

All-Brain Challenge Project

Large-Scale Brain Systems

Over the last several decades, neuroscience has expanded its reach dramatically to include cognitive, computational, communicative, and behavioral approaches to understanding "how the brain works", namely, the relationship between brain activity and observable inputs and outputs. The huge diversity of outputs and the overwhelming complexity of brain structure and physiology make it unlikely that there will be a single, simple 'master' equation governing these relationships. However, by relentlessly developing, discovering, and combining new theories, analytical methods, and experimental tools, the level of our understanding has significantly grown from single neurons to sensory perception to neural circuits and beyond. Some notable recent examples include network analysis, deep learning as a tool for discovery, the development of sophisticated statistical modeling of neural populations, and the rapid development of in vivo high-throughput recording of neurons and sub-second neuromodulator dynamics via techniques such as Optogenetics and calcium imaging. Thus, we can expect the next several years to yield even further progress as researchers continue to scale this 'neural stack' towards an ultimate understanding of brain functionality in its entirety.

The Swartz Foundation views as the core of its mission to actively encourage and support such theory-centric research that shows promise in making great strides toward achieving this All-Brain "grand challenge" that provides global and multi-level formalism describing how the brain functions. Such research may involve, for example, new theoretical perspectives addressing the behavior and evolution of complex systems, multi-scale/multi-layer investigations that link cellular and system properties to global activity, and extracting new insights from breakthrough experimental methods yielding high-throughput data, all making it possible to propose and confirm new theories that provide deeper understanding of how the human brain learns, remembers, predicts, plans, and creates.