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**Animal behavior reflects the interplay of two types of responses: those that arise innately, from neural circuits pre-programmed into the genome, and those acquired by learning from past experience. Using the simple neural circuitry of the fruit fly *Drosophila,* Ruta works to define how behaviors are adapted through individual experience or evolution.**

Animal behavior arises from an interplay between instinct and learning. Certain behaviors are invariant across members of a species, suggesting they are genetically hardwired. However, behavior must also be flexible to allow individuals to adapt to their unique and changing experience of the world. The Ruta lab delineates the neural circuits and computations that underlie innate and learned behaviors, and reveals how these circuits can be modified through evolution or individual experience to generate novel behavioral adaptations. The group uses a multidisciplinary toolkit—including optical tracing techniques, electrophysiology, functional imaging, and quantitative behavior—to study the concise chemosensory circuits of the fly, with the goal of revealing how they mediate fixed and flexible behaviors at the level of synapses, cells, and circuit motifs.

One focus of the Ruta lab has been to explore how the nervous system flexibly encodes and assigns meaning to the complex and vast chemical world. By examining the functional architecture of the *Drosophila* mushroom body, an associative brain center that is essential for olfactory learning and memory, they demonstrated how neuromodulation can act to rapidly reconfigure circuit properties and allow the same odor to drive alternative behavioral responses. In recent experiments, the Ruta lab developed a virtual reality system to record neural responses as a fly navigates within an odor plume, allowing them to directly link the neural and behavioral changes that unfold during learning. They also showed that the temporal sensitivity of molecular pathways within the mushroom body gives rise to temporal dependence of associative learning, allowing an animal to infer the causal link between an odor and a reward, even within a dynamic environment.

In parallel, the Ruta lab has used *Drosophila* courtship as a paradigm to explore how innate behaviors emerge from genetically specified neural circuits and are modified through evolution to generate species-specific variations in mating behavior. The lab has begun to translate genome editing tools from *D. melanogaster* to several closely related species, allowing them to reveal how evolution can tinker with brain circuits to produce different behaviors. Recent work showed how the same pheromone can promote mating in one species of *Drosophila* but suppress it in another due to rewiring of a central node within the brain.

In other work, the Ruta lab has been exploring how olfactory receptors evolve to allow flies and other insects to rapidly adapt to diverse chemical niches. Insect olfactory receptors form the largest and most diverse family of ion channels but bare no similarity to other chemoreceptors. The Ruta lab resolved the first structure of an insect olfactory receptor using cryo-electron microscopy. The lab continues to perform biochemical, electrophysiological, and structural studies of this receptor family to provide insight into the molecular basis for odorant signaling in insects and to lay the foundation for the development of novel strategies to prevent the transmission of insect-borne diseases.

EDUCATION

B.A. in chemistry, 2000
Hunter College of the City University of New York

Ph.D., 2005
The Rockefeller University

POSTDOC

Columbia University, 2005–2010

POSITIONS

Associate Research Scientist, 2010–2011
Columbia University

Assistant Professor, 2011–2017
Associate Professor, 2017–2022
Professor, 2022–
The Rockefeller University

Investigator, 2021–
Howard Hughes Medical Institute

AWARDS

New York Stem Cell Foundation–Robertson Neuroscience Investigator, 2012

Pew Biomedical Scholar, 2012

McKnight Scholar, 2012

Sinsheimer Fund Scholar, 2012

Irma T. Hirschl/Monique Weill-Caulier Trust Research Award, 2013

Alfred P. Sloan Research Fellowship, 2013

NIH Director's New Innovator Award, 2013

The Rockefeller University Distinguished Teaching Award, 2015

MacArthur Fellowship, 2019

SELECTED PUBLICATIONS

Del Marmol, J. et al. The structural basis of odorant recognition in insect olfactory receptors. *Nature* 597, 126–131 (2021).

Hindmarsh-Sten, T. et al. An arousal-gated visual circuit controls pursuit during Drosophila courtship. *Nature* 595, 549–553 (2021).

Handler, A. et al. Distinct Dopamine Receptor Pathways Underlie the Temporal Sensitivity of Associative Learning. *Cell* 178, 60–75 (2019).

Butterwick J.A. et al. Cryo-EM structure of the insect olfactory receptor Orco. *Nature* 560, 447–452 (2018).

Seeholzer L.F. et al. Evolution of a central neural circuit underlies *Drosophila* mate preferences. Nature 559, 564–569 (2018).