VRG15-005 - Network Medicine - An interactome-based approach to rare diseases

Abstract

The human body functions through an intricate interplay of countless biomolecules interacting within complex networks. Diseases often arise when these networks are disrupted, much like a machine breaking down when critical components fail. To systematically understand these disruptions, the field of network medicine applies tools from network theory to map and analyze the “interactome”—the complete network of molecular interactions in our cells.

Rare diseases, many of which are caused by single genetic mutations, offer a unique window into understanding these disruptions. While their genetic origins are often better defined than those of common diseases, identifying the precise mutation responsible in a patient can feel like searching for a needle in a haystack. Our project sought to uncover how specific genetic mutations affect the interactome, leading to disease, and to develop computational tools for identifying and prioritizing these mutations.

Over the course of this project, we achieved several milestones:

- We constructed multi-layered network maps that integrate information across different biological scales, enabling a deeper understanding of how rare diseases disrupt molecular and cellular systems.
- We developed novel computational tools for identifying disease-associated genes, which have been successfully applied to neurological and immunological diseases in collaboration with clinical partners.
- We developed a pioneering Virtual Reality (VR) platform that allows for an immersive exploration of large biological networks, providing new perspectives to analyze complex data.

Through these methods, we identified novel genetic mutations underlying rare diseases, providing new insights into their molecular mechanisms and potential targets for treatment. Rare diseases are just the beginning. The methods and principles developed in this project can be applied to a wide range of conditions, bringing us closer to the vision of personalized medicine. By tailoring medical interventions to the unique molecular makeup of each individual, we aim to improve outcomes for patients and transform the way diseases are diagnosed and treated. This project represents an important step toward a future where the complexities of human biology can be understood—and harnessed—on an unprecedented scale. This WWTF-funded project laid the groundwork for the establishment of the Ludwig Boltzmann Institute for Network Medicine (LBI-NetMed). The institute will build on the achievements of this project and take the work to the next level, focusing on a holistic understanding of health and disease through network medicine.

Scientific disciplines:
Systems biology (50%) | Bioinformatics (30%) | Medical statistics (15%) | Statistical physics (5%)

Keywords:
Network Medicine; Computational Biology; Systems Biology; Rare Diseases

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Further links to the persons involved and to the project can be found under
https://www.gmbh.wwtf.at/funding/programmes/vrg/VRG15-005/