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Form Submission

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The Idea

Many tasks in biology require tiny, accurate motion – achieved with expensive hardware. We have used inexpensive, 3D printed parts to make high performance mechanisms for low cost science. Our best example is a microscope small and cheap enough to be left in an incubator or fume hood for days or weeks. This will enable new science, for example by observing cells as they grow in an incubator.

We will improve this microscope's imaging capabilities (adding fluorescence and phase contrast) and demonstrate its use in an incubator. We will also show that printed mechanisms can be used for other tasks, for example the mechanical manipulation of micropipettes for microinjection or patch clamping.

Who we are

Richard Bowman: Physics Research Fellow in the Nanophotonics Centre at the Cavendish Laboratory, background in optical tweezers and microscopy.
Stefanie Reichelt: Head of Light Microscopy at Cancer Research UK.
Hugh Matthews: Reader in Sensory Physiology, Department of Physiology, Development and Neuroscience.

Sign team up to SRI site?

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Implementation

We plan to develop and improve the 3D printed microscope for use in an incubator. We plan to improve its imaging capabilities by adding Hoffman phase contrast and fluorescence imaging modes, for which we have requested some optical components. This work will primarily be carried out at the Nanophotonics Centre by Dr. Bowman assisted by a vacation student. We also plan to investigate the potential improvement in mechanical properties using ABS plastic, for which we have requested an upgraded printer and consumables, again to be based in the Nanophotonics Centre. ABS plastic is desirable over our current medium, PLA, as it has a higher glass transition temperature and will thus withstand higher operating temperatures. ABS is also less likely to degrade in a humid environment, and will be more robust to sterilisation e.g. by autoclave (at relatively low temperature). Testing of the microscope in an incubator environment will be carried out in conjunction with Dr. Reichelt at the Light Microscopy Facility in the Cancer Research UK Cambridge Institute. This will demonstrate the use of the microscope in a biologically relevant environment, to carry out timelapse experiments over several days in their sterile cell culture lab. Micromanipulation experiments will be performed in conjunction with Hugh Matthews, Department of Physiology, Development and Neuroscience. Together we aim to design a low cost printed manual micromanipulator, suitable for use in electrophysiology or microinjection experiments. We will also investigate possibilities for motorising this system, to allow automation and/or more precise control.

Benefits and outcomes

This project will develop both an underlying technology (plastic flexure mechanisms) and a number of ready-to-use tools (microscopes and micromanipulators). The tools will be made available open-source, together with documentation, to enable synthetic biologists across and outside the university to perform more experiments in parallel through the availability of low cost microscopy and micromanipulation.
The three collaborators involved in this application have not worked together before, so we will be forming two new interdisciplinary links, between the Physics and Physiology, and Physics and Cancer Research. We will exploit these links to introduce printed flexure technology to the biological community, as a means of dramatically reducing costs and enabling new, massively parallel experiments.

Sponsor for the research and cost centre

Prof. Jeremy Baumberg, Department of Physics, jjb12@cam.ac.uk

Sponsor support confirmed?

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Budget

Initial support from the Nanophotonics Centre has enabled this project to run so far, including the purchase of our first 3D printer. We would like to request funding for the following: £1000: 3D Printer (RepRapPro Ormerod II) to enable printing in ABS, plus upgrades and consumables £600: Optics for fluorescence imaging and higher resolution bright-field imaging £1000: Automation kits for several microscopes and micromanipulators, installed in collaborators' labs. £1400: Open Access Fee for the first publication describing this microscope. There are also many opportunities to bring this technology to schools and other venues as an outreach activity: as well as documenting the development of a microscope and micromanipulator, we will use the £1000 allocated to dissemination and outreach to produce a class set of microscopes, together with Raspberry Pis and possibly including small monitors or touch screens. We will also purchase a set of suitable fixed samples to view, as well as preparing instructions on how to prepare onion cells, hair, cheek cells, etc. This will enable us to take the microscope into schools, and in the long run to prepare instructions that will enable other schools to replicate the microscope and experiments for themselves.