



Building an Automated Mushroom Growing Environment

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A guide for Schools, Scouts and other Youth groups

Cornelia Schmitt, Maynooth University

Mushroom growing is a fun project for any youth group. It allows producing your own food with quick success, is a great educational tool, and most importantly is fun!

In this project, you will build a system that controls moisture and CO₂ and use it to grow mushrooms like Grey Oyster Mushrooms. The controller will, after initial setup, keep time requirement to an absolute minimum, and ideally even improve the results (yield and quality of the mushrooms) you are getting.

An Irish Scout (Scout, Venture or Rover section) could use aspects learned in this project for their Skills (Electronics) or Environment (Gardening) Special Interest Badges. For British scouts, this project can cover parts of the Electronics, Environmental Conservation, DIY and Farming Activity Badges.

A school group might want to experience growing their own food first hand as part of their biology class, and learn about the importance of environmental factors. The assembling might be done by the class, or by an extracurricular Technology club.

Environmental groups could use this as part of a reuse/recycle project, as many good growth media can be found in things that would else go to waste: used coffee grounds, cardboard, wood shavings from not chemically treated wood, ...

While a low tech approach is definitely possible - and would bring on a different valuable set of experiences - many of these groups might struggle to care for the mushrooms daily:

Meetings might only be weekly, there are holidays and school breaks, ...

In addition to that, this setup provides an introduction to Arduino, a very useful tool that can be used for all kinds of project, from hobby project gadgets right up to professional microcontroller prototyping!

All in all, this project will take about a month, with four 2h sessions, a week apart each. You won't be able to speed it up much by meeting more often - the mushrooms need the time to grow! Ideally, preparing for the second stage (fruiting) will perfectly fit into the time for the first stage (colonisation). The third stage is of course harvesting and eating the mushrooms

For this project you need the following:

Components/Materials	Cost	Notes
Grow box	5-10€	Ideally a mini greenhouse/propagation box, often sold as planting sets - sold at Aldi once a year, or at a garden center Alternatively, any big plastic box can be used
Arduino Uno or compatible equivalent	8€	A brand Arduino will cost about 20€, but any compatible off-brand version (like this one https://amzn.to/2Wl6rJG) will work just as well
Temperature and humidity sensor	8.72€	As available here: https://bit.ly/2YSynN9 Any other DHT sensor should work with the code supplied, but just tested with this brand
CO ₂ sensor	14.01€	As available here: https://bit.ly/2G0YI9l Any other DHT sensor should work with the code supplied, but just tested with this brand
Fan	0-8€	Any 5V fan - might be able to get one from an old laptop, a plug-in USB fan etc.
Atomizer for adding moisture	8.72€	As available here: https://bit.ly/2l3F2ie
Mushroom spawn (ideally some variety of oyster mushrooms)	3.32-10 €	For example this one: https://bit.ly/2UzKxuR There are plenty of species and varieties available, so have a look around before you buy! It might also be worth joining a local Mushroom growing Facebook group, and contact local sellers
Breadboard and jumper wires	4.10€	As available here: https://bit.ly/2ldQffj To wire the components up
N-channel MOSFET	1.20€	As available here: https://bit.ly/2X2pZZp
2x Wall plug	2x 0-1.20€	As available here: https://bit.ly/2UAHOkT , might be able to use existing ones
USB cable (to micro USB, USB type C, or other)	0-1€	As available here: https://bit.ly/2WQjNnv , Might be able to use a no longer used one - The cable will be cut in the process, so you won't be able to use it for its original purpose after!
Growing medium : • Coffee • Cardboard • Wood shaving • Straw • Toilet paper	0 0 6€ 8€ 4€	There are various suitable substrates - use what is available to you! This might also work as a recycling project, for things that would otherwise go to waste (coffee grounds, cardboard). I heard of people using old books as well, but would advise being cautious of potentially toxic inks!
Total costings	53-85€	

It is also worth noting that many components (especially the Arduino and the breadboard) can be reused for many different projects, so it is a long term investment, not just for this one activity!

Start:

This project consists of two parts: the electronic one, and the one directly related to mushroom growing.

I will first explain the first part of the mushroom growing (colonisation), which can be done without much regulation and should be able to be done in group meeting. Then I'll explain the electronics - there is a lot of parts to it, so it will take two meetings. By the end of the second one you should have the system fully set up, to keep the conditions in a way that the mushroom growth produce mushrooms. And the week after, you'll be able to pick your harvest!

The following instructions are for any kind of oyster mushroom, for other species like Shiitake or Button mushrooms, there are slight differences - you will still be able to research most of

Starting to grow mushrooms

When growing mushrooms, they take their energy from material called substrate - we can use anything from coffee grounds, to wood chips, to straw, to toilet roll, to cardboard (when using cardboard, make sure there is no print on it - mushrooms gather up toxins from where they grow! Some people grow on old books too - while this is definitely cool looking, I would not recommend it on the basis of the ink in them). I did one bag using cardboard, and one using coffee grounds.

The time when the mushroom spreads to all of the substrate (so it can get as much nutrition as possible) is called colonisation.

To prepare the substrate, boil it to kill any potential germs or remainders of mold. If you want to make sure, you can also heat it in the microwave for a few seconds additionally. It is also good practice to heat your tools with hot water, to avoid contamination from them.



Then, strain the substrate until it is moist but not soaking. Wait until it has cooled down to room temperature.

In a small plastic bag, add the spawn (the spawn is the “seeds” from which the mushroom grows. It will most likely be grains covered in a white substance): If you grow on cardboard, layer a few pieces of cardboard, then some crumbs of spawn, and repeat until the bag is full. If you grow on another material, fill the plastic bag and stir the crumbled up spawn in.



Close the bag, then poke a number of small holes in the side the the mushroom can “breathe”

Next we prepare the grow box. I built two little platforms (one on each side) from takeaway boxes by cutting a rectangle from each side, and then taping them in place. Then I filled the bottom of the box with water. While this isn’t necessary, it helps keep the moisture up, and makes setting up for the second part (fruiting) easier.



Place the bags in the box, add the lid, and cover with a sheet of paper to keep them dark for the next two weeks.

The electronics:

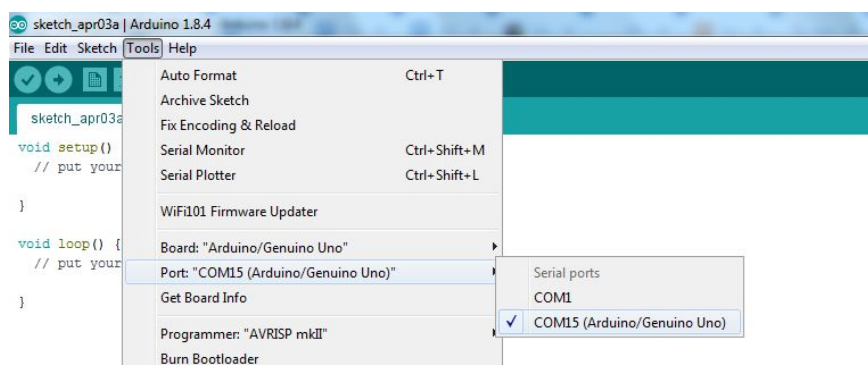
This project uses an Arduino Uno. Arduino is a prototyping platform, meaning it is made to quickly and easily build, test and run things - Uno is the standard model. It is open source so you might be able to get it, with exactly the same build, considerably cheaper from other companies.



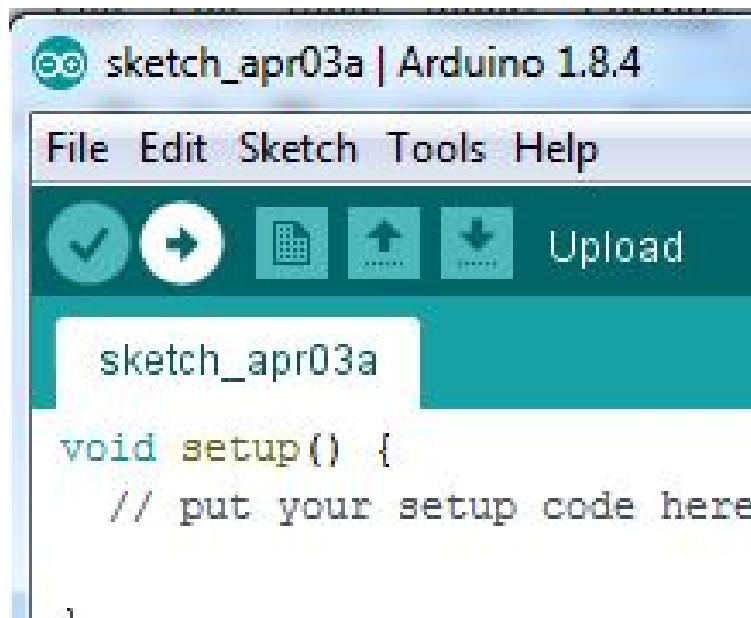
<https://store.arduino.cc/arduino-uno-rev3>

You will also also need the Arduino IDE (Integrated Development Environment, somewhere to write, edit and upload program code), a free computer program to tell the Arduino what to do. You can get it here: <https://www.arduino.cc/en/Main/Software>

After connecting the Arduino to the computer (the cable goes to the metal box on the Arduino, and any USB connector on your computer), you can try it out right away, by selecting File->Examples->Blink. To run it, then first make sure the computer finds the Arduino by selecting the right port at Tools->Port and then the right port (the correct port is the one that is NOT COM1):



and then clicking the arrow (highlighted in white below) to upload



The small LED on the board should now blink, with being on and off for one second each.

The code for running the mushroom growing environment controller can be found on <https://bit.ly/2VgbQaN>, as well as code to test the individual components after each step. You can run each step after you connect the hardware (you can open your own or downloaded files over Files->open. Try this with the version of the blink code you download - if it worked the LED should now blink faster.

Next we need a way to connect all components. For this, we use a half size breadboard - somewhere to stick the wires. Some holes are already connected, like shown in the photo below. On each light blue line, all the holes are connected:

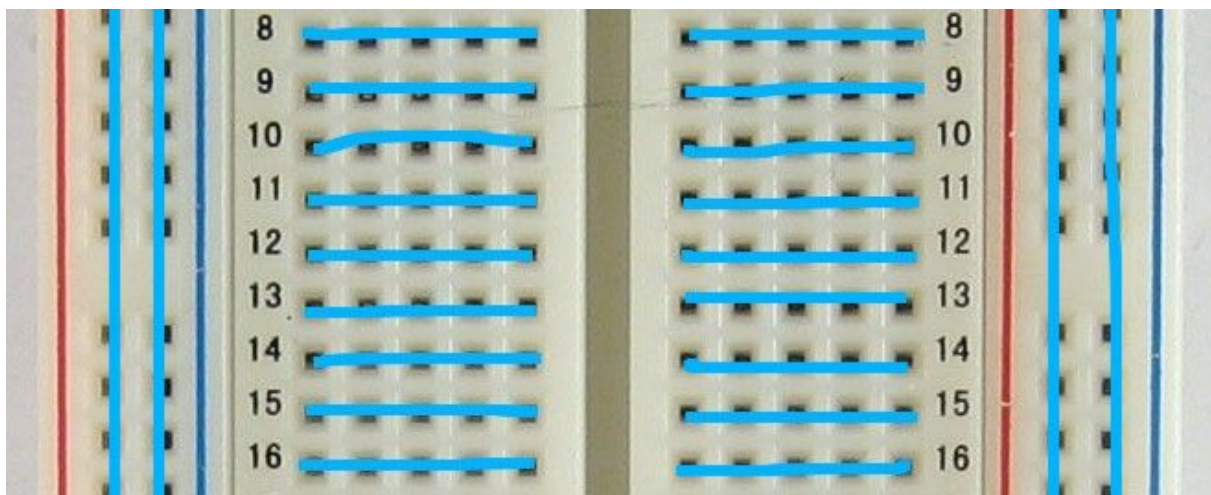


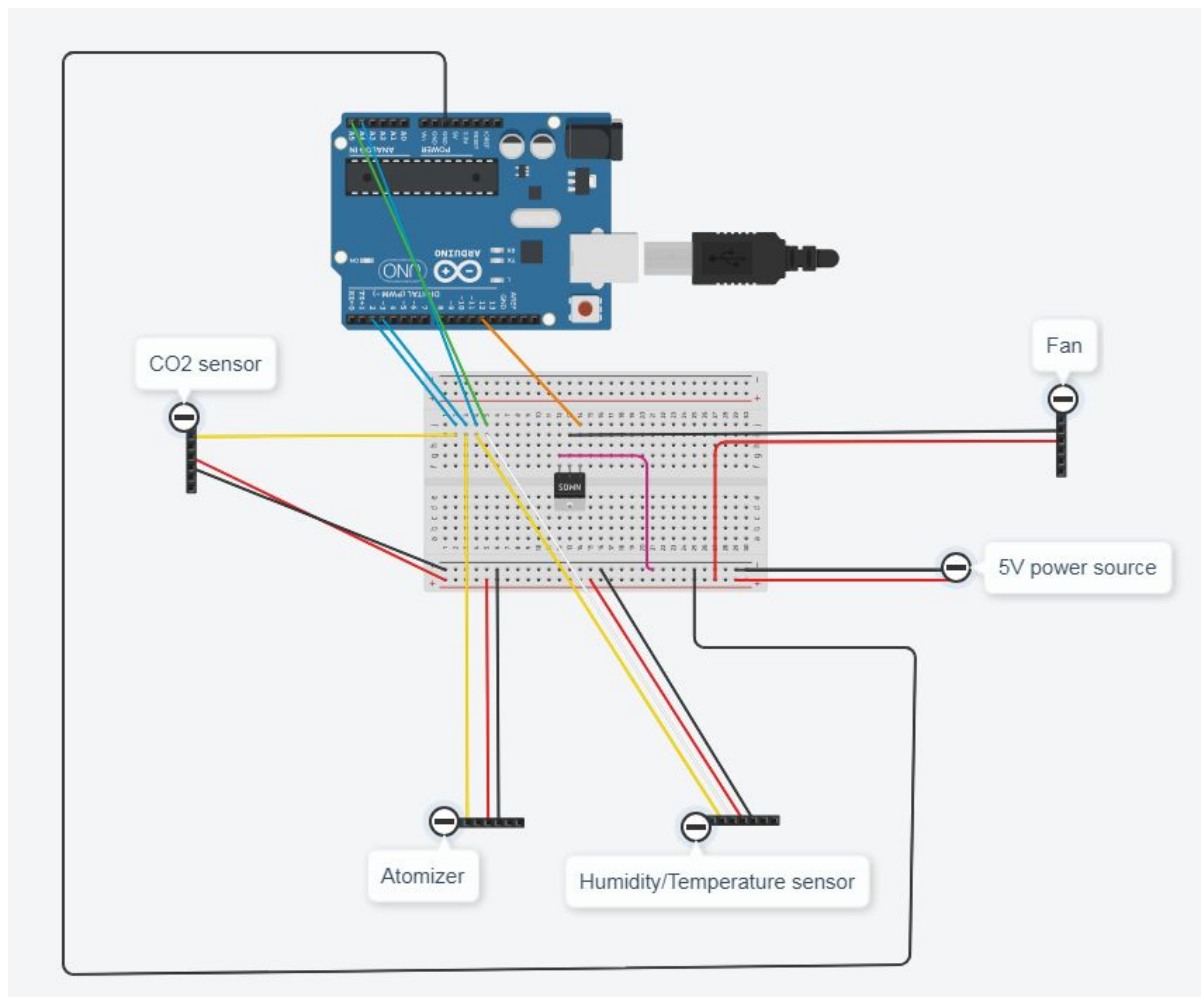
Image: <https://os.mbed.com/handbook/Breadboard>)

All the pins next to the red line are connected on each side, which I will call the Power Rail (or 5V) from here on. The blue one is the Ground Rail (or GND or 0V).

Then, all the pins in each numbered row on each side are connected. We will be only using one side for this project, but the other one is a symmetric copy.

All components used (and almost all other components) have a common colour scheme - red is Power and black is ground. The only slight exception is the fan, as no control is built in, so we need to put something between the Power Rail and its power ourselves - more about this later. The white and yellow cable are the information cables of the sensors and are connected to breadboard, which is the connected to the Arduino with green and blue. We will always connect the row on the board to a pin on the Arduino with the same number, but this is only for convenience, not necessity.

Here is an overview of how all components will be connected in the end (don't worry if that seems like a lot, I will explain step by step below)



Set up Power and ground:

Next you need power. For the Arduino, the easiest thing to start is to just connect it to the computer, like explained above - you can upload your program to it, and power it at the same time. When you have the code you want uploaded, you can also unplug the USB side and plug it in anywhere else: a power bank, a phone charger, anything that has a USB plug!

Next, we need to set up the power for the other components (the Arduino could power some of them, but we need too much power, so we need something else)

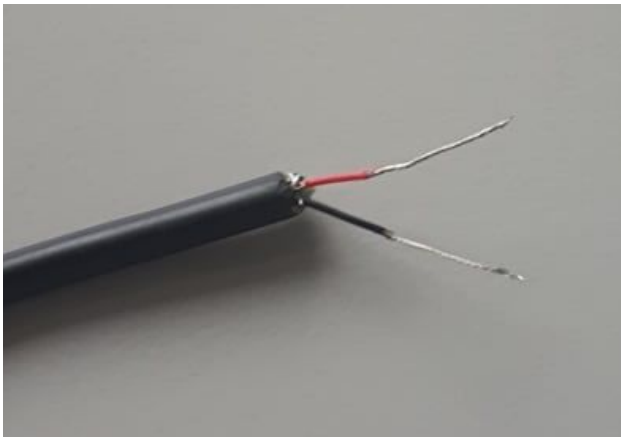
For this, take a USB cable you don't need any more (USB ports can supply a maximum of 5V, which means we don't have to handle high voltages). Cut it near the end of the smaller USB plug:



Now strip away the outer rubber. Inside there should be a red and a black cable. There might also be shielding (thin wires without colour and/or something that looks like tinfoil), and two other wires (green and white) - we don't need any of this, and can simply cut all of this away.



After we cut away everything but the red and black wire, we strip the rubber off the ends of them, until we have an end that looks like this:



This is our 5V power source. Like the other USB cable (from the Arduino), you can plug it into a computer, phone charger or power bank.

Connect the red wire of your power source to the 5V rail, and the black one to the ground. Since we need the Arduino to “know” what ground is as well, we connect one of the pins saying GND to the ground rail as well (the long wire on the overview diagram)

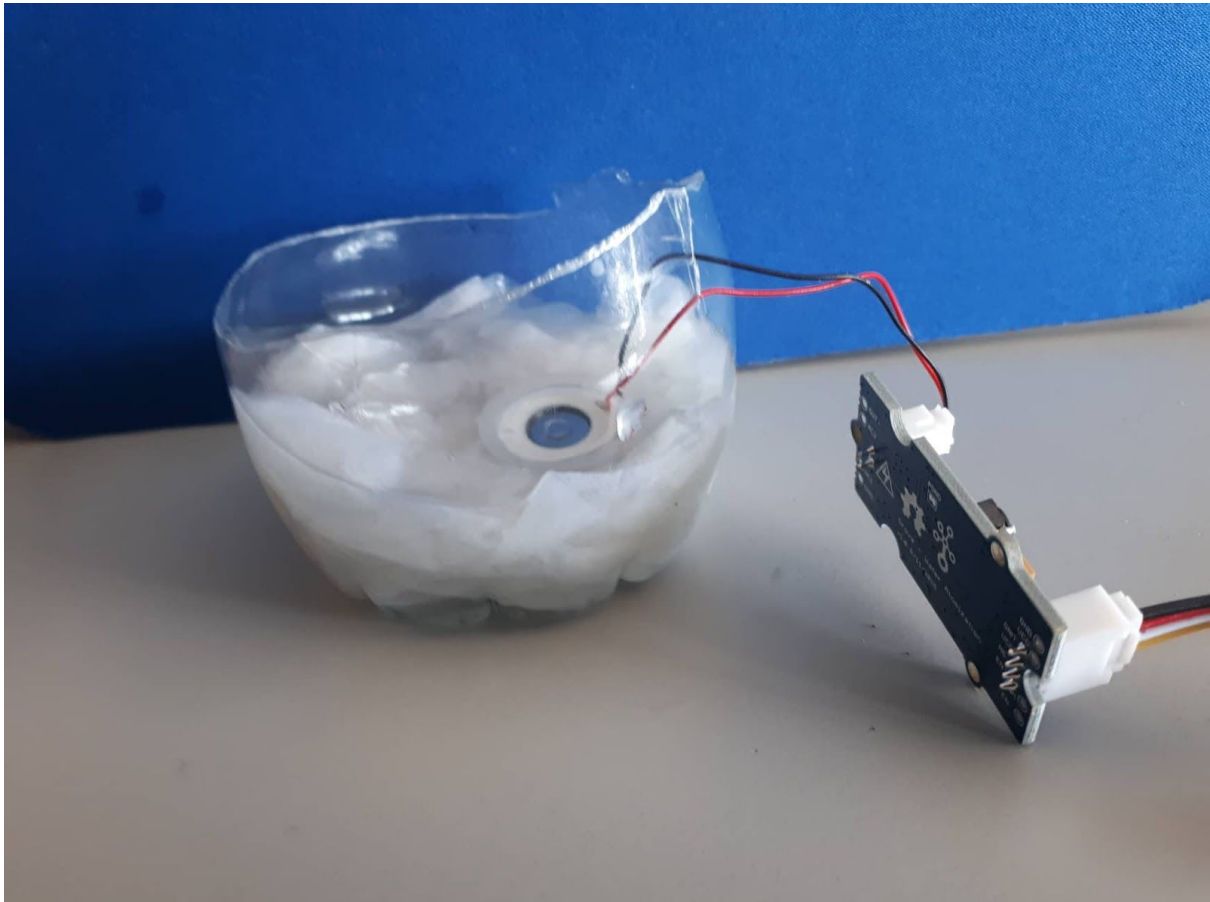
Set up the Moisture control:

Atomizer

The Atomizer has a four part connection cable. The red and black one are 5V and Ground, respectively, the yellow one Enable (your on/off switch) which will be connected to Pin 3 and the white one not connected. To get started, connect the red one to the Power Rail, the black one to the Ground Rail and the yellow one to row 3 on the breadboard, which in turn is

connected to pin 3 on the Arduino. Important: it is labeled 3, not “A3”. (also see the diagram at the top for help).

For building a test water reservoir, take a paper cup, plastic bottle, or similar, and trim it to about 5cm in height. Cut a small cut - about half a centimeter - on one side, to keep the cables in place. Fill it about half way up with water, and add two sheets of toilet paper to soak it up. Place the disc shaped part on the toilet paper (the top of the disc should not be covered in water).



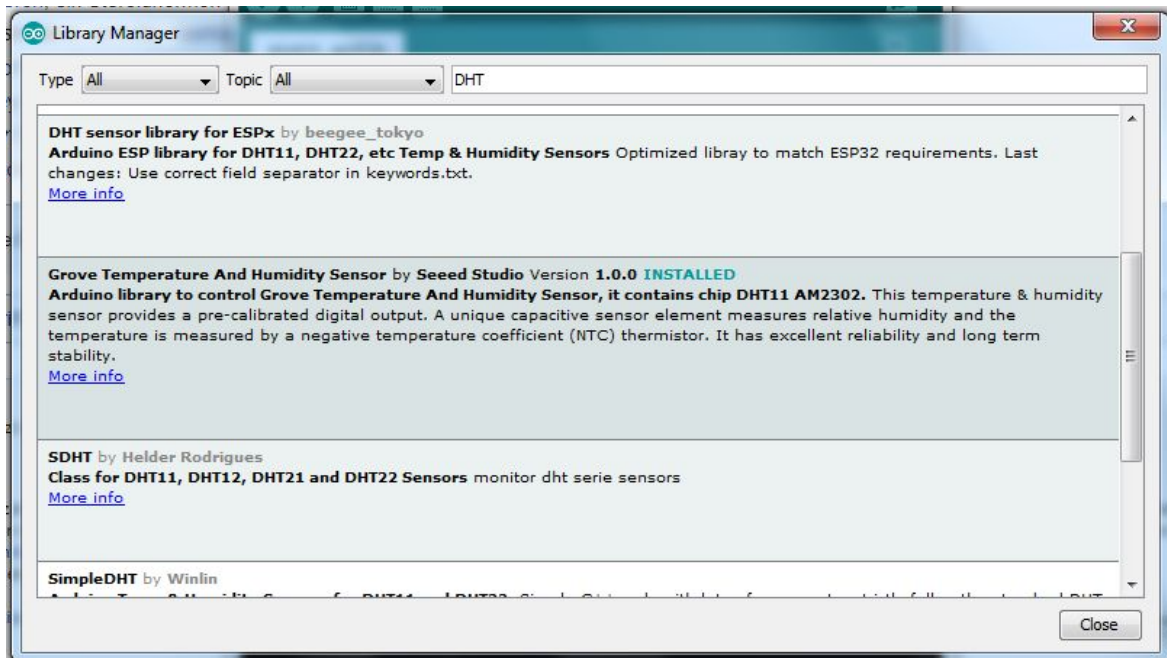
If you want, you can test this step with the Atomizer code from the Drive now, like you did with the second blink code before. When powered and switched on, you should now see a small column of vapour raising from it.

Temperature & humidity sensor

The setup for this is a little more complex. To use it, we have to download a “library” - code someone else has written to make certain tasks easier.

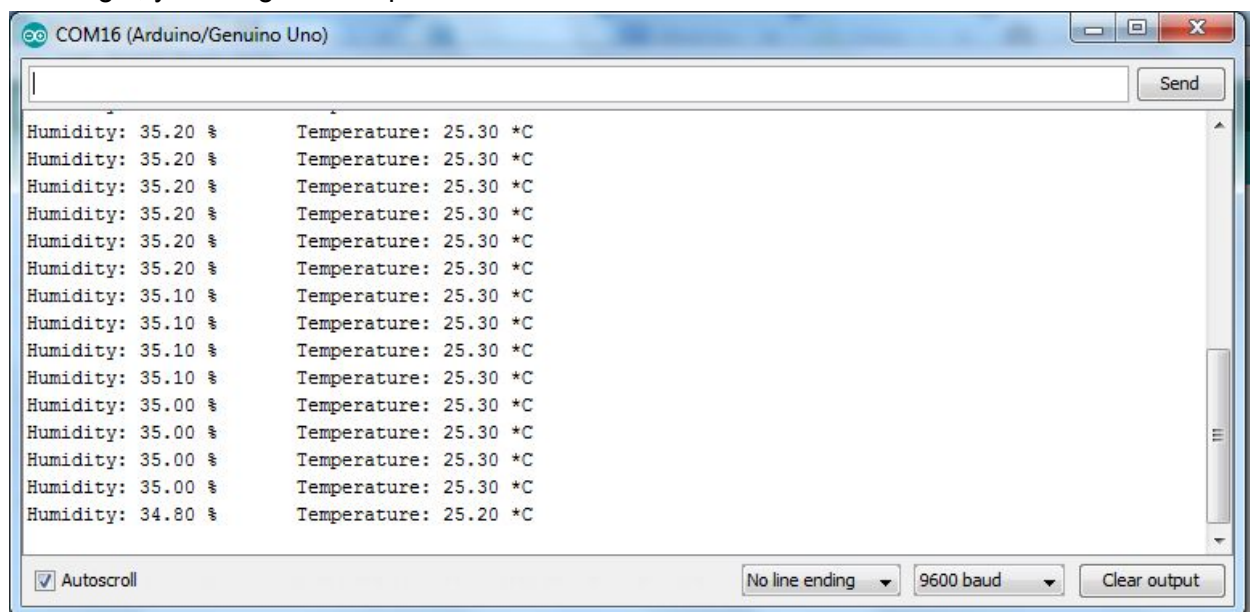
First of all, open Sketch>Include Libraries>Manage Libraries...

Search for “DHT”, and scroll until you find “Grove Temperature and Humidity Sensor” by Seeed Studio. Click “more info”, and then “install”, then close the library manager by clicking “close”



Now connect the red cable to the Power Rail, the black one to Ground, and the yellow one to row 2 on the breadboard, which you connect to pin 2. You can run the test code from File>Examples>Grove Temperature and Humidity Sensor>DHT Tester, or download it from the Drive above.

Running it, you will get an output similar to this:



If you gently breathe on it, you will see the humidity reading increase

If this is working, you can also try bringing the last two steps together - just upload the Combined Humidity Control from the link above.

CO2 sensor:

Open the library manager again, by selecting Sketch>Include Libraries>Manage Libraries... like above. Search for SGP and install "Adafruit SGP30 Sensor"

This one is a little more complicated to connect: The white cable needs to be connected to 4 and the yellow one to 5, which are then connected to A4 and A5 respectively (note that this is different from 4 and 5!), the red and black to Power and Ground as usual.

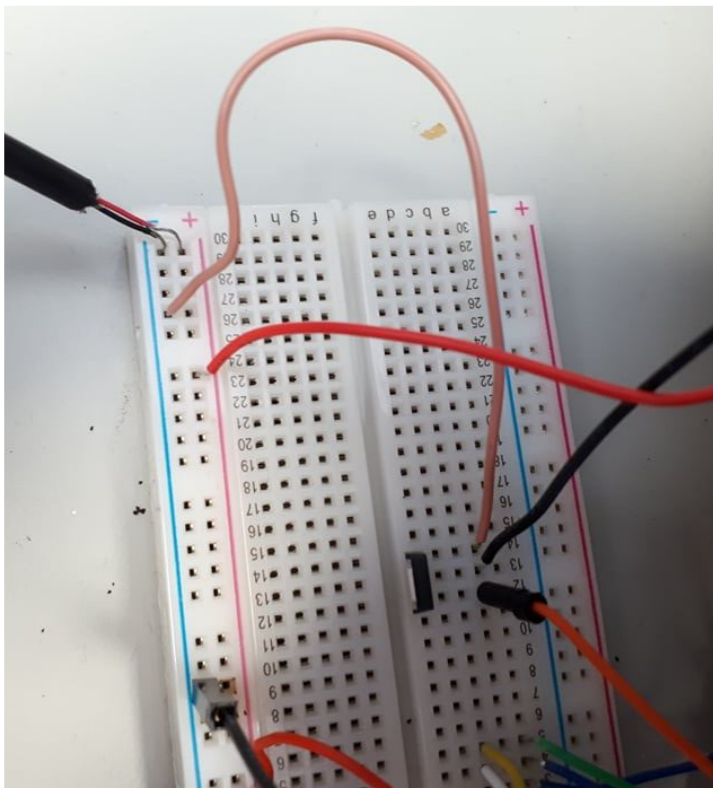
Having done this, you can run the example code (File>Examples>Adafruit SGP30 Sensor>sgp30test) or download it from the drive. Again, you should see the effects when you breath on the sensor - the air you breathe out contains much more CO2 than fresh air (Note that there is a startup period of about 10-20s where readings are not correct)

Fan:

The last part to set up is the fan.

Place the FET on the breadboard, row 12 to 14, so that if you look at it from the side of row 1 the black side is on the right and the metal one on the left.

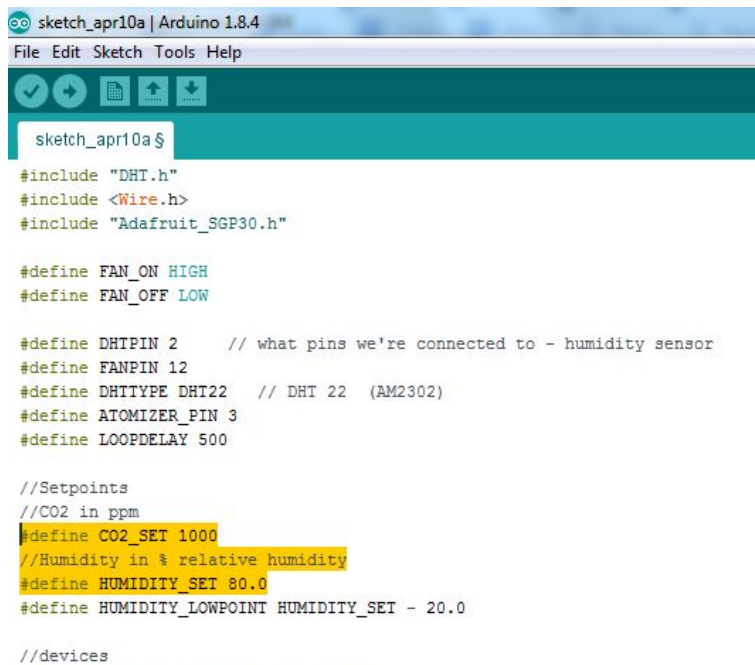
Connect row 12 to pin 12, the black cable of the fan to row 13, and row 14 to ground. The red cable to the ground then goes to power.



(orange goes to pin 12, black and red are the cables of the fan. The pink one goes to the ground rail)

Now that you have connected all the components, you can run one of the Environment control files by opening it like the files above. When you place all your sensors and actuators in the box, the conditions in the box are now controlled by the Arduino to be ideal for Grey Oyster mushrooms.

If you want, you can change the setpoint values by replacing the numbers 1000 and 80.0 in the highlighted area by the CO2 (in ppm) and humidity levels (in % relative humidity) you want. The humidity should have a .0 at the end, because it is saved as a decimal number, not an integer



```
sketch_apr10a | Arduino 1.8.4
File Edit Sketch Tools Help

sketch_apr10a $
#include "DHT.h"
#include <Wire.h>
#include "Adafruit_SGP30.h"

#define FAN_ON HIGH
#define FAN_OFF LOW

#define DHTPIN 2    // what pins we're connected to - humidity sensor
#define FANPIN 12
#define DHTTYPE DHT22 // DHT 22 (AM2302)
#define ATOMIZER_PIN 3
#define LOOPDELAY 500

//Setpoints
//CO2 in ppm
#define CO2_SET 1000
//Humidity in % relative humidity
#define HUMIDITY_SET 80.0
#define HUMIDITY_LOWPOINT HUMIDITY_SET - 20.0

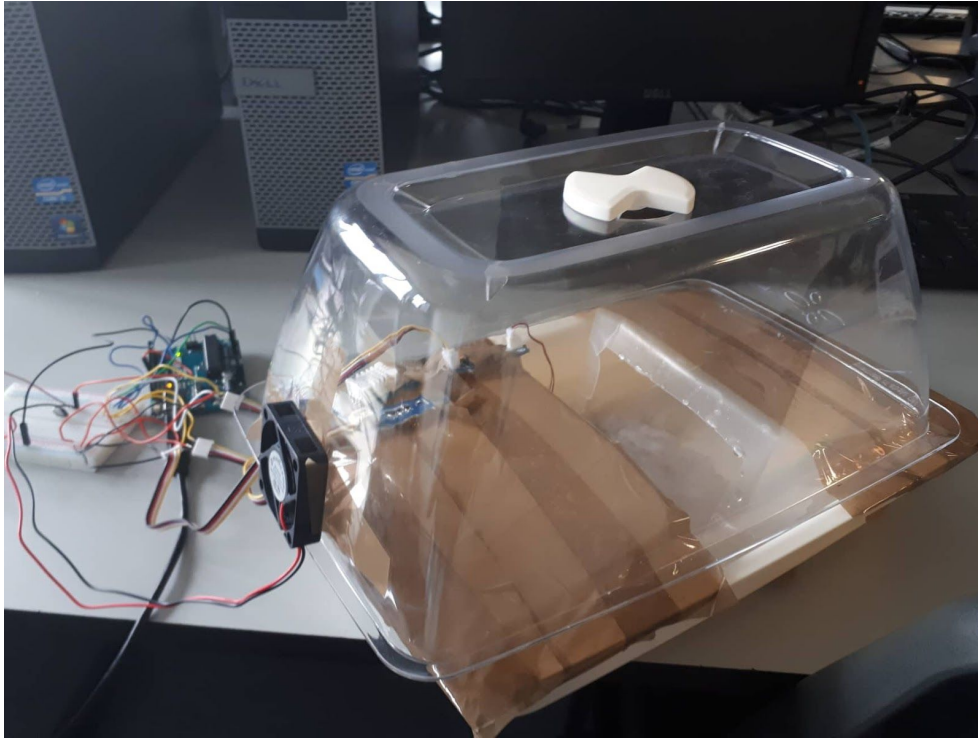
//devices
```

Typical values are CO2 of 1000ppm and humidity of 80.0% but you can look up a list for many varieties here: <https://bit.ly/2D2PqCz>

Growing Mushrooms, part 2:

Now set up the sensors in the grow box, and the fan on one of the holes. If you put some tissues in the water under the platforms, you can use it as a reservoir for the atomizer - because it is a bigger amount of water, it is less likely to run out of water!

It should now look like this:



Place the bags inside, run the control program on it, and wait until mushrooms appear.



The ideal time to pick for oyster mushrooms is when the caps are neither curled up (slightly too late) or down (slightly too late), but there is a lot of flexibility, so don't worry about not getting the timing perfectly right!

Happy growing!

Recipes:

If you reach this, you have successfully grown your first mushrooms! Well done!

Here are two ideas how to eat them:

Mushroom omelet:

A hand full of mushrooms

Two eggs

Oil

Salt and pepper

Wash the mushrooms, then cut into cubes of half an inch length

Fry the mushrooms with the oil, and season with salt and pepper.

Open the eggs into a bowl, add the mushrooms, and mix.

Pour into a pan, wait 2min, then turn like a pancake.

Fry fully through, then serve

Breaded mushrooms:

Five big oyster mushrooms

One egg

Some flour

Breadcrumbs (alternatively stuffing)

Oil

Wash the mushrooms.

Place the breadcrumbs, the flour and the egg in shallow bowls, and stir the egg until fully mixed.

Take a mushroom, place it in the flour bowl and turn until completely covered. Do the same with egg and breadcrumbs. Repeat the same for all mushrooms.

Fry in oil, then serve

Enjoy!

Side note: If you follow this set of instructions, you do so at your own risk. All steps, electronic and otherwise, are safe to my best knowledge, and I try to point out risks where relevant, but I do not take any responsibility for any of the risks involved in this project, or the correctness of any information. There is no step I wouldn't do, or let children of appropriate age do under my supervision, but in the end, you will have to make the decision of what you want and don't want to do yourself.

With further questions concerning this project, feel free to contact me at conni.schmitt@gmx.de, or Facebook: <https://www.facebook.com/cornelia.schmitt.359>. I'd also love to see your photos!

For Mushroom growing related questions, the following groups might be helpful:

https://www.facebook.com/groups/mushroomgrowinguk/?ref=br_rs

<https://www.facebook.com/groups/1386696498248239/>

https://www.facebook.com/groups/mushroomgrowers/?ref=br_rs

https://www.facebook.com/groups/214527411897213/?ref=br_rs

The mushrooms on the title page are Pink Oyster Mushrooms - great thanks go to Zsuzanna Török for letting us use this impressive photo!

Now all that's left to say - have fun!