GENSPACE

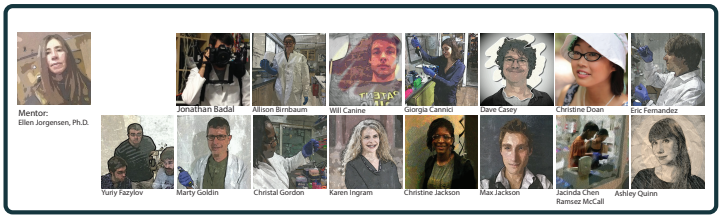
New York City's Community BioLab

iGEM

OpenLab-Blueprint

What is the Open Lab?

Genspace has a unique opportunity to expand its impact beyond its physical presence in New York and bring hands-on involvement with synthetic biology to schools and communities around the world. The Open Lab is the key step towards this vision; it is the complete set of knowledge, tools, and resources required to successfully develop a thriving community biolab, all created following open source principles. Enthusiast communities and organizations around the world can use the Open Lab to fill in key gaps in knowledge, tools, or resources to launch their own community biolabs.



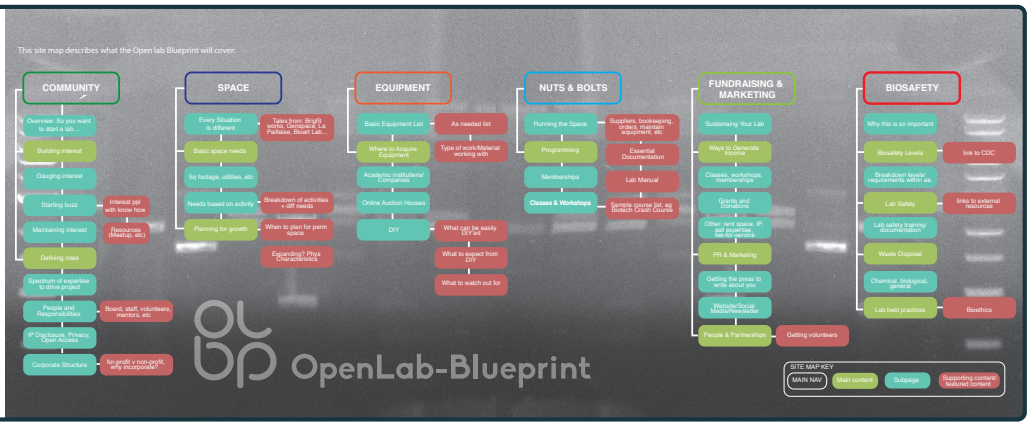
1 OPEN LAB BLUEPRINT

The Open Lab Blueprint is an easy-to-follow guide to launch and develop a sustainable community biolab. The website is a work in progress and is hosting at OpenLab-Blueprint.org. This Blueprint is a holistic view of the community biolab and includes the following components:

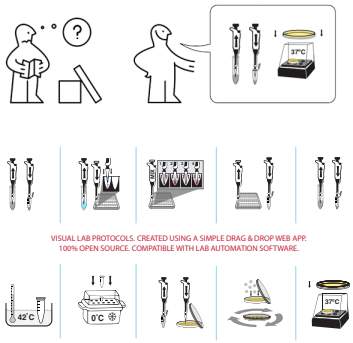
Starting up a lab, including identifying the right space, acquisition of key equipment, and efficiently implementing safety standards and best practices.
Developing a community, including building awareness, developing programs of engagement for students, the amateur scientists, and the general public, and collaborating with the broader scientific and educational communities.
Creating unique content, including educational resources, using the Genspace curriculum and engaging activities, focused on tailored, site-specific explorations and experiments.
Operating a biolab, including a resource base of protocols for standard genetic engineering activities, geared towards a budget-constrained lab, operational best-practices ranging from procurement of reagents to proper storage of experiments, and financial sustainability models.

COMUNITY SPACE BIOSAFETY

EQUIPMENT NUTS & BOLTS MARKETING & FUNDRASING



2 BIOGLYPHICS



There are 4 problems with text protocols.

1. Poor Consistency
Each person writing a protocol phrases things a bit differently and focuses on different content. For a beginner in the lab this can be confusing.
"Spin down" vs. "Centrifuge"

2. Poor Visualization
It can be hard for a beginner in a lab to connect the text of a protocol with clear actions they need to perform.

3. Low Efficiency
Writing text protocols is not very time efficient. You need to spend time deciding word choice and what level of detail to cover.

4. Machine Illegible
Because the text of protocols is not consistent in language or formatting, computer programs that run lab automation software are not able to use it.

Why We Like It.

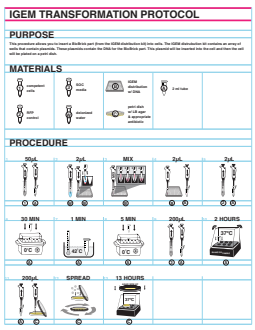
100% consistent.
Each protocol follows the same logical format.

Easy to understand and visualize. Materials and Procedures are visually defined just like IKEA instructions.

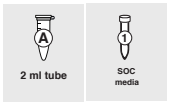
Fast & easy to create. Simple drag and drop web/android/iOS app interface.

Will be 100% machine readable for lab automation software. Making a protocol in this format will automatically build machine code behind the scenes.

Drag and drop web app for creating a BIOGLYPHICS protocol.



STEP 1: DEFINE YOUR MATERIALS

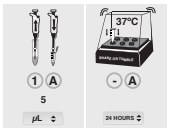


We have an empty 2ml Tube defined as A

We have a test tube of Soc Media defined as 1

STEP 2: CREATE YOUR PROCEDURE

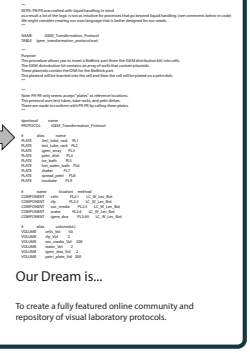
Use procedure icons and materials to create your protocol.



We are pipetting 5 microliters of 1 into A.

We incubate & shake A for 24 hours.

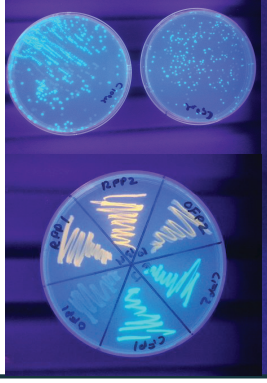
When you create a visual protocol... The web app will automatically generate lab automation code.



Our Dream is...

To create a fully featured online community and repository of visual laboratory protocols.

3 IP-FREE GENES



We started the competition period with a lofty goal- to create a small library of biobrick parts that would be open to the DIYbio community. The realities of an adult team that all have full time day jobs made it necessary to scale back that ambition, so we decided to focus on some fluorescent protein genes since turning E. coli K-12 cells green has become the "Hello World" experiment of citizen scientist groups everywhere. Little did we realize how twisted the path to open source biology is!

The Registry of Standard Biological Parts does not appear to contain many fluorescent proteins that are free of intellectual property limitations. Four are listed (BBa_J97003, BBa_J97002, BBa_J97000, BBa_J97001) but none of these are physically deposited in the Registry. So we decided to focus our efforts on submitting an IP-free GFP, RFP, CFP, YFP and OFP that we could give out to other community labs just starting up.

We were delighted to see that the company DNA2.0 listed a collection of proteins on its product site that it called "IP-Free© synthetic non-Aequorea fluorescent proteins". We reasoned that by using the right PCR primers we could easily copy these genes out of the commercial plasmid and biobrick them.

The registered trademark sign after the words "IP-Free" should have alerted us to dig deeper, and by the time we did we had already committed too much time and resources to the project to take an alternate path. DNA 2.0's intellectual property policy is very specific- you can use the gene for a further invention only if you buy it in their plasmid at a cost of $245 per gene. You are not allowed to have it synthesized. You are not allowed to distribute it unless it is modified such that the function is changed or enhanced. We did not realize this, and so our biobricked parts can only be used for purely academic pursuits, which are allowed by DNA2.0. However, if you then want to commercialize your invention you must purchase the gene directly from them.

A lesson learned to dig deeply whenever IP issues arise.

This left us with a dilemma. Do we continue and potentially submit genes that are of no use? We did not know whether or not the restriction on use by DNA2.0 would result in no team being able to get them from the registry. Since non-commercial use of the genes appears to be OK, we reasoned that perhaps the registry would make them available under those conditions. But giving them out to other DIYbio labs might not be possible.

We considered three alternative courses of action. The first would be to abandon the idea of giving out these genes based on the IP restrictions. That would be a shame, since we worked all summer to clone them. The second would be to contact DNA 2.0 and see if we could get some sort of exception or special licence to distribute to community labs with the understanding that if any commercial product came out of the work they would have to buy the plasmid from DNA 2.0. The third most radical course would be to challenge the "IP-Free" designation as deceptive advertising and give out the plasmid to precipitate legal action. This would be the most interesting, but also risky and somewhat combative initiative in spirit- we were not sure that this was a fight we wanted to get into if we were choosing our battles wisely.

In the end, we decided to go with the middle alternative and contact DNA 2.0 as a first action. We are awaiting an introduction to key individuals at DNA 2.0 and will see where that leads...

Our cloning strategy was simple.

Design primers that bracket the gene and upstream RBS but add biobrick prefix and suffix
Clone the fragment into pSB1C3
Test the color generation by cutting out the fragment and cloning into pUC19 which puts it under the control of the constitutive T7 promoter
All the genes were in the DNA2.0 plasmid backbone FPB-xx-444 that includes AmpR. The upstream and downstream regions surrounding the open reading frame were the same for all plasmids. We designed one forward primer that could be used for all five genes, but we had to design specific reverse primers for them all since there was an EcoR1 site immediately after the termination codon.

Forward primer for all: ATGAATTCGCGGCCGCTTCTAGAGCGAGACCTTAGGAGGTAAAC

Color Name	Plasmid	Reverse Primer
Green	GFPComet	FPB-26-444GCCGCTGCAGCGGCCGCTACTAGTATTAACGGTAAGTTTCCAG-GT
Red	RFPRudolph	FPB-31-444GCCGCTGCAGCGGCCGCTACTAGTATTACGTTTCTTTAACGTCGA
Cyan	CFPCindyLou	FPB-20-444GCCGCTGCAGCGGCCGCTACTAGTATTACTGATACGTCTCCAGAT
Yellow	YFPKingle	FPB-48-444GCCGCTGCAGCGGCCGCTACTAGTATTAGCGATACGTCTCCAGGT
Orange	OFPYukon	FPB-30-444GCCGCTGCAGCGGCCGCTACTAGTATTACGTTTCTTTAACGTCGA

We realized later that the YPF had an internal EcoR1 site that we had missed, and for some reason we failed to get good clones of the GFP, so we submitted and tested the RFP, OFP and CFP protein genes as documented on our registry pages.

They look great!
But our next step is to pursue the cloning of truly IP-free fluorescent protein genes.

4 OPENTRONS ROBOT

An important part of synthetic biology is to use standardized parts to quickly assemble and test multiple constructs. Community labs do not have the equipment needed to actualize this, as the liquid handling robots necessary for automation of the process cost hundreds of thousands of dollars.

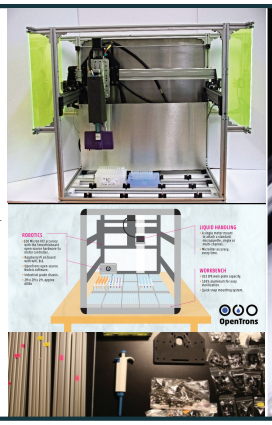
The DIYbio community has produced classic reverse-engineered lab equipment such as the Pearl gel box and the Open PCR. We felt that a liquid handling robot could be similarly constructed. OpenTrons is the name we have given our program to reverse engineer several critical pieces of lab equipment. The liquid handling robot is the first.

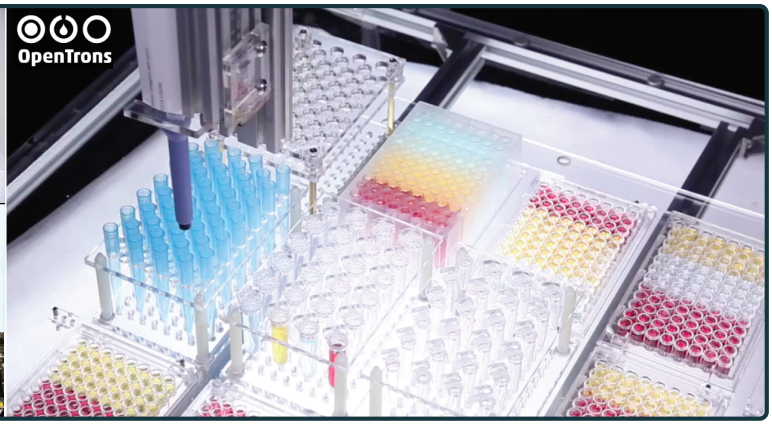
The OpenTrons DIY BioBot robot shown in the picture above was the first iteration. It cost less than $2000 to build. It is open source, and we hope that the users will customize it and develop it further to suit their own needs. It can pick up and move tubes, deliver liquids, and generally be modified to do a number of tasks found in protocols. We are very excited about its potential to bring high-throughput synthetic biology to community labs.

We have since designed the next version, compatible with mass production, and will demo it at iGEM. The assembly guide for the initial version is hosted on Synbiota under OpenTrons. It is in four sections:
Assembling the X, Y, Z, and A carriages.
Assembling the robot's frame.
Connecting all the wires, motors, and homing switches.
Moving your robot and building your first automated task.
We are extremely grateful to the developers of the open-source technologies we were able to use in developing OpenTrons.

Synthetos' TinyG motion controller is an amazing contribution to open robotics. It is a professional grade 3-axis motion controller that you can easily communicate with over Bluetooth. The work they have done is essential to this DIY BioBot, and we could not be more thankful for their openness and excellent documentation.

The Shapeoko CNC and Inventables have done a ton to make 3-axis robotics easier for makers. Their excellent assembly instructions were super helpful at the beginning and are an inspiration for anyone making kits in open hardware.





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AUTODESK.