Handheld syringe pump with heating element

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Cornelius will supervise the project, and provide expertise on electronics, Arduino, mechanical design, sensor and feedback controls.
Nicola will provide expertise on electronics, CAD design, and mechanical engineering.
Benedikt will provide expertise on software programming, mechanical engineering, and prototyping.

Summary
A handheld syringe pump with an included heating element will be constructed for microfluidic applications. An Arduino will be used as the central controlling element. It adjusts the temperature via a mantle-type heating element wrapped around the syringe, and sets the flow rate and target volume by regulating the rotation of a stepper motor. A 3D-printed structure will be used will be used making the device light, inexpensive, and easy to replicate. The temperature control provides a novel feature, making the device an ideal tool for microfluidic cell culture applications.

Proposal
i) For culturing cells in a microfluidic device, syringes are used for a wide range of applications, e.g., an exchange of the medium to supply the cells with nutrients, an infusion of stimuli or an infection with bacteria. To avoid a disruption of cells by applying too high shear stresses when using a manual syringe and to achieve steady flow rates, it is of advantage to use an electronic syringe pump capable of controlling flow rates much more accurate.
Commercially available syringe pumps are expensive, bulky and difficult to handle in a microbiological safety cabinet. Moreover, they do not provide a control over the temperature of the syringe, which is known to be critical for cell culture.
ii) The device will be employed in the following biological systems:
Nicola: Epithelial cells are cultured in microfluidic chambers. Cilia movement during the application of flow is recorded and analysed. During medium exchange a small and steady flow rate is very critical to maintain optimal conditions.
Cornelius: Bacteria are infused with a syringe to infect these cells. A flow-rate based adhesion assay is performed.
Benedikt: Malaria p. falciparum infection assays in a microfluidic device are performed. Temperature stability is essential to ensure parasite viability, and controlled flow rates are crucial for a successful infection of red blood cells.
iii) The hardware will be small, light-weight, portable, affordable, yet powerful, stable, and easy to handle.
iv) A schematic of the device is depicted in Fig. 1. The mechanical parts will be 3D printed. The drive of the pump comprises a stepper motor, which is controlled electronically via an Arduino interface. The motor rotates a threaded rod, held by block **B**, which in turn moves block **A,** containing a thread, forwards or backwards. Block A will push or draw the plunger of the syringe.
A heating mantle element is wrapped around the syringe to heat it up. A temperature sensor at the top of the syringe feeds back to the Arduino which then controls the heating element to achieve a stable temperature using PID programming.
A cable connects the handheld part of the syringe pump to the fixed controller, comprising of Arduino, touchpad and power source.
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The touchpad will be used to set the flow rate (controllable by the rotations per second of the stepper motor), the target volume and the temperature. Different syringe types will be usable by setting the diameter of the syringe chamber.
v) The handheld syringe will propose an alternative method to commercial, expensive tools. It will indeed be more easy to use inside a safety cabinet, thanks to its handheld design. The small form factor will increase the versatility, for example by allowing for a placement inside incubators. The controllability of the temperature will be a unique feature not available from suppliers. Additionally, researchers around the world will benefit from our work by following GitHub protocols and built a device themselves.

Components (additional to the starter kit)
Threaded rod,
3D printed parts,
stepper motor (24V),
heating element,
temperature sensor,
24V power source,
wires, solder, soldering ion, volt meter, syringes, electrical tape, copper tape.