Sloop Bioprinter
Assembly Guide
By: Andres Garcia Rubio

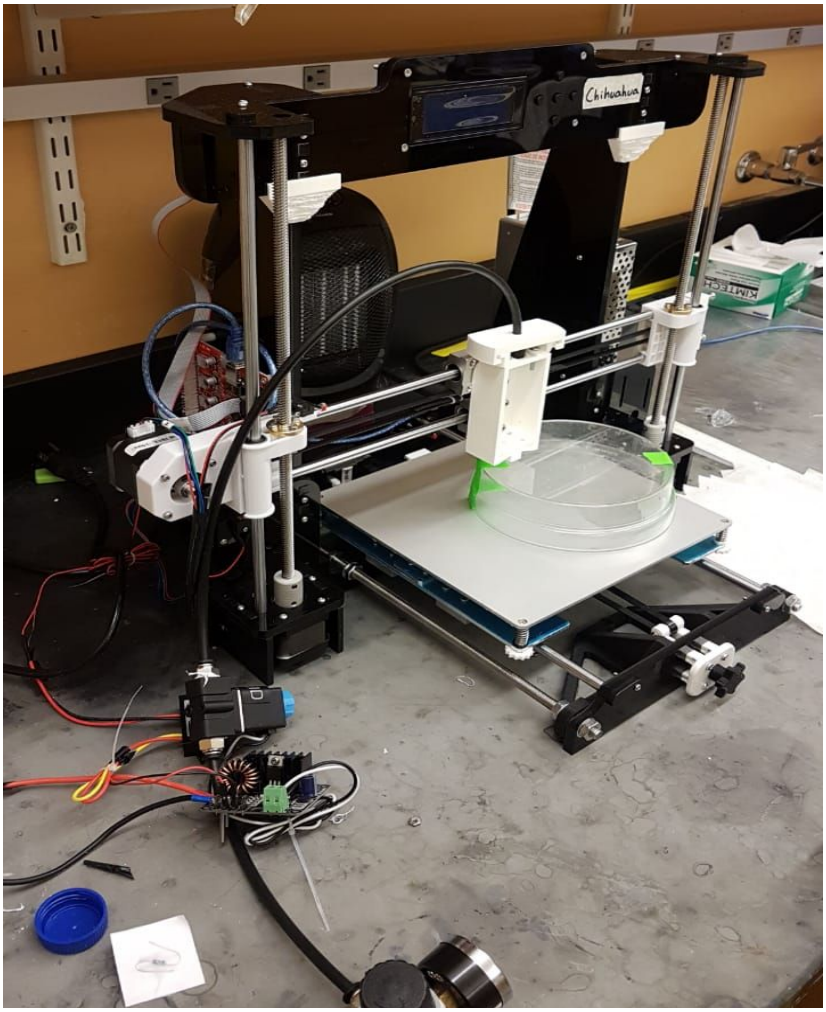


Figure 1: SLOOP bioprinter Assembled

Why build it?

We're in the dawn of the digital fabrication revolution, and in the early stages of the personalized medicine revolution. 3D bioprinting represents the middle ground between these two upheavals even though most of its real world applications still lie in the future.

Sixty years ago computers could only be used by mammoth educational institutions and military research labs because they were the only organizations that could afford them. The rise of personal computing changed all this. If there should be a similar path of democratization and commercialization in 3D bioprinting, the corresponding technologies must be freely available to the public. Smaller institutions should get access to the processes of 3D bioprinting.

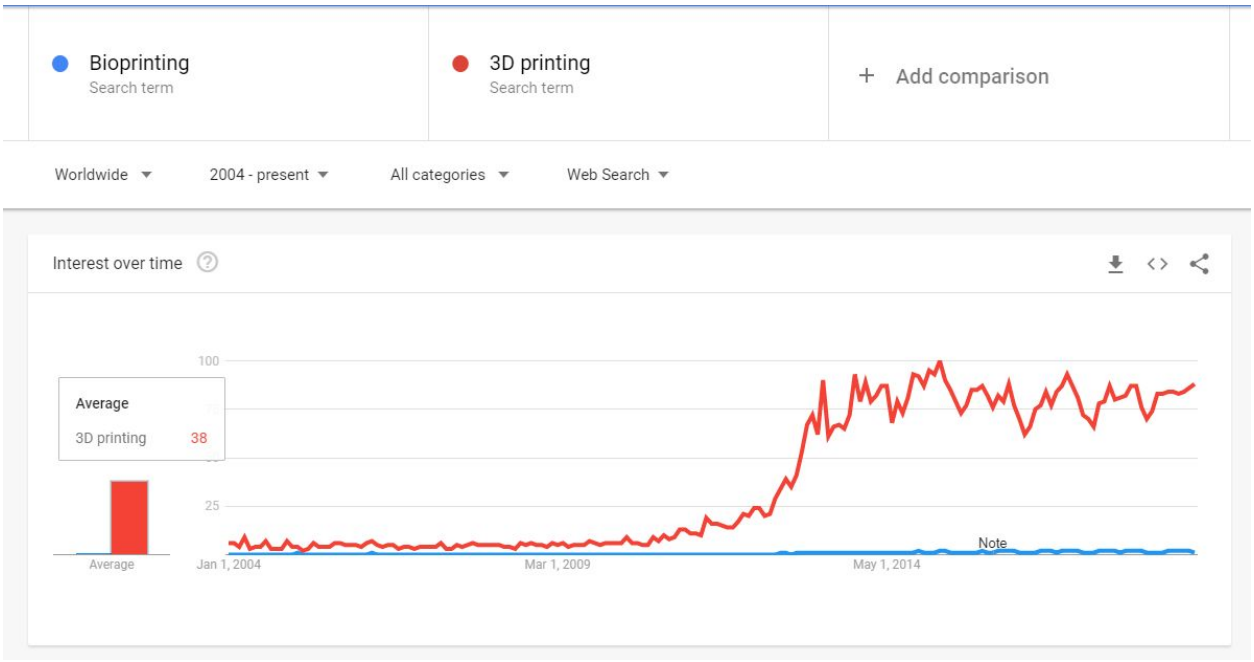


Figure 2: Google Trends

One of the advantages of computing using a digital electronics platform is its self-bootstrapping capability. One can start with computer hardware and an input-output channel, and then build assemblers and compilers for higher level applications. Once these applications are sophisticated enough, they can be used to build even better tools. One of the promises of digital fabrication is mimicking this with tangible materials.

The spoof bioprinter was the end result of a bootstrapping process The build process was completed without external CNC machines (other than a 3D printer, which can be the Anet A8 itself), using materials from a local hardware store. The whole process can be completed in a weekend. As of February 2019 this is the least expensive bioprinter you can get.

I once talked with a colleague who is seriously into the bio-materials side of 3D printing. I asked her if and when we would have routine organ 3D printing. She answered that she thought we would see full organ 3D printing in our lifetimes, but the methods and technology to achieve it would be so expensive that only millionaires would afford it.

As of today in the developed world, most people can use a computer and a desktop printer. With enough paper available they can get their own copy of War and Peace without getting out of their homes. This would have been very hard to imagine 30 years ago. Thanks to digital fabrication this could happen with many other objects in our daily lives in a generation, and eventually we could print backups for our organs.

Figure 3: The Altair 8800. The Altair 8800 mini computer was quite simple and didn't have useful applications, but its introduction to the market ignited the computer revolution because hobbyist could use it and improve it. I believe bioprinting has reached a similar technological milestone.

The hacker ethic requires that information should be free, that technology should not be a black box, and that creative shortcuts should be celebrated.

Bootstrap Process

1. **Get an Anet A8 Printer**

An Anet A8 can be bought on Amazon. It was chosen because it was the most inexpensive expensive alternative for a 3D printer that can be easily modded. Even though this guide focuses on the Anet A8, any Prusa i3 clone could be used to make a bioprinter with minor modifications.

Assembly takes approximately 8 hours for one person who hasn't assembled a desktop CNC machine on the first try. Three individuals with experience could complete the assembly in a couple of hours.

Once it's assembled it's time to mod it. It's hard to get a high print resolution on the vanilla Anet A8, as it requires a perfect assembly. Modding the printer makes any Anet A8 a good contender to most mid range 3D printers pertaining print quality. The mod parts can be printed using the Anet A8 itself, or any 3D plastic printer.

2. **Mod it**

Most of these mods where taken directly from ALL3DP. The mods go from the parts which are easiest to install and have a low printing resolution, up to the larger and more detailed pieces. This way, after installing a mod, the print quality improves just enough so that the next mod can be printed.

For all these mods, 1kg of PLA filament is enough.

- Extruder Pusher button
  This mod is needed in order to avoid calloused hands when inserting more filament.

- Centered Cooling Fan
  This mod increases the quality of the following prints

- X-Belt Tensioner
  This mod is easy to install and will increase print quality on the X axis

For this mod you'll have to buy:

Machine Screw 4mm x 30mm with hex nut, two of each.
Machine screw, 3mm x 24mm with lock nut (the kind with a plastic insert)

- Anet A8 T corner

This mod increases the sturdiness of the Anet A8.

- Anet A6/A8 Bed Level Thumbwheel Upgrade

For this mod you'll have to buy:

8x M3 Nut (Optional: Use self-locking nuts for thumbwheels)
4x Steel/nylon M3 washer (Optional: I used large, but regular is OK)

- Anet A6/A8 upgrade: Y-Belt tensioner

This mod will increase print quality on the Y axis.

For this mod you'll have to buy:
5 M3 screws and nuts(1x ~30mm and 4x ~10mm).

- Anet A8 Front & Rear Frame Brace

This mods really increase the sturdiness of the Anet A8 and keeps the rods at the bottom of the printer in place.

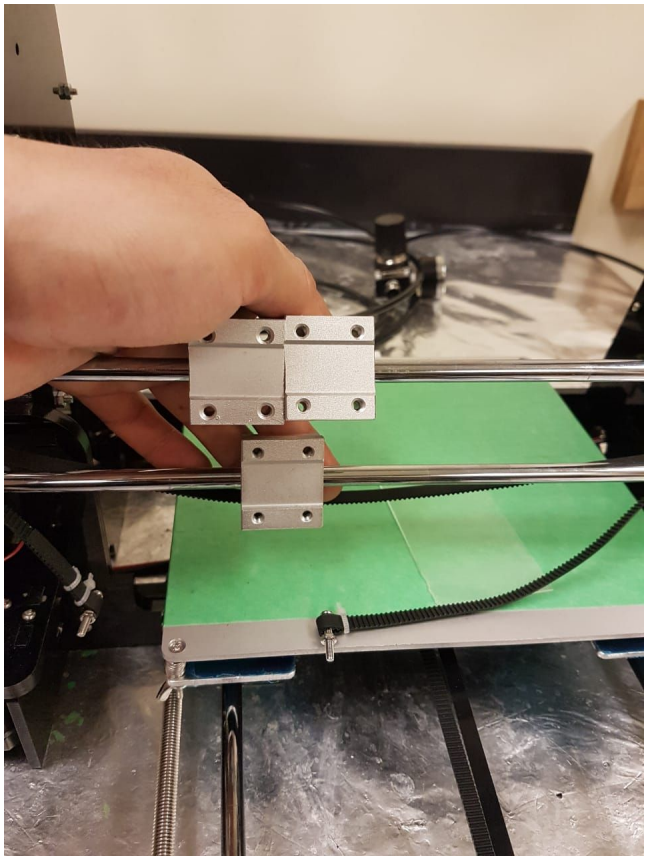
3. Once all the mechanical mods are in place, the printing resolution should be as good as it gets with the Anet A8 printer. Print all the necessary pieces to make the syringe extruder head. The necessary pieces can be found in:

    - Grabcad
    - Thingiverse
    - Github

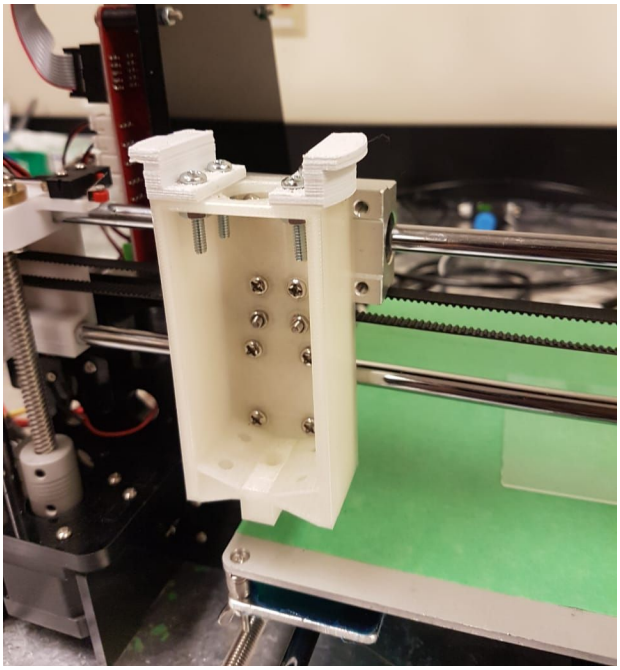
    Print them.

4. Disconnect all the electronic wires from the printers bed and from the extruder head. Keep the large extruder fan for the next steps.

5. Take away the extruder head. Throw away all of the cables except for the fan.



Install the 3D printed pieces in the empty rails

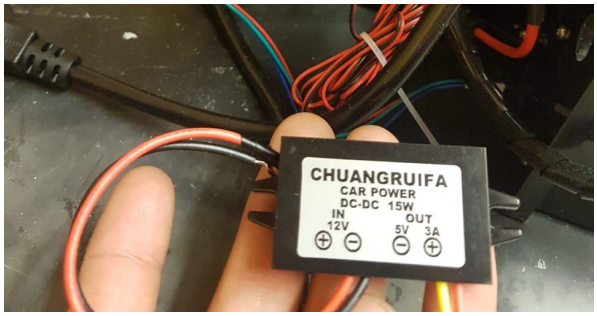


6. Installing the electronics:

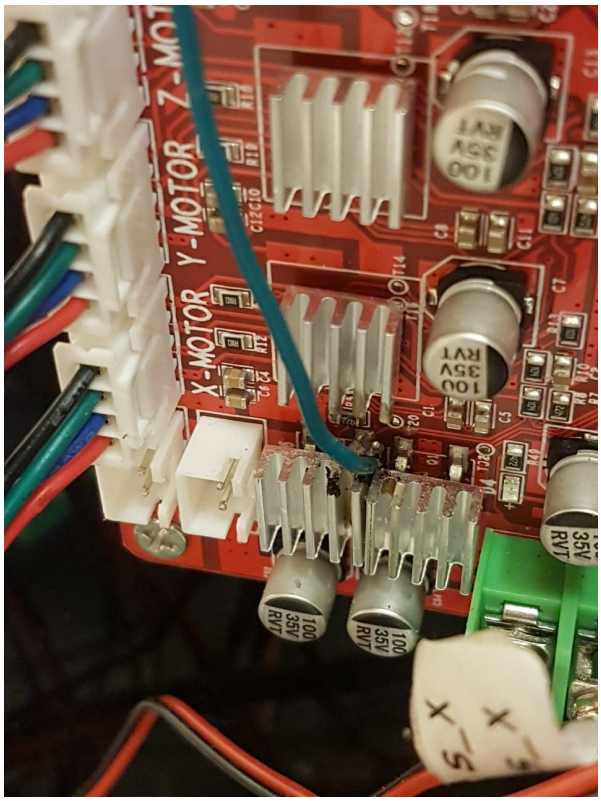
   Connect your 24 Volt Source to a 120AC mains outlet.

Connect a 24 Volt source to Driver. Ou might need some wire terminals to connect the 24 Volts to the wire. There are two ways to connect the printers electronics to the driver

a. Use a buck down converter to change the 12 Volt PWM signal to the fan to a digital signal. To do this you'll have to cut the Fan #2 wire and solder it to the buck down converter



b. Take the 5V PWM signal that powers fan #2 straight from the PCB. The schematics are in a github repo.

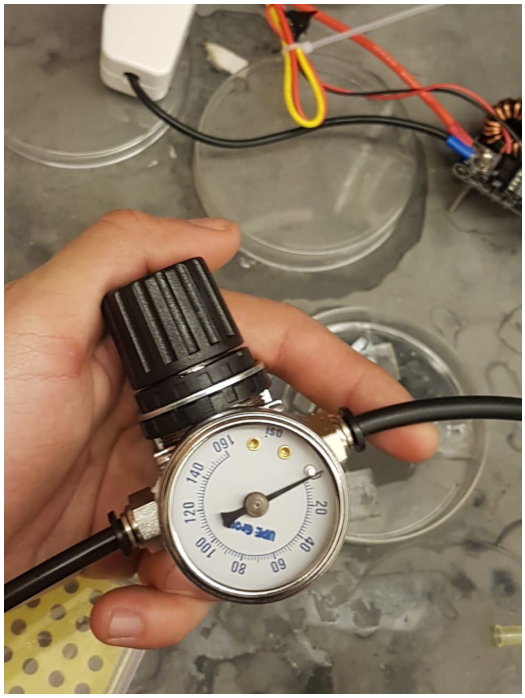


Once the input for the driver is connected, connect the output to the solenoid.

7. Installing the pneumatics
   For most of these connections some piece of thread sealant tape will be needed

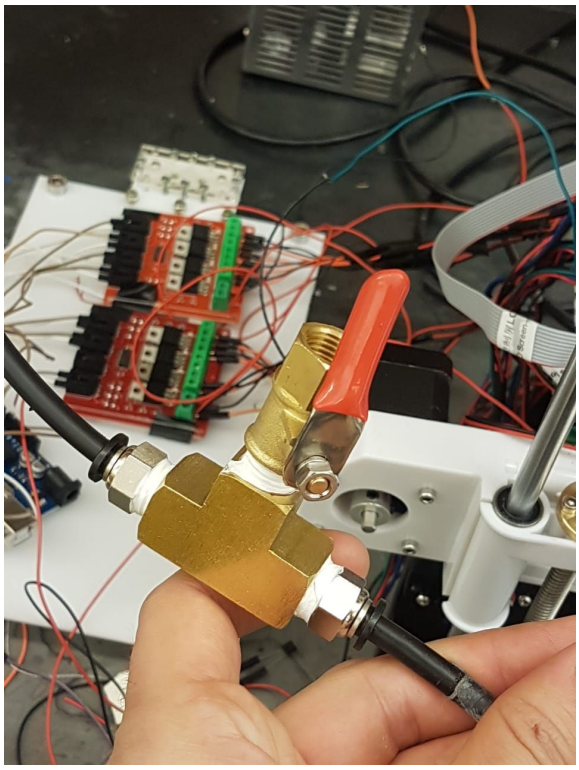
   Get a pneumatic pump or a tank of compressed and hook a piece of air line to it (the length depends on the setup)

Use the air line to connect the tank to the pressure pressure regulator.



Connect the pressure regulator to the solenoid with using the threaded connectors.

Add a relief valve with a T. This will make taking the syringe at the end of the prints easier, venting the pressure.



Insert the 10 ml syringe with a cork in the syringe.

Go to quick setting in the ANET A8 and turn on the FAN at 100%. If you hear the clicking sound from the solenoid, that means its working

8. Use a script to change Gcode

Here's a quick script to turn normal 3D printing Gcode into Gcode that works on this printer. It replaces the Extruder Gcode instruction with M107 S255 (turn fan on at full speed) and M106 to turn it off.

Kudos to:

- Yu Shrike Zhang lab for providing the funds for the first two spoof printers and space on which to use them.
- Artisan's Asylum for providing 3D prints and help on the design.

- People on All3DP for the mods which improved the Anet A8 considerably
- Carolina Chavez and Jane Shin and Marina Ruelas for testing these printers with actual bioinks.

Some other printers out there:

https://openhardware.metajnl.com/articles/10.5334/joh.6/

Proposed Bioprinting New Mods:

- **Temperature control**
- **Pressure control**
- **Multi Material printing**
- **Open Version of microfluidic chip for multi extrusion**
- **Open GUI for the printer**
- **Post processor and slicing software for bioprinters**
- **Open protocol repository for bioinks**

About the Author:

Outside of the internet “garbio” is Andres Garcia-Rubio. He has designed an IOT oxygen measuring system and a chain smoking robot. Will do CAD design for food. He spends his days thinking about digital fabrication and fighting the good fight on opens source hardware.

License