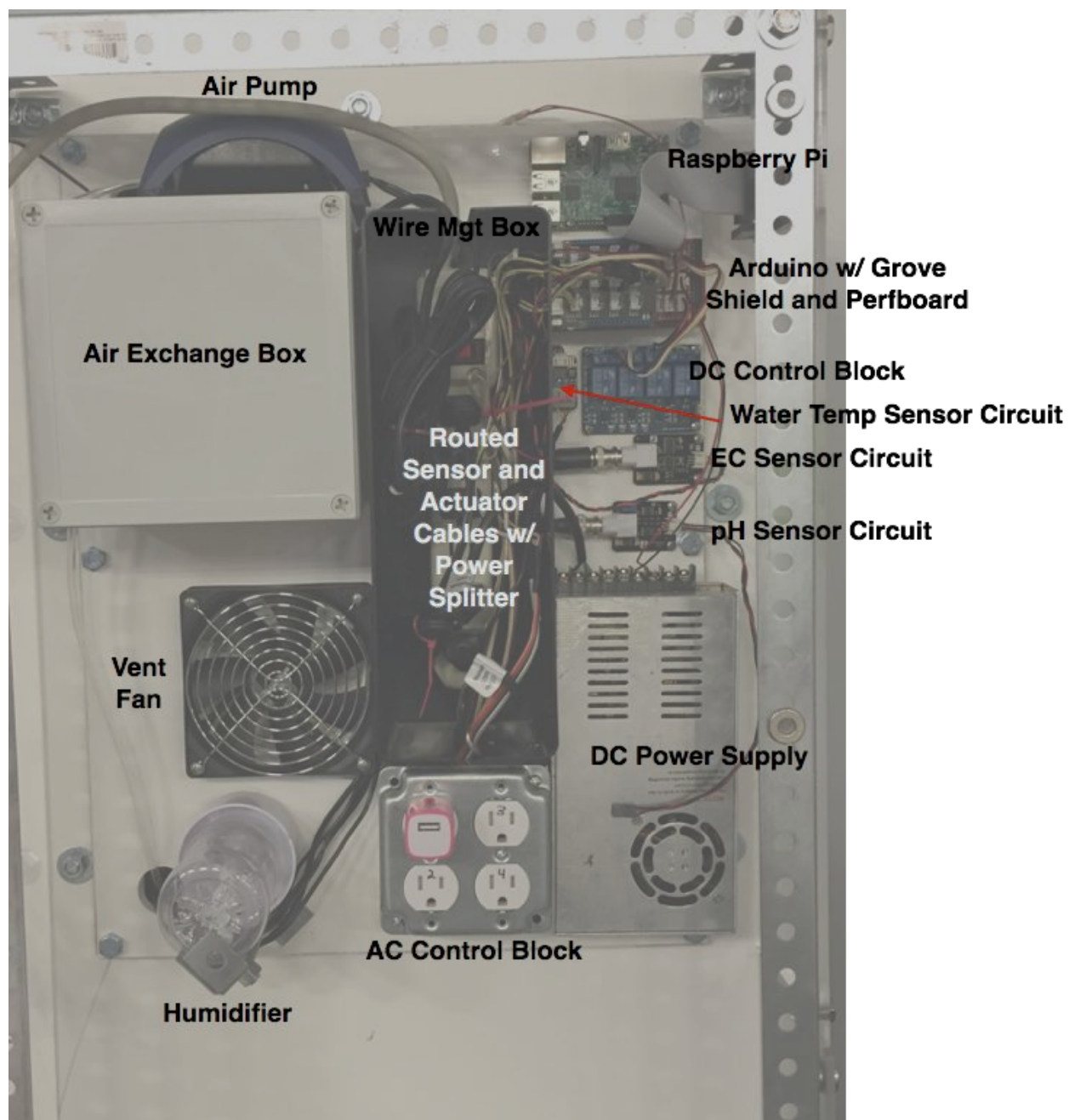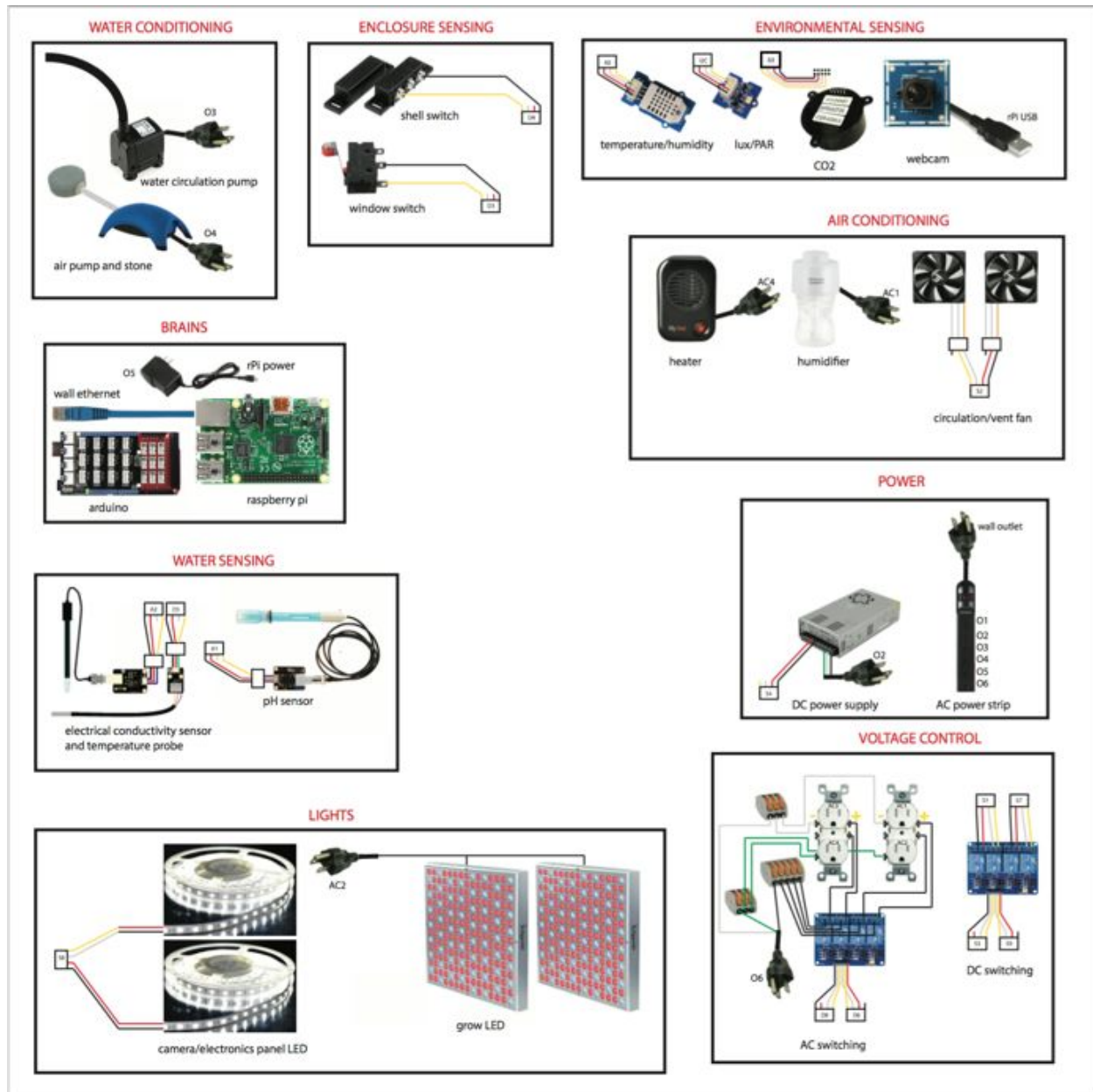Plant side of electronics panel

User side of electronics panel

(a larger zoomable copy of this schematic is in the documentation)

*Assembling the electronics panel is tricky but manageable, you just have to consult two or three of the diagrams at once. The pictures of position give an indication of where the components are placed on the panel. The schematic gives real wiring/polarity directions for assembling the subcomponents. Soldering will be required to join some wires.

1. <u>**120VAC Control Module**</u>
   a. Materials

i. 2-gang box bottom
ii. 2-gang box top
iii. 2-channel AC socket x2
iv. 4-channel relay
v. Female jumper-to-grove cable x2
vi. 6-channel, male-to-female jumper wire
vii. 6 foot, 3-prong extension cable
viii. 3-port, Wago, lever connector x2
ix. 5-port, Wago, lever connector
x. 0.5" screw x4

b. Tools
i. Medium, phillips screwdriver
ii. Wire strippers
iii. Hot glue gun
iv. Hammer

c. Tools Consumables
i. Hot glue
ii. Electrical Tape
iii. Duct tape
iv. Permanent Marker

d. Instructions
i. Create shortened AC connector (10" total length, male).
   1. Cut the extension cord 8" away from the base of the male side of the cable. The total cable length will be approximately 10".
   2. Strip off approximately 2" of the outer encasement from the cable.
   3. Strip off approximately ½" of insulation from each of the three wires that are now exposed.
ii. Tap out a center tab from the 2-gang box bottom
iii. Feed the exposed wire end on the extension cable through this hole and connect to the wago lever connectors. **IMPORTANT**: you must put the extension cable through the hole **before** attaching the connectors otherwise the cable will not fit through later in the assembly.
   1. Connect the black wire (hot) to a 5-port connector
   2. Connect the white wire (neutral) to a 3-port connector
   3. Connect the green wire (ground) to a separate 3-port connector
iv. Create intermediary AC wires (6" segments - x6 BLK, x3 GRN, x3 WHT)
   1. Using the remains of the extension cable cut x6 - 6" segments and pull out all the wires from the encasement.
   2. Strip each wire such that there is approximately 1" of exposed wire on one end and ½" of exposed wire on the other end. Create x6 black wires, x3 green wires, and x3 white wires.
v. Create x2 modified AC sockets

1. **Break off the tab connecting the "hot" screw terminals**. The "hot" screw terminals have gold screws and are labeled "hot" on the back of the sockets. Note: this tab is located in between the screw terminals and is a very small lip that is the same gold color as the plating around it.
2. Using the permanent marker, label the top plug on one of the sockets "1" and the bottom plug "2". Do the same on the other socket, however, label them "3" and "4".
3. Bend the protruding mounting tabs that are located on the top and bottom of the socket so they form 90 degree angles and are able to fit into the 2-gang box
4. Connect the 1" end of a black wires to each "hot" screw terminal on the socket. Remember: the "hot" terminals have the golden screws and are labeled on the backside of the socket. You will connect two black wires per socket.
5. Connect the 1" end of a white wire to either of the neutral screw terminals on the socket. These terminals have silver screws and are also labeled on the back of the socket.
6. Connect the 1" end of a green wire to the ground screw terminal on the socket. The ground screw terminal is green.

vi. Connect the ground and common from both AC sockets to the Wago 3-port lever connectors containing the ground and common from the extension cable, respectively.

vii. Connect the AC sockets to the relay block.
1. Connect the black wire ("hot") from the socket labeled "1" to the middle screw terminal labeled K1 on the relay block. Do this for sockets 2,3,4 connecting to K2, K3, and K4 respectively.
2. When viewing the screw terminals on the relay block head on, connect x4 black wires to the left terminal in each of K# block.
3. Connect all 4 of the black wires connected to the left terminal on the relay block to the Wago 5-port lever connector containing the black wire from the extension cable.

viii. Screw the sockets to the 2-gang box top such that the 1-2 socket is on the left and the 3-4 socket is on the right.

ix. Connect control cables to the relay block
1. Connect the 6-channel, male-to-female jumper cables to the 6 exposed header pins on the relay block
2. To keep headers securely fastened, squirt a hefty amount of hot glue around the connection.
3. Using a single female jumper-to-grove cable, connect the **black** wire on the grove cable to the wire attached to **GND** on the relay**,**the **white** wire on the grove cable to the wire attached to **IN1** on the relay**,** the **yellow** wire on the grove cable to the wire

attached to **IN2** on the relay. This cable will connect to the **D8** receptacle on the arduino grove shield so it is recommended you use the permanent marker to label the end of the connector "D8".

4. Using the other female jumper-to-grove cable, connect the **red** wire on the grove cable to the wire attached to **VCC** on the relay,the **white** wire on the grove cable to the wire attached to **IN3** on the relay, the **yellow** wire on the grove cable to the wire attached to **IN4** on the relay. This cable will connect to the **D6** receptacle on the arduino grove shield so it is recommended you use the permanent marker to label the end of the connector "D6".

5. For each cable, hot glue the connection between the male-to-female jumper cable and the female jumper-to-grove cable and then wrap the connection in electrical tape once the hot glue dries

6. Route these cables out of the box from the same hole that was knocked out to insert the extension cable.

x.   Insulate the bottom of the relay block

1. Place a layer of electrical tape on the bottom of the relay block
2. Place a layer of duct tape over the layer of electrical tape on the bottom of the relay block

xi.   Using the small screws, attach this module to the motherboard on top of the footprint labeled "AC"

xii.   Screw in the top of the 2-gang box

xiii.   Once the wire management module is built, the extension cable will plug into the power strip.

xiv.   Test the device by plugging in something to each AC port. Use 5V and the ground pin of an Arduino to power and activate each relay channel on the relay block.

2. **12V-30A Power Supply Module**
   a. Materials
      i.   12V-30A power supply
      ii.   6 foot, 3-prong extension cable
      iii.   4-pin, buckled, 50cm grove cable
      iv.   14" x 1" mounting tape
   b. Tools
      i.   Medium, phillips screwdriver
      ii.   Wire strippers
      iii.   Tape measure
      iv.   Multimeter
   c. Instructions
      i.   Create shortened AC connector (10" total length, male).

1. Cut the extension cord 8" away from the base of the male side of the cable. The total cable length will be approximately 10".
2. Strip off approximately 2" of the outer encasement from the cable.
3. Strip off approximately 1" of insulation from each of the three wires that are now exposed.

ii. Connect shortened AC connector to power supply (BLK-L, WHT-N, GRN-GND)
1. Connect the **black** wire (hot) from the shortened ac connector to the screw terminal on the power supply with the **"L"**symbol overhead. Note: a better connection is made by placing the wires on the left hand side of the screw so that when the screw is tightened (turned to the right), the wire stays within the receptacle.
2. Connect the **white** wire (neutral) from the shortened ac connector to the screw terminal on the power supply with the **"N"** symbol overhead.
3. Connect the **green** wire (ground) from the shortened ac connector to the screw terminal on the power supply with the **"GND"** symbol overhead. Note: the GND, or ground, symbol is the the symbol with multiple horizontal lines.

iii. Create modified grove cable
1. Cut off one side of the grove cable very close to the base. Either side will work.
2. Strip off approximately 1" of insulation from the red and black wires. Do nothing with the white and yellow wires.

iv. Connect modified grove cable to the power supply
1. Connect the **black** wire from the grove cable to one of the **-V** screw terminals on the power supply.
2. Connect the **red** wire from the grove cable to one of the **+V** screw terminals on the power supply.

v. Tune power supply so it outputs exactly 12V
1. Use the multimeter to probe the +V and -V terminals on the power supply. Using the adjustment screw, tune the output voltage to be as close to 12V as possible.

vi. Apply 2 strips of approximately 7" strips of mounting tape to the underside of the power supply and place it nearly flush against the AC control module. The bottom of the power supply should be tangent with the bottom of the AC relay box leaving approximately ¼" gap between the two verticals.

vii. Once the wire management module is built, the **AC extension cable** will plug into the **power strip**.

viii. Once the arduino protoshield module is built, the **grove connector** will plug into **S4**.

3. **Air Exchanger Module**
    a. Materials
        i. Heater
        ii. 7" x 7" x 5" project box
        iii. USB-to-AC converter
        iv. 6" Fans x2
        v. 6" Fan Guards x3
        vi. 4" Louvre
        vii. Humidifier
        viii. 6" x ½" weather stripping
        ix. Air pump
        x. Air stone
        xi. 24" of .125" inner diameter tubing
        xii. Small (.5") screws x4
        xiii. Medium (1") screws x4
        xiv. Long screws (1.5") x4
        xv. Standoffs (can just use bolts from frame) x4
    b. Tools
        i. Power Drill
        ii. 1 ¾" hole saw drill bit
        iii. 4 ½" hole saw drill bit
        iv. 12" x 1" mounting tape
        v. Hand file
    c. Instructions
        i. Create modified project box.
            1. A few tips before starting. First mark all holes on the box. Check they are in the correct positions. When drilling each hole, drill pilot holes first. Then, create groove by running hole saw bit in reverse direction. Finish cut by running hole saw bit in forward direction. For the large hole saw bit you may need to do the entire cut by running the bit in the reverse direction. After cuts are made, clean up edges with a file.
            2. When viewed from the back of the box, drill a 4 ½" diameter hole that is centered 2 ⅜" right and 2 ⅜" up from the bottom left corner.
            3. When viewed from the back of the box, drill a 1 ¾" diameter hole that is centered 1" left and 2 ⅜" up from the bottom right corner.
            4. When viewed from the right of the box (from the front of the box), drill a 1 ¾" diameter hole that is centered 1 ½" left and 1 ½" down from the top right corner of the box.
        ii. Mount heater into modified project box
            1. When looking into the project box with the big hole on the right and the little hole on the left the heater will be mounted upside down with the front of the heater oriented through the big hole.

The heater will be pushed all the way into the bottom right corner of the box.

2. Make sure the heater is switched ON. Route the heater able through the right side hole then apply mounting tape to the all sides of the heater that will be in contact with the project box.

iii. Attach project box to the motherboard
1. Place the modified project box with the heater inside of it onto the motherboard on the section labeled "air XC".
2. Secure the box by screwing x4 small screws into the corners. Seal the project box cover. Drop the screws into the holes and use a screwdriver to drive them into the PVC.

iv. Assemble and mount the air pump on top of the air exchange box
1. Push one end of the tubing onto the end of the air pump. Route this line down the left side of the motherboard and pop the tube through the hole on the lower left side of the panel.
2. The power cord from the air pump will go into the wire management module and plug in directly to the power stip. The air pump will therefore always be running when the power is on.
3. Hot glue the feet of the pump so that the pump does not fall off the air exchange box when the motherboard panel is jostled. Mount the air pump as far from the wall as possible because wires will have to be able to make it through that hole.

v. Assemble and mount the vent fan
1. Place one of the fans on top of the lower large hole of the motherboard panel such that the air is blowing into the grow chamber. There is a graphic on a side of the fan with arrows that indicate which direction the fan blows air as well as which direction the fan spins.
2. Place a fan guard over top of the fan such that it is on the surface furthest from the inside of the grow chamber.
3. Using x4 of the medium sized screws, mount the fan to the motherboard.

vi. Assemble and mount the louvre
1. The inner cylinder on the louvre protrudes too far into the opening of the motherboard. Shorten the cylinder with an exacto knife by at least half its length.
2. The louvre will be mounted on the inside of the motherboard, on the surface inside the grow chamber. Make sure the louvre is oriented such that gravity keeps them closed.
3. Using x4 of the small sized screws, mount the louvre to the motherboard.

vii. Assemble and mount the circulation fan

1. Mount the circulation fan on the inside of the electronics panel in the lowest possible position that is closest to the front of the bot. Make sure the fan is oriented such that it is blowing into the chamber. In order to generate airflow, standoffs (3 washers) must be placed in between the fan and the motherboard. Also for safety, place a fan guard on the surface furthest into the grow chamber. Use the long screws to attach to the motherboard. For clarity, the order of materials is: inside of motherboard, standoffs, fan, fan guard, long screws running through to hold it all together.
2. The circulation and vent fan will be wired together. Consult the schematic for polarity. Each fan has a three channel cable. The gold cable is ground, and the center cable is power (12V). The third cable is not used. Taking a grove cable, connect red and black to the circulation fan power and ground, and white and yellow to the power and ground of the vent fan. The connector end of the grove cable will then plug into S2.

viii. Assemble and mount the humidifier

1. The humidifier mount bracket is created from a 6" long section of stamped angle. First, a notch is cut down the spine of the angle about 1" in length with a bandsaw. Next, using a metal brake, each side of the angle is flared out at the 1" mark to create a tab perpendicular to the main length of slotted angle. Finally, bolt a 1" section of stamped angle to the end of the bracket to prevent the humidifier from slipping out.

2. Drill holes for humidifier, diameter 1 ¾" 4" from right side and 2 3/4" from bottom (when looking at grow chamber side). Drill two 5/16" humidifier mount holes 1 ¾" apart and 2" below the center of the humidifier hole. The bracket will help with alignment. Using a ⅜-16 tap, thread the 5/16" holes.
3. Bolt in the humidifier mount to the board.

4. Apply weather stripping to the lower top surface of the humidifier. The part that will sit against the motherboard. NOT the part that will protrude through it.
5. When the humidifier is pressed up against the motherboard, make sure that the usb port is facing directly to the right. With the usb port facing to the right, carefully take off the plastic encasement of the wick. Note how this encasement fits back onto the humidifier. Using a heat source, either a heat gun, lighter, or something equivalent, slowly head the center of the encasement and slowly bend the piece down. The entire purpose of doing this is so that the wick can suck up water when the humidifier is placed in a horizontal position so make sure the way you bent the wick complies with this goal as well as orienting the usb port to the right.
6. Press fit the modified humidifier into the mount and connect the usb port. Route the cable through the wire management unit and plug it into the USB-to-AC converter. Plug in the converter to the **AC Control module in port 2**.
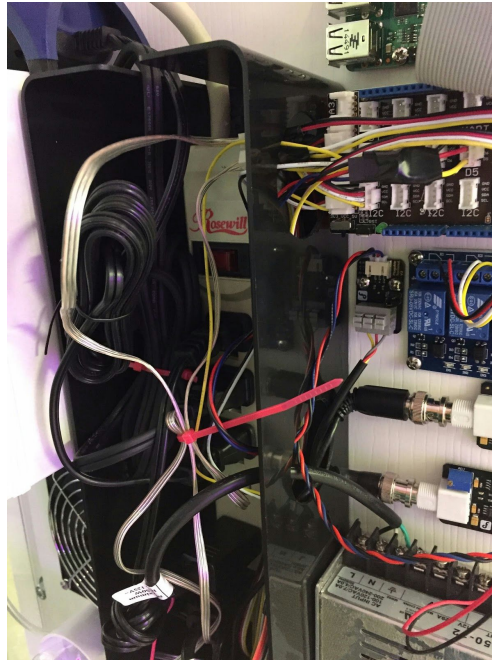
4. **Wire Management Module**
    a. Materials
        i. Wire management box
        ii. 6-channel power strip
        iii. 34" x 1" mounting tape
    b. Tools
        i. Power drill
        ii. .5" diameter drill bit
        iii. 1.5" hole saw bit
    c. Instructions
        i. Viewed from the right side of the wire management box, drill a 1/2" diameter hole centered 1" down and ¼" to the left from the upper right corner of the box and such that the bottom of the hole is flush with the motherboard. This hole will accommodate the USB port on the arduino, so you gauge position necessary by the height the arduino sits above the motherboard.
        ii. Viewed from the right side of the wire management box, drill a 1.5" diameter hole centered 1 1/2" down and 2" to the left from the upper right corner of the box.
        iii. Viewed from the right side of the wire management box, drill a 1.5" diameter hole centered 6" down and 1/2" left of the upper right corner of the box and such that the bottom of the hole is flush with the motherboard.

The two holes will provide cable paths to the Arduino and for the water sensors

      iv.   Viewed from the top of the wire management box, using a 10" strip of mounting tape to secure the power strip to the lower left corner of the inside of the box such that the trailing power cable will protrude towards the top of the motherboard.

      v.   Using 2 strips of 12" segments of mounting tape, attach the top of the wire management module flush with the top of the air exchange box and 12V-30A power supply. There should be approximately 1" gap between the top of the AC control module and the bottom of the wire management module.

5. **DC Control Module**
   a. Materials
      i. 4-channel relay block
      ii. Female jumper-to-grove cable x2
      iii. 4-pin, buckled, 10cm grove cable
      iv. 6-channel, male-to-female jumper wire
      v. small .5" screws x4
   b. Tools
      i. Wire strippers
      ii. Hot glue gun
   c. Tools Consumables
      i. Hot Glue
      ii. Electrical Tape

        iii.   Permanent Marker
- d. Instructions
  - i. Connect control cables to the relay block
    1. Connect the 6-channel, male-to-female jumper cables to the 6 exposed header pins on the relay block
    2. To keep headers securely fastened, squirt a hefty amount of hot glue around the connection.
    3. Using a single female jumper-to-grove cable, connect the **black** wire on the grove cable to the wire attached to **GND** on the relay,the **white** wire on the grove cable to the wire attached to **IN1** on the relay, the **yellow** wire on the grove cable to the wire attached to **IN2** on the relay. This cable will connect to the **S3** receptacle on the arduino protoboard module so it is recommended you use the permanent marker to label the end of the connector "S3".
    4. Using the other female jumper-to-grove cable, connect the **red** wire on the grove cable to the wire attached to **VCC** on the relay,the **white** wire on the grove cable to the wire attached to **IN3** on the relay, the **yellow** wire on the grove cable to the wire attached to **IN4** on the relay. This cable will connect to the **S9** receptacle on the arduino protoboard module so it is recommended you use the permanent marker to label the end of the connector "S9".
    5. For each cable, hot glue the connection between the male-to-female jumper cable and the female jumper-to-grove cable and then wrap the connection in electrical tape once the hot glue dries.
  - ii. Connect the switch cables to the relay block
    1. Cut the 10cm grove cable into 2 segments. One segment ⅔ of the cable and the other ⅓.
    2. Strip approximately ½" of insulation off the tips of each cable
    3. On the longer cable, connect **black** to the **center port of the K1** screw terminal (K1-SW). Connect **red** to the **left port of the K1** screw terminal (K1-ON). Left is defined by viewing the screw terminals from the front, or looking into the board. Connect **white** to the **center port of the K2** screw terminal (K2-SW).Connect **yellow** to the **left port of the K2** screw terminal (K2-ON). Left is defined by viewing the screw terminals from the front, or looking into the board. This cable will connect to the **S1** receptacle on the arduino protoboard module so it is recommended you use the permanent marker to label the end of the connector "S1".
    4. On the shorter cable, connect **black** to the **center port of the K3** screw terminal (K3-SW). Connect **red** to the **left port of the K3**

screw terminal (K3-ON). Left is defined by viewing the screw terminals from the front, or looking into the board. Connect **white** to the **center port of the K4** screw terminal (K4-SW).Connect **yellow** to the **left port of the K4** screw terminal (K4-ON). Left is defined by viewing the screw terminals from the front, or looking into the board. This cable will connect to the **S7** receptacle on the arduino protoboard module so it is recommended you use the permanent marker to label the end of the connector "S7".

    iii.   Insulate the bottom of the relay block
        1.   Place a layer of electrical tape on the bottom of the relay block
        2.   Place a layer of duct tape over the layer of electrical tape on the bottom of the relay block
    iv.   Mount the relay block onto the motherboard
        1.   Using the small screws, mount the relay block to the segment on the board labeled "DC"

6. **Water Sensors Module**
    a. Materials
        i.   EC and Water Temperature Sensor
        ii.   pH Sensor
        iii.   small .5" screws x6
        iv.   Male jumper-to-grove cable x3
    b. Tools
        i.   Small, phillips screwdriver
        ii.   Hot glue gun
    c. Tools Consumables
        i.   Hot Glue
        ii.   Electrical Tape
    d. Instructions
        i.   Build the temperature sensor module
            1.   Plug in the temperature sensor (the silver cylinder with a wire coming out of it) to the temperature sensor PCB. The **yellow** wire goes to the **A** terminal, **red** wire to the **B** terminal, and **grey** wire to the **C** terminal.
           2.   Plug in the small red, black and green cable into the temperature sensor PCB. Using a male jumper-to-grove cable, connect the **red grove** wire to the **red sensor** wire, the **black grove** wire to the **black sensor** wire, and the **yellow** grove wire to the **green sensor** wire.
           3.   This cable will connect to the **D5** receptacle on the arduino grove shield module so it is recommended you use the permanent marker to label the end of the connector "D5".
        ii.   Mount the temperature sensor module to the motherboard

1. Using two electronics screws, mount the temperature sensor to the two pre-drilled holes that sit directly to the left of the DC relay module. The module should be oriented such that the green, red, and black wires are towards the top of the motherboard.
2. Route all cables coming from the PCB through the lower drilled hole in the wire management module. Route the grove cable through the upper drilled hole in the wire management module. Route the sensor through the bottom slat in the wire management module and through the bottom hole leading into the grow chamber. Once the panel is connected to the chamber, snake the sensor into the corner of the water tray such that it is beneath the styrofoam grow tray.
iii. Build the EC sensor module
1. Like the temprature sensor, use two screws to mount the EC board directly below the DC relay module. Connect the corresponding EC probe and route through the center hole in the wire management box and route down and out the bottom hole to the grow chamber.
iv. Build the pH sensor module
1. Mount the pH board below the EC board and also connect and route the cable through the wire management box and down and out through the hole into the grow chamber.

7. **Water Circulation Module**
   a. Materials
      i. Foam tray with holes cut for the sensors and horticubes
      ii. 12" of .5" inner diameter tubing
      iii. Aquarium water pump
      iv. reservoir tub
   b. Tools
      i. Scissors
      ii. ShopBot
   c. Instructions
      i. Use the ShopBot to cut the foam tray.
      ii. Place the aquarium pump in the reservoir tub and attach the tube to the outlet of the pump
      iii. Place the sensors through the holes in the foam tray so that the ends stick in the water. Make sure that the tips are always in liquid, either water or the solutions they came with.

8. **Arduino Mega Protoshield Module**
   a. Materials
      i. Protoshield package

      ii.   Grove connector sockets x9

      iii.   Wire-wrapping wire assortment

b. Tools

      i.   Wire strippers

      ii.   Soldering iron

      iii.   Wire wrapping tool

c. Tools consumables

      i.   Solder

      ii.   Solder wick

      iii.   Permanent marker

d. Instructions

      i.   Solder all header pins onto the shield

      ii.   Label special grove connector sockets (S1-S9)

      iii.   Solder S1-S9 onto the shield as shown below. The receptacle pins are slightly smaller than the holes in the perfboard so you will need to bend them out slightly.
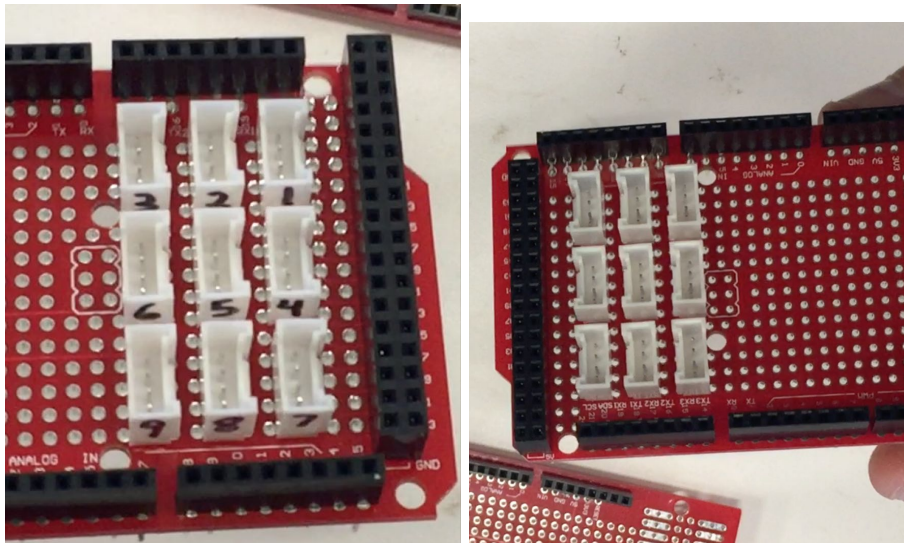
      iv.   Follow the schematic when connecting wires. **Tips:**

         1. Wire wrapping is easier than soldering to the pins on the grove connectors. Where multiple connections to a single point are required, try to make the multi-connection point be something that you can wire wrap.

         2. If you are unsure what a wire wrapping tool is or how to use it, by searching for "wire wrapping electronics tutorial" you will find some good information.

         3. As you can see from the schematic, there are a lot of connections routed to many different places. This will result in the wires on the

schematic forming a sort of ratsnest. To help manage this complexity, it is recommended you try to color code the wires as best as possible. One schema to do so is:

    a. Ground: Black
    b. Voltage Source: Red
    c. Signal: Else

4. A soldering iron with a fine pointed tip will make the job easier.

9. **Controller Module**
    a. Materials
        i. Arduino mega 2560
        ii. USB A-to-B cable
        iii. Finished arduino mega protoshield module
        iv. Grove base shield
        v. Raspberry Pi 2
        vi. 8 GB SD card
        vii. Raspberry Pi 2 power supply
        viii. 20' ethernet cable
        ix. Touch screen display
        x. 2x13 ribbon cable
        xi. small .5" screws x8
        xii. Reed Reay
    b. Tools
        i. Hot glue gun
        ii. small screwdriver
    c. Tools Consumables
        i. Hot glue
    d. Instructions
        i. Screw the arduino into the electronics panel
        ii. Place the perfboard on the arduino mega
        iii. place the grove shield on top of the perfboard
        iv. Screw the raspberry pi into the electronics panel
        v. Screw the screen into the acrylic front plate of the food computer and connect to the raspberry pi with the ribbon cable
        vi. Load the image onto the SD card and place in the raspberry pi
        vii. Connect the Arduino usb cable to the raspberry pi
        viii. *Note, connect the signal line of the reed relay to pin 22 on the Arduino. The power and ground are used to break the connection on the EC sensor so that there is not noise when the pH sensor is recording. Connect the power and ground of the EC to the power and ground out of the reed relay.

10. **Air Sensors Module**

a. Materials
    i. Cozir CO2 Sensor
    ii. Grove Digital Light Sensor
    iii. Grove Temperature/Humidity Sensor Module
b. Tools
    i. Screwdriver
    ii. small .5" screws
    iii. 1"x1" square of .5" thick pvc
    iv. .75"x2.5" rectangle of .5" thick pvc
    v. 1" stamped angle section
    vi. double sided foam tape, about 5"x1"
c. Instructions
    i. The temp/humidity and light sensors sit between the circulation fan and the vent fan louver.
    ii. First start by taping the rectangle of PVC lengthwise to the angle, so that the end of the rectangle is flush with the same surface as the angle.
    iii. Next apply tape to the back of the angle and place it so that it is flush with the louver and 6" above the lowermost surface of the window to the grow chamber.
    iv. Next tape the temperature/humidity center vertically on the front face of the angle below the cantilevered PVC rectangle (see below).
    v. Next tape the light sensor to the top of the PVC rectangle so that it is at the very edge. This ensures that nothing will obstruct light from reaching the sensor
    vi. Finally, tape the 1"x1" square of PVC to the back of the CO2 sensor and then tape to the electronics panel right above the circulation fan
    vii. Wire the sensors to the ports specified in the schematic

11. <u>Lights</u>
   a. Materials
      i. one rope of white LEDs
      ii. grove cable
   b. Tools
      i. Knife
   c. Tools Consumables
      i. Clear shipping tape
   d. Instructions
      i. The strip of LEDs will go around the circumference of the electronics panel. Starting above the wire management box and wrapping counterclockwise, stick the strip to the edge of the PVC. Use intermittent clear tape to hold the leds onto the panel.
      ii. As per the schematic, connect the power and ground of the strip to the white and yellow wires of a grove connector. The red and black will go to the second LED strip on the LED panel assembly.

12. <u>Grow LED Panel and Camera Assembly</u>
   a. Materials
      i. two grow LED panels
      ii. 18" stamped flat
      iii. 24" stamped flat
      iv. 8" stamped flat

v. 19.5" ⅜-16 threaded rod
vi. 1.5"x1.5" PVC square
vii. Webcam and wire
viii. small .5" screws
ix. 3" stamped flat
b. Tools
i. ⅜" drill bit
ii. power drill
iii. knife
iv. bandsaw
v. screwdriver
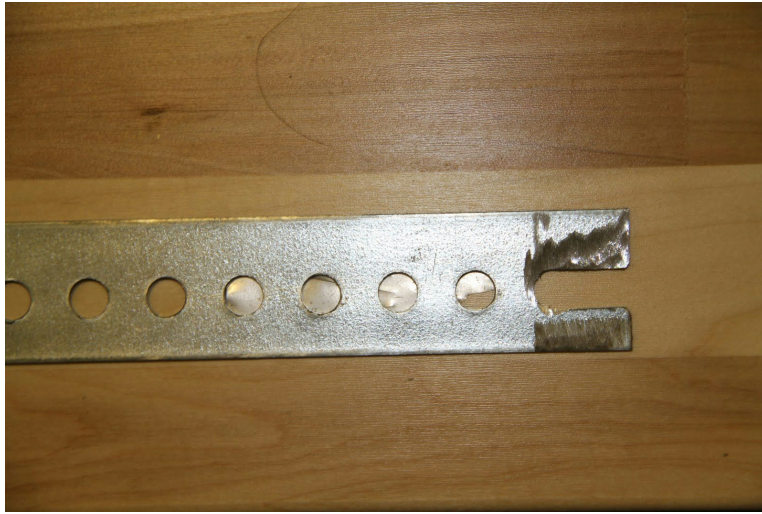c. Tools Consumables
i. Clear shipping tape
d. Instructions

i. Start with two panels
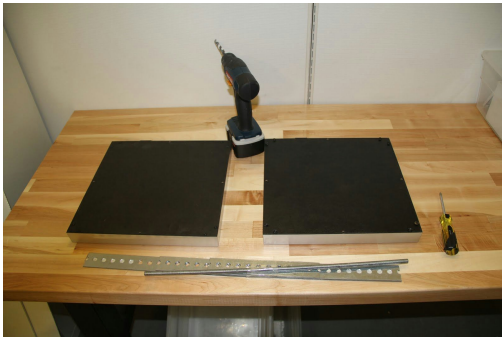
ii. Unscrew the covers and save the screws
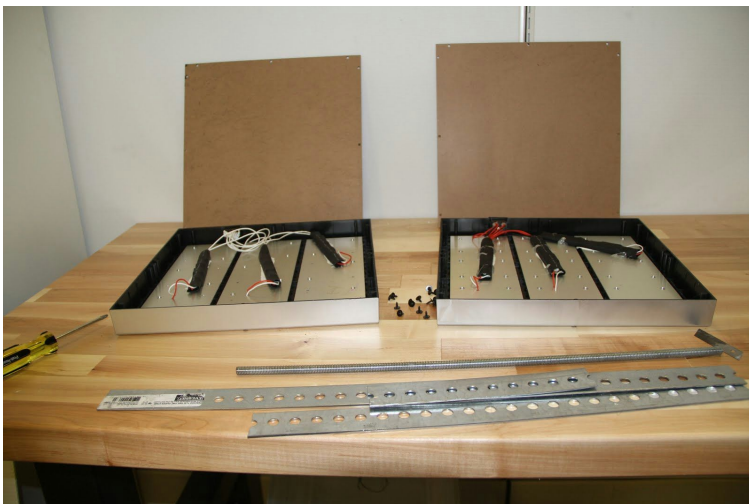
iii. Take the 18" section of stamped flat to the shop and cut a tab on either end the width of the hole (⅜"). Sand so that there are no sharp edges.

iv. Align the 18" section with one panel so that the plug is to the right. Drill two holes and bolt the stamped flat to the light plastic enclosure.
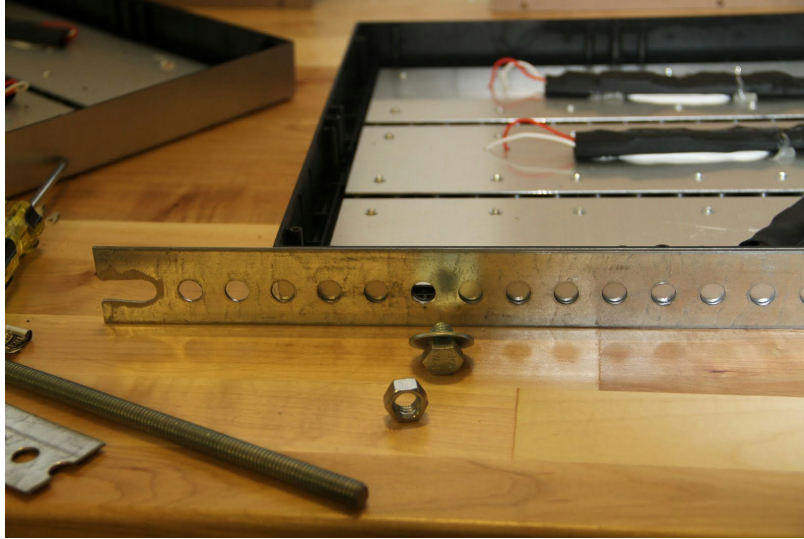
v. Place a second panel adjacent to the in the orientation below (both plugs facing back) and attach the 24" section to the front face the same way.
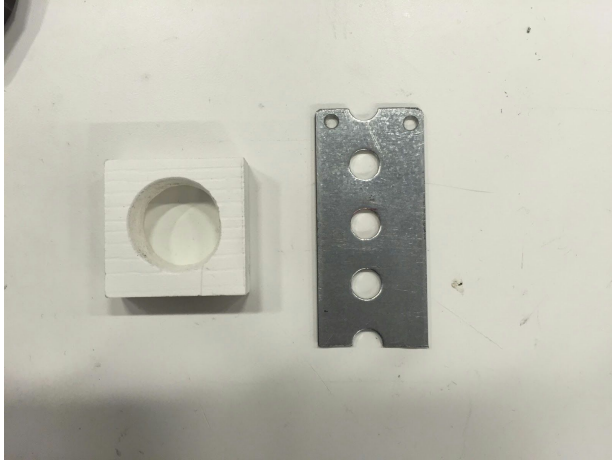
vi. Take the 8" section and attach to the side with the plugs.

vii. Drill a hole through the center seam of the two panels. This will be used for the camera mount.

viii. Take the PVC and drill a .75" hole through the center. Drill two small (.125") holes in the bottom of the 3" stamped flat section
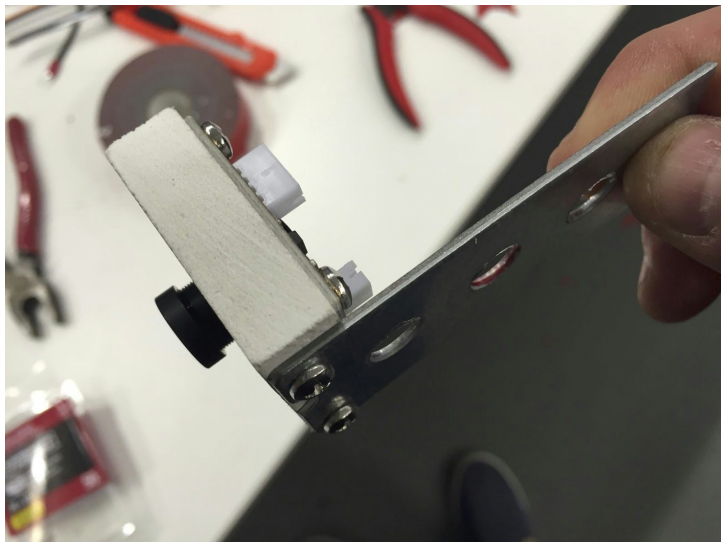
ix. Clip the corners of the webcam where the mounting holes are. This creates room for the screws. Place the webcam on the PVC block so that the lens goes through the center. Screw through the corners to secure the webcam to the block
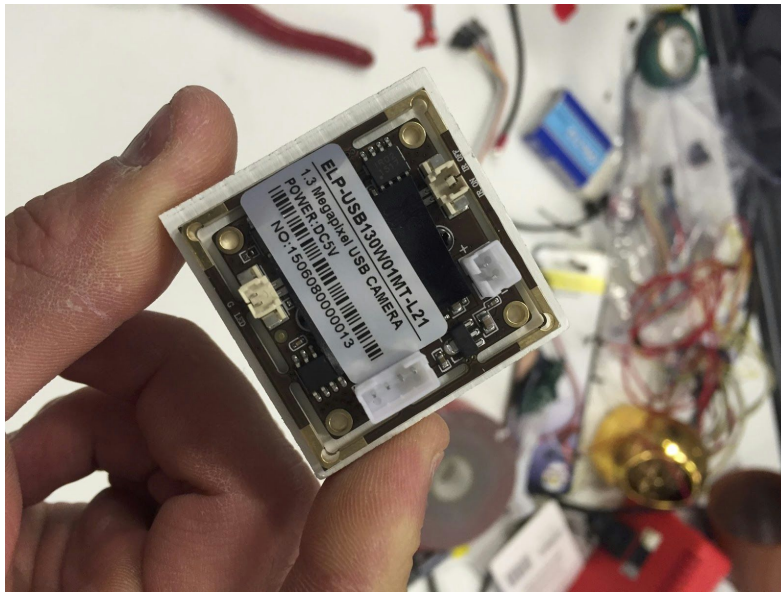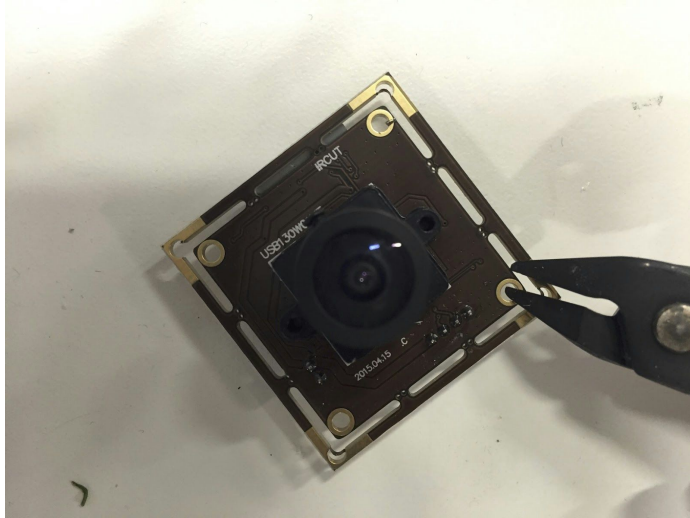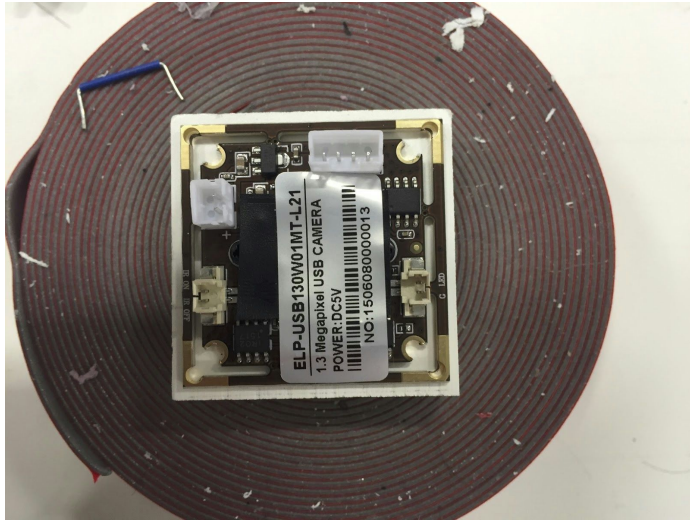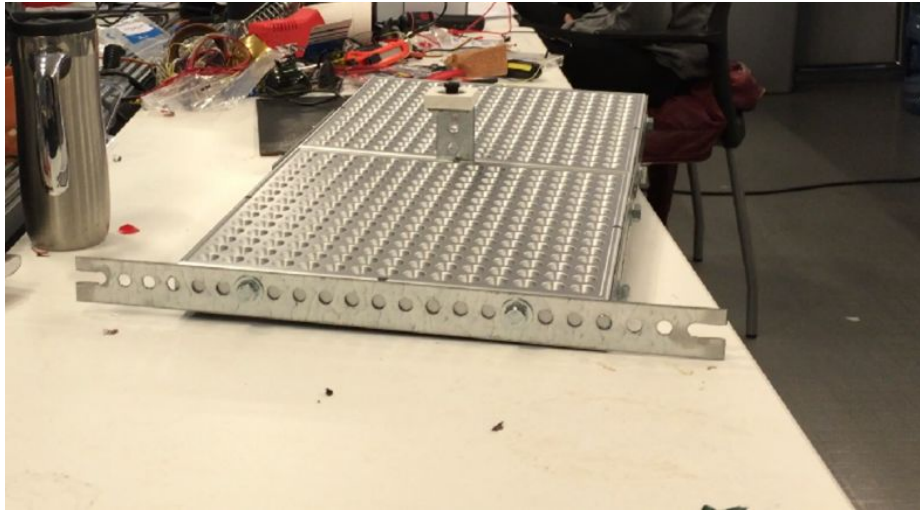
x. Screw the 3" stamped flat to the block on one of the sides.

xi. Place the webcam assembly through the center so that the uppermost hole on the stamped flat aligns with the center hole through the plastic enclosures. Bolt through all three and tighten. Replace the coverings on each LED panel and it is ready for assembly.

xii. Assemble the support rod. Screw a nut from each edge of the rod 5" in. Place a washer and second nut and tighten. Place one more nut on each side and thread through the frame. Tighten with nuts on the outermost edge. This is what the front of the lights rests on.

The tabs are used to hold the other side of the lights to the frame.

Finally lay a strip of leds on the face of the led panel. Extend the LED wires and pass them through the hole in the electronics panel upper corner. Connect to the black and red wires of the other LED grove connector. Place both in port S2.

14. System Testing / Debugging

Upload the microcontroller code to the arduino mega 2560. This code can be found on github under OpenAgInitiative/gro-controller/src.For initial testing, use the arduino serial monitor. The easiest way to do this is with the arduino IDE. Assuming the code is uploaded to the arduino and the serial monitor is open, there will be a giant stream of text running down the screen. This console is a window into how all sensors and actuators are interfaced with. A single stream message looks something like this:

"{"GTYP":"Stream","SWPH 1":6.9,"SWTM 1":25.4,"SWEC 1":2.6,"SLIN 1":33,"SLPA 1":0.73,"SATM 1":24.7,"SAHU 1":31.3,"SACO 1":400,"SATM 2":25.2,"SAHU 2":39.0,"SGSO 1":0,"SGWO 1":1,"AAHE 1":0,"AAHU 1":0,"AAVE 1":1,"AACR 1":1,"ALPN 1":0,"ALPN 2":0,"ALMI 1":1,"GEND":0}"

This is a message that contains a sequence of instruction codes:
- "GTYP":"Stream" - This message type is a stream message.
- "SWPH 1":6.9 - The 1st Sensor of Water PH is reporting a value of 6.9
- "SWTM 1":25.4 - The 1st Sensor of Water Temperature is reporting a value of 25.4 degrees C
- "SWEC 1":2.6 - The 1st Sensor of Water Electrical Conductivity is reporting a value of 2.6 mS/cm
- "SLIN 1":33 - The 1st Sensor of Light INtensity is reporting a value of 33 lux
- "SLPA 1":0.73 - The 1st Sensor of Light PAr (Photosynthetically Active Radiation) is reporting a value of 0.73 umol/(s*m^2)
- "SATM 1":24.7 - The 1st Sensor of Air TeMperature is reporting a value of 24.7 degrees C
- "SAHU 1":31.3 - The 1st Sensor of Air HUmidity is reporting a value of 31.3 % relative humidity
- "SACO 1":400 - The 1st Sensor of Air CO2 is reporting a value of 400 ppm (parts per million)
- "SATM 2":25.2 - The 2nd Sensor of Air Temperature is reporting a value of 25.2 degrees C
- "SAHU 2":39.0 - The 2nd Sensor of Air HUmidity is reporting a value of 39.0 % relative humidity
- "SGSO 1":0 - The 1st Sensor that is Generally detecting if the Shell is Open is reporting 0 (false)
- "SGWO 1":1 - The 1st Sensor that is Generally detecting if the Window is Open is reporting 1 (true)
- "AAHE 1":0 - The 1st Actuator that is an Air HEater is reporting 0 (off)
- "AAHU 1":0 - The 1st Actuator that is a Air HUmidifier is reporting 0 (off)
- "AAVE 1":1 - The 1st Actuator that is an Air VEnt is reporting 1 (on)
- "AACR 1":1 - The 1st Actuator that is for Air CiRculation is reporting 1 (on)
- "ALPN 1":0 - The 1st Actuator that is a Light PaNel is reporting 0 (off)
- "ALPN 2":0 - The 2nd Actuator that is a Light PaNel is reporting 0 (off)

- "ALMI 1":1 - The <u>1</u>st <u>A</u>ctuator that is for <u>L</u>ight <u>M</u>otherboard <u>I</u>llumination is <u>1</u> (on)
- "GEND":0 - End of message

The first thing to test is whether or not all the sensors are reporting correctly. These sensing point values are generally representative of ambient conditions (where the light panels are turned off). Usually sensing points that are attached to the same sensor will be incorrect. Here is a list that indicates which sensing points are matched to which sensor:
- DFR01610300 - SWPH 1, SWTM 1, SWEC 1
  - This sensor "module" is actually 3 separate sensors that have dependencies on each other so we lump them into the same module. These come from DFRobot and each sensor has its own circuit board that is labeled. To get more info about this sensor go to the DFRobot website and use their associated SKU numbers (0161 and 0300). Note: 0300 is a package with Temperature and EC.
- TSL2561 - SLIN 1, SLPA 1
  - Adafruit has some nice info about this.
- DHT22 - SAHU 1, SATM 1
  - Adafruit has some nice info about this.
- GC0011 - SACO 1, SAHU 2, SATM 2
  - Cozir has some nice info about these. This sensor has its own microcontroller onboard. To communicate with it you can send the command "SACO 1 C <msg>". More on this soon…
- Limit switch - SGWO 1
  - Functions like any switch
- Magnetic switch - SGSO 1
  - Functions like any proximity switch

Once all the sensors are up, the next thing to do is test the actuators. By typing the actuator instruction code, id and value into the console, that will set that actuator to that value. Be sure the console is set to "Newline" and "9600 Baud" in the lower right hand corner. Here are a few examples:
- AAHE 1 1 - turn ON the air heater actuator
- AAHE 1 0 - turn OFF the air heater actuator
- ALPN 1 1 - turn ON the 1st light panel actuator (the grow lights)
- ALPN 2 1 - turn on the 2nd light panel actuator (the led strip)
- AAHU 1 1 - turn on the air humidifier actuator

It is a good idea to go through all the actuators and make sure they can turn on and off. Once this is done, replug the usb cable back into the raspberry pi.

Now, configure the controller (Raspberry Pi). Download the pi image from the OpenAgInitiative github. Upload it to an SD card. Plug it into the pi. Assuming the image has been downloaded onto the SD card and once the ethernet cable is plugged in it is likely the bot will just connect to the internet and get an IP address. Acquire a usb keyboard and plug it into a free USB port on

the raspberry pi. Assuming you the touch display is connected to the pi there will be a screensaver that is a picture of veggies. Close this out by using the "ctrl + w" keyboard shortcut. Note: you have 60 seconds before the screensaver pops back up, in which case you will need to "ctrl-w" it again. Once the screensaver is closed navigate to the raspberry pi's terminal: Menu->Accessories->Terminal and type the command "ifconfig". After typing this command look in the paragraph to the right of eth0 and you should see a string of text that looks like "inet addr: 12.456.7.89". The string of numbers separated by the periods is the bot's IP address. This is the IP address used to connect the user interface to your specific bot.