Master (internship/thesis) projects in Cao Lab

Project 1

Title: Nanopore single-molecule detection of glycans

Keywords: Bioengineering, biochemistry, biosensor, single-molecule detection

Glycans are major building blocks of life. They play a central role in many biological processes and are involved in most major diseases. However, glycoscience remains relatively understudied due to a lack of tools to probe the highly diverse, heterogeneous and complex structures of glycans. In contrast, the nanopore technique has been successfully applied to sequence long strand DNA, which has revolutionized the development of precision medicine. Therefore, we aim to develop biological nanopores as a novel analytical tool for glycan analysis, with the benefits of high sensitivity, low-cost, label-free, high-throughput, and potential for integrating into portable devices. The research is inherently interdisciplinary, intersecting biochemistry, biophysics, glycobiology, and bionanotechnology. Our lab is well-equipped with a strong foundation in these areas to support you throughout this project.

Project 2

Title: First steps toward single-molecule sensing of protein biomarkers by using novel bioengineered nanopores

Keywords: Nanopore, protein biomarkers, peptides, neurodegenerative diseases

We are looking for some students interested in the development of nanopore-based next generation DNA and protein sensing and sequencing approaches. Biological nanopores have been developed mainly from pore-forming toxins and used for the single-molecule detection of DNA, peptides, and other small molecules, with already some commercial applications. In this project, the student will test and assess several novel biologically engineered nanopores (mutants or chimeras of existing biological nanopores), which have been designed to improve the sensitivity and efficiency towards detection of peptides. Specifically, we are interested in the detection of unique protein biomarkers for neurodegenerative diseases from heterogeneous mixture samples, but also in the development of more sensitive biological nanopore to better assess peptides composition. This work is the first step towards single-molecule protein sensing and sequencing, which is probably the next revolution in biology, since it could help us to understand many fundamental biological processes and help in the early discovery of biomarkers for nowadays incurable diseases, such as Parkinson or Alzheimer disease.

Project 3

Title: Nanopore-based single-molecule proteomics
Keywords: Nanopore, biochemistry, biophysics, protein engineering

Biological nanopores have been successfully applied in sequencing long DNA, and this achievement has inspired its application for single-molecule proteomics, which is an exciting and emerging field to explore. The project will focus on applying various biological pores (that are available in the lab) for application in single-molecule proteomics, including protein sensing and/or sequencing.