GaLSIC Guest Seminar

“Glycan Footprints Across the Tree of Life: Mass Spectrometry Meets Bioinformatics”

Prof. Kazuhiro Aoki, PhD

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Director, Mass Spectrometry Core, Translational Metabolomics Shared Resource, Cancer Center, Medical College of Wisconsin

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Engineering Building　E408

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Prof. Kazuhiro Aoki, PhD
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Research

- My research focuses on advancing mass spectrometry technologies for glycomics, proteomics, metabolomics, and lipidomics, as well as developing spatial omics approaches to visualize biomolecular distributions in tissues. These tools are applied to investigate molecular alterations in rare genetic disorders, cancer, and autoimmune diseases. A particular focus is on ST3GAL5 mutations that impair ganglioside GM3 biosynthesis, underlying conditions such as Amish Epilepsy Syndrome and Salt & Pepper Syndrome. In collaboration with the Clinic for Special Children and UMass Chan Medical School, we aim to support diagnosis and therapeutic development including EV and AAV-based strategies by elucidating the ganglioside interactome and its role in disease pathogenesis.
- Additionally, I have been closely working with Dr. Kiyoko Aoki-Kinoshita to apply bioinformatics approaches that deepen insights into glycan structural diversity and disease mechanisms.

Bio

- I am an Associate Professor and Director of the Mass Spectrometry Core at the Medical College of Wisconsin. With over 20 years of expertise in mass spectrometry-based omics, my research focuses on developing advanced analytical workflows in glycomics and related fields to better understand the functions and biological significance of biomolecules in disease mechanisms, cell-to-cell interactions, and fundamental biology. One of my long-term research interests is exploring glycan diversity across evolution, a fascination that began during my undergraduate studies. Previously, I worked at the Complex Carbohydrate Research Center, University of Georgia, where I further developed my expertise in glycoscience.
- Over the past decade, my laboratory has collaborated extensively with Dr. Kiyoko Aoki-Kinoshita, providing glycomics data from diverse biological samples including mouse stem cell populations, Drosophila melanogaster, microorganisms, and fishes, which serve as valuable resources for developing glycobioinformatics tools. Our ongoing collaboration focuses on developing GlycoFish, a glycan structural database covering multiple fish species, supported by the J-GlycoNET and GaLSIC at Soka University. This work aims to characterize glycan diversity across the evolutionary tree of life, enhancing our understanding of evolutionary relationships and molecular complexity. I will present a seminar on glycan diversity across various organisms, mass spectrometry data, and related efforts to further enhance our glycan database.

Glycan Footprints Across the Tree of Life: Mass Spectrometry Meets Bioinformatics

Carbohydrates, or glycans, are attached to proteins and lipids forming glycoconjugates that play essential roles in cell communication, development, and immunity. Unlike DNA and proteins, glycan structures are not directly encoded in the genome. Instead, glycosylation results from the coordinated action of multiple biosynthetic and degradative enzymes, including glycosyltransferases and glycosidases, as well as the cellular pools of nucleotide sugar donors and specific transporters. The expression and activity of these components vary across cell types, developmental stages, and species. Consequently, glycan diversity across species cannot be reliably predicted from genomic data alone, making direct glycomic analysis critical for studying their evolutionary and biological significance.

This seminar introduces the concept of glycan “footprints” as molecular signatures that exhibit species-specific variation and reflect evolutionary and environmental influences, as revealed through mass spectrometry analysis. Advanced analytical technologies, integrated with glycobioinformatics, enable comprehensive and comparative characterization of glycan signatures across a wide range of organisms, from microbes to vertebrates. Examples from collaborative research, including the development of GlycoFish, a glycan structural database for fish species supported by J-GlycoNET (Award #25A019), demonstrate how this work bridges analytical chemistry and biology to expand glycan resources and deepen our understanding of glycosylation repertoires and their diversification across the tree of life.

These efforts provide a robust framework to guide future studies on the biological functions of glycans and their relevance to species-specific traits and evolutionary processes. The expansion of glycan databases, together with advances in computational tools, promises to open new avenues for exploring glycan diversity and its broader implications.