Spring 2024 MBS Mini Courses

BLOCK 1

The following courses will take place between January 16 - February 12, 2024.
*MBS First Year PhD Students: Please select 2 from this block.

Block 1 - January 16 - February 12, 2024
16:695:621; #13061

Title: Ubiquitin-Proteasome System
Instructor(s): Kiran Madura
Schedule: M/W - 9 to 10:30 a.m.
Building: RWJMS - V12

Description: The ubiquitin/proteasome system (UPS) is one of the most conserved mechanisms in eukaryotic evolution. The UPS is a proteolytic system that promotes the degradation of regulatory and damaged proteins, and the biochemical mechanism is very well understood. A Nobel Prize was awarded in 2004, just 20 years after the initial discovery of this mechanism. Notwithstanding this award, many aspects of this pathway are poorly understood. This mini-series of lectures will discuss i), the seminal studies that led to our mechanistic understanding of the UPS, ii), topics that continue to be actively investigated iii), the implication of protein turnover in human diseases, and iv) non-proteolytic roles for ubiquitin and ubiquitin-like systems. This course will introduce you to novel experimental approaches, model systems, and a general appreciation for the intersection of the UPS in diverse biological systems.

Structure: Dr. Madura will present all the lectures. Publications (1-2) pertinent to each lecture and a PowerPoint slide deck will be provided. Students should review the studies and paper(s) before each lecture and be prepared to engage in active discussions.

Outcome: Two key concepts will be understood. First, the conjugation of ubiquitin to other proteins typically marks them for degradation. This process is highly conserved, but also remarkably versatile, permitting different biochemical and cellular effects. Second, the protein ubiquitination step is temporally and spatially separated from degradation by the proteasome. By understanding these biochemical events you will be able to appreciate how a limited number of targeting factors can promote the targeted degradation of thousands of proteins with exquisite specificity.

Grading: Attendance at all lectures is mandatory, and participation in discussion is expected. A take-home final exam will be issued during the last lecture period.

Block 1 - January 16 - February 12, 2024
16:695:622; #13062

Title: CRISPR Gene Editing and its Applications in Gene and Cell Therapy
Instructor(s): Victor Shengkan Jin
Schedule: M/W - 12 to 1:30 p.m.
Building: RWJMS - V12

Description: CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) gene editing technology has revolutionized many biomedical research fields. The one-month, 8-session mini-course will cover the most important gene editing approaches by CRISPR technology and provide example applications of each gene editing modality. Students will get oriented in this exciting but highly complexed field, learn the CRISPR methodologies currently used in the literature, become familiar with the various CRISPR approaches and tools, and learn to choose the right CRISPR gene editing tools for their research.

Structure: The course director will give an overview lecture on CRISPR biology and CRISPR technologies in the first session. 7 “classic” research articles in CRISPR technology field will be assigned by the course director to students. These research articles will be presented and discussed in the following sessions. At the end of the course, there is a take-home exam to help students learn the take-home messages of the course. The take-home exam includes two to three questions on choosing the correct genome editing platform technology for gene therapy for different genetic diseases.

Outcome: Through the lecture, group learning, and take-home exam, the students are expected to understand, learn, and use the various gene editing strategies of CRISPR technology.

Grading: Grading components: 1. Presentation of the assigned research article (40%); 2. Participation of discussion (30%); 3. Take-home exam (30%).

Block 1 - January 16 - February 12, 2024
16:695:624; #13064

Title: Models of Human Cancer
Instructor(s): David Axelrod
Schedule: M/W - 2 to 3:30 p.m.
Building: ZOOM

Description: Model systems have provided information about aspects of human cancer not available directly from humans. Models include viruses, bacteria, yeast, cell lines, organoids, worms, flies, fish, mice, microfluidic systems, mathematical, and computational models, etc. The information includes molecular and cellular aspects about tumor initiation, progression, evolution, invasion, metastasis, prevention, and therapy. The instructor will introduce unmet challenges of human cancer, and a survey of model systems, with references to published review articles. Each student will select any model system that has been used to illuminate a cancer problem. Each student will make a presentation reviewing experimental articles about the selected model system, lead a discussion, and write a two-page letter of intent arguing for the use of their selected model system to illuminate a particular cancer problem.

Grading: Grades will be based upon each student's presentation (40%), participation in discussion of other students' presentations (10%), and each student's two-page letter of intent (40%).
Title: Approaches in Gene Therapy
Instructor(s): Honghua Li
Schedule: T/H - 2 to 3:30 p.m.
Building: RWJMS - V12

Description: Gene therapy is a fast-growing field in biomedicine with major impact on treatment of many diseases that are not limited to genetic disorders. The proposed course covers the major concept (one hour), approaches (four hours) and clinical applications (two hours) with emphasis on approaches. The course completes with a brief summary and an essay exam (one hour).

Structure: A combination of reputable review articles and primary literature will be used as reference handout. Students are required to read the assigned handout for each class. One student will give a brief presentation to the class followed by comments of all other students. The amount of time for each student will be allocated based on the number of students. Instructor will give a summary of the class and provide important supplementary information that is not covered by the reference and class discussion to conclude the class.

Outcome: The class will expose students to the major aspects of the fast advancing field of gene therapy which will become one of the powerful tools in clinical practice and involves both basic research and clinical practice. Knowledge and training in gene therapy may let students gain advantage and become a great option in their career development. In addition, gene therapy can be used as a powerful tool in research and many other applications in biomedicine, for example, combatting deadly viruses including COVID-19.

Grading: Three aspects will be taken into consideration to determine the grades: 1. quality of presentation, 35%; (2) participation of class activities, 25% and (3) essay, 40%.

BLOCK 2

The following courses will take place between February 19 - March 22, 2024.
*MBS First Year PhD Students: Please select 2 from this block.

Block 2 - February 19 - March 22, 2024
16:695:626; #13065

Title: Cancer Epigenetics
Instructor(s): Jian Cao
Schedule: M/W - 9 to 10:30 a.m.
Building: RWJMS - V12

Description: Epigenetic mechanisms play a crucial role in cancer development, encompassing DNA methylation, histone post-translational modifications, and regulation of chromatin structure. Recent research indicates that tumors often exploit these epigenetic mechanisms to facilitate tumor initiation, progression, metastasis, and resistance to treatment. Consequently, the pharmaceutical modulation of epigenetic regulators, such as 'writers', 'readers', 'erasers', and 'remodelers', holds great promise in restoring a normalized epigenetic landscape and treating tumors. In this minicourse, we will delve into a comprehensive exploration of critical epigenetic regulators that contribute to
tumorigenesis. Moreover, we will examine approved epigenetic medicines, as well as those currently under clinical trials, aiming to provide a comprehensive understanding of their potential in cancer treatment. Through this course, we hope to shed light on the latest developments in the field of cancer epigenetics and its potential implications in cancer therapy.

**Structure:** The first session will be an introductory lecture on cancer epigenetics, delivered by the instructor. In the subsequent six sessions (2nd to 7th), the format will be as follows: (1) the instructor will present a 30-minute lecture on a specific topic related to cancer epigenetics; (2) a student will conduct a 45-minute paper presentation on a selected research article; and (3) a 15-minute question and answer session. Students are required to submit questions to the instructor. A list of questions will be distributed to all students in the lead-up to the final week. Each student will select one question from the list. In the final session, students will conduct a brief 5-minute presentation followed by a 5-minute Q&A session dedicated to addressing their chosen question. These questions will be well-defined, requiring students to perform some literature searches without delving too deeply into the readings. Examples of questions and corresponding presentations will be provided during the first lecture.

**Outcome:** This minicourse aims to foster a comprehensive understanding of cancer epigenetics by combining instructor-led lectures, student-led paper presentations, and engaging Q&A sessions. It also provides an opportunity for students to deepen their knowledge and presentation skills through their individual research and presentations on specific topics.

**Grading:** Grading will be based on attendance, student presentation (journal club), question submission, student presentation (question addressing in the last class), and active engagement in discussions.

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**Block 2 - February 19 - March 22, 2024**

16:695:627; #13066

**Title:** The AI-Driven Revolution in Protein Structural Biology

**Instructor(s):** Sagar Khare and Vikas Nanda

**Schedule:** M/W - 2 to 3:30 p.m.

**Building:** RWJMS - V12

**Description:** Explore the cutting-edge intersection of artificial intelligence (AI) and structural biology in this minicourse. As machine learning continues to advance at an unprecedented pace, the fields of biology and computational science are converging to revolutionize our understanding of the molecular basis of life. In this course, we will explore cutting-edge powerful AI-driven tools to predict complex protein structures, interactions and more. The class will combine lectures, hands-on exercises, and real-world case studies. You will learn the power and limitations of current methods, and how they could be used to advance your research.

**Structure:** The course will be a mixture of formal lectures, guided practical exercises and a personal project to be presented at the end of the course.

**Outcome:** The students that successfully complete the course will be able to use the state of the art tools in AI-assisted protein structure prediction and design, to inform hypotheses in their research, validate predictions, plan experiments, and understand the extended uses and limitations of these tools in their field.

**Grading:** Students are expected to attend all classes and actively participate in discussions and hands-on activities (25%). During the course, the students will identify a protein modeling question and solve it using the tools examined in class. At the end of the course, they will submit a research report describing the question, rationale for
experimental design, and present an analysis and interpretation of results in a biological context (75%).

Block 2 - February 19 - March 22, 2024
16:695:628; #13067

Title: Integrated Stress Response - a paradigm for translational control
Instructor(s): Tracy Anthony and Paul Copeland
Schedule: M/W - 12 to 1:30 p.m.
Building: RWJMS - V12

Description: (taken in part from Costa-Mattioli and Walter, 2020): The integrated stress response (ISR) is an intracellular signaling program that is required for an organism to adapt to a variable environment and maintain health. In response to a variety of environmental and pathological conditions, including protein homeostasis (proteostasis) defects, nutrient deprivation, viral infection, and oxidative stress, the ISR restores balance by reprogramming gene expression. The 5 various stresses are sensed by four specialized kinases that converge on phosphorylation of a single serine on the eukaryotic translation initiation factor eIF2 (gene = EIF2S1). eIF2 phosphorylation blocks the action of eIF2’s guanine nucleotide exchange factor termed eIF2B, resulting in a general reduction in protein synthesis. Paradoxically, phosphorylation of eIF2 also triggers the translation of specific mRNAs, including key transcription factors, such as ATF4. As such, the mechanistic underpinnings of this stress response network lie solidly in the world of post-transcriptional gene regulation at the translational level. This course will delve into the mechanism and methodology behind this essential stress response pathway, aberrations in which cause a myriad of diseases.

Grading: Student presentations of a paper will count toward 75% of the grade. The remaining 25% will be in the form of a concise (1-page) written project that requires answering a qualifying exam-type question based on a literature search and identification of lynchpin experiments.

Block 2 - February 19 - March 22, 2024
16:695:629; #13068

Title: Stem Cell Therapy
Instructor(s): Randall McKinnon
Schedule: T/H - 2 to 3:30 p.m.
Building: RWJMS - V12

Description: Stem cells are important source for healthy tissue regeneration. This course will examine the primary literature detailing the identity and function of both pluripotent and tissue specific stem cells. The emphasis will focus on molecular mechanisms of signal transduction processes and their nuclear regulatory factor targets that dictate stem cell identity. Students will also gain skill sets necessary to critically read, evaluate and present scientific data from the biomedical literature.
Block 2 - February 19 - March 22, 2024
16:695:630; #13069

Title: How to make a good egg: A Molecular Perspective
Instructor(s): Karen Schindler and Shuo Xiao
Schedule: T/H - 9 to 10:30 a.m.
Building: RWJMS - V12

Description: Production of high-quality gametes is essential for sexual reproduction. In females this process takes place within the follicle, a supporting structure and functional unit of the ovary. This process is highly error prone, affected by aging exposure to reproductive toxicants and many disease states. Students will learn about the latest technological advances that clinicians use to select quality eggs, developments in contraception and in fertility preservation.

Structure: The course will provide a mixture of lecture, active learning and primary literature discussion.

Outcome: After taking this course, students will have a working knowledge of the ovarian processes involved in generating developmentally competent eggs, understand exposures and disease states that impact egg quality. They will be able to synthesize biomedical findings to communicate the implications of these finds in writing to an audience with broad scientific knowledge.

Grading: Students will be graded on attendance and participation (10%) and production of 2 “News and Views” style writing assignments (90%).

BLOCK 3

The following courses will take place between April 1 - April 26, 2024.
*MBS First Year PhD Students: Please select 2 from this block.

Block 3 - April 1 - April 26, 2024
16:695:631; #13070

Title: Metabolic Vulnerabilities: Liver Disease and Cancer
Instructor(s): Moshmi Bhattacharya and Lauren Poole
Schedule: M/W - 9 to 10:30 a.m.
Building: RWJMS - V12

Description: Disruption of metabolic homeostasis plays key roles leading to metabolic disorders. In this course we examine the molecular and physiological basis of human metabolic diseases focusing on the liver. Methodologies leading to scientific discoveries and potential preventive and therapeutic agents will also be discussed. Structure: Introductory lectures and student presentations of publications.

Outcome: At the end of this course students will be able to explain and apply the integrated biochemical pathways that are discussed in lectures as they relate to liver metabolism, in a disease related context. Students will also be
able to apply their knowledge in participatory in-class “Journal Club” type assessments of published papers.

**Grading:** The classes require active participation and will emphasize student-led critical evaluation and discussion of assigned current literature. Final grade will be out of 30 total points: 16 points are based on participation in each of 8 class periods. Participation points for each class period are broken down as follows: 0 points= student absent, 1 point= student present, 2 points= student actively participates in class discussion by answering questions, asking additional questions, or building on discussion topics. The remaining 14 points are based on their presentation. In sessions 3-8, the instructors will assign a current journal article. Two students per class period will individually present a figure of their choice from the assigned publication that they believe “makes or breaks” the publication. The presentation will consist of 1) a 5-minute “elevator pitch” outlining key background information and methods, 2) a 5-minute overview of the results and 3) a 10-minute analysis of the strengths and limitations of the studies in the figure. The two presenting students will also each submit 4 questions, based on the publication, for class discussion.

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**Block 3 - April 1 - April 26, 2024**

16:695:632; #13071

**Title:** Regeneration - all cut up to be

**Instructor(s):** Kiran Chada

**Schedule:** M/W - 2 to 3:30 p.m.

**Building:** RWJMS - V12

**Description:** Regeneration involves the replacement of missing organs, appendages, or large body regions and has always been fascinating at the gross and morphological level. The course will detail the recent tremendous advances that have been made at the cellular and molecular level using highly regenerative model organisms. These studies will identify principles that explain how regeneration can occur so as to provide an understanding into this biological phenomenon. Additionally, these insights have also revealed common molecular pathways that are used in non-regenerating systems.

**Grading:** During each session, 1-2 students will give a presentation of the cellular and molecular basis of the regenerative capacity of a single organism. It is expected that all the students will have read the paper that forms the basis of the presentation and will participate in the discussion after the presentation. Students are expected to attend all classes. The presentation will constitute 50% of the grade, class participation 25% and 25% on a 3-5 page paper on regeneration in mammals.

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**Block 3 - April 1 - April 26, 2024**

16:695:634; #13072

**Title:** Chromosome Chaos Unleashed: Exploring Aneuploidy's Role in Cancer and Disease Dynamics

**Instructor(s):** Cristina Montagna

**Schedule:** M/W - 12 to 1:30 p.m.

**Building:** RWJMS - V12

**Description:** This mini course delves into the molecular complexities of somatic aneuploidy and its relevance to disease. Aneuploidy, characterized by aberrant chromosome numbers, emerges as a quintessential factor in a
spectrum of pathologies, with cancer at the forefront. This focused mini-course immerses participants in a comprehensive exploration of the dysfunction-causing mechanisms, complex consequences—specifically pertaining to cell fitness and transformation into cancer—and potential therapeutic avenues inherent to aneuploidy. As a cornerstone of molecular biosciences, this course not only unveils the molecular complexities governing disease but also cultivates the analytical skills vital for future research endeavors and therapeutic advancements within the field.

**Structure:** The course adheres to a structured approach that emphasizes critical thinking and comprehensive understanding by utilizing peer reviewed literature. Each session centers around a carefully selected scientific paper and a review article, both addressing pertinent topics within aneuploidy research. The session begins with a brief introduction by the instructor to the day’s topic. Within each session, two students will be assigned roles: one to present the introductory review for the day’s topic, and the other to present the research paper. After these presentations, a group discussion will involve all participants. Engaging actively in the discussions, students contribute by sharing insights and participating in conversations related to the session’s content. Outcome: By exploring the intimate connections between aberrant chromosome numbers and disease manifestations, with a particular emphasis on cancer, this course equips students with the nuanced understanding necessary to decode the molecular foundations of complex disorders.

**Grading:** Students will undergo evaluation through two distinct grading methods: Presentation and Assignment Summaries: This method evaluates the students' proficiency in presenting the assigned review or paper and their ability to comprehend, summarize, and effectively communicate the findings from the material. Instructors will assess the clarity, accuracy, and depth of understanding in these presentations and summaries. Participation and Discussion Engagement: The second component assesses students’ active engagement in group discussions and their overall participation during the sessions. Instructors will evaluate the quality of students’ contributions and their involvement in these discussions, which will also contribute to their final evaluation.

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**Block 3 - April 1 - April 26, 2024**
16:695:635; #13073

**Title:** Innate T cells: Development, Function and Disease Relevance

**Instructor(s):** Lisa Denzin, Derek Sant’Angelo and Qi Yang

**Schedule:** T/H - 2 to 3:30 p.m.

**Building:** CHNJ - Room 3209

**Description:** This course will focus on the biology of MAIT and NKT cells, two important subsets of innate T cells. We will first study the antigen processing pathways that provide the unique ligands necessary to activate MAIT and NKT cells. The development and function of MAIT and NKT cells in the immune system will then be dissected. Input from the students will be used to define the last week of the course which will focus on the role of these two cell times in disease and/or the immune response to infection. A prior introductory immunology course would be beneficial but is not required.

**Structure:** Each class will start with a short (>30 min) didactic lecture to introduce the topic and paper followed by paper-based discussion. In general, one paper will be covered in detail each session, although more may be assigned (for example, a recent review on the topic).

**Outcome:** The students will gain an understanding of the development and function of these two innate T cell populations in immune system function with a focus on the roles these powerful subsets of T cells play. The students will gain experience dissecting primary immunological literature with a focus on critical evaluation of the experimental
evidence used to support the novel ideas that have defined the roles of these T cell subsets.

**Grading:** 65% - class participation 10% - literature search for last week 25% - A short paper (2 pages max) describing the role of an innate T cell population in the immune response; due April 29, 2024

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**Block 3 - April 1 - April 26, 2024**
16:695:636; #13074

**Title:** Genome Origami
**Instructor(s):** Kevin Monahan
**Schedule:** T/H - 9 to 10:30 a.m.
**Building:** Nelson Labs - A237

**Description:** If it were to be fully extended, the DNA that makes up a single diploid human genome would be over two meters long, yet our cells fold and package this DNA so that it fits in a micron-scale nucleus. This folding is not random. Instead, DNA is organized into a hierarchy of structures that serve various functions, such as spatially separating the active and inactive regions of the genome and delimiting the sets of genes that are controlled by noncoding regulatory elements. This minicourse will cover the rules and mechanisms of genome folding, and we will then go on to explore the emerging role of these processes in development and disease.

**Structure:** Most sessions will consist of a short introductory lecture followed by a student-led discussion of a research paper. Discussions will be structured like a journal club, with the presenters guiding the class through a critical discussion of the selected paper. All students are expected to actively participate in these discussions. The final two sessions of the course will be organized around student presentations. In consultation with the instructor, each student will select a recent research paper to present to the class. In the final 1-2 sessions, depending on class size, each student will present a 10-minute talk that highlights the key idea or finding from their selected paper. In addition, each student will write a 1-page critique of the paper they selected, which will be due at the final class.

**Outcome:** This course will introduce students to the ideas and key findings from the rapidly advancing field of nuclear organization. Students will learn about the mechanisms that control genome folding and the emerging role of genome folding across diverse fields such as development and cancer. The course will also cover cutting-edge research methods in genomics and imaging.

**Grading:** Students will be graded based upon their group paper discussion (30%), their short presentation (30%), their written critique (30%), and overall participation (10%).