

Internal Webinar

Protein Structure, Dynamics, and Interactions: Computational Insights into Molecular Organisation and Function

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Proteins are cellular machinery responsible for the sustained functioning of the living systems, and analysing these complex machineries from a structural biology perspective provides clearer and deeper insights into their intricate coordination. In this talk, I'll walk you through the hidden structural grammar and dynamic interaction rules governing multi-domain proteins to advance how we map, model, and predict macromolecular behaviour. I'll introduce a systematic framework that extends classical complex-interaction logic to a single polypeptide chain, revealing that intra-protein domain interfaces split into permanent and transient interactions guided by several distinct properties. Next, shifting focus from static backbones to amino acid networks, I demonstrate how remote homologous domains adapt their internal communication pathways to their evolutionary neighbours. By employing graph-spectral network analysis, I show that pairing a domain with a different structural partner forces a massive reorganisation of local residue clusters and architectural hubs, which directly dictates global backbone orientation shifts. To further classify highly complex, dynamic multi-domain structures like the SARS-CoV-2 spike protein, I present a near-automated pipeline wherein Principal Component Analysis (PCA) utilises structural features to successfully overcome the structural noise and heterogeneity limitations of traditional pairwise RMSD metrics to cleanly segregate functional states. Moreover, since macromolecular communication is rarely straightforward, I will highlight my postdoctoral research investigating the precise mechanisms of allosteric regulation within the E3-E2 ubiquitination complex. Finally, I will outline my translational work on computational biology studies like biomarker studies, drug-species lethality studies, antibody-antigen engineering and modelling and dynamics research. I was involved as an associate scientific manager at Partex.AI. Ultimately, this collective trajectory bridges the gap between fundamental structural grammar and applied biotechnology, providing the predictive rules and automated toolsets necessary to drive innovation across structural biology, target discovery, and therapeutic engineering.



Thursday, Oct 22nd 2026

11:30 Hrs