Harvard College/GSAS: 159655

Spring 2023

Instructor: Catherine Dulac dulac@fas.harvard.edu

Teaching Fellows:

- **Maoting Chen mchen1@g.harvard.edu**
- **Ethan Glantz ethanglantz@g.harvard.edu**
- **Tricia Horvath patricia_horvath@fas.harvard.edu**
- **Nic Pena npena@g.harvard.edu**
- **Courtney Whilden courtneywhilden@g.harvard.edu**

Class Times:

- Tuesday and Thursday 1:30 to 2:45 PM in Harvard Art Museums, Menschel Hall (entrance on Broadway)

Course Calendar (click here)

Section Times (must attend assigned section every week):

- Tuesday 3-4pm in Biolabs 1087 (Tricia Horvath)
- Tuesday 3-4pm in Biolabs 1058 (Courtney Whilden)
- Wednesday 5:30-6:30pm in Biolabs 1058 (Maoting Chen)
- Wednesday 5:30-6:30pm in Biolabs 1087 (Nic Pena)
- Thursday 3-4pm in Biolabs 1087 (Tricia Horvath)
- Thursday 3-4pm in Biolabs 1058 (Ethan Glantz)
- Thursday 4:30-5:30pm in Biolabs 1058 (Ethan Glantz)
- Friday 11am-12pm in Biolabs 1087 (Courtney Whilden)

Office Hours:

- Every Monday 1pm-2pm (Pr. Dulac) (with exceptions) and by appointment (Biolabs 4017)
- Tricia: Every Monday 6-7pm (BL 1087)
- Courtney: Tuesdays 6:30-7:30pm (BL 1087)
- Ethan: Wednesdays 1-2pm (zoom)
- Nic: Wednesdays 6:30-7:30pm (BL 1087)
- Maoting: Friday 4:30-5:30pm (Northwest B129)

Course Documents:

Syllabus

MCB Neuro125 short syllabus 2023.docx

MCB125 detailed syllabus 2023.docx

Link to online textbook (requires Harvard library login)

Course Description:

Modern molecular and genetic approaches are revolutionizing neuroscience and our understanding of how the brain controls behaviors and emotions, with direct applications to mental illness. This course will cover newly developed experimental strategies in molecular neuroscience, and explain how they help uncover the identity and mode of function of behavior circuits and associated changes in mood disorders and neurodegeneration. Key examples of neural controls of mammalian behavior will be explored with an emphasis on instinctive and social behavior circuits, their functional organization and development in healthy and diseased brains, and how new approaches help unravel disease mechanisms and open new avenues for diagnosis and treatment.

Course Grading: 6 Take Home Problem Sets (15% each Pset) + Participation 10% *(see course calendar)*

COURSE TESTIMONIALS FROM PREVIOUS STUDENTS

Simon:

As an MCB concentrator, MCB/Neuro 125 was my first neuroscience course at Harvard. For me, MCB/Neuro 125 was an amazing introduction to neuroscience, as contrary to my expectations, it was not a tedious course on memorizing different parts of the brain but a course that introduced modern approaches to investigate and analyze brain functions. I was excited to learn about genetic tools (such as Cre/loxP and DREADDS) that are useful even outside the field of neuroscience. Despite the general applicability of the genetic tools studied, I was surprised by the usefulness and necessity of genetics in modern neuroscience. I greatly appreciated that the course was not too focused on reciting facts, contrary to many other science classes, but was built on the premise to help advance the investigative skills of us students. And who would be better suited to teach research skills to students than Breakthrough Prize-winner Catherine Dulac? I can recommend MCB/Neuro 125 to every MCB or Neuro student, as to me the knowledge and skills taught in this course seem essential for working and excelling in either field in the future!

BRIEF INTRODUCTION TO CONTENT OF THE COURSE:

Some striking examples of recent findings about the molecular and neuronal basis of behavior are listed below. We will discuss these and many other studies in class.

- Daily Rhythm of Behavior

  Narcolepsy is a chronic neurological disorders. Patients are subject to excessive daytime sleeping. Narcolepsy in dogs also exists and has been one of the first models to study the disease. Similar to human patients, narcoleptic dogs display fragmented sleep triggered by emotional excitement. In the video below, dogs fall rapidly asleep upon joyfully greeting their owners. Studies on the molecular basis of canine and human narcolepsy are ongoing (Lin, L. et al., "The sleep disorder canine narcolepsy is caused by a mutation in the hypocretin (orexin) receptor 2 gene." *Cell*, 1999).

- Molecular Basis of Solitary vs. Social Lifestyle

  The nematode *C. elegans* only has 302 neurons and all connections (synapses) among these neurons have been mapped. The worm is thus an excellent model to connect its behaviors to individual neurons and molecules. In the image below, an aggregating, socially feeding strain (left) is shown next to a solitary strain (right). The solitary strain is likely evolutionarily derived, and possibly partly domesticated (solitary worms are easier to pick off the agar plate they are kept on, and worms may thus have been artificially selected for solitary behavior). Molecular work revealed that a genetic polymorphism in the G protein-coupled receptor NPY underlies social vs. solitary behavior by mediating sensory input and metabolic turnover in these worms (de Bono, M., Bargmann, C.I. "Natural Variation in a Neuropeptide Y Receptor Homolog Modifies Social Behavior and Food Response in C. Elegans." *Cell*, 1998).

- Molecular Basis of Parenting

  Parental behavior is a suite of species-specific behaviors aimed at the care and protection of young. Modern tools of neuroscience have offered new opportunities for dissecting the molecular and neural mechanisms controlling these types of specific social responses. We will discuss how these findings open new avenues to deconstruct infant-directed behavioral control in males and females, and to help understand the neural basis of parenting in a variety of animal species, including humans. In particular, my lab has recently uncovered the key role of galanin-expressing neurons in control of parental behavior (Wu, Z. et al, "Galanin neurons in the medial preoptic area govern parental behavior." *Nature*, 2014). Shown below is a video of a male mouse retrieving pups. A marker of neuronal activity, immediate early gene c-fos (shown in red), is activated during parental behavior in neurons controlling parenting. Galanin (gal, shown in green) highly overlaps (co-labeled cells in yellow) with neural activity associated with parental behavior. Viewers are kindly requested not to upload this movie to other publicly accessible sites (video courtesy of C. Dulac and A. Autry)

- Aggression

  Aggressive behavior, because of its ubiquity in the animal kingdom and its self-destructive consequences on the human population, has attracted considerable attention from researchers over the past two millenia. Recently, aggression research has undergone a new revival due to modern neurotechnology. The movie below shows a male mouse that attacks a glove, which is induced by stimulating a region of the hypothalamus in the brain with optogenetic technology (Lin, D. et al., "Functional identification of an aggression locus in the mouse hypothalamus." *Nature*, 2011). Viewers are kindly requested not to upload this movie to other publicly accessible sites.