Project #33 **Affordable Fluorescent Microscope for Education**

Executive Summary: Tong BME Design Award, BME 301
John Rupel, Zach Alden, Kaitlyn Gabardi, Kadina Johnston
Advisor: Professor Jeremy Rogers Client: Professor Matthew Merrins

Our team is designing an affordable, FRET-capable microscope that the consumer can personalize easily for their specific needs. Fluorescence Resonance Energy Transfer (FRET) is an imaging technique where a single wavelength of light is used to excite an acceptor fluorophore, at which point the acceptor fluoresces at a specified wavelength. The acceptor fluorescence excites a donor fluorophore. The closer the acceptor is to the donor, the brighter the donor fluoresces. FRET microscopy is used to study such intracellular interactions as signal transduction and protein assembly. A typical fluorescent microscope may cost over $100,000, which exceeds a typical course budget; therefore, this prevents practical use in an educational setting. The team's client, Professor Matthew Merrins, teaches a human biochemistry lab at the University of Wisconsin-Madison in which his students utilize a FRET-based biosensor to study lactate levels in pancreatic islet beta cells. Direct engagement with current research technology, such as FRET-capable microscopes, will provide a basis for future researchers to establish experimental procedures, criteria, and analytical skills necessary for proper research. Hence, it is imperative to the students' knowledge and experience to have access to these resources.

The current design involves a simplified microscope with a sample stage, LED light source, platform with filter-switching interface, objective and tube lenses, and camera. The data collected from the camera is controlled by IC Capture, and a FIJI macro will be used to extract data and perform analysis. Current design plans include optical simulations, validation of the excitation source, and assembly of the microscope. This will make it the only affordable fluorescent microscope for FRET on the market. Research microscopes on the market are expensive partially due to their broad, built-in functionality. However, these functionalities are not always required in an educational setting where the same experiment is conducted every year. Currently, the Lumascope 620 is a common FRET microscope used to image living cells; however, the variety of configurations of the objective lens, laser options, filters, and detectors make the device too expensive to obtain multiple devices for student use. On the other hand, the Dino-Lite is an affordable fluorescence microscope, but the Dino-Lite only detects a single wavelength of light. This is not ideal for FRET since FRET requires the use and detection of two fluorophores and therefore two wavelengths of light. Our device is best equipped for the requirements of an educational setting since it is built for a specific microscopy technique (FRET) at a low cost (<$2,000). The filters and light source will also be removable and sold separately so that a consumer can choose the specific wavelengths of interest.

Our microscope is capable of commercialization due to its possibility for a course to purchase multiple for student use. The target market would be research institutions offering lab courses on cellular imaging or any lab course in which FRET microscopy is mentioned. In the United States alone, there are 115 R1 institutions and 334 R1, R2, or R3 universities that likely offer one or more courses where the ability to teach practical FRET microscopy would be valuable to its students. Additionally, there is a potential that some research labs may be interested in purchasing our cheaper microscope to avoid the significant initial capital investment required for a traditional microscope. We anticipate that FRET will continue to be vital for biological research and that future researchers will need to experience the capability of FRET microscopy firsthand, sustaining the demand for our microscope.