Building a Brain: Development of Synaptic Connectivity

Neuro95hfu

Half course (throughout the year). Fall/Spring: Weds., 7–8:30.

Prerequisite: Life and Physical Sciences A or Life Sciences 1a, MCB 80, and permission of the instructor.

CLASS LOCATION: To be determined

INSTRUCTOR: Ryan Draft draft@fas.harvard.edu

Ryan's Office Hours: 3-5 PM (except Tuesdays) Biolabs 1082A

- **Course Overview…**

In this course we will learn about the precise patterning of synaptic connections within neural circuits. In particular, our focus will be on understanding how molecules and neural activity organize synapses in early life. To do this, each week we will read, discuss and debate research articles. Most weeks will we read a paper that reviews a different model circuit, as well as papers that provide evidence and ideas on how that particular circuit's organization arises. In this way, we will learn not only about developmental principles but also about different brain regions and model organisms in Neurobiology.

- **Course Goals…**

The goals of this course are:

1) To learn the developmental principles and mechanisms that shape synaptic connectivity
2) To learn how different circuits are organized at the cellular level
3) To improve your skills in reading, discussing and deconstructing research articles
4) To learn the current methods used in the field of Neurobiology
5) To provide a relaxed, stimulating, and interactive atmosphere

- **Why should I be interested in this course?…**

  …because it's the perfect opportunity to advance your study and understanding of the brain to the level of a scientist. In this course you will learn to read, present, and evaluate primary research articles. As a neurobiologist, this literature will become your principle means of staying up-to-date with the field and its ever-changing body of knowledge.

  Also, this course is meant to introduce the fundamental concepts in one area of brain development: how specific synaptic partnerships are made. The brain is the most organized piece of matter in the known universe. We will explore the 'logic' that underlies this organization. And as we learn about developmental concepts, we will learn about the circuitry and processing of the circuits themselves – giving you a strong foundation in the organization of neural circuits.

- **A Typical Class…**

For most meetings a different student will present the assigned papers' figures, and we will go through and discuss the methods, ideas, context, significance, and weakness of the research. When necessary, I will prepare a brief lecture with ancillary information/background before the discussion. However, the vast majority of class time will be spent understanding, discussion, and critiquing the papers. At the end of each class we will integrate and review what we covered as preparation for the end of semester quiz.

- **Work Expectations…**

You are expected to come prepared to each meeting. That entails: 1) reading the papers, thinking about the papers, and making notes about the papers; 2) completing a pre-class worksheet on the papers. You should expect to spend 3-4 hours with the material before class.

Twice a semester you will lead the discussion about the assigned papers. On one of these occasions you will be expected to create a power-point presentation that includes background and figures for the assigned material (detailed guidelines and an example will be provided).

There will be one quiz per semester that reviews the material we have covered. There will also be one writing assignment (1-2 pages) per semester to help you practice scientific writing and citing.

- **Attendance Policy…**

Weekly attendance is required; 2 unexcused absences throughout the year will result in the drop of a whole letter grade. Two absences can be made up if you contact me in advance of the absence and we agree on an additional assignment to complete in lieu of your participation in that class.

- **Grading…**

30% Weekly pre-class worksheet (due the night before every class)

50% Discussion/participation (every class)

20% Quiz (1/semester), Power-point presentation (1/semester), writing assignment (1/semester)

All Harvard College policies regarding plagiarism apply. In class I will provide you with guidelines about how to incorporate citations into your scientific writing. Please read and follow them carefully. If you have any questions about the correct use of materials that are not your own (e.g., images, data, ideas, theories, etc.), please contact me.

Schedule of Topics

Fall Semester		
Sept 1	No Class	• Follow Monday schedule
Sept 7	Organizational Information / Course Introduction	• Review of key developmental concepts.
Sept 14	The Nature and Nurture of Brain Wiring: PART 1.	Guidelines for presenting papers. The chemo-affinity hypothesis. • **Readings: Sperry 1956; Sperry and Attardi 1963; + Background material.**
Sept 21	The Nature and Nurture of Brain Wiring: PART 1.	Molecular gradients and topography. • **Readings: Brown…Oleary 2000 + Review.**
Sept 28	The Nature and Nurture	Role of sensory information in synaptic circuitry.

	of Brain Wiring: PART 2.	• **Hubel and Wiesel 1964 + Background materials**
Oct 5	The Nature and Nurture of Brain Wiring: PART 2.	Axonal dynamics and NMDA receptor activation • **Ruthazer…Cline 2003; Lichtman and Purves**
Oct 13	Retina (Mouse)	Retinal circuitry. Electrical waves and Hebbian development. • **Readings: Meister…Schatz 1991 + Butts 2001**
Oct 19	Optic Tectum (Mouse)	Spike Time Dependent Synaptic Plasticity • **Readings: Zhang…Poo 1998; Kampa et al 2007**
Oct 26	Superior Colliculus (Mouse)	Activity dependent spatial map formation • **Readings: Triplett 2009.**
Nov 2	Cortex (Mouse)	Critical period onset mechanisms • **Readings: Sugiyama (2 papers)**
Nov 9	Field Trip to the Imaging Center	Intro. to Confocal Imaging Take your own pictures of neurons! • **Reading: Lichtman, 2006** • **Writing assignment 1 due**
Nov 16	Olfactory Bulb (Mouse)	The olfactory circuit. Odor receptors establish topographic map. • **Readings: Imai 2006; Firestein 2009.**
Nov 23	No Class	
Nov 30		The Scientific Method • **Readings: TBA**
Dec 7		**Review; Anatomy Quiz**
Dec 14	No Class - Finals	
Spring Semester		
Jan 25	Neural Networks	Connectivity, complexity and information processing • **Ryan will lecture**
Feb 1	Motorsystem: Spinal Cord	Spinal circuitry and modulation of movement • **Readings: Fetcho…Mclean (review) + McLean..Fetcho 2008**
Feb 8	Motorsystem: Motorneurons	Synaptic competitions in motor neurons • **Reading TBA** • **Ryan will lecture on his research.**
Feb 15	Motorsystem: Cerebellum	Cerebellar circuitry Axonal competition at Purkinje cells. • **Readings: Sugihara I, 2006 + Hashimoto et al 2009.**
Feb 22	Motorsystem: Cerebellum	Cerebellar circuit continued • **Readings: Bosman (Review) + Miyazaki**
Feb 29	Hippocampus	Dendritic dynamics (stability and plasticity) • **Readings: Maletic…Savatic 1999 + Fiala et al 1998**
Mar 7	Brain Dissection	• Participation optional
Mar 14	No Class	• Spring Break

Mar 21	Neuromodulation	**TBA**
Mar 28	Learning & Plasticity I	**TBA**
Apr 4	Learning & Plasticity II (Motor Cortex)	Connectivity & Behavior changes during motor learning • **Readings: Holtmaat and Svoboda; Xu…Zuo 2009**
Apr 11	Learning & Plasticity III (Motor Cortex)	Connectivity & Behavior changes during motor learning • **Readings: Yang, Pan, Gan 2009 + News and Views**
Apr 18	Connectomic Approaches	Serial-EM reconstructions of brain volumes • **Readings: TBA**
Apr 25	Diseases of Development	Disease and thoughts on treatment • **Readings: TBA**
May 2	Reading Period Review	• **Review + Queens Head Pub Night**
May 9	No Class - Finals	