I. Bulletin description

PSYC G4498. Behavioral Epigenetics (seminar).
4 pts. Mondays 2:10 – 4 PM in 405 Schermerhorn Hall
Prerequisites: Basic background in neurobiology (for instance PSYC 1010, 2450, 2460, 2480, and G4499) and the instructor’s permission.

This course will provide an overview of the field of epigenetics, with an emphasis on epigenetic phenomena related to neurodevelopment, behavior and mental disorders. We will explore how epigenetic mechanisms can be mediators of environmental exposures and, as such, contribute to psychopathology throughout the life course. We will also discuss the implications of behavioral epigenetic research for the development of substantially novel pharmacotherapeutic approaches and preventive measures in psychiatry.

II. Full course description:

Epigenetics is the study of changes in gene expression and cellular phenotype through mechanisms that do not involve changes in DNA sequence. During development, epigenetic mechanisms are essential for the establishment of cell-specific gene expression patterns and cellular differentiation. In addition, epigenetic marks are responsive to environmental cues throughout the lifespan of an individual, and can be stably maintained leading to long-lasting effects of the environment on gene expression. In this course, we will explore the role of epigenetic mechanisms in regulating brain gene expression, brain development and the adult brain function. We will particularly focus on the neuronal epigenome as a biological substrate through which environmental exposures can contribute to the development of behavioral and cognitive disorders.

In the first part of the course, we will explore the major epigenetic mechanisms of gene regulation and the research tools that are used to study epigenetic modifications in different model systems, including humans. Following this introduction, we will discuss the most sensitive periods during which the epigenome can be disrupted by environmental factors, including prenatal and early-life development. We will further consider the role of epigenetic mechanisms in the dynamic regulation of the adult brain function, as well as epigenetic dysregulation that may underlie various psychiatric...
disorders. In addition, one session will be focused on exploring epigenetic phenomena as mediators of sex differences in brain structure, brain function and the risk for developing certain mental disorders. Finally, we will discuss one of the most controversial topics in current biology: the hypothesis that environmentally-induced epigenetic modifications can be heritable, contributing to disease susceptibility of multiple generations.

The topics of the course will be introduced through overview lectures given by the instructor. A total of four sessions (two in the midterm and two at the end of the course) will be devoted to student journal presentations and class discussions on the previously covered topics.

III. Rationale for giving the course:

This course is designed to familiarize the students with basic and more advanced concepts of an emerging and rapidly evolving field of behavioral epigenetics. Epigenetic research has recently been incorporated in the major neuroscience-related areas, such as studies of neurodevelopment, animal models of behavioral and psychiatric disorders, studies on learning and memory, neuroendocrinology, psychopharmacology, and psychiatric epidemiology. The first part of the course will cover basic epigenetic mechanisms of gene regulation and epigenetic techniques, and will prepare students for more specific topics as well as enable them to critically evaluate epigenetic literature. The second part of the course will provide a synthesis on the role of epigenetic mechanisms in regulating normal brain function and their contribution to the development of psychopathology. The readings will consist of the most up-to-date review articles written by the leaders in the field. Throughout the course, we will explore the landmark studies that paved the way for the establishment of the field. The course will also emphasize possible implications of behavioral epigenetic research for the development of novel pharmacological interventions, diagnostic procedures, and preventive measures in psychiatry.

While the main goal of the course is to provide overview of all relevant topics in behavioral epigenetics, the students will be urged to further explore their specific area of interest by choosing a topic and type of article for presentation and essay writing. Student presentations and discussions will be aimed to foster critical evaluation of primary research literature. Students will also be required to write a term paper in the form of a review article, for which they will be asked to summarize the current state of knowledge and research on a particular topic.

Overall, this course is designed to provide a foundation for the advanced study in behavioral epigenetics, behavioral neuroscience, neuroendocrinology, neuropsychopharmacology, and related research areas, as well as to provide an introduction to the field of behavioral and psychiatric epigenetics for students interested in clinical psychology and psychiatry.

The Psychology Program Goals that will be advanced in this seminar (see http://www.columbia.edu/cu/psychology/dept/ugrad/goals.html) include 1. Knowledge
preliminary syllabus


PSYC G4498 is an advanced seminar, designed particularly for graduate students, for advanced undergraduates who are majoring in Psychology or in Neuroscience and Behavior, and for students participating in the Psychology Postbac Certificate Program. These students will have priority in registration, followed by junior majors followed by non-majors.

The seminar will be well suited to students who have completed two or more lecture courses beyond W1001, such as W1010 (Mind, Brain, and Behavior), W2215 (Cognition and the Brain), W2450 (Behavioral Neuroscience), W2460 (Drugs and Behavior), or W2480 (Developing Brain). It will help ameliorate a serious shortage of advanced seminars giving students opportunities to develop their oral and written presentation skills.

It fulfills the following degree requirements:

- For Psychology Graduate Students, PSYC G4498 will apply toward the “two seriously graded seminars” requirement of the Master’s degree.

- For the Psychology major or concentration in the College and in G. S., for the Psychology minor in Engineering, and for the Psychology Postbac Certificate, G4498 meets the Group II (Psychobiology and Neuroscience) distribution requirement.

- For the Neuroscience and Behavior joint major, G4498 will fulfill the 5th Psychology requirement: “one advanced psychology seminar from a list approved by the Psychology Department advisor to the program.”

- For non-majors in the College and GS, G4498 – by virtue of its numbering in the 4400's--will count as one term of the natural science requirement, provided that students obtain the necessary permission and have taken the prerequisite psychology courses. Graduate students, and students who are majoring in Psychology or in Neuroscience and Behavior, and postbac certificate students will have priority over students who are taking the course for the science requirement. For this reason, as well as because of the course prerequisites, we anticipate the course will rarely be used for the science requirement.

- For the Psychology Postbac certificate, PSYC G4498 will fulfill the advanced seminar requirement.

- For the Barnard Psychology major, PSYC G4498 will fulfill the senior seminar requirement.
IV. Weekly outline of topics and readings [subject to revision]:

**Week 1**  
**Course introduction**  
- discussion of topics and course requirements;  
- Behavioral epigenetics – introduction

READINGS:  

**Week 2**  
**An overview of epigenetic mechanisms of gene regulation**  
- DNA methylation, histone modifications, chromatin remodeling, histone variants, non-coding RNAs;

READINGS:  

**Week 3**  
**Epigenetic techniques in neuroscience**  
- Molecular techniques and animal models used in the studies of epigenetic phenomena.

READINGS:  
Week 4  
**Fetal origins of the adult disease and psychopathology: the role of epigenomic disruption**  
- Epigenetic reprogramming during development; epigenetic and behavioral consequences of prenatal toxicological exposures, maternal stress and diet.

**READINGS:**


Week 5  
**Early life experiences, epigenetic changes and the adult behavior**  
- epigenetic marks as mediators of the long-lasting effects of early life experiences (maternal care, early abuse and maltreatment) on the adult behavioral phenotype.

**READINGS:**


Week 6  
**Journal article presentations/review session**  
-3 students will critically evaluate a research article on a selected topic covered in weeks 2-5; every presentation will be followed by class discussion.

Week 7  
**Journal article presentations/review session**  
-3 students will critically evaluate a research article on a selected topic covered in weeks 2-5; every presentation will be followed by class discussion.

Week 8  
**Epigenetic mechanisms in learning and memory**
- the role of DNA methylation and histone modifications in neuronal activity-dependent gene regulation, synaptic plasticity, learning and memory.

READINGS:


**Week 9**

**Epigenetic changes and molecular targets in psychiatric disorders**
- epigenetic dysregulation in schizophrenia, depression, drug dependence and other psychiatric disorders: implications for epigenetic therapy in psychiatry.

READINGS:


**Week 10**

**Epigenetics and brain sex differences**
- the role of epigenetics in the establishment of sexual dimorphism in brain structure and function, sex-specific responses to environmental cues, and sex-biased development of mental disorders.

READINGS:


**Week 11**

**Transgenerational epigenetic inheritance: what an epigenome remembers?**
- experimental evidence for transgenerational inheritance of epigenetic modifications; possible mechanisms; implications for multigenerational transmission of psychopathology.

**READINGS:**


**Week 12**

**Journal article presentations/review session**
-3 students will critically evaluate a research article on a selected topic covered in weeks 8-11; every presentation will be followed by class discussion.

**Week 13**

**Journal article presentations/review session**
-3 students will critically evaluate a research article on a selected topic covered in weeks 8-11; every presentation will be followed by class discussion.

**V. Course requirements and grading [subject to revision]:**

**Oral Presentation and Essay:**
Students will be expected to give a presentation and write a paper on a single subject chosen from a list of topics covered in the class. Four separate sessions will be devoted to student presentations (3 presentations/session), in which each student will be given 30 minutes to present followed by 5-10 min for questions and discussion. Presentations should focus on one to two recently published research articles of special relevance to student’s area of interest. The presentations should include: introduction to the research area, discussion of methods, results and conclusions of each paper, as well as future directions. Students not presenting will be expected to read the papers before coming to

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the class and to participate in discussions following presentations. Throughout the course, students will also be expected to participate in class discussions that will follow the overview lectures given by the instructor. The 10-page term paper will be due at the end of the course, and should be written in the style of a review article that summarizes the current state of knowledge and research in the student's area of interest.

**Course grades** will be based on: class attendance and participation (30%), oral presentation (30%), and the term paper (40%).