Executive Summary: Tong BME Design Award, BME 402

Microscope Compatible Cell Culture Incubator

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As cellular experimentation has expanded into new fields, tools enabling cell survival have evolved to accommodate the variable needs of cell researchers. Many of these changes have been motivated by efforts to reduce the prohibitively high cost of cell culture. These efforts have been largely successful, however, one fundamental tool lacks more affordable solutions: cell culture incubators.

While many costs are associated with researching stem cells and other diseased cell lines, one of the most critical, unavoidable costs is equipment used for cell culture and imaging. Thermo Fisher Scientific, one of the largest incubator suppliers, reported $7.03 billion in revenue from laboratory products and services in 2016 ("Financial Report", 2016). Additionally, many researchers desire the ability to observe their cells in real time. Real time imaging incubators incorporate both imaging and incubation capabilities, and provide a unique means of evaluating long-term cell behavior in order to draw conclusions about how cells, diseased tissues, and organs behave over time. Current commercial microscope-based incubators are expensive, compatible with only one microscope and cell plate size, and ineffective at evenly controlling the environment. The cost for an industrial, integrated microscope /incubator system begins on the order of $30,000 and can quickly exceed $100,000. For many researchers, live cell imaging would enhance their experimental data but is not vital, thus this cost has limited the market for such a system. While more affordable and flexible alternatives on the scale of $1,200 exist, such as the Warner Instruments DH-40iL (Warner, 2017), the available systems do not provide the stringent and consistent environment demanded for publication quality research.

The Yin Yang Incubator was developed to bridge the gap between expensive, high-end incubators and cheaper, inconsistent alternatives. The chamber consists of a rapid-prototype ABS body, glass imaging surfaces, and rubber seals to trap humidity. To maintain consistent environmental conditions, heat, humidity, and CO_2 are controlled on feedback from sensors for each parameter within the chamber. This incubator can accommodate various cell culture plates, and is compatible with multiple inverted microscopes. Most importantly, the final prototype was created within a budget of $400, and could be sold very competitively compared to other available systems.

Environmental control was tested in short-term validation tests for maintained temperature, humidity, and CO_2 levels. The system was able to not only maintain the specified environmental parameters of 37℃, 5% CO_2, and 95% relative humidity, but was also able to recover to baseline environment parameters following a chamber opening within 10 minutes. To test imaging, various material and focal length tests were performed to affirm the ability to capture in-focus images with cells in the incubator.

In summary, this design fills the current demand for an alternative to the current market of real time imaging incubators. Introduction of such a device would allow more researchers to access technology essential to biological discovery, and fill the gap in the market between low and high-end systems.