

# Establishing 3D Printed Microfluidics for Molecular Biology Workflows

Steven Burgess

Email Address: [sjb287@cam.ac.uk](mailto:sjb287@cam.ac.uk)

## The Idea

The basic tools of a molecular biologist have changed little since the early 1990s; procedures tend to be performed manually and involve the use of large volumes meaning progress is slow and low throughput. These factors become problematic as research begins to move into the era of whole genome engineering. Over the last decade there have been significant advances in the field of microfluidics leading to the production of lab-on-chip devices, but the downside of these approaches is that they tend to rely on expensive, specialist equipment, meaning they are out of reach to most molecular biology laboratories. Several recent publications have begun to address this issue, utilizing advances in 3D printing to create low cost alternatives. By utilizing expertise in Cambridge and the NBI (Norwich Biosciences Institutes), the aim of this proposal is to design and test a 3D printed, modular microfluidic setup for molecular biology. All designs will be documented and open access, and, by instigating a standard for modular microfluidics, the outputs can serve as a basis for further innovation.

## Who We Are

Dr. Steven Burgess (CAM)– Molecular Biology

Dr. Tom Meany (CAM) – Microfluidics/ 3D printing/ Optics

Dr. Richard Bowman (CAM) – Optics/ 3D printed microscope

Dr. Oleg Raitskin (TSL) – Molecular Biology

Dr. Neil Pearson (TGAC)- 3D printing

## Implementation

### Part I:

The first step will involve adapting existing designs for 3D printed microfluidics to make them compatible with each other; this will also require defining a standard for interfacing between modular microfluidic components. In developing this standard, we will seek to consult with the wider synthetic biology standards and microfluidics communities.

In the initial stage, we will build five modules with wide applications in molecular biology, using published designs as a starting point:

1. A microfluidic pump for movement of liquids.
2. A water droplet generator for encapsulation.
3. An optical setup for droplet analysis.
4. A component for isolating DNA based on magnetic beads.
5. A component for thermal cycling.

### Part II:

Once the 3D printed components have been created, we will test the operation of the modules.

Experiment one will be to test the pump, droplet encapsulation and microscope in combination for encapsulation of aqueous solutions. This has the potential for future applications in single cell analyses. Experiment two will test the ability of the pump, thermal cycler and DNA isolation component for the construction of plasmid constructs, by current cloning techniques such as golden-

gate assembly. We intend to run several iterations of the design-build-test cycle to improve the functioning of components.

## Benefits and outcomes

1. A standard for 3D printed modular microfluidics.
2. Five designs for compatible 3D printed modules for molecular biology workflows.
3. Protocols for droplet encapsulation and DNA assembly on 3D-printed microfluidic devices
4. DocuBrick (<http://docubricks.com/>) documentation for all parts. By characterising the designs and making them open access, it will facilitate use by the wider community.

## Budget

| Component   | Cost                |
|---|---------------------|
| Microfluidic Pump: Consumables (3D printing)  | ~£100 per iteration |
| Water Droplet Generator: Consumables (3D printing)  | ~£100 per iteration |
| Optics: Consumables (3D printing)   | ~£200 per iteration |
| DNA isolation: Consumables (3D printing)  | ~£100 per iteration |
| Thermal Cycler: Consumables (3D printing)   | ~£100 per iteration |
| Total Cost per iteration  | £600 per iteration  |
| Subtotal:<br>(Cost for 4 iterations of each device plus duplication of final design for simultaneous testing of function in two laboratories) | £2400               |
| DNA isolation: Electromagnet  | 2 @ £ 100 each      |
| Thermal Cycler: Diode Laser   | 2 @ £ 600 each      |
| Molecular biology reagents e.g. MagJET Plasmid DNA Kit (96 preps; K2791),<br>TypeIIIS enzyme (ThermoFisher Bsal ER0291)                       | £200                |
| Misc. costs e.g. package and shipment of 3D printed devices between Norwich<br>and Cambridge  | £100                |
| Total   | £4100               |