Optical Sensing using Laser Spectroscopy at the Single Molecule Level

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Optical Methods of Analysis in the Dunn Group

Our group employs a variety of optical techniques in order to develop new platforms for analyzing biological samples. Areas of interest include biosensor development, investigating lipid membrane dynamics, and point-of-care diagnostics.

Multiplexed Biosensor Development:

Ovarian cancer remains the fifth-leading cause of cancer related death among women, despite being one of the most curable cancers if diagnosed early. Our group is working on new approaches for the early screening of cancer that uses laser light confinement within small resonators to detect multiple biomarkers of disease. We are developing biosensors based on a technique referred to as whispering gallery mode (WGM) detection, which takes advantage of the resonant confinement of light within small, transparent spherical structures. Sensing methods based on this phenomenon have garnered increasing interest due to their superior performance metrics and label-free detection capabilities. Our group utilizes techniques such as fluorescence microscopy and tunable diode laser spectroscopy to further develop a novel form of WGM sensing for the early detection and diagnosis of ovarian cancer. In this project you will learn how to design and execute bioassays involving novel optical techniques.

Lipid Membrane Dynamics:

Biological membranes are complex mixtures of lipids and proteins that are ubiquitous in nature and serve essential structural and functional roles in cells. Due to their inherent complexity, numerous techniques have been developed to create simplified model membranes. Methods are continuously being developed to study these models with high-resolution techniques to understand the influence of various additives and environmental factors on membrane structure and dynamics. Our group has shown that single-molecule orientation measurements can be used to probe membrane structure at the molecular level without the effects of ensemble averaging inherent with other approaches. In this project you will learn how to make model membranes and use various forms of microscopy to probe their structure/function.

Disease Detection with Compact Disc (CD) Technology:

Infectious diseases, like leishmaniasis and malaria, are responsible for over half the deaths in emerging countries. While yes/no diagnostic devices for resource limited settings have been introduced, the development of quantitative techniques that can measure biomarker levels are more challenging in these settings. Our group is exploring a variety of projects to develop quantitative diagnostic assays and data analysis methods on CD platforms. Compact disc players are engineered with sophisticated lasers and optics, yet have a modest unit price given the high demand. They are ubiquitous even in resource limited areas and laptops can operate in the field or settings where even electricity is scarce and unpredictable. We are developing assays that can be carried out on the CD media and the results analyzed using a conventional CD drive. The assays will be quantitative and since the CD remain uncorrupted, the results and patient information will be written onto the same CD used in the assay. In this project, you will

learn how to develop novel biological assays on highly mobile platforms for resource limited regions.