**Methods in Neuroscience**

**Spring Semester, 2021**

**Rutgers University Psychology Department**

**Course Information:**

Rutgers Course Number: 16:830:646 Problems in Behavioral Neuroscience: Methods in Neuroscience

Date and Time: Thursdays 9:30 AM – 12:00 PM

Index Number: 17661

Location: Psychology- TBD

Prerequisite: Advanced college-level neuroscience coursework

**Instructor:**

Dr. David J. Barker

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Office: Psych 322 (Busch Campus)

Office Hours: By virtual appointment until further notice.

**Introduction and Goals for this Course:** Scientific advancement is almost always preceded by the development of new technologies. A recent example of this is the Nobel Prize winning CRISPR-Cas9 gene editing technology, which has now led to hundreds of papers, new scientific approaches, and even some promising avenues for novel treatments. Scientists must therefore continue to learn new technologies, while maintaining the ability to work with established tools. Effectively navigating experimental design requires experimenters to understand the advantages and disadvantages of new technologies while also comparing them with classical approaches in order to choose the best tool for their experimental questions.

The ultimate goal of the course is to provide students with a comprehensive overview of many classic and modern methods in neuroscience, including a survey of molecular, cellular, circuit-based, and whole system techniques. As a part of this, we will discuss when certain methods are best to answer specific scientific questions, how to choose between similar techniques or when to apply complimentary approaches, the proper controls to employ for sound experimental design, and the ethical considerations that accompany all scientific research. Lastly, the course will ask you to consider “who” is using these techniques and “how” they are using them, by asking students to venture out into the field, attend a few of the many virtual seminars being offered around the world, and to bring some of what they learn back into the classroom. \* Discussions of Responsible conduct of research are designed to meet the NIH requirements for training grants, but will be tailored specifically to students in Psychology/Behavioral and Systems Neuroscience.

**Textbook:** *Guide to Research Techniques in Neuroscience*, by Carter & Shieh. (2015) Second Edition, Academic Press. ISBN 978-0-12-800511-8

This book provides a broad overview of neuroscience methods. The book is written at a broad conceptual level and does not cover many of the methods in depth. However, it does provide a good overview of neuroscience methods and is a great laboratory field guide for you to keep around. In addition, this book can serve as a good reference when helping you to navigate the scholarly literature.

**Reading:** Reading assignments will consist of papers from the primary literature that relate to the techniques being discussed. In addition, you will be required to come to class having read case studies related to specific topics for the responsible conduct of research (RCR). RCR is an NIH required training for anyone on or planning to apply for a training grant. Moreover, the NIH strongly believes that this training and discussion should be field specific. *All reading should be done before class.*

**Canvas:** The course has a dedicated Canvas site. All registered students should be automatically added to the site. Please contact me if this is not the case. This site contains all of the required resources for the course. Also, Canvas will be used for announcements and other class communications.

**Evaluation:** Your will be evaluated based on four assignment categories, each worth 25% of your grade.

1) Responsible conduct of research topics/discussion/assignments (200 points).

2) Getting to know new techniques through seminars. Attend four in-person or virtual seminars and provide a short-writeup of what you learned about the methods used (1 page; 50 points each for 200 total points).

3) A final paper on a method of your choice (200 points). The paper should include the history of the technique (i.e. who invented it and when), the details of its implementation, proper interpretation of results, necessary controls, and its overall advantages and limitations. Papers will be submitted via Canvas by **April 22nd.**

4) Quizzes on the topics covered (200 points). There will be 4 quizzes covering the material across the semester, each worth 50 points. The exam questions will be drawn from the assigned chapters in the textbook, assigned readings, or classroom lectures.

**Academic Integrity**

All students are required to comply with the University’s Academic Integrity Policy, as presented at http://academicintegrity.rutgers.edu. Cheating on exams or assisting others in cheating on the exams will be treated in accordance with University Policy.

**Course Schedule for Methods in Neuroscience**

**January 21**

Introduction to the course. A brief history of neuroscience, including its origins in physiology, anatomy, and behavioral psychology (among others).

**RCR- Mentor and Trainee Relationships “Bullied or Mentored” Accompanying Talk: Psychology Seminar by Dr. Gerald Zamponi (January 22nd)\***

\*Huang et al., 2020, Cell Reports

**January 28**

Behavioral experimentation: Spontaneous and observable behaviors, classical and operant conditioning, common apparatus, novel tools.

**Accompanying Talk: Psychology Seminar by Dr. John Salamone (February 5th)\***

\*Yohn et al., 2016, Neuropsychopharmacology.

**February 4**

Immunohistochemistry and *in situ hybridization*: Fluorescent, radioactive, and chromogenic approaches as well as methods for quantification of both *in situ* and immunohistochemical data, including stereological approaches. **RCR- Research misconduct: “Were these slides falsified”**

**February 11**

Structural and functional anatomical methods: anterograde & retrograde tracers, transsynaptic tracers, viral vectors, Nissl staining, stereotaxic atlases, classical stains, ultrastructure and electron microscopy; activity markers.

**February 18**

Microscopy & optical imaging of structure: essentials of optics and microscopes; wide-field vs confocal/multiphoton scanning fluorescence microscopy, light sheet microscopy, image processing and quantification.

**RCR- Authorship and Publication “My Lab Boss Puts His Name on My Papers and Proposals”**

**February 25**

**Quiz #1**

Molecular biology in vitro: PCR, next-gen sequencing, transfection/transformation, gels, blots, cDNA libraries, gene chips, forward/reverse screens, ELISA, DNA/RNA-Seq, co-immunoprecipitation, CHiP

**RCR- Data Acquisition and Management: “Creating a public archive of sensitive data”**

**March 4**

Molecular biology in vivo: transgenics, CRISPR-Cas9, intersectional expression (Lox-Cre, tet, etc), RNAi, gene delivery, conditional expression **RCR-Social Responsibility: “The Magic Key”**

**Accompanying Talk: Psychology Seminar by Dr. Mary Kay Lobo (March 8th)**

\*Engeln et al., 2020, Molecular Psychiatry

**March 11**

Methods in human neuroscience - MRI/PET/SPECT, BOLD signals, FNIR, EEG, MEG, behavior paradigms for simultaneous scanning

**RCR-Conflict of Interest/ Social responsibility: “Career Dreams up in Smoke?”**

**March 18--** SPRING RECESS- NO CLASS

**March 25**

**Quiz #2**

Neural stimulation and optogenetics: patterned electrical stimulation, transcranial magnetic stimulation, channelrhodopsin, halorhodopsin, expression methods, control experiments, light delivery, and patterning, DREADDS, combinations with other methods, potential applications; controls and unintended consequences

**RCR- Peer Review “Getting Scooped by a Reviewer”**

**Accompanying Talk: Psychology Seminar by Dr. Daniel Polley (March 26th)** \*Vila et al., 2019 J. Neural Eng.

**April 1**

Optical neurophysiology: Single cell calcium imaging and fiber photometry. Deep versus superficial imaging and technologies for head-fixed versus freely moving. Calcium sensors, voltage sensors, neurotransmitter sensors and other fluorescent indicators. Analysis approaches.

**April 8 Quiz #3**

In vitro electrophysiology: slice preparation & visualization, intracellular vs patch-clamp, miniatures, current/voltage clamp, intracellular conductance’s, synaptic physiology, single-channel recording

**April 15**

In vivo electrophysiology: field potentials, unit-recording methods (anesthetized vs freely behaving, electrode options, spike sorting, analysis, histology), analytical approaches. **Accompanying Talk: Psychology Seminar by Dr. Elyssa Margolis (March 16th)**

\*Margolis et al., 2020, BioRxiv

**April 22**

Open-Source tools: Open source hardware and software, circuit design, custom fabrication methods, video analysis tools, data analysis, etc.

**RCR- Collaboration “When collaborators disagree”**

**April 29 Quiz #4**

Methods showcase! Bring a paper to share something new and exciting, or classic and classy with your classmates. Anything that has inspired you. Be prepared with a 5-10 minute quick pitch.