



## Graduate Programs in the Biomedical Sciences

# COURSE CATALOG

Spring 2024 Block III

# Spring 2024 Course Descriptions

## *Block III*

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*Subject to change*

*Rev. Feb 21, 2024*

## **CLRM 5821 – Advanced Epidemiologic Research**

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**COURSE LEADER:**

Illir Agalliu, MD, ScD

**COURSE SCHEDULE:**

February 1 – April 18, 2024

Thursdays, 11:00-12:50

**COURSE DESCRIPTION:**

This course will introduce advanced methods in epidemiology with the primary goal of expanding knowledge of evolving methodological issues for epidemiological studies and causality inference. Topics include efficient study designs (e.g. nested case-controls, case-cohort, case-crossover) in epidemiological studies, causal diagrams and causal inference, propensity score and instrumental variable analysis to address confounding and bias. At the end of the course students will have a better understanding of various epidemiological methods used in clinical and epidemiological studies.

**REQUIRED MATERIALS:**

Rothman KJ, Greenland S, Lash TL. Modern Epidemiology; 3rd Ed. 2008. Lippincott, Williams & Wilkins, Philadelphia, PA; ISBN-10:1451190050, ISBN-13: 9781451190052

**PREREQUISITES:**

Clinical Research Intensive; Epidemiologic Research Methods

**SUITABLE FOR 1ST YEAR STUDENTS:**

No. This is an advanced course.

**STUDENT ASSESSMENT:**

Case Studies, In-Class Discussion, Written Critiques and Final Exam.

**CREDIT HOURS: 2.0**

## **BIOS 7409 – Approaches to Study Neural Circuits in Behaving Animals**

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**COURSE LEADER:**

Anita Autry, PhD | Lucas Sjulson MD, PhD

**COURSE SCHEDULE:**

March 13 – May 1, 2024

Mondays, Wednesdays, 1:30-3:30

**COURSE DESCRIPTION:**

This course will introduce students to techniques for in vivo recording of neural activity and approaches to define connectivity and expression profiling of neurons. Emphasis on techniques, instrumentation, and data analysis (demos for analysis). We will introduce the basics of measurement and instrumentation for in vivo physiology, in vivo calcium imaging, and introduce methods for manipulation, anatomy, and expression profiling of neurons. A key motivation in going over the techniques will be to compare methods for recording and manipulation (i.e. physiology versus imaging, optogenetics versus chemogenetics) in terms both of the mechanisms at the level of individual neurons and how that manipulation will impact resulting data and interpretation of behavioral/activity outcomes. Course meetings will be lectures to go over the basic information as well as hands on demonstrations with equipment and example data analysis. Students will be evaluated based class participation and on a final presentation (around 15 minutes) of recent advances in the application or analysis of one of the techniques discussed in class.

**COURSE OBJECTIVES:**

- understand principles of measurement and analysis
- understand the advantages and limitation of specific approaches for neural recordings
- get hands-on experience handling data sets from in vivo recording experiments
- understand the advantages and limitations of methods for manipulating neurons
- become versed in visualizing and interpreting data from neural recording and neural manipulation experiments

**PREREQUISITES:**

None

**REQUIRED MATERIALS:**

If students would like to follow along with data analysis demonstrations, a computer and free software (TBA) will be required. Demos will also be shown on a screen.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes. Priority enrollment is given to grad students, but postdocs and other are welcome if the max enrollment has not been reached.

**STUDENT ASSESSMENT:**

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

Students will be assessed based on in-class participation and a final presentation (75% participation; 25% final presentation). Participation will be assessed by daily or weekly reflections on Canvas, that will include short summaries of the main points covered in that week, and assessment of lab notebook.

### **COURSE ATTENDANCE POLICY:**

No more than one unexcused absence will be allowed. All absences (excused or otherwise) must be “made-up” by completing the requisite work completed in class.

**CREDIT HOURS:** 2.0

## **CLRM 5861 – Design and Analysis of Longitudinal Data Studies**

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**COURSE LEADER:**

Shankar Viswanathan, DrPH

**COURSE SCHEDULE:**

February 6 – April 16, 2024

Tuesdays, 11:00-12:50

**COURSE DESCRIPTION:**

This course consists of 14 lectures/labs which will be taught in two 7-week modules. The first module will cover logistic regression and the second module will cover survival analysis. Each module has a required textbook and will have weekly reading and graded homework assignments and a take-home exam.

**COURSE OBJECTIVES:**

- To learn the basics and applications of logistic regression in assessing associations between exposure/explanatory variables and a dichotomous outcome variable.
- To learn fundamental methods in analyzing time to event data using survival analysis, especially Cox proportional hazards modeling.
- Use STATA software to conduct both logistic regression and survival analysis and to be able to interpret the statistical output related to these modeling techniques.

**PREREQUISITES:**

N/A

**RECOMMENDED MATERIALS:**

- For Module One: Applied Logistic Regression by David W. Hosmer & Stanley Lemeshow (2nd edition), 2000, Wiley; ISBN-13: 978-0471356325
- For Module Two: Survival Analysis: A Self-learning Text by David Kleinbaum and Mitchel Klein (3rd edition) Springer; ISBN: 978-1-4419-6645-2 (Print) 978-1-4419-6646-9 (Online) NOTE: this textbook is available via the Einstein library.

**SUITABLE FOR 1<sup>ST</sup> YEAR STUDENTS:**

No.

**STUDENT ASSESSMENT:**

A final grade of pass/fail for Biostatistics III will be assigned based on both modules: Class Participation 10%; Homework 30%; Module one exam 30% and Module two exam 30%

**CREDIT HOURS: 2.0**

## **CLR 5000 – Design and Conduct of Clinical Research**

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**COURSE LEADER:**

H. Dean Hosgood, PhD | Patricia Friedman, MS | Nadia Laniado, DDS, MPH, MS

**COURSE SCHEDULE:**

March 13 – May 15, 2024

Wednesdays, 5:30-8:30

**COURSE DESCRIPTION:**

This seminar course aims to introduce students to clinical research with a focus on epidemiology and study design. The course uses an introductory clinical research text, along with a critical assessment of papers from the scientific (clinical and epidemiologic) literature, in order to learn about study designs: their strengths and weaknesses and how such studies are conducted. Topics to be covered include basic epidemiology, measures of association, basic statistics, cohort studies, case control studies, clinical trials, causal inference, and research ethics.

**PREREQUISITES:**

Interest in and some familiarity with clinical research preferred.

**REQUIRED MATERIALS:**

Designing Clinical Research, Hulley SB, Cummings SR, Browner WS, Grady DG, Newman TB., 4th Ed. Lippincott Williams & Wilkins; Philadelphia: 2013. ISBN-10: 1608318044 | ISBN-13: 978-1608318049

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes

**STUDENT ASSESSMENTS:**

Class participation, in class problem sets and final presentation.

**CREDIT HOURS: 2.0**

## **BIOS 7002 – Human Metabolism: Regulation and Disease**

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**COURSE LEADER:**

Maureen Charron, PhD

**COURSE SCHEDULE:**

March 12 – June 18, 2024

Tuesdays, Thursdays; Lectures 3:20-4:10, Discussions, 3:20-4:45

**COURSE DESCRIPTION:**

The course combines lecture, self-study and weekly small group student-led discussions of contemporary literature relevant to the lecture topics.

The course is both an extension of Biochemistry taught during Block I as well as an opportunity for students to develop a more cohesive view of the nature and regulation of human metabolism. The course will cover key areas in metabolism and will highlight relationships to clinically relevant topics and the integration and regulation of carbohydrate, lipid, amino acid and nucleic acid metabolism.

**COURSE OBJECTIVES:**

The goal of Human Metabolism: Regulation and Disease is to provide students with an understanding of the principles of the interrelated pathways of human metabolism and the ability to apply those principles to discussion of the pathophysiology and the design of new therapies for human disease.

**PREREQUISITES:**

A passing grade in, or exemption from *Biochemistry* (Block I), is required.

The student should be conversant in the basic concepts of biochemistry that are presented in the Biochemistry course prerequisite. These include but are not limited to a familiarity with the fundamental biochemical species of amino acids, lipids, oligosaccharides and nucleic acids, biochemical energetics, the fundamental energy-producing biochemical pathways, enzymatic catalysis and enzyme regulation.

**REQUIRED MATERIALS:**

Textbook: Thomas M. Devlin (ed) Textbook of Biochemistry with Clinical Correlations, 6th edition. ISBN 978-0-471-67808-3

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes.

**STUDENT ASSESSMENT:**

- Exam 1 covering sections 1 and 2: 40%
- Exam 2 covering sections 3 and 4: 40%
- Discussion 1: 5%
- Discussion 2: 5%
- Discussion 3: 5%
- Discussion 4: 5%



## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

### **COURSE ATTENDANCE POLICY:**

**Students are expected to attend all lecture, discussion and exam sessions.** If an absence is anticipated, the student must contact the Course Director *before* the session.

Attendance at the Review Sessions given throughout the course and before each exam is optional but highly recommended.

**CREDIT HOUR:** 4.0

## **BIOS 7026 – Introduction to Systems Biology**

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**COURSE LEADER:**

Yinghao Wu, PhD

**COURSE SCHEDULE:**

March 11 – June 17, 2024

Mondays, Wednesdays, 1:10-2:40

**COURSE DESCRIPTION:**

This course will introduce the students to the many aspects of Systems and Computation Biology. The syllabus is based on a set of seminars given by all members of the department, with an emphasis on providing a broad view of their respective areas of research. Students will learn the state of the art in these research areas, from the basic concepts to the detailed methodologies, and how to critically think about designing experiments in these research areas. Selected topics include: introduction to probability, statistics and stochastic processes; modeling protein structure, dynamics and interactions; modeling the dynamics of gene regulatory networks and cell signaling networks; the computational simulations of cell movements; the microbial ecology of human health; the metabolic network models and analysis of -omics data; computational neuroscience; and the evolution of complex traits.

**COURSE OBJECTIVES:**

The goals of the course are to give the students an introduction to the research areas in systems and computational biology. Students are expected to learn the basic concepts and detailed methodologies in these areas and how to use these methods to design experiments in systems and computational biology.

**PREREQUISITES:**

None.

**REQUIRED MATERIALS:**

Computer.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes.

**STUDENT ASSESSMENTS:**

Three submitted papers will be assessed by their corresponding lecturers. The lecturers will evaluate the quality of the papers and determine if the papers are acceptable based on their own criteria. Feedback and comments of the papers will be sent back to the students by the lecturers.

The final grade of a student is based on the feedback of the three written assignments from the lecturers.

**CREDIT HOURS: 3.0**

## **BIOS 7013 – Mechanisms of Disease**

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**COURSE LEADER:**

David Fooksman, PhD

**COURSE SCHEDULE:**

March 11 – June 17, 2024

Mondays, Wednesdays, 10:30-11:50

**COURSE DESCRIPTION:**

This multidisciplinary course will investigate the pathobiology of various human diseases and relevant animal models. Topics to be explored will be cancer biology (mechanisms, and also focus on pancreatic cancer, blood cancer, and osteosarcoma), various infections (Ebola, TB, Malaria, Parasitic, HIV), inflammatory/autoimmune disease (Type I diabetes, Lupus), Cardiovascular disease, Liver disease. The course will focus on molecular, biochemical, cellular mechanisms of disease, as well as risk factors such as aging, environmental, genetic contributors. Each class will focus on a particular disease or concept, with a topic expert who will provide a brief lecture followed by a student-led discussion of a seminal paper related to the topic, run by the assigned student. Students will also have follow-up written assignments to propose new avenues of research based on their assigned reading.

**COURSE OBJECTIVES:**

The course will provide background knowledge of pathologic processes, including genetic, biochemical, inflammatory and immunological mechanisms, and neoplasia. The goal is to demonstrate knowledge of the epidemiology, etiology, pathogenesis and mechanisms of several diseases. Knowledge of gross and histopathologic morphology of diseased and normal organ function will be examined. An understanding of the strategies employed to study disease pathogenesis and models to advance treatment and function. Demonstrate an understanding of select mycobacteria, viruses, fungi and parasites with respect to their epidemiology, pathogenesis, clinical manifestations and their potential treatment in select models of disease. An understanding of the rationale behind the translational approach and the research to explore and reduce the pathogenesis of the disease state.

**PREREQUISITES:**

Knowledge of Immunology and Biochemistry is helpful.

**REQUIRED MATERIALS:**

The course requirements will be assigned readings and open discussion, 2 oral presentations, and a written assignment. The class is capped at 22 students with priority for Pathology department students. There are 22 lectures. All students will independently present at least 1 oral presentation. Depending on the number of enrolled students after add/drop, some presentations in the second half of the class will be presented individually or paired groups of students. Students will be assigned randomly to topics.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes.

**STUDENT ASSESSMENT:**

## **GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES**

Grading will be based on class participation (25%) and oral presentation(s) (25% each), and a follow-up assignment(s) (25%). Attendance is mandatory for all lectures.

For class participation, students will be expected to read assigned papers and prepare to discuss the papers at each class. Participation quality will be prioritized over quantity. For oral presentations, presenting student will prepare with a deeper understanding of the papers and topic, understanding the nuances of the approaches, results, the gaps in knowledge, implications of the work, limitations, and next steps. Presenter will be responsible for conducting an effective journal club discussion and engaging peers in the conversation. Follow-up written assignment will be based on their presentation, developing next steps in the form of a short grant aim. Grading will be pass/fail/honors. Completion of all assignments will be required for passing. Honors will be based on quality of class participation, depth and quality of oral presentations, and quality of the follow-up assignment.

### **COURSE ATTENDANCE POLICY:**

No unexcused absences are permitted.

**CREDIT HOURS: 3.0**

## BIOS 7035 – Modern Artificial Intelligence in Biomedical Research I - Foundations

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**COURSE LEADER:**

Ruben Coen-Cagli, PhD

**COURSE SCHEDULE:**

March 12 – May 14, 2024

Tuesday, Thursdays, 1:30-3:20

**COURSE DESCRIPTION:**

This elective course will provide an introduction to modern methods in Artificial Intelligence (AI), particularly focusing on AI for biomedical research, through frontal classes and critical reading and discussion of selected papers.

During the last decade, AI has achieved impressive progress in real-world applications that appeared out of reach just a few years ago, and now features regularly in both scientific and general news. Modern AI methods are also becoming increasingly recognized as an integral component of the toolbox of the biomedical research community. The goal of this course is to provide an introduction to the most important paradigms in modern AI, through lectures, critical reading and discussion of research papers relevant for graduate students in biomedical sciences. Each of the selected papers adopts those algorithms in one of three ways: 1) as a powerful tool for analysis of complex and/or large scale data (e.g. “alpha-fold”, a deep-learning algorithm for protein folding); 2) as a core component in semi-automated medical applications (e.g. the “UNet” for analysis of CT scans and x-rays); 3) as a computational model of biological processes (e.g. “deep convolutional neural networks” to explain the logic of neural activity in visual areas of the brain).

The course will last 7 weeks, with a total of 7 frontal classes and 7 paper discussion classes. The contents of each class are detailed in the list of lectures.

**COURSE OBJECTIVES:**

The objective of the course is to learn foundational techniques in machine learning, how they are used in modern AI methods, and their application to biomedical research, through a combination of frontal lectures and group discussion of selected papers.

After the course, students will have acquired literacy and experience with relevant applications of AI. This will enable them to communicate fluently with AI experts, both in academia and industry, as well as provide the starting point for those who may be interested in applying modern AI methods in their thesis research.

**PREREQUISITES:**

Recommended course: *Introduction to the Mathematics of Theoretical Systems Biology* (Block I).

It is recommended that students be familiar with the following maths prior to enrolling in this course:

- Linear algebra (matrix-vector operations; tensors).
- Calculus (integrals, derivatives and function optimization).

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

- Probability and statistics (Marginal/conditional/joint distribution; Bayes rule).

Students can use this online resource <https://compneuro.neuromatch.io/tutorials/intro.html> in the 'pre-reqs refresher' section for introductory tutorials.

**REQUIRED MATERIALS:** Reading materials will be provided for each class.

**SUITABLE FOR 1ST YEAR STUDENTS:** Yes.

### **STUDENT ASSESSMENT:**

Two or three papers (depending on class size) will be discussed in each discussion class. Each paper is presented by one group of students, and criticized by one other group. There will be a 15-20 minute presentation, followed by 15-20 minute Q&A/scientific debate between the two groups.

Grades will be based on the understanding of papers, demonstrated by the clarity of presentation of the assigned papers and by the relevance of questions to other presenters. Specifically, when presenting a paper, students need to clearly explain the scientific background (in the context of related scientific literature), the main hypothesis or challenges addressed by the paper, the methods used to perform the work, whether the results presented are sound and compelling, and the limitations and broader implications of the paper. When criticizing the paper presented by the other group, students will be assessed on whether the questions/criticisms are relevant (e.g. they address a conceptual or methodological issue of the paper, or they highlight important limitations of the paper) and on whether they support their criticism with pointers to other literature or with specific pointers to the text/figures of the paper.

Although students present and criticize papers as a group, each student is expected to present a section of their paper, and to ask questions/criticism about the other group's paper; therefore, each student will receive an individual grade.

In addition, class participation will be evaluated for frontal lectures: specifically, whether students ask relevant questions, and answer when questions are posed by the lecturer. Paper discussion grades account for 80% of final grade, class participation 20%.

The final grade (H/P/F) is cumulative and will be transmitted at the end of the course. A grade of H can be obtained by consistently (i.e. throughout all classes) showing knowledge and understanding beyond the assigned papers, for instance, by identifying other papers related to the assigned paper and finding deep connections or conflicts between them. A student will receive F if they consistently fail to present clearly their paper, or to ask relevant questions about the other papers.

### **COURSE ATTENDANCE POLICY:**

Students are expected to attend all classes. If missing a discussion class, students will write a 1 to 2 page (plus figures and bibliography, optionally) critical review of the two papers.

**CREDIT HOURS:** 2.0

## **BIOS 7038 – Modern Artificial Intelligence in Biomedical Research II - Coding**

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**COURSE LEADER:**

Ruben Coen-Cagli, PhD

**COURSE SCHEDULE:**

March 15 – May 10, 2024

Fridays, 1:30-3:20

**COURSE DESCRIPTION:**

This elective course will offer a practical introduction to modern methods in Artificial Intelligence (AI) for biomedical research, by means of hands-on coding workshops and participation in a coding challenge.

During the last decade, AI has achieved impressive progress in real-world applications that appeared out of reach just a few years ago, and now features regularly in both scientific and general news. Modern AI methods are also becoming increasingly recognized as an integral component of the toolbox of the biomedical research community. Students will be grouped in one or more teams (depending on the number of students enrolled). Each team will design and implement a model, based on the resources learned in the course, to attempt to solve the specific challenge proposed in the competition. An additional goal of participating to the competition, is to introduce students to scientific teamwork: they will be guided to divide the challenge into smaller tasks (e.g. data preprocessing, designing the architecture, model training and evaluation), and work in synergy.

The practical resources and experience gained through this course will provide an entry point for students that may be interested in further understanding those AI tools in depth (i.e. to become developers) or in using them in practice in their thesis research (i.e. to become informed users).

The course will last seven weeks, with one class per week. During the first three weeks, students will learn the PyTorch framework: how to implement and apply key algorithms and architectures (e.g. CNN, RNN, Transformer) and how to work with datasets for training and evaluation. In addition, details of the competition will be explained. During the next four weeks, teams will work on their design and implementation.

**COURSE OBJECTIVES:**

To learn how to use foundational techniques in machine learning and modern AI methods, and apply them to a specific biomedical research question, through participation in coding workshops and developing solutions to a coding challenge.

To provide a practical introduction to software and computational tools that support the most important paradigms in modern AI, through hands-on coding tutorials and workshops.

To demonstrate the application of these tools to a real-world biomedical research question, through participation in an open challenge or competition (e.g. brain-score.org and algonauts.csail.mit.edu, to predict neural activity patterns in response to visual stimuli).

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

### PREREQUISITES:

Recommended course: *Introduction to the Mathematics of Theoretical Systems Biology* (Block I).

Familiar with Coding in Python.

It is also recommended that students be familiar with the following maths, prior to enrolling in this course:

1. Linear algebra (matrix-vector operations; tensors).
2. Calculus (integrals, derivatives and function optimization).
3. Probability and statistics (Marginal/conditional/joint distribution; Bayes rule; common distributions e.g. Gaussian, Gamma, Bernoulli, Poisson).

Students who need a refresher with 1-3 can use this online resource

<https://compneuro.neuromatch.io/tutorials/intro.html> in the 'pre-reqs refresher' section for introductory tutorials.

4. Foundational concepts of machine learning and deep learning (supervised and unsupervised learning; multilayer perceptron, convolutional neural networks; cost function, backpropagation)

Students not familiar with 4 should take Module 1 (Foundations) of this course concurrently with Module 2 (Coding).

### REQUIRED MATERIALS:

Laptop with an internet browser for tutorial classes. Students should create an account on Google Colab (<https://colab.research.google.com/#>).

### SUITABLE FOR 1ST YEAR STUDENTS:

Yes.

### STUDENT ASSESSMENT:

During the workshops on the first three weeks, students will be required to complete coding exercises. During the next four weeks, students will work on their assignment (a submission for the coding challenge).

Grades will be based on completing the exercises in class (or as homework, if needed; 50%), implementing a working model for the challenge (25%), and final presentation of the model design and results (25%).

Individual grades for the model will be identical for all students in the group. For the final presentation, each student will present a different aspect of the work, and individual grades will be based on the clarity and depth of presentation of each student's portion of the presentation. The final grade (H/P/F) is cumulative and will be transmitted at the end of the course. A grade of H will be obtained by students whose model for the challenge performs competitively with respect to basic benchmarks (as provided by the organizers of the challenge) and whose presentation is delivered clearly, in addition to completing all exercises. A student will receive F if they consistently fail to complete exercises.

### COURSE ATTENDANCE POLICY:

Students are expected to attend all classes. If missing a workshop class, students will have to complete the exercises on their own time (code and guidance will be provided).

**CREDIT HOURS: 1.0**



## **BIOS 7014 – Molecular Approaches to Drug Action and Design**

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### **COURSE LEADER:**

Derek Huffman, PhD | Hayley McDaid, PhD

### **COURSE SCHEDULE:**

March 12 – June 13, 2024

Tuesdays, Thursdays, 10:30-11:50

Some Fridays, 10:00-11:20

### **COURSE DESCRIPTION:**

As a society, where would we be without drugs? Antibiotics, chemotherapeutics and small molecules for the treatment of infections, cancer, diabetes, blood pressure, pain and a multitude of other conditions has allowed us to live longer, healthier and more productive lives. This course will provide an essential foundation of pharmacology for students interested in understanding how some of the most impactful drugs were discovered or designed and their mechanisms of action via state-of-the-art lectures and in-depth discussion. Modules will cover the principles of modern pharmacology (e.g., pharmacokinetics, pharmacodynamics, pharmacogenomics), methodologies of drug discovery/design and therapeutics for the treatment of cancer, metabolic diseases and infections. The course will also introduce newer concepts in drug development, including drugs to target aging, neurodegenerative diseases, and the role of the microbiome. Throughout, emphasis will be placed on the biology and chemistry of interactions between agents and their cellular targets, including specific enzymes, and their cellular processes. When available, their impact on physiologic systems will also be discussed, including preclinical data that spurred these drugs toward clinical trials, to evidence for their eventual successes (or failures) in humans.

### **COURSE OBJECTIVES:**

- Develop a fundamental understanding of pharmacology concepts and their application to guiding drug development
- Become familiar with how various types of drugs, from small molecules to antibodies, are designed, developed and tested for potential clinical use
- Become familiar with major classes of drugs, including their mode of action, used to treat common chronic conditions, including cancers, type 2 diabetes, infections and metabolic disease
- Gain a holistic understanding of the challenges and opportunities in successfully developing and bringing a drug candidate to market

### **PREREQUISITES:**

Should have the equivalent of graduate school biochemistry. Specifically, students should have some familiarity with thermodynamics, enzyme kinetics, protein structure and function, receptor ligand interactions.

### **REQUIRED MATERIALS:**

None

### **SUITABLE FOR 1ST YEAR STUDENTS:**

Yes

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

### **STUDENT ASSESSMENT:**

Student performance will be dependent on class participation (30%), three mini take-home exams (10% each), and two student group presentations (20% each). Student participation will be based on regular attendance and discussion during faculty lectures and student projects. Students will also be expected to demonstrate mastery of concepts learned during lectures on both take-home exams and group projects/presentations.

### **COURSE ATTENDANCE POLICY:**

Class attendance is mandatory and, along with participation, comprises 30% of the final grade. Students are expected to notify the course leaders in advance of an anticipated absence due to a known schedule conflict or within a reasonable amount of time due to extraneous circumstances (illness, emergency, etc.).

**CREDIT HOURS:** 3.0

## **BIOS 7034 – Principles of Magnetic Resonance Imaging**

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**COURSE LEADER:**

Mark Wagshul, PhD | Craig Branch, PhD | Qi (Chris) Peng, PhD

**COURSE SCHEDULE:**

March 11 – June 17, 2024

Mondays, Wednesdays, 4:10-5:30

**COURSE DESCRIPTION:**

The course will cover the basic principles of magnetic resonance imaging, including the fundamentals of magnetic resonance, image formation and applications. Specific topics will include: fundamentals of nuclear magnetic resonance, relaxation and the Bloch equations, spin and gradient echoes, contrast mechanisms, principles of image formation, signal to noise ratio and resolution. Individual modules will give students exposure to MRI pulse sequence design and to clinical imaging, with hands-on experience on a 3T MRI scanner.

**COURSE OBJECTIVES:**

The overall goal of the course is to provide a basic understanding of how MRI works, including detailed methods of image formation and acquisition. At the end of the course, students should be able to describe the physical processes involved in acquiring and processing MRI data, the difference between various MRI imaging techniques, and clinical applications of these various methods.

**PREREQUISITES:**

College level physics (basics of magnetism) and mathematics (exponentials functions, algebraic functions, basic calculus concepts, e.g., derivatives and integrals). While not required, basic programming skills will be used in this course (experience with any language will be helpful, although we will be using Matlab) and students with no formal programming coursework are recommended to do online learning in advance. Suggested online modules will be emailed out a few weeks prior to the first lecture.

**REQUIRED MATERIALS:**

E. Mark Haacke, "Magnetic Resonance Imaging: Physical Principles and Sequence Design" ISBN-10: 0471351288; ISBN-13: 978-0471351283.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes.

**STUDENT ASSESSMENTS:**

Final take-home exam (50%), Problem sets (25%, 4-5/semester), attendance (10%), participation (15%)

Final project will be in the form of an either 1) written specific aims and study design, using MRI methods to address a fundamental question in clinical or pre-clinical medicine, or 2) critical review of a peer-reviewed MRI methods paper. The student will present and defend their proposal/paper review in an oral presentation (15-20 min) to be delivered during the last week of classes.

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

Problem sets will be handed out ~ every other week, with 1-2 problems designed to test students on their mastery of the imaging principles covered in class, and their ability to apply these principles to clinical or basic science applications.

Attendance will be graded based on attendance to the lectures (on a sliding scale, with full credit for at least 90% attendance). In the event of occasional, valid reasons for missed classes, students can discuss with the course instructors to make up missed material.

Participation will be expected of all students, in the form of occasional queries during class; while there will be no formal discussion sessions, all of the modules will be taught in an interactive manner, with adequate opportunity for interactive participation from students during class. Reasonable effort on the part of a student to participate in these discussions will be expected.

**CREDIT HOURS: 3.0**

## **BIOS 7029 – Stem Cells, Development and Disease**

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**COURSE LEADER:**

Andreas Jenny, PhD | Teresa Bowman, PhD

**COURSE SCHEDULE:**

March 12 – June 18, 2024

Tuesdays, Thursdays, 4:20-5:30

**COURSE DESCRIPTION:**

The course focuses on the fundamentals of developmental biology, stem cells and regenerative medicine. The pathways and processes central to embryogenesis are often reused during tissue regeneration. Moreover, many diseases have their origins in mis-regulation of developmental pathways. A fundamental knowledge of development can thus strengthen your understanding of regenerative biology, aging, and disease. In this course, we will focus on the major principles and appropriate experimental approaches utilized in researching questions in development and stem cell biology.

The course is comprised of lectures, team-based learning discussions and writing sessions (ending in a 'study section' where specific aims pages are being judged by the class). For all aspects of the course, students are highly encouraged to raise their own questions about material presented and to voice their agreement (or dissent!) with thoughts raised during discussions. Course leaders and instructors will make sure that everyone has a chance to participate in the discourse.

**COURSE OBJECTIVES:**

The goal of this course is for students to get an overview of the state-of-the-art of research in developmental biology and stem cells. Students will learn to critically evaluate literature and seminars, to understand relevant experimental approaches, and to develop logical thinking and good experimental design skills for studying development and stem cell biology.

**PREREQUISITES:**

None

**REQUIRED MATERIALS:**

None; 'Developmental Biology' by Gilbert et al. or similar standard textbooks can be helpful. Instructors will point out relevant literature for further reading. Material to be studied in advance will be posted with sufficient notice on Canvas.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes.

**STUDENT ASSESSMENT:**

Grading is primarily based on participation. Course leaders and instructors evaluate participation of student (preparedness, quality of questions and answers) during lecture-based classes and journal club presentations. In case of paper discussions, a student will act as facilitator and will introduce the topic and randomly select students to present figures or answer questions emerging from the ongoing discussion.

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All students are expected to be part of the paper discussion. The facilitator will summarize conclusions and future directions or details that should be further addressed. Discussion leaders of JCs will receive extra credit.

Additionally, there is a group writing exercise that will comprise 12.5% of the final grade. The class will be divided into groups of 3-4 students each. Each group will write a one-page grant proposal on a development or stem cell topic, and then present it to the class. Grades will be assigned based on the logic and experimental approach of the proposal and presentation.

### **COURSE ATTENDANCE POLICY:**

Attendance and participation in ALL classes are required. Absences must be excused prior to class meeting. More than two absences per term will result in a failing grade for the course.

**CREDIT HOURS:** 2.5

## **BIOS 7412 – The Cellular, Molecular and Genetic Basis of Neurological and Psychiatric Disorders**

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**COURSE LEADER:**

Herbert Lachman, MD

**COURSE SCHEDULE:**

May 16 – June 18, 2024

Tuesdays, Thursdays, 2:00-4:00

**COURSE DESCRIPTION:**

This block will be subdivided into four, weekly sessions devoted to neurological and psychiatric disorders, as follows:

- Psychiatric disorders (schizophrenia, bipolar disorder, addiction)
- Speech and hearing disorders; auditory processing
- Neurodegenerative disorders (e.g., Alzheimer Disease, Parkinson Disease, Huntington Disease)
- Neurological disorders (e.g., epilepsy, stroke)

The lectures will combine a clinical description of the disorders with the modern approaches being used to understanding their molecular and genetic basis, for the purpose of developing novel therapies. The methods that will be discussed include genome wide association studies (GWAS), copy number variant (CNV) analysis, whole genome and exome sequencing, induced pluripotent stem cell disease-modeling, CRISPR-editing, high throughput drug screening using human neuronal cells, regenerative medicine, and gene therapy/antisense oligonucleotides.

The course provides an overview of a broad range of neurological, neurodevelopmental and psychiatric disorders, along with descriptions of modern research tools designed to help understand their underlying basis. The course has a unique translational perspective. There is no other course at Einstein dedicated to teaching about brain disorders.

**COURSE OBJECTIVES:**

Acquaint Ph.D. students with the clinical features of various neurological and psychiatric disorders, which are among the most disabling disorders in the world, and show how the tools of modern basic science research are being used to develop novel therapies.

**PREREQUISITES:**

None.

**REQUIRED MATERIALS:**

Suggested reading: Each lecture will be accompanied by one article; either a review or a relevant research paper related to that particular lecture.

**SUITABLE FOR 1ST YEAR STUDENTS:**

Yes

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

### **STUDENT ASSESSMENT:**

40% of the final grade will be based on attendance and class participation. At the end of each class, the students are expected to upload a short (250 word) paragraph to canvas on what they have learned in class.

**CREDIT HOURS:** 1.25



## BIOS 7015 – Viruses

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### **COURSE LEADER:**

Ganjam Kalpana, PhD | Vinayaka Prasad, PhD | Kartik Chandran, PhD

### **COURSE SCHEDULE:**

March 12 – June 18, 2024

Tuesdays, Thursdays, 1:20-2:40

### **COURSE DESCRIPTION:**

The study of viruses helped lay the foundation of modern molecular biology, and continues to provide new insights into the biology of cells and organisms. We live in an increasingly interconnected and crowded world in which “new” viruses can emerge and spread throughout the globe seemingly overnight, and are being discovered at an ever-accelerating pace through cutting-edge genome sequence-based technologies. At the same time, “old” viruses such as HIV-1 remain a global threat and viruses we thought we had defeated, such as measles, are resurgent today. Therefore, a sophisticated and broad-based understanding of animal viruses is needed now more than ever. In this course, we will study how viruses are put together, how they multiply in their hosts and cause disease, how we find new viruses and characterize them, and how we exploit them as tools for basic research and therapeutics.

'Viruses' will be kicked off with lecture/seminar by noted virologists. This will be followed by didactic lectures featuring Einstein's own virology faculty complemented by invited outside speakers. All speakers are international experts in different areas of the study of viruses. The course is organized into 5 units and the lectures will cover virus structure, mechanisms of virus entry and replication, regulation of viral and host gene expression, virus assembly, virus egress, host responses to viral infections, and viral pathogenesis. 'Viruses' will demonstrate how these basic principles offer opportunities for diagnosis, prevention, and treatment of prevalent and emerging viral diseases, and for the development of new applications that utilize viruses as tools.

This year we have arranged two special events for the benefit of Viruses students on March 23rd. The first one is an inaugural seminar by Dr. Stanley Perlman, a world renowned expert on Coronaviruses. This is a school-wide seminar from 12:00 to 1:00 PM open to everyone and the students will specifically benefit from this lecture. The second one is a special kick-off lecture at 1:20 to 2:40 PM by the authors of “Principle of Virology”, Drs. Vincent Racanielo and Theodora Hatzioannou.

### **COURSE OBJECTIVES:**

To be able to understand the fundamentals about viruses: how they replicate, how they cause disease, how they evolve. Students should be able to appreciate the intricacies of viral biology to a level that allows them to be able to think about how to devise strategies of control – by virus inhibition or via vaccines.

### **PREREQUISITES:**

Biochemistry, Gene Expression: Beyond the Double Helix, and Molecular Genetics courses are recommended, but not mandatory.

## GRADUATE PROGRAMS IN THE BIOMEDICAL SCIENCES

### REQUIRED MATERIALS:

- A computer to access email and internet.
- Principles of Virology 4th Edition. by S.J. Flint, V. R. Racaniello, Rall, G. and A.M. Skalka (2015) ASM Press. ISBN # 978-1-55581-9330.

### SUITABLE FOR 1ST YEAR STUDENTS:

Yes

### STUDENT ASSESSMENT:

The entire course is graded on two take home exams. The exams are graded on a curve. No minimum set.

**CREDIT HOURS: 3.0**