

## Hypoxia Capstone Meeting Minutes 10/1/20

- Preliminary model that Colin made (simple box, no door, only enough room for the 4 well plates)
- Izzie found that glass might be the cheapest option, but acrylic or polycarbonate are easier to work with
- There are other polycarbonate boxes for sale that are cheap (~\$50) that we could buy and customize
- Need to look into whether 3D printing will be okay for corner pieces and sensor housing
- Thickness -- ~1/4 inch
- Ask Dr. Schiele
  - Optimal way to create hydration in chamber
  - Let him know we want to have the chamber be air-tight, which means we'll need to tap into his CO2 system
  - Is using filter caps acceptable for sanitation
  - Optimal way to diffuse gas into the chamber
  - How to get rid of old air that might be toxic (exhaust)
  - Ask about possible need for shelves or if he wants a 1x4 stack
  - How long can the cells be kept at room temperature as the chamber heats back up after gases are distributed
- Pumping in CO2
  - Discussed the finding of a \$109 sensor that could detect CO2, humidity, and temperature
  - Pumping in both gases creates control system issues, so possibly premix the gases in another container and then pump them into the chamber
- Wanting to use solenoids to control gas flow (can be opened or closed at specified times to control flow)
- Pump gas in at the bottom and then out at the top
- Using both an Arduino for controlling the gas and a Raspberry Pi to work the user interface
  - Option to download files using a USB
  - PID type controls? Ask Dr. Sullivan?
- Think about how to safeguard for the chamber failing and releasing gases into the room
- Design ideas
  - Lower thickness of the chamber
  - Add corner pieces that will be 3D printed, while the faces of each box are acrylic sheets
    - Andrew's design
  - Door that hinges to either a side or the bottom that has an o-ring
  - Possibility of adding a shelf on the bottom that has holes in it so that a sponge could be put on the bottom for humidity
- Questions for Ian
  - What thickness should we use?
  - Are there materials on campus that we could use?
- Action Items

- Send questions to Dr. Schiele
- Check designs with Ian

## Hypoxia Capstone Meeting Minutes 10/2/20

- Created Project Schedule
- Reviewed Colin's model for the chamber
- Will make rough prototype out of cardboard for Snapshot 1

## Hypoxia Capstone Meeting Minutes 10/6/20

- Ian is worried that our current design idea would eventually fail because the adhesive might not withstand moving, and we'd lose our integrity
- However, it would be simple to just print it out and then test it, so we can do that for this snapshot
- Ideas to correct this
  - Could screw through the acrylic so that the adhesive is really just there for a seal instead of bearing the weight of actually holding the box together
  - Could extend the corner pieces to be fully along the sides instead of just the corners
- More of a jigsaw way of attaching the acrylic to the corner pieces
- Trying to get the design done by Thursday so that we can get the box made for snapshot
- Need to find a way to support top piece
  - Could also use jigsaw-ish method
- Going to go without a door for now
  - Want to create the piece for the door, but not seal it right away so that we can put things in for snapshot, and then we can seal it later for testing
  - Need to ask Ian if this is feasible
- Showed off sensor housing design
- Adjusted OneDrive files to match portfolio requirements
- Will add an input tubing so that we can test the sealing later

## Hypoxia Capstone Meeting Minutes 10/8/20

- Convert all our files to pdfs to make it easier to turn in for our portfolio
- Went over Andrew's sensor housing idea
  - Could attach to the outside of the chamber or be inside the chamber
    - Either way we'll need holes in the chamber to let things go outside
  - Want to make housing able to split into 2 parts so that we can put the sensors inside
  - Has a screw cap that the filter cap will fit onto
  - Will make slots for the sensors to fit into to keep them steady
  - Want to keep the threads steady, the 3D printing might not hold
  - Might want to buy 2 sensors to make sure we know how long it takes to get an equilibrium
  - Could make it cylindrical
- Went over Colin and Jacob's new design for the chamber
  - Has jigsaw sides to add structural stability
  - Has the corner pieces
  - Door needs some work, thinking about having it hinge at the bottom and open top-down, and have an o-ring for the seal
  - Needs to be exported as a dxf file
  - Make sure Ian knows what unit system we're using for laser cutting (inches)
  - Can't manufacture as is right now because we'd have to redo lots of parts and wouldn't be able to close up the chamber
  - Need to take away the jigsaw on the front face so the door can seal in
  - If we're putting hinges on the outside bottom then we need to "stilt" it up higher so that there's room
- Project Schedule
  - Have more solid milestones for the schedule so that we have deliverables
- Snapshot
  - Have Colin let Dr. Schiele know that he can join us for snapshot
  - Have at least two people in our room going over the slides at all times
  - We can rotate and look at other projects as well
- Need to buy the acrylic and 3D printing filament to create the chamber
  - Might check Moscow Building Supply for acrylic
  - Need to check nominal/actual sizes
  - Might have access to wood for building
  -
- Will try to see if we can get the chamber created for snapshot

## Hypoxia Capstone Meeting Minutes 10/12/20

- Snapshot Schedule
  - We'll all stay for about 15 minutes (3:30-3:45)
  - Jacob, Izzie, and Alex will take first half (3:45-4:15)
  - Andrew and Colin will take second half (4:15-4:45)
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## Hypoxia Capstone Meeting Minutes 10/15/20

- Review Snapshot
  - Have we checked into seeing if we can find a chamber that's already airtight that we can modify
  - Dr. Schiele -
    - Testing with a sensor in the incubator itself might
    - Measuring humidity is definitely on the back burner, not very important
    - We should expect the door to open about once a day, with most of those being very quick, then every three days they'll change out the medium that the cells are in
    - It could take more than a few minutes to reach equilibrium and be just fine because the cells sit in the chamber for days and days during the experiment
- Dev really thinks that we should buy an already airtight chamber so we don't have to spend time trying to make sure ours is airtight
  - Sealed container: <https://www.walmart.com/ip/Snapware-Airtight-Plastic-17-Cup-Rectangle-Food-Storage-Container-4-Pack/17202462?wmlspartner=wlp&selectedSellerId=466>
- DFRobot CO2 sensor
  - CO2 sensor: [https://www.amazon.com/DFROBOT-Gravity-Analog-Sensor-Arduino/dp/B00R5CCH7U/ref=b2b\\_gw\\_d\\_simh\\_1/146-4611514-5640501?encoding=UTF8&pd\\_rd\\_i=B00R5CCH7U&pd\\_rd\\_r=6e5dcfc4-7a42-45e8-a319-759c3df926d8&pd\\_rd\\_w=uhxyX&pd\\_rd\\_wg=yDrja&pf\\_rd\\_p=735a47f3-23e0-4241-8d86-8c87b91c9083&pf\\_rd\\_r=WWB3SEB5GZVW5Q0Y5HRM&psc=1&refRID=1TV0J9B9ZYD8B69ST45](https://www.amazon.com/DFROBOT-Gravity-Analog-Sensor-Arduino/dp/B00R5CCH7U/ref=b2b_gw_d_simh_1/146-4611514-5640501?encoding=UTF8&pd_rd_i=B00R5CCH7U&pd_rd_r=6e5dcfc4-7a42-45e8-a319-759c3df926d8&pd_rd_w=uhxyX&pd_rd_wg=yDrja&pf_rd_p=735a47f3-23e0-4241-8d86-8c87b91c9083&pf_rd_r=WWB3SEB5GZVW5Q0Y5HRM&psc=1&refRID=1TV0J9B9ZYD8B69ST45)
- We're not sure what the lifetime of our sensors is, so we should check and make sure we won't be needing to replace them every few months
  - The \$110 one we found is great, but we don't necessarily need to be checking for humidity and temperature
- Chamber
  - Dr. Schiele wants the chamber to be bigger
  - The new idea for the door is to have a cut-out door that would latch onto the front face so that we don't have to redo the jigsaw
  - Might not be a great idea to have to hold the door, could possibly change up the design to still be a hinged door despite being inside the jigsaw portion?
- Goals for next snapshot
  - Functional prototype
    - Have a chamber built that can seal
    - Have the sensors hooked up
    - Have the control system set up enough to read measurements from the sensors and open/close the gas valves

- Short term tasks
  - Choose if we want to manufacture or buy a chamber
  - Figure out if sensors will be inside or outside the chamber
  - Figure out how precise the sensors need to be, will they allow us to hit our setpoints, communication method
  - What is the lifecycle of the sensors and how often do they need to be calibrated
  - How will we control the gas (solenoids etc)
  - How to deal with humidity
- Chamber options
  - Manufacture our own
  - Buying one
  - Sensor options – inside or outside
- Action Items by Tuesday
  - Colin and Jacob
    - Will scale up the chamber and add door design (possibly both the removable door and door with hinge)
    - Need to know prices for acrylic, door material, 3D printing, hinge, latch, etc
  - Izzie
    - Look into other boxes that could be purchased to use as our chamber instead (acrylic material, tupperware, almost anything)
  - Andrew and Alex
    - Researching sensors – will they hit our setpoints, what's their lifecycle, how we'll control the gases,
- Try to meet with Dr. Schiele to present our design in a week and a half-ish



## Hypoxia Capstone Meeting Minutes 10/21/20

- Began work on the Design Validation document
- Izzie went over options for pre-made chambers
  - Tupperware ones seem to be already airtight and have lids that can seal well, but they might need some work to adjust the lid to work well
    - Could add stilts to lift it up so that unlatching the bottom side is easier
    - Using those latches could jostle the chamber too much
  - Fish tanks
    - Worry about airtight seal
    - Glass is difficult to adjust
  - Most of these chambers are \$20-\$40
- Andrew shared pros/cons of sensor placement
  - Sensors outside of incubator
    - Would mean needing to add a way to pump the gas through tubes to reach the sensors
    - Would decrease response time by quite a bit
  - Sensors inside of incubator
    - Probably fastest response time
    - Will need to design our own sensor housing
    - If something goes wrong with sensors they are difficult to get to without losing hypoxic environment
      - We could possibly design a plug for the hole left by the sensor housing to help with this
- Sensors
  - The oxygen and CO2 sensors we already found seem to be our best options. They hit all our setpoints (sensing O2 from 0-21%, sensing CO2 at 5%). The high percentage of CO2 is what contributes to the higher cost of the CO2 sensor.
- Chamber Design
  - Jacob and Colin finished adding the door design
  - They priced out building our own chamber and it comes to about \$100
- Solenoids
  - What pressure will they need to be rated to?
  - Will solenoids themselves need to be sterile, or how will we ensure that the gas they are controlling is sterile?
  - How will they be controlled exactly?
  - They seem to be about \$80 per solenoid
- Action Items
  - Colin – write overview of pricing
  - All – fill out Solution Ideas Excel file with pricing and pros/cons of all our options

## Hypoxia Capstone Meeting Minutes 10/23/20

- Went through pros/cons of buying a prebuilt chamber vs building our own
  - Dr. Dev thinks it would be worthwhile to continue to design our own chamber and prototype both in order to compare them in real life
  - Prebuilt – we'd need to drill holes for tubing and possibly add stilts so that the lid can be opened easily
  - Our design – has a shelf for humidity, is complete with door design now, it might not be airtight
    - Could maybe add 3D printed supports for the shelf instead of having it jigsaw into the walls of the design
- We decided to manufacture both designs so that we can test both
- Buy acrylic sheets that are less than 32x18 inches (not a big deal)
  - Buy from a Moscow glass shop (??)
- Control system pros/cons of sensors inside/outside
  - Might want to have a separate tank of premixed gases at the right percentages to act as a contingency plan if something goes wrong -- this is a project for later
  - Want to minimize holes into the chamber – could
- Ian is worried about pressure
  - Might have difficulties getting gas to go out the exhaust tube
  - We could have a control system that opens up the exhaust tube whenever we pump gas in
  - The CO<sub>2</sub> sensor can measure pressure, so we could have the control system make sure it's maintaining a certain setpoint for the pressure of the chamber.
    - This solution would mean having the sensors be inside the chamber
- The sensors we picked out are good for this project
- Need to know what pressure the solenoids should be rated for
- Door materials
  - Might need a different way to manufacture the door instead of laser cutting so that it's still see-through
  - Ian will check to see if there's a material we could use (such as plastic) that will withstand manufacturing and still be see-through
- To purchase items: give Dr. Schiele a list of everything we want and he'll buy it for us
- Action Items
  - Working towards manufacturing
    - Chamber - **Colin and Jacob**
      - Figure out if we need to redo door design
      - Get holes for tubes figured out
      - Figure out how tubes are going to be attached
      - Build supports for the shelf
      - Pick out final materials for the chamber
    - Pick out tupperware chamber - **Izzie**

- Sensors
  - We know the sensors and Arduino board we need, need to see if we need adaptor boards for this
  - Need to create full list of materials to give to Dr. Schiele to get them ordered
  - Create BOM – **Alex and Andrew**

## Hypoxia Capstone Meeting Minutes 10/29/20

- Went through changes to design
  - Added 3D supports for the humidity shelf
  - Fixed the way the door will be manufactured
  - Just needs holes placed for the tubing/control system and it can be manufactured
  - Would ethanol mess with the epoxy? (chamber can't be autoclaved because of acrylic)
    - Nope!
- Izzie found a good plastic chamber on Amazon
  - \$26 for a pack of 6
  - Can fit quite a few well plates
  - Will need supports built for it, holes drilled in, humidity cup placed inside
  - Needs to be bought sooner rather than later
- Electronics BOM
  - Sensors
  - Solenoids
  - Arduino & Raspberry Pi (?)
- Still need ways to deal with gas
  - Even 3psi will cause problems
- Ordering parts:
- Need to get holes figured out
  - Create three holes, all 15mm. One at the top and two at the bottom
- Action Items
  - For Friday: finish powerpoint for Dr. Schiele
  - By Tuesday: finish BOM for manufacturing chamber and electronics to send to Dr. Schiele so that materials can be ordered
  - Next week: prep for concept design review, begin manufacturing chambers and control system as it arrives, decide on sensor system

## Hypoxia Capstone Meeting Minutes 10/30/20

- Reviewed powerpoint
  - Maybe in the future create a way to have an emergency pressure release valve
  - Will build door without latches initially to test for what amount of pressure will pop off the door, then add latches to final design once we know our control system will successfully control pressure
  - See if there are larger sizes of tupperware
  - Might want to check for 3/8 inch instead of using 1/2 inch thickness for door acrylic
  - Might want to redesign humidity
    - Larger pan on the very bottom that has larger surface area which would increase surface area, cover it with a shelf with holes
  - Sensors
    - Condensation issues?
    - For sensors outside we might need to have temperature controls to avoid condensation
    - Find check valves to ensure that tubing is one-way
  - Seems like gases should diffuse on their own and mix well within the chamber
    - How long will the gases take to de-stratify(??)
    - Gases will sit and be static in the chamber for a maximum of 3 days
- Chemical solvent and then epoxy it to seal chamber
-