Course Title: Regulation of behaviors for survival

Course Number: BIOLUN3320

Prerequisites: Taken after, or concurrent with UN3004 (Cellular and Molecular Neurobiology) and or permission from instructor.

Course Type: Seminar

Credits: 4

Location: 407 Mathematics Building

Meeting times: Wednesdays 10:10am – 12:00pm

Class size (maximum): 18

Course description:

To maximize their survival animals must regulate their behavior in response to external environmental cues and their own internal state. A fundamental goal of neuroscience is to understand how neural circuits in the brain function to influence behavior. The aim of this course is to highlight the neural basis of neuropeptide regulation of innate behaviors that are critical for survival and discuss modern approaches to study the neuronal control of classically studied aspects of behavior. We will explore motor control (escape responses), sensory systems (vision, taste, and olfaction), and survival behaviors (feeding, drinking, mating, and aggression). Focus will be on recent and current research, the diversity of approaches for studying it, and how this knowledge can be applied to solve scientific questions. Students will read primary scientific literature and a significant portion of the course will be presentation and discussion-based.

To ensure participation of all students in the course discussions a maximum of 18 students will be admitted. Graduate students are welcome but undergraduate students in their junior and senior years majoring in Neuroscience and Behavior will have preference. Auditors will not be accepted.

Instructor: Laura B. Duvall, Ph.D.

Dept of Biological Sciences

Office: 731 Mudd Building

lbd2126@columbia.edu

Office Hours: Fridays, 9:00am – 10:00am (731 Mudd Building)

Teaching Assistant: Lizzie Bradford

Dept of Biological Sciences

efb2138@columbia.edu

Office Hours: Thursdays, 5:00pm – 6:00pm (709 Fairchild Building)

Required Text: There will be no required textbook for this course; each week you will be assigned readings and papers from the scientific literature. These readings will be posted in Courseworks.

Recommended texts:

Alcock, J. 2013. "Animal behavior: an evolutionary approach" 10th edition. Sinauer Associates Publishers.

Tinbergen N. 1991 "The Study of Instinct". Oxford Univ Press.

Course Learning Objectives:

The objectives of this course are to introduce students to the mechanisms by which neural signals and circuits shape behavioral responses and to broaden their intellectual horizons and practice their presentation and scientific communication skills. The course evaluation will be based largely on written work, participation in discussions, and presentations.

By the end of this course, students will be able to:

1. Give examples of how genes, circuits, and behavior have evolved among diverse taxonomic groups (e.g., give examples across a range of insect taxa of how they find food, how they find mates, how they protect themselves from predators, etc.)
2. Based on observations of behavior in nature and in the laboratory, develop hypotheses for the function of the behaviors observed

1. Describe methods employed to study the neuronal regulation of behavior and be able to propose specific experiments to logically test hypotheses
2. Evaluate and critically assess articles from the primary literature in the field
3. Describe how scientists are using our modern understanding of behavior to solve research questions

Course Format:

Lectures

Once per week by course instructor.

Presentations/Discussion

Once per week led by students.

Sign up for topics on the googledocLinks to an external site..
Students will select a research paper, prepare 2 discussion questions for the class, present the paper, incorporate discussion questions into the presentation, and lead class discussion. **Paper selection is due to Dr. Duvall (via email) by noon on the Friday before class discussion. Discussion questions are posted directly into the discussion question googledocLinks to an external site. and are due at noon on the Monday before class discussion.**

Non-presenting students must prepare short answers to discussion questions are due before class on Wednesday morning via email to Lizzie Bradford.

"1 pagers" should include short response to each discussion question. Each week students respond to 3 common questions:

Common Q1: Why did the authors choose to study this system?

Common Q2: What figure or subfigure most strongly supports the authors' claims?

Common Q3: What is an interesting future experiment to try?

And 2 specific questions added by the presenters. Students will be called on randomly to answer questions in class.

Grading:

1. A short literature review (maximum 5 pages) on any of the topics discussed will be due at the end of the semester (**25%** of final grade)
2. Research paper presentation (**25%** of final grade)
3. Active class participation (during lecture & paper presentations) (**20%** of final grade)
4. Written discussion questions (**20%** of final grade)
5. Attendance (no more than 2 absences without instructor approval) (**10%** of final grade)

Overview of Syllabus:

1. Lectures 1 and 2: Introduction to the course/History of the field + How to read a scientific paper
2. Lectures 3 and 4: Basics of Innate Behavior & Neuronal signaling + Circadian behavior
3. Paper presentation 1 (Circadian behavior) + Lecture 5: Social behaviors
4. Paper presentation 2 (Social behaviors) + Lecture 6: Female mating behaviors
5. Paper presentation 3 (Female mating behaviors) + Lecture 7: Parental behavior
6. Paper presentation 4 (Parental behavior) + Lecture 8: Escape responses
7. Paper presentation 5 (Escape responses) + Lecture 9: Stress and addiction
8. Paper presentation 6 (Stress and addiction) + Lecture 10: Olfaction
9. Paper presentation 7 (Olfaction) + Lecture 11: Gustation
10. Paper presentation 8 (Gustation) + Lecture 12: Navigation
11. Paper presentation 9 (Navigation) + Lecture 13: Aggression

No class – CU Thanksgiving Holiday

12. Paper presentation 10 (Aggression) + Lecture 14: Sleep
13. Paper presentation 11 (Sleep) + Class wrap up and final discussion
14. CU study days
15. Final 5 page mini-review due

Detailed Syllabus:

1. **Wednesday September 6, 2023**

Lecture 1: Introduction/history of the field and Lecture 2: “How to read a scientific paper”

1. Readings:
    1. Tinbergen “The Study of Instinct” VIII The Evolution of Behavior [Chapter 1: Ethology: The Objective Study of Behavior]
    2. Alcock, J. 2013. “Animal behavior: an evolutionary approach” 10th edition. Sinauer Associates Publishers. [Chapter 1 “An Introduction to Animal Behavior”]
    3. How to read a scientific paper (2016) Adam Ruben doi:10.1126/science.caredit.a1600012
    4. How to (seriously) read a scientific paper (2016) Elisabeth Pain doi:10.1126/science.caredit.a1600047

Assignments: Rank your presentation topic preference using the google sheet by Tuesday Sept 12th. On Wednesday Sept 13th, Dr. Duvall will make final assignments and announce these in class.

2. **Wednesday September 13, 2023**

Lecture 3: Innate behaviors and introduction to neuropeptide signaling

These lectures provide an overview of the study of conserved innate behaviors in experimental organisms and the genetic and neural basis for these.

1. Readings:
    1. Alcock, J (2013) "Animal behavior: an evolutionary approach" 10th edition. Sinauer Associates Publishers. [Chapter 13 "How Neurons and Hormones Organize Behavior"]
    2. Strand, FL (1999) "Neuropeptides: Regulators of Physiological Processes" MIT Press. [Chapter 1: The Neuropeptide Concept and the Evolution of Neuropeptides]
    3. Katz PH and Harris-Warrick RM (1999) The evolution of neuronal circuits underlying species-specific behavior. *Curr Opin Neurobiol*. 9(5): 628 -633.

Lecture 4: Circadian behavior

Mutations in genes controlling daily rhythms were among the first to demonstrate genetic control of complex behaviors. This lecture will focus on the study of circadian rhythms in *Drosophila* and mammals.

1. Readings:
    1. Alcock, J (2013) "Animal behavior: an evolutionary approach" 10th edition. Sinauer Associates Publishers. [Chapter 13 "How Neurons and Hormones Organize Behavior"]
    2. Konopka RJ and Benzer S (1971) Clock Mutants of Drosophila melanogaster. *Proc Natl Acad Sci.* 68(9): 2112-2116.

3. **Wednesday Sept 20, 2023**

Paper presentation (Circadian behaviors)

Lecture 5: Social behaviors

Social behavior includes the suite of interactions that occur between two or more individuals, usually of the same species, when they form simple aggregations, cooperate in sexual or parental behavior, engage in disputes over territory and access to mates, or simply communicate across space. This lecture will focus on eusocial behavior in bees and naked mole rats.

1. Readings:
    102. Fischer EK and O'Connell LA (2017) Modification of feeding circuits in the evolution of social behavior. *J. Exp Biol*. 220, 92-102.
    103. Ament SA, Corona M, Pollock HS, Robinson GE (2008) Insulin signaling is involved in the regulation of worker division of labor in honey bee colonies. *PNAS*. 105(11) 4226 – 4231.

4. **Wednesday September 27, 2023**

Paper presentation (Social behaviors)

Lecture 6: Female mating behavior

Female mating behavior is often influenced by signals transferred from her partner – sex peptide in *Drosophila* is one of the most well-studied of these. This lecture will focus on the regulation of post-mating behavior in fruit flies and rodents.

1. Readings:
    9933. Liu H and Kubli E (2003) Sex-peptide is the molecular basis of the sperm effect in Drosophila melanogaster. *PNAS*. 100(17): 9929-9933.
    9934. Labov JB (1981) Pregnancy blocking in rodents: adaptive advantages for females. *The American Naturalist*. 118(3): 361 – 371.

5. **Wednesday October 4, 2023**

Paper presentation (Female mating behavior)

Lecture 7: Parental behavior

Parental care varies widely between species and is regulated by neuropeptides including oxytocin. This lecture will focus on parental care in beetles and mice.

1. Alcock, J (2013) “Animal behavior: an evolutionary approach” 10th edition. Sinauer Associates Publishers. [Chapter 9 “The Evolution of Parental Care”]
2. Cunningham CB, VanDenHeuvel K, Khana DB, McKinney EC, Moore AJ (2016) The role of neuropeptide F in a transition to parental care. *Biology Letters*. 12(4): 20160158
3. Bendesky A, Kwon Y-M, Lassance J-M, Lewarch CL, Yao S, Peterson BK, He MX, Dulac C, Hoekstra HE. (2017) The genetic basis of parental care evolution in monogamous mice. *Nature*. 544: 434 – 439.

6. **Wednesday October 11, 2023**

Paper presentation (Parental behavior)

Lecture 8: Escape responses

The drive to escape from potential threats is deeply conserved. This lecture will focus on the circuitry of escape responses in *Drosophila* and zebrafish and how these are regulated.

1. Readings:
    186. Card GM (2012) Escape behaviors in insects. *Curr Opin Neurobiol*. 22: 180 – 186.
    187. Tinbergen “The Study of Instinct” [Chapter 7: The Adaptiveness of Behavior: Activities of Direct Advantage to the Individual: Escape Behavior]

7. **Wednesday October 18, 2023**

REMINDER: Topic, title, and 10 references due today!

Paper presentation (Escape responses)

Lecture 9: Stress and addiction

Stress can occur when animals have to make extreme and/or prolonged physiological and behavioral adjustments in order to cope with their environment. This lecture will focus on the regulation of stress responses in rodents and *Drosophila*.

1. Readings:
    212. Deussing JN, Wurst W (2005) Dissecting the genetic effect of the CRH system on anxiety and stress-related behaviour. *C.R. Biologies*. 328: 199 – 212.
    213. Shohat-Ophor G, Kaun KR, Azanchi R, Mohammed H, Heberlein U. (2012) Sexual deprivation increases ethanol intake in *Drosophila*. *Science*. 335: 1351 – 1355.

8. **Wednesday October 25, 2023**

Paper presentation (Stress and addiction)

Lecture 10: Olfactory behaviors

Chemosensation is critical for evaluation of the environment, olfaction is critical for foraging, courtship, and escape response behavior in many animals. This lecture will focus on olfactory behavior in flies and mammals.

1. Readings:
    10. Rosen JB, Asok A, and Chakraborty T (2015) The smell of fear: innate threat of 2,5-dihydro-2,4,5-trimethylthiazoline, a single molecule component of a predator odor. *Front Neurosci.* 9(292): 10.3389
    11. Grunwald Kadow IC, Gompel N (2020) Sensory evolution: making sense of the Noni scent. *Current Biology*. 30: R698-R720

9. **Wednesday November 1, 2023**

Paper presentation (Olfaction)

Lecture 11: Gustation behaviors

Taste, or gustation is critical for evaluation of potential food sources and conspecifics and potential mates. This lecture will focus on gustatory behavior in flies and hummingbirds.

1. Readings:
    63. Pool A-H and Scott K (2014) Feeding regulation in Drosophila. *Curr Opin Neurobiol*. 0: 57 – 63.
    64. Baldwin MW, Toda Y, Nakagita T, O'Connell MJ, Klasing KC, Misaka T, Edwards SV, Liberles SD (2014) Evolution of sweet taste perception in hummingbirds by transformation of the ancestral umami receptor. Science. 345(6): 929 – 933.

10. **Wednesday November 8, 2023**

Paper presentation (Gustation)

Lecture 12: Navigation

Spatial awareness and the ability to appropriately move through the environment are key skills for survival. This lecture will focus on innate navigation behaviors in ants, butterflies, and fish.

1641. Wolf H (2011) Odometry and insect navigation. *Journal of Experimental Biology*. 214: 1629 – 1641.
1642. Yong E (2013) Monarch butterflies navigate with compass but no map. *Nature*. doi:10.1038/nature.2013.1275

11. **Wednesday November 15, 2023**

VIRTUAL CLASS DAY – OPTIONAL PAPER WRITING WORKSHOP WITH LIZZIE BRADFORD

Lecture 13: Aggression – AVAILABLE ON COURSEWORKS

Aggression is defined as threats or harmful actions directed toward another individual and can include threat displays. In animals, aggressive behaviors are a means of communication. This lecture will focus on aggression in *Drosophila* and baboons.

1. Readings:
    563. Kravitz EA and de la Paz Fernandez M (2015) Aggression in Drosophila. *Am Psych Assoc.* 129(5): 549 – 563. (selected sections)
    564. Alcock, J (2013) "Animal behavior: an evolutionary approach" 10th edition. Sinauer Associates Publishers. [Chapter 6 "When to Invest in Territorial Defense"]

Lecture 14: Sleep – AVAILABLE ON COURSEWORKS

Sleep is a naturally recurring state of mind and body, characterized by altered consciousness, reduced sensory activity, reduced muscle activity and inhibition of nearly all voluntary muscles, and reduced interactions with surroundings. This lecture will focus on sleep regulation in mammals and jellyfish.

28461. Keene AC and Duboue ER (2018) The origins and evolution of sleep. *J. Exp Biol*. 221: jeb159533.

28462. Lesku JA and Ly LMT (2017) Sleep Origins: Restful Jellyfish are Sleeping Jellyfish. *Curr. Biol.* 27. R1060-R1080.

12. **Wednesday November 22, 2023**

No class – CU Thanksgiving Holiday

REMINDER: Title, abstract, and 15 references due today!

13. **Wednesday November 29, 2023**
14. Paper presentation (Navigation)

Paper presentation (Aggression)

15. **Wednesday December 6, 2023**

Paper presentation (Sleep)

Final discussion and course wrap-up (lab field trip)

16. **Friday December 15, 2023**

Final 5 page literature review due

Faculty Statement on Academic Integrity

The intellectual venture in which we are all engaged requires of faculty and students alike the highest level of personal and academic integrity. As members of an academic community, each one of us bears the responsibility to participate in scholarly discourse and research in a manner characterized by intellectual honesty and scholarly integrity.

Scholarship, by its very nature, is an iterative process, with ideas and insights building one upon the other. Collaborative scholarship requires the study of other scholars' work, the free discussion of such work, and the explicit acknowledgement of those ideas in any work that inform our own. This exchange of ideas relies upon a mutual trust that sources, opinions, facts, and insights will be properly noted and carefully credited.

In practical terms, this means that, as students, you must be responsible for the full citations of others' ideas in all of your research papers and projects; you must be scrupulously honest when taking your examinations; you must always submit your own work and not that of another student, scholar, or internet agent.

Any breach of this intellectual responsibility is a breach of faith with the rest of our academic community. It undermines our shared intellectual culture, and it cannot be tolerated. Students failing to meet these responsibilities should anticipate being asked to leave Columbia.

Faculty Statement on Disability Accommodations

If you are a student with a disability and have an DS-certified 'Accommodation Letter' please come to office hours to confirm your accommodation needs. If you believe that you might have a disability that requires accommodation, please contact Disability Services at 212-854-2388 and disability@columbia.edu.