SCRB 182

Got (new) Brain?
The Evolution of Brain Regeneration

Fall 2016  
Capped at 22 students

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Course Time:  
DAYS: Mondays and Wednesdays  
TIME: 2:30-4PM  
LOCATION: Sherman Fairchild building 268

Office hours:  
Paola Arlotta Mondays 4-5:00PM  
Giorgia Quadrato Tuesday 11AM-noon  
Ryoji Amamoto Thursday 2-3:00PM

Teaching Staff:  
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Contact with questions on course syllabus, course site, attendance and material.

Course Grading  
30% - Class participation: attendance, class discussions, and lab participation  
25% - Midterm Exam I  
25% - Midterm Exam II  
20% - Final research project and presentation
Prerequisites: Life and Physical Sciences A or Life Sciences 1a; Life Sciences 1b; MCB 80 or equivalent Introduction to Neuroscience course (or permission of the instructor).

Suggested Readings: Selected chapters from:
1. Developmental Biology (10th Edition) by Scott Gilbert
(Both books reserved at Harvard Libraries)
Selected Review articles (available on course website)
Selected primary articles (available on course website)

Description:
Why can planarians regenerate their brain and we can’t? Is an immutable brain the price to pay to be human? This course will cover concepts and theories on the evolutionary changes in the capacities by different organisms to regenerate their nervous system. Material will be taught in a dynamic setting that combines lectures and brainstorming of the literature with hands-on experience in the laboratory. Students will become familiar with classic, paradigm-changing experiments that have shaped the way we think about brain regeneration and repair and also consider the newest theories on cellular reprogramming as a way to regenerate the nervous system. Material covered in class will be used as a starting point to consider, contrast and evaluate how regenerative capacities have changed during evolution and to brainstorm paths forward towards new solutions for brain regeneration in species, like humans, that have not mastered this art. Emphasis will be placed on allowing students to creatively think about key scientific questions and to “feel” the excitement of scientific discovery in this fast changing field.

Date | Topic
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Wed 8/31: | Making a new brain? The “raise and fall” of dogmas about brain regeneration.
 | Introductory lecture
Mon 9/5: | Labor Day (NO CLASS)
Wed 9/7: | Craziness in biology. The evolution of extreme regenerative strategies for survival.
 | Lecture: We will cover and discuss informative strategies used by different organisms to regenerate tissues and organs and consider their trade-offs for organ function and survival of the organism.
 | Suggested Readings:


Mon 9/12:

From stem cells to tissues and back again: Reprogramming strategies to make new neurons.

Lecture: We will consider the capacity of different cell types to reprogram their identity and make new neurons.

Suggested Readings:


Wed 9/14

Guest Lecture: Evolution of regeneration in invertebrates.

Prof. Mansi Srivastava (Harvard University)

Suggested Readings:


Mon 9/19

**Regenerative landscape through evolution.**

*Lecture:* We will discuss the “mystery” of why different species have distinct regenerative responses. Not just a matter of complexity.

*Brainstorming:* This class will entail a brainstorming session to collectively consider aspects of nervous system regeneration and why some species can regenerate while others can’t.

*Suggested Readings:*


Wed 9/21

**Tissue regeneration in planaria: can “memory” be regenerated?**

*Brainstorming:* This class will entail a brainstorming session to collectively consider aspects of nervous system regeneration in planaria and the ability to perhaps regenerate previously encoded “memories”.

*Lecture:* Development and evolution of the vertebrate brain Part 1. We will cover the main events and some of the mechanisms that shape the development of progressively more complex nervous systems.

*Suggested Readings:*


Mon 9/26

**Laboratory Ia: Regeneration in invertebrates.**

*Laboratory:* In this hands-on laboratory class, students will have an opportunity to run their own experiments designed to test the regenerative capacities of regenerative, invertebrate model organisms.
 Wed 9/28: Development and evolution of the vertebrate brain. Part 2. Lecture: We will cover the main events and some of the mechanisms that shape the development of progressively more complex nervous systems.

Suggested Readings:


Mon 10/3: Neurogenesis and axon growth. Lecture: we will cover key experiments that shed light on the capacity that organisms have to make new neurons and to wire into new circuits in response to stimuli like injury.

Suggested Readings:


Wed 10/5: Rewiring the brain. Is it even possible? Brainstorming: this class will be dedicated to brainstorming ideas on ways to change brain wiring and/or affect the birth of new neurons in adult organisms. 45 minutes will be dedicated to review and practice exam material.
Mon 10/10  Columbus Day (NO CLASS)

Wed 10/12  Midterm Exam I

Mon 10/17  Laboratory Ib (analysis): Regeneration in invertebrates. We will analyze the results of experiments performed in laboratory Ia. This will include (but is not limited to) imaging and analysis of the results, troubleshooting of experimental design, and use of data to model the process of regeneration.

Wed 10/19  Brain regeneration in vertebrates: a tale of salamanders and mice. 
Lecture: we will cover concepts of nervous system regeneration in vertebrates endowed with prominent capacities to regenerate multiple organs (i.e. axolotls).

Suggested Readings:


Mon 10/24  Laboratory IIA: Regeneration in vertebrates
Laboratory: In this hands-on laboratory class, students will have an opportunity to run their own experiments to test the regenerative capacities of vertebrates, using salamanders (axolotls) and mice as model systems.

Wed 10/26  Plasticity of neurons and circuits as a form of functional repair.
Lecture: We will consider and contrast the capacity of young and adult brains to change local circuit and synapses and evaluate this in the context of functional brain repair.

Suggested Readings:

Mon 10/31

**Brain machine interfaces: plasticity at work**

*Lecture:* We will consider the capacity of the brain to move mechanical devices and the underlying cellular and circuit level mechanisms.

*Brainstorming:* This class will include a 45 minutes brainstorming component to allow students and instructors to consider application of these methods to brain repair.

*Suggested Readings:*


Wed 11/2

**Human neurodegenerative and neuropsychiatric disease: what happens to the brain and why can’t we fix it?**

*Lecture:* We will cover molecular, cellular and structural changes associated with prominent human neurodegenerative and psychiatric diseases and brainstorm potential solutions to regain brain function.

*Suggested Readings:*


Mon 11/7

**Guest Lecture: Professor Steven McCarroll**

**Suggested Readings:**


Wed 11/9

**Making a new brain in the dish: Stem cell-derived cerebral organoids.**

**Lecture:** We will explore the latest technologies and experimental approaches used to generate complex brain tissue from pluripotent stem cells and application to understand human development, regeneration and disease in the dish.

**Suggested Readings:**


Mon 11/14:

**Brainstorming of all materials covered: review and practice exam material.**

Wed 11/16

**Midterm Exam II**
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| Mon 11/21  | Laboratory IIb (analysis): Regeneration in vertebrates  
We will analyze the results of experiments performed in laboratory IIa. This will include analysis of the data, examination of distinct regenerative outcomes, brainstorming of underlying mechanisms and of implications for brain function. |
| Wed 11/23  | Thanksgiving Holiday (NO CLASS)            |
| Mon 11/28  | Final Assignment                            
Students will work in small groups to conceive present a research project that addresses questions related to brain regeneration. |
| Wed 11/30: | Final Assignment                            
Students will work in small groups to conceive present a research project that addresses questions related to brain regeneration. |