Molecular Neuroscience

How does experience alter the way our brain works? How exactly are memories stored and recalled – or forgotten? Can we troubleshoot faulty brain circuitry, just as we might rewire a shorted-out DVD player?

Researchers at the University of Maryland's Neuroscience and Cognitive Science (NACS) Program utilize cutting-edge technologies to examine these and other questions about how the brain functions at the cellular level. Their study of neurons, synapses, and other brain circuitry is helping us unlock the mysteries of plasticity.

Elizabeth Quinlan's work suggests we can rejuvenate neural plasticity in adults by changing what the brain perceives as experience. This research could help cure people with congenital blindness whose brains stopped processing information from their eyes.

Hey-Kyoung Lee examines the basic circuitry of memory storage. By learning how to strengthen connections among specific neurons, her team hopes to discover treatments for memory-related problems such as Alzheimer's Disease.

Patrick Kanold develops ways to "rewire" the brain after impairment. His work has led to breakthroughs in our understanding of diseases such as cerebral palsy and schizophrenia.

Ricardo Araneda "listens" to communications between the brain and the olfactory network. His research has produced exciting insights into neurogenesis – the birth of new neurons – in the adult brain.

http://www.nacs.umd.edu/

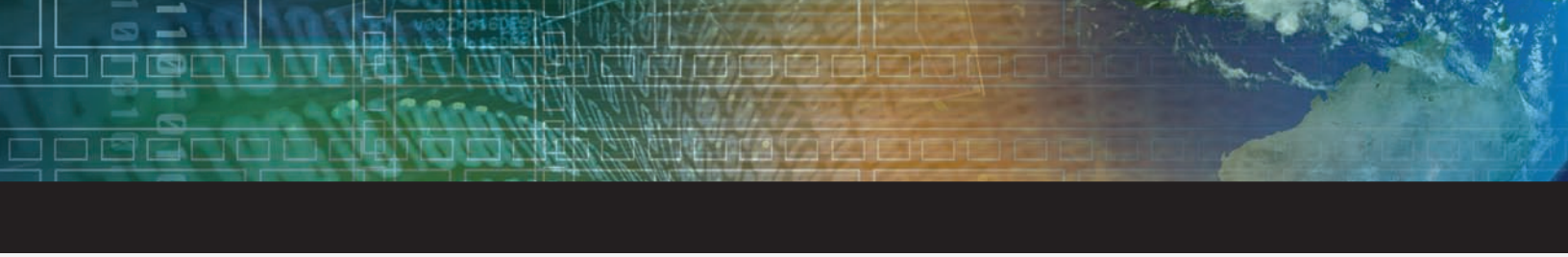
Restoring Plasticity by "Erasing" Bad Experiences

Elizabeth Quinlan uses visual deprivation to "reverse" biochemically encoded experiences in adult brains caused by injuries or birth defects.

Our lived experience changes the composition and functions of synapses. For example, for a person with normal eyesight, the neurons in the visual cortex develop because they "experienced" signals associated with visual perception. However, these same neurons do not develop if they are connected to an eye with congenital cataracts. Even if the eye function is restored later in life, the eye will still be blind because the brain has not had the "experience" necessary to develop seeing. Adult brains do not have the plasticity, or flexibility, to generate the new seeing function.

Integrating insights from biochemistry, molecular biology, physiology, and behavioral sciences, Quinlan experiments with visual deprivation to "turn back the clock," in essence reversing experience and thereby restoring plasticity. Her work with rats and apes has reversed molecular-level mechanisms associated with decreased plasticity, successfully restoring vision in eyes with congenital cataracts. This research holds promise for human sight restoration.

Elizabeth Quinlan equinlan@umd.edu http://www.life.umd.edu/biology/QuinlanLab/home.html



Strengthening Synaptic Functions to Solidify Memory

Hey-Kyoung Lee's work on the role of synaptic plasticity and memory could pave the way for new treatments for blindness, addiction, and Alzheimer's disease.

Lee uses electrophysiological recording to "eavesdrop" on neurons. The technique has isolated the key role played by AMPA receptors (binding agents) in weakening or strengthening communication between neurons. Experiments that target receptors to specific synapses demonstrate how memory accumulates at the cellular level, and help scientists determine the crucial early steps for developing therapeutics.

In collaboration with the Johns Hopkins School of Medicine, the Lee Laboratory studies synaptic plasticity in relation to Alzheimer's disease. They have identified key factors associated with changing the strength of signals between neurons in dementia patients.

Hey-Kyoung Lee hlee21@umd.edu http://www.life.umd.edu/biology/leelab/

"Troubleshooting" Faulty Brain Circuitry

Patrick Kanold hopes to discover ways to restore mental plasticity by "rewiring" circuits in the brain. Though neurons are individual cells, they link up to form complex branching networks of neural circuit pathways. When an injury or congenital abnormality disrupts this plasticity in early development, the brain can become irreversibly mis-wired. For example, injury to the brain circuits of babies in the womb has been linked to cerebral palsy and other neuro-developmental disorders.

Using advanced imaging and electrophysiological methods, Kanold's research team records neuron activity an all scales – from large-scale nerve assemblies down to the single-cell level. They integrate this information into computational models, with the goal of determining the role that every brain "circuit" plays in plasticity – the brain's ability to change.

Kanold hopes that understanding how these circuits work will allow him to artificially duplicate them. Thus, synthetic neurons could be used to "rewire" brain circuits in people with neuro-developmental diseases such as cerebral palsy, schizophrenia, and epilepsy.

Patrick Kanold pkanold@umd.edu http://www.chemlife.umd.edu/biology/faculty/kanold/

Connecting Smell to Behavior and Neurodegenerative Diseases

Ricardo Araneda's research into the connections between smell and behavior may help lead to therapeutics for diseases such as multiple sclerosis, schizophrenia, and Huntington's Disease.

Araneda combines cutting-edge electrophysiological and molecular imaging technologies to study olfactory bulb neuromodulation, or the processing of biochemical signals from the brain. Understanding synaptic changes at this cellular level demonstrates how smell directs behavior in regard to safety, food, and even finding mates.

Recent research has shown that adult brain cells in the olfactory bulb exhibit neurogenesis – the birth of new cells. By studying how adult mammals integrate newly- born neurons into the olfactory bulb circuitry, Araneda explores the potential for rebuilding new circuits that could counter neurodegenerative diseases.

Ricardo Araneda raraneda@umd.edu http://www.chemlife.umd.edu/biology/aranedalab/