A pilot biophotonics outreach program

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Abstract: A virtual outreach program was developed specifically for the field of biophotonics. The program consisted of hands-on activities using kits sent to students in advance, real-time video lab tours and prerecorded video content.

1. Introduction

Biophotonics is the field of study that applies light and light-based technologies to problems in biology and medicine [1]. While the term "biophotonics" only emerged in the late 1990s [2], this field has been around at least since the invention of the microscope in the 17th century. Many high school students learn about science in narrowly defined disciplines: biology, chemistry, physics and sometimes engineering, but rarely a combination of these subjects. This results in a general lack of awareness of the field of biophotonics, even among undergraduate science, technology, engineering, math, and medicine (STEMM) majors [3].

With this in mind, we developed a pilot biophotonics outreach program aimed at 9th grade students. The program was developed by researchers at the Wellman Center for Photomedicine at Massachusetts General Hospital (MGH). The Wellman Center is a research center which focuses on the development of new optics and photonics-based technologies and applies them directly to clinical settings. Despite being located within a hospital, most of the Wellman Center researchers are PhD-holders or engineers as opposed to MDs, as shown in Fig. 1. We therefore designed our program to illustrate the multidisciplinary nature of biophotonics and how researchers make an impact in medicine without being a physician.

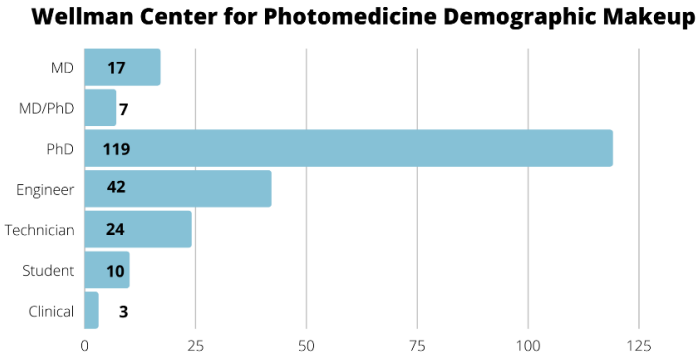

Fig. 1: Demographic makeup of the Wellman Center for Photomedicine

2. Program development

Owing to the restrictions brought on by the COVID-19 pandemic, we pursued a virtual program consisting of an outreach kit distributed to students for hands-on experiments, three live sessions focusing on basic optical concepts through video-conferencing, and a YouTube video [4] relating these optical concepts to photomedicine technologies developed at the Wellman Center. We designed our program around four themes, targeted to 9th grade students:

- **Absorption and transmission of light:** Many modern medical devices utilize tissue absorption and transmission properties. Students experimented with different light-emitting-diodes, gummy bears, and their fingers to investigate how efficiently different wavelengths of light are transmitted through different materials.
- **Pulse oximetry:** The students were provided with oximeters and invited to measure their oxygen saturation. We discussed how the oximeter works, and more generally how differences in light absorption and transmission are connected to the inherent properties of tissue.

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Fig. 2: Still frames from "The Oxygen Sensing Ring" YouTube video [4], which highlights a research project in the Evans Lab. (a) Helen Keshishian introduces the concept of measuring oxygenation using a familiar device: a pulse oximeter. (b) Emmanouil Rousakis explains the limitations of the pulse oximeter for monitoring tissue oxygenation, aided by an overlaid animation. (c) Rousakis demonstrates the Evans Lab's innovative oxygen-sensing ring on the finger of a nitrile glove that is filled with compressed air or carbon dioxide to simulate regular oxygenation or tissue hypoxia (respectively). (d) Keshishian discusses the role of "healthy volunteers" in bringing medical inventions like the oxygen-sensing ring from the lab to the clinic.

- **Fluorescence:** Fluorescence was introduced as an example of an extrinsic source of optical contrast for visualizing important biomarkers in biology and medicine. The kit provided a UV LED, a fluorescent highlighter, black post-it notes, cuvettes, and household items that are naturally fluorescent, e.g. olive oil and turmeric powder. Students were invited to observe the colors of samples under different illumination.
- **Microscopy:** We provided students with a Foldscope [5] to demonstrate the concept of microscopy: using optics to magnify structures that cannot be observed through bare eyes. We introduced the standard components of a microscope and showed clinically relevant fluorescence microscope images.

In addition to these hands-on activities and presentations, the program included two real-time lab tours, connecting the topics covered to real-life biophotonics research. The program concluded with an "ask-me-anything session", where each volunteer shared their individual career journey and current role at the Wellman Center.

3. Program implementation

The program was incorporated into the longstanding MGH Youth Scholars program. Within MGH, the Mass General Research Institute (MGRI) builds partnerships with local industry, philanthropic organizations, and community groups to facilitate bench-to-bedside translation of MGH medical innovations. MGRI offers education and outreach programs connecting MGH doctors and researchers with members of the public. The Youth Scholars program is a STEMM education program for grades 9 through 12, with continuing post-secondary education and career support. It serves local students from Boston, Chelsea, and Revere who represent a variety of backgrounds, often from minoritized groups and many who would be first in their family to attend college. Previously, this program focused almost exclusively on clinical or patient-facing healthcare careers. We implemented the biophotonics outreach module as a new element of the existing program, bringing a new perspective to a total of 33 9th grade students. Our intention to make a long-term impact on the STEMM education of minoritized and underprivileged students aligns well with the goals of the MGH Youth Scholars program, which supports these students throughout high school and beyond.

4. Conclusion and future directions

A biophotonics-specific outreach program was developed which included the distribution of 33 kits to 9th grade students in the Greater Boston Area. Following the success of this pilot program, we plan to incorporate feedback from students and MGRI facilitators in order to refine our lesson plans and materials list before making them publicly available. A first video in a planned video series was also launched as part of this project on the topic of tissue oximetry. Future directions will include incorporating in-person activities, continuing the video series, and possibly extending our curriculum to 10th, 11th, and 12th grade students.

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