CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

S1419

Project Title

Microfluidic Chip and Software Interface for Multi-Week Tissue Culturing Experiments

Abstract

Objectives/Goals

The purpose of this engineering project is to design an end-to-end system to enable multi-week tissue culture experiments. Such experiments are not possible using traditional petri-dish culturing techniques nor commercially available microfluidic devices. The latter accommodate cells in suspension not whole tissue samples. Live imaging of cellular behaviors, drug screening and toxicological tests are some of the areas of research that could benefit from long duration tissue culturing experimentation.

Methods/Materials

The system I designed includes a novel large, open-top chamber, high fluidic resistance microfluidic device, an inexpensive two-way hardware controller, and an open source software stack supplemented by a custom software layer I developed. The equipment used includes my custom microfluidic chip fabricated by Stanford University's foundry, an Arduino, an open source, two-way single-board microcontroller, 8 solid state relays, 8 Festo solenoid valves to control the on-chip pumps, a Windows PC for AutoCad based microfluidic chip design, and a Linux laptop to write and test the controller software.

Results

Software tests confirmed that arbitrary experiments could be scripted and run remotely over the Internet. Hardware tests confirmed that software scripts could effectively control the microfluidic flows and that the scripts could actuate the valves at frequencies exceeding the 10Hz required for microfluidic peristaltic pumps. Flow tests on two versions of the chip confirmed that fluid could flow in and be evacuated from the culture chambers. Flow rates were compatible with cell survival. Cells were introduced by my customer in a fully functioning end-to-end system and were successfully cultured for 20 hours.

Conclusions/Discussion

Chip and software tests demonstrate that an automated microfluidic solution can fulfill the customer's requirement for long-term culturing. Based on new customer input and insights from the first set of experiments with cells, a second generation chip was designed and fabricated. It will be used to rigorously verify the biological efficacy of the microfluidic system employing cell tissues. A point-and-click interface will be added to enable non-programmers to automate experiments. A whole class of modern biological research involving cell tissues could be aided by the combination of these capabilities.

Summary Statement

I designed a microfluidic chip and a software interface to enable multi-week tissue culturing experiments.

Help Received

Prof. Heller suggested microfluidic project and let me use equiptment, Stanford U. foundry made the chips.