

## SYLLABUS: BIOPHRM 5555 EPIGENETICS

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Office Hours: By appointment

**Credits:** 3

**Description:** This course will provide an in depth understanding of the molecular mechanisms underlying epigenetic inheritance, which is the inheritance of traits not encoded in the sequence of a genome. In addition, the course will provide students an opportunity to demonstrate command of the subject matter through a presentation from the current scientific literature.

**Prerequisites:** The course is open to graduate students in the Biomedical Sciences Graduate Program, the Ohio State Biochemistry Program, the Molecular, Cellular and Developmental Biology Program, the Neuroscience Graduate Program, the Biophysics Graduate Program, the Microbiology Graduate program, the Molecular Genetics Graduate Program and other programs with permission of the instructor. The course is open to senior undergraduates in a biological or chemical science major. Undergraduates should have taken MOLGEN 4606 or Biochemistry 5613, 5614 and 5615 or permission of the instructor.

**Grading:** The grade for this course will be based on 2 exams, participation in paper discussions and a student presentation. Each exam will contribute 35% to the final grade (70% total), participation in paper discussions will contribute 10% and the student presentation will contribute 20%. Final grades will be based on the percentage of total points received: 100% - 93%=A, 92%-90%=A-, 89%-87%=B+, 86%-83%=B, 82%-80%=B-, 70%-77%=C+, 76&-73%=C, 72%-70%=C-, 69%-67%=D+, 66%-63%=D, 62%-60%=D-.

### Learning Objectives:

Successful students will be able to:

1. Chromatin structure
  - a. Define the phenomenon of epigenetic inheritance.
  - b. Describe the necessity for condensing eukaryotic genomes.
  - c. Define the primary structural components of chromatin.
  - d. Describe the structure of the nucleosome.
  - e. Define the higher levels of chromatin structure.
  - f. Describe the fundamental characteristics of euchromatin.
  - g. Describe the fundamental characteristics of heterochromatin.
  
2. Regulation of chromatin structure
  - a. Describe the physical effect of acetylation on histone proteins.
  - b. Describe potential mechanisms by which acetylation regulates chromatin structure.
  - c. List the enzymes responsible for the acetylation of histones.

- d. Describe the basic properties of the families of histone acetyltransferases.
- e. Describe the important complexes that contain histone acetyltransferase activity.
- f. List the major histone deacetylases.
- f. Describe the properties of the major histone deacetylases.
- g. Describe mechanisms for the interplay between histone acetylation and deacetylation in the regulation of transcription.
- h. Describe the levels of methylation found on lysine residues.
- i. Describe the levels of methylation on arginine residues.
- j. List the enzymes responsible for the methylation of histones.
- k. Describe the basic properties of the families of histone methyltransferases.
- l. Describe the important complexes that contain histone methyltransferase activity.
- m. List the major histone demethylases.
- n. Describe the properties of the major histone demethylases.
- o. Describe mechanisms for the interplay between histone methylation and demethylation in the regulation of transcription.
- p. Describe the other major types of histone modification.
- q. Describe the complexity of interactions between different histone modifications.
- r. Define ATP-dependent chromatin remodeling.
- s. List the major classes of chromatin remodelers.
- t. Describe the mechanisms by which chromatin remodelers modulate chromatin structure.
- u. Define the mechanisms of interplay between chromatin remodelers and histone modifications.
- v. Define histone reader proteins.
- w. Define mechanisms of action for the major histone reader domains/proteins.
- x. Describe how DNA replication functions in a chromatin environment.
- y. Describe how DNA replication influences epigenetic inheritance.
- z. Describe how DNA damage is repaired in a chromatin environment.

### 3. DNA Methylation

- a. Define DNA methylation and DNA hydroxymethylation.
- b. Describe the distribution of DNA methylation throughout the genome.
- c. Describe the enzymes responsible for DNA methylation (DNMTs).
- d. Describe the mechanisms regulating the activity of DNMTs.
- e. Define the mechanisms of DNA methylation erasure.
- f. Describe the enzymes involved in removing DNA methylation.
- g. Describe the mechanisms involved in X-chromosome inactivation.
- h. Define imprinting
- i. Describe how DNA methylation controls imprinting.

4. Epigenetics and human disease
  - a. Explain how metabolism influences chromatin structure and epigenetic inheritance.
  - b. Describe how mis-regulation of chromatin structure leads to cancer.
  - c. Define oncohistone mutations.
  - d. Explain how chromatin structure influences neurodevelopmental and neurodegenerative disorders.
  - e. Describe the evidence linking epigenetics to the aging process.

### **Class Schedule**

<b><u>Class</u></b>	<b><u>Topic</u></b>
1	Introduction: What is epigenetics?
2	Chromatin Structure 1
3	Chromatin Structure 2
4	Chromatin as Regulator
5	Histone Acetylation/Acylation 1
6	Histone Acetylation/Acylation 2
7	Histone Acetylation/Acylation 3
8	Histone Methylation 1
9	Histone Methylation 2
10	Other histone modifications
11	ATP-Dependent Chromatin Remodelers
12	Review
13	Exam 1
14	Paper Discussion
15	Histone Chaperones
16	DNA Methylation 1
17	Paper Discussion
18	DNA Methylation 2
19	Chromatin and Transcriptional Activation
20	Paper Discussion
21	Heterochromatin 1
22	Heterochromatin 2
23	Paper Discussion
24	Chromatin, Epigenetics and DNA Replication
25	Chromatin and DNA Damage Repair
26	Paper Discussion
27	Long-Range Interactions and Genome Architecture
28	Chromatin Through the Cell Cycle
29	Paper Discussion
30	Epigenetics and Nuclear Condensates
31	Epigenetics and Disease
32	Paper Discussion/Review
33	Exam 2

## CLASS POLICIES

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**Exam Makeups Policy:** If you are too ill to take an exam or must miss for another legitimate reason (the funeral of a family member, for example), you must contact the instructor, within 24 hours of the exam. Make up exams will be given only to students who produce, at the make up or before, documentation of a legitimate reason (at the time of the absence) for missing a quiz or exam. Medical excuses will be considered only if you have been treated by a medical professional on the day of the exam (excuses from the student health center website will not be accepted). The exam must be made up within one week of when it was given.

If you anticipate having to miss an exam due to attendance at a university sanctioned event or other qualifying conflict, you must contact the instructor at least one week in advance of the exam and supply written documentation signed by an appropriate official. Valid excuses are limited to problems that are beyond the student's control, such as military duty, intercollegiate athletic or academic activities, funerals, etc. Written documentation of these activities must be provided.

Students arriving late to an exam may take the exam in the time remaining. Once someone has completed the exam and left the room, however, students arriving late may take the exam in the time remaining but with a 25% penalty. Lack of transportation, loss of electricity, travel plans, etc. are not considered valid excuses. If suitable documentation is presented a make-up exam will be given. The format of makeup exams is at the discretion of the instructor.

## UNIVERSITY POLICIES:

**Accessibility:** The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let the head TA know immediately so options can be privately discussed. To establish reasonable accommodations, we may request that you register with Student Life Disability Services. If you anticipate academic barriers, please make arrangements by the end of the first week to discuss your accommodations. SLDS contact information: [slds@osu.edu](mailto:slds@osu.edu); 614- 292-3307; [slds.osu.edu](http://slds.osu.edu); 098 Baker Hall, 113 W. 12th Avenue.

**Academic Misconduct:** Each student is responsible for completing assignments in his/her own words. It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term “academic misconduct” includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct <http://studentlife.osu.edu/csc/>.

**Diversity and Inclusion:** The College of Medicine promotes a welcoming and inclusive environment for all students and staff, regardless of race, age, religion, gender, ethnicity, national origin, disability, or sexual orientation. There is no tolerance for hateful speech or actions. All violations of this policy should be reported to the OSU Bias Assessment and Response Team (BART, [www.studentaffairs.osu.edu/bias](http://www.studentaffairs.osu.edu/bias)).

**Sexual Harassment (and Relationship Violence):** Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at <http://titleix.osu.edu> or by contacting the Ohio State Title IX Coordinator, Kellie Brennan, at [titleix@osu.edu](mailto:titleix@osu.edu).

**Lyft Ride Smart:** Lyft Ride Smart at Ohio State offers eligible students discounted rides, inside the university-designated service area, from 9 p.m. to 3 a.m. Each month, 10,000 discounted rides will be made available on a first-come, first-served basis with the average cost expected to be \$2 or less. Once the monthly allotment of 10,000 discounted rides is exhausted, Lyft’s normal service rates will apply for the remainder of the month. Prices may be impacted by distance, traffic, time of day, special events and prime time surcharges. To qualify for program discounts, users must select "shared ride" when booking in the Lyft app. For more information, visit: <https://ttm.osu.edu/ride-smart>.