Research

Research Focus

One of the most striking features of the brain is the abundant synaptic connections between nerve cells. These connections allow very rapid signalling between nerve cells and serve as the fundamental mechanism for information processing and storage in the brain. Prof Augustine's laboratory is interested in the function of these synaptic connections and they are studying 3 important questions within this general area:

Molecular basis of neurotransmitter release from neurons

The rapid secretion of chemical signals (neurotransmitters) serves as the basis for communication between neurons. They are identifying the proteins that are involved in the synaptic vesicle trafficking reactions underlying neurotransmitter secretion, with particular emphasis on proteins involved in exocytosis and endocytosis. Their current research is largely focused on the functions of synapsins, a family of proteins whose functions include cross-linking vesicles into a "reserve pool". The questions they are pursuing include: (1) Why are there so many different synapsin isoforms? and (2) What unique functions do these isoforms serve at different types of synapses?

Optogenetic mapping of brain circuitry

Synaptic circuits between neurons form the "wiring" that allows the brain to process information. Optogenetics has revolutionised the ability to elucidate the function of these circuits: with light-activated ion channels, such as channelrhodopsins, we can photostimulate genetically-defined populations of neurons. Likewise, genetically-encoded fluorescent sensors, such as SuperClomeleon, allow Prof Augustine and his team to detect the resulting responses in postsynaptic neurons. Together, these optogenetic technologies create tremendous opportunities for understanding how the brain works and for determining how brain circuitry goes awry during various neurological and psychiatric diseases. The questions they are addressing are: (1) What is the function of a specific brain circuit? and (2) What is the spatial organization of this circuit? With this approach, they are focusing on circuits in two brain areas: the cerebellum and the claustrum.

In the cerebellum, a part of the brain involved in motor coordination and other functions, theyhave mapped the functional organization of most local circuits, as well as projections from cerebellar cortex to other brain areas. Among their achievements is the discovery of an entirely new type of cerebellar interneuron. Prof Augustine laboratory's next goal is to determine the role that these neurons, and their circuits, play in cerebellar information processing.

The claustrum is a mysterious part of the brain that has been proposed to mediate higher-order functions such as consciousness. To understand the function of the claustrum, Prof Augustine laboratory's is employing a "bottom up" approach. To date, they have classified the intrinsic electrical properties of all neurons found within the claustrum and have mapped out most of the local synaptic circuits formed by these neurons. Armed with this knowledge, their next goal is to examine the role of the claustrum in behaviours.

In these projects, Prof Augustine's lab employs a wide range of technologies including electrophysiology, neuronal cell biology, molecular biology, optical microscopy, computational approaches, and optogenetics.

Video:
LKCMedicine Research Spotlight: The Inner Circuits of the Brain by Prof George Augustine