

Symposium Title:

MECHANISMS OF DEVELOPMENTAL PLASTICITY: FROM FIRST BREATH TO ADOLESCENT COGNITION

Presenters:

Bryan Kolb (xxxxxx@uleth.ca)

Janice Juraska (xxxxxx@illinois.edu)

Michele Brumley (xxxxxx@isu.edu), Co-Chair

Jessica Whitaker-Fornek (xxxxxx@ufl.edu)

Tania Roth (XXXXXX@UDEL.EDU), Chair

Symposium Abstract:

Throughout development, animals incur rapid changes in their body, brain, environment, and life experiences. Plasticity in different regions of the nervous system supports developmental changes in behavior across ontogeny, providing a rich substrate for continual adaptation to the environment. In this symposium we explore mechanisms of developmental plasticity in animal models, highlighting various periods in the development of behavior and across different species. In the first presentation, Dr. Bryan Kolb will discuss mechanisms of adaptive developmental plasticity, with a focus on the cerebral cortex. Next, Dr. Janice Juraska will examine neuronal changes in the rat prefrontal cortex associated with cognitive development during adolescence. Dr. Michele Brumley will explore behavioral epigenetic changes in the spinal cord of rats supporting developmental changes in motor behavior, from the neonatal through adolescent period. Finally, Dr. Jessica Whitaker-Fornek will discuss her work on age-dependent shifts in breathing circuits in the hindbrain of zebra finch embryos. Collectively, this symposium will highlight various mechanisms of plasticity using different animal preparations and systems (i.e., in vitro and vivo, brain and spinal, mammal and bird) throughout crucial developmental periods. Dr. Tania Roth will serve as the symposium discussant, facilitating conversation on how we can use animal models to inform our understanding of how the CNS adapts to environmental conditions during ontogeny. This symposium will bridge research at multiple levels in a way that is consistent with the purpose of the ISDP. Research will be integrated across multiple species, multiple developmental time points, multiple research techniques and levels of analysis, and across different developmental systems.

List of abstracts and presenters:

MECHANISMS OF DEVELOPMENTAL ADAPTIVE CNS PLASTICITY

Bryan Kolb, Ph.D., Professor of Neuroscience, University of Lethbridge, CA

The developing brain is remarkably plastic as it changes in response to a wide range of experiences including sensory and motor experience, psychoactive drugs, peer

relationships, parent-infant interactions, gonadal hormones, intestinal flora, diet, and injury. There are sensitive periods for many of these experiences in development such as during the time of intense synaptogenesis vs apoptosis. One of the challenges in understanding the nature of plasticity during development is to identify the mechanisms. There are several putative mechanisms of the underlying developmental plasticity including: 1) modifications of cortical inputs and outputs as well as modifications to the intrinsic cortical connectivity and neuronal morphology; 2) changes in functional connectivity as measured by functional MRI; 3) neurogenesis and astrogliosis; 4) changes in perineuronal nets; 5) changes in gene expression; and 6) gonadal hormones. It is also important to note that developmental plasticity can be either adaptive or maladaptive. The focus of this presentation will be on plasticity in cerebral cortex.

THE LAST STAGE OF DEVELOPMENT: THE RESTRUCTURING OF THE CORTEX DURING ADOLESCENCE ESPECIALLY AT PUBERTY

Janice Juraska, Ph.D., Professor of Psychology, University of Illinois at Urbana-Champaign

There is considerable reorganization in the prefrontal cortex during adolescence in humans and also in rodents, where the cellular basis can be explored. In the rat medial prefrontal cortex peripubertal pruning occurs in the number of synapses, dendrites, and neurons. In addition, perineuronal nets, extracellular structure that control plasticity, are pruned peripubertally which may further open the adolescent prefrontal cortex to environmental influences such as stress and drugs. All of these decreases are larger in female rats and more definitively tied to puberty than is evident in males. In females, even estrogen receptor beta mRNA decreases at puberty. Rats of both sexes also perform better after puberty on a test of cognitive flexibility in the water maze. Thus adolescence, especially puberty, should be considered part of development when both structure and function are changing.

BEHAVIORAL EPIGENETICS IN THE DEVELOPING SPINAL CORD

Michele R. Brumley, Ph.D., Professor of Psychology, Idaho State University

Epigenetics is an important mechanism that underlies plasticity in the brain and behavioral adaptation to the environment. Environment-driven changes in gene activity in the brain have been reported following learning, memory, environmental enrichment, early-life adversity, and use-dependent activity, with changes often occurring on the BDNF (brain-derived neurotrophic factor) gene. In particular, DNA methylation has been shown to be an important regulator of gene expression in the brain. Although epigenetic activity in the brain is well documented, information on how the environment regulates and contributes to plasticity and behavioral potential in the spinal cord remains limited. In this presentation, we present recent data on developmental changes in motor

behavior (from newborn period through adolescence) in rats following an early spinal cord injury, and concurrent changes in BDNF gene methylation levels in different regions of the spinal cord in males and females. Current studies are examining activity-dependent changes in behavior and spinal epigenetic regulation following treadmill training and experienced variations in maternal care. This work highlights the spinal cord as being dynamically responsive to environmental changes and plasticity processes.

AGE-DEPENDENT EFFECTS OF PH ON BREATHING BIORHYTHMS IN A BIRD EMBRYO: EVIDENCE FOR DEVELOPMENTAL PLASTICITY OR MATURING PH REGULATION?

Jessica Whitaker-Fornek, Ph.D., Postdoctoral Researcher in Pharmacology and Therapeutics, University of Florida

Newborns often exhibit impaired breathing control that leaves them at risk for apneas, poor autoresuscitation, and sudden unexpected death. A more complete understanding of the embryonic development of central breathing control circuits would provide insight into the breathing problems faced by some infants. The zebra finch embryo is ideal for tracking the day-by-day construction of breathing biorhythms since birds develop in hard shelled eggs outside of the mother. Using an *in vitro* preparation of the zebra finch embryo hindbrain, I tested the hypothesis that acidosis and alkalosis influence early breathing biorhythms over the entire gestation/incubation period. pH naturally changes in the egg environment over incubation and it is the primary driver for breathing in adults. Thus, the focus of this presentation will be the role of pH in the production of breathing biorhythms in prenatal- through perinatal-stage zebra finch embryos. Age-dependent differences in the acute effects of pH on breathing biorhythms will be discussed in relation to concepts of developmental plasticity and the maturation of intra- and extracellular pH regulation.

Symposium Discussant

Tania Roth, Ph.D., Professor of Psychological and Brain Sciences, President-Elect of ISDP