EINSTEIN
Albert Einstein College of Medicine

Graduate Programs in the Biomedical Sciences

GRADUATE COURSE CATALOG

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Graduate Course Listing by Block

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Block I

BIOS 7001 – Biochemistry

COURSE LEADER:
Tyler Grove, PhD

COURSE DESCRIPTION:
This is an introduction to fundamental topics in biochemistry and physical biochemistry. Topics include: protein structure, folding, and function, nucleic acid structure and protein-DNA interactions, enzymology, energetics & allostery, posttranslational modification of protein function, transcription, translation, and DNA replication. The material is presented in formal lectures in conjunction with a protein/nucleic acid structure-based tutorial.

COURSE OBJECTIVES:

- To educate students on the fundamentals of biochemistry including protein and nucleic acid structure, enzymology, and DNA replication, transcription, and translation.
- To learn how to interpret and manipulate protein and nucleic acid structures.

PREREQUISITES:
One semester of undergraduate biochemistry and a course in organic chemistry are required. Undergraduate physical chemistry is also helpful preparation. Students who are uncertain about the adequacy of their undergraduate training for this course should discuss the issue with their advisory committee and then consult the course leader. Students should be familiar with the general principles of biochemistry including basic knowledge of amino acid and nucleic acid structure. They should also be familiar with general principles such as DNA replication, transcription and translation. All students who want to register for Graduate Biochemistry must complete the assessment exam during Orientation Week.

REQUIRED MATERIALS:
Biochemistry, 4th Edition, D. Voet and J. G. Voet. ISBN 978-0470570951

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
There are three closed-book exams (2 hours each) administered throughout the Block worth 30% each. In addition, 10% of the grade will be based on tutorials for nucleic acid/protein structure.

CREDIT HOURS: 5.0

BIOS 7413 – Computational NeuroEthology

COURSE LEADER:
Mikhail Kislin, PhD

COURSE DESCRIPTION:
How should we measure behavior? What are the numbers one should use to describe how an animal moves and interacts with the world? Which parameters of behavior are under neural control?

Computational Neuroethology is a multidisciplinary framework focused on the computational modeling of the neural basis underlying animal behavior. This course integrates the methodologies of computational neuroscience with the ethological perspective to create models that account for neural activity, peripheral biomechanics, and ecological context in an equal manner.

Students will explore how computational simulations can provide insights into the complex interplay between brain, body, and environment that gives rise to animal behavior. Topics covered will include:
1. Introduction to Python and large language models for coding
2. Traditional statistical approaches and thinking beyond the p-value
3. Novel metrics and measurement techniques for studying behavior, leveraging ideas from nonlinear dynamics, statistical physics, information theory, computer vision, and machine learning
4. Modeling for preprocessing and analysis of LFPs, single and multiunit recordings, imaging calcium or other fluorescent probes data.
5. Linking behavior to neural activity.
Teaching methodologies combine interactive lectures, hands-on coding workshops, and collaborative group projects. Students will lead weekly assignments, fostering practical skills and theoretical insight in modeling and data-driven analyses.

The six-week duration maximizes learning outcomes and ensures the course is comprehensive yet concise, practical yet theoretical, and intensive yet digestible. It provides a structured timeline to cover the five key topics, build computational and analytical skills, and apply them to neuroethological questions.

COURSE OBJECTIVES:
Upon completion of this course, students will have acquired the skills necessary to apply computational neuroethology to address fundamental questions in animal behavior and neuroscience research. Students will gain a deeper understanding of how to approach those questions with an open-source statistical package and machine learning tools and develop skills to critically evaluate research data, formulate analysis directions, and present the results of scientific research.

PREREQUISITES:
None. Undergraduate neuroscience and statistics recommended. Basic familiarity with neuroscience concepts, ideally from introduction to Principles of Neuroscience, is encouraged, though it is not mandatory. Coding experience is not required, as the course introduces Python. An interest in quantitative analysis and animal behavior is beneficial.

REQUIRED MATERIALS:
Computer, tablet or smartphone with internet access – contact the course instructor if this is an issue. Students should create an account on Google Colab.
No textbook required; optional references for background:

- *Principles of Neural Science* by Kandel et al. (ISBN: 978-1259642234)
- *Modeling Neural Circuits Made Simple with Python* by Rosenbaum (ISBN: 9780262548083)
- *Principles of Animal Behavior* by Dugatkin (ISBN: 9780226448381)

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
20% Class participation
20% Small weekly assignments
30% Lead an in-class project (bring research to a class)
30% Final project

The final grade will be cumulative and reported as Honors (H), Pass (P), or Fail (F) at the end of course. To pass, students must complete 70% of final grade. To receive an H, students must complete all coding exercises, deliver a clear and well-executed presentation; F results from consistent failure in exercises and non-participation in final project (<30%). During the group project presentation of a model design, implementation, and results, each student will present a unique aspect (e.g., behavioral or neuronal metrics, data vizualisation and analysis, statistical relevance), with individual grades based on the clarity, depth, and insight of their portion. This structure ensures students gain practical skills while fostering teamwork and individual accountability.

Attendance:
Any absence, whether excused or unexcused, must be compensated for by completing the assigned work (e.g., coding exercises), with data, code, and guidance will be provided to support this. A maximum of one unexcused absence is permitted, beyond which additional absences may impact the final grade.

CREDIT HOURS: 1.0

BIOS 8012 – Health Technology Innovation Biodesign

COURSE LEADER:
Sunit Jariwala, MD

COURSE DESCRIPTION:
Health technologies such as therapeutics, medical devices, and digital tools have great potential to transform the delivery of healthcare and encourage personalized medicine. This 4-week elective course aims to provide students with an understanding of needs-based innovation biodesign, prototype development and validation, and sustainability through entrepreneurship.

Elective participants will pair in teams of 2-3 individuals per team. Team members will work together to complete cases, conceptualize an innovation project, and present an end-of-elective presentation regarding this project. This 4-week elective will give trainees an entrepreneurial-focused perspective regarding the 'journey' of commercially viable health technology solutions. The elective will consist of Zoom-based small group sessions (case discussions, topical presentations by experts in the innovation biodesign arena) and didactics (required articles, cases, videos, podcasts).

COURSE OBJECTIVES:
1. Students will demonstrate an understanding of the innovation biodesign process and the importance of health technology innovation, as assessed by: 1) Trainees' completion of assigned articles, cases, and an innovation project; and 2) Trainees' feedback/survey and exit interview responses.
2. Students will demonstrate an understanding of conducting the needs-based innovation process, market assessments, competitive landscape analyses, and SWOT analyses.
3. Students will prepare for and present an end-of-elective pitch presentation.

PREREQUISITES:
None.

REQUIRED MATERIALS:
Computer with an internet browser for accessing the assignments and participating in the virtual class sessions.

SUITABLE FOR 1ST YEAR STUDENTS:
No. Open to 3rd year graduate students or higher (who have completed the Qualifying Exam), and postdocs.

STUDENT ASSESSMENTS:
Three articles and cases will be discussed in each discussion session. Each team will present a case and article summary and will be constructively critiqued by the other students. Each 20-30-minute presentation will be PowerPoint-based and will be followed by an interactive discussion by the entire group of elective participants. Grades will be based on an understanding of the articles and cases as demonstrated by the clarity of presentations and quality (i.e. thoughtful contributions and questions and answers) of discussion.

Attendance:
Students will be expected to attend and participate (i.e. present, contribute to the discussion when not presenting) in all sessions. Those missing a session will need to review the session recording within 1 week of the session and submit a 1-page summary of the articles and cases assigned for that missed session.

Final Grade:
60%: Completing and demonstrating an understanding of the articles and cases, as demonstrated by thoughtful presentations and discussions during the sessions.
40%: Final presentation – grade will be based on the quality of the presentation slides and presentation delivery and adequately answering questions from elective participants and the course leader(s)

The final grade (Honors, Pass, Fail) will consist of student contributions aggregated among the sessions and will be submitted by the course leader(s) following the end of the course. A grade of honors can be achieved if students exceed the course expectations, for example, by identifying additional articles related to the discussion topic. Students will receive a grade of fail if they do not adequately present the cases or articles or final presentation and if they do not meaningfully participate in the interactive discussions.

CREDIT HOURS: 0.5

BIOS 7037 – Introduction to the Mathematics of Theoretical Systems Biology

COURSE LEADER:
Aviv Bergman, PhD

COURSE DESCRIPTION:
An introduction to the mathematical topics necessary to conduct theoretical and computational systems biology. Topics covered are stochastic processes, dynamical systems, modeling using ODEs and PDEs, and the basics of machine learning. Lecture-based learning with office hours discussion.

COURSE OBJECTIVES:
To equip students with the tools required to model and analyze computational models of biological systems, and provide them with the basic knowledge to understand and feel more fluent in the underlying mathematics.

PREREQUISITES:
Calculus, Linear Algebra, Basic Probability Theory.

REQUIRED MATERIALS:
Computer with MATLAB and R.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
10% participation, 20% homework, 30% midterm, 40% final. A grade above 60 required to pass. Feedback regarding grades will be regularly provided during the course.

CREDIT HOURS: 3.0

BIOS 7036 – Mechanisms in Cancer Biology

COURSE LEADER:
Kamini Singh, PhD | Jonathan Backer, MD | Eugen Dhimolea, PhD | Praveen Agrawal, PhD

COURSE DESCRIPTION:
This course will provide an in-depth understanding of the fundamental mechanisms involved in cancer biology. A key component of this course is a detailed examination of the molecular and cellular signaling processes that lead to the initiation and progression of cancer. The course will also cover topics such as genetic and epigenetic changes, the role of oncogenes and tumor suppressor genes, the impact of the tumor microenvironment on cancer progression, and the mechanisms of metastasis. The course will discuss the latest research and techniques used to study cancer biology, including genomics, proteomics, and bioinformatics. While cancer therapeutics is not a major focus, students will be exposed to current immunotherapy and targeted therapeutics research. Through didactic lectures and team-based learning exercises, students will critically evaluate the latest research literature on cancer signaling and mechanisms. Upon completion of the course, students should be equipped with a solid foundation in the mechanisms and pathways involved in cancer signaling, and the skills and knowledge necessary to apply this understanding to critically evaluate and design experiments in cancer research.

COURSE OBJECTIVES:
The objectives of this course would typically include:

1. Provide a detailed examination of signaling pathways involved in cancer initiation, progression, and metastasis through didactic lectures.
2. Understand the role of oncogenes and tumor suppressors in cancer development.
3. Define how changes in DNA repair processes, stem cells and intermediate metabolism promote cancer initiation and progression.
4. Explore the molecular mechanisms underlying tumor metastasis and its regulation by the tumor microenvironment.
5. Critically evaluate and interpret the latest research literature in cancer signaling and mechanisms through team-based learning discussions and peer review exercises.

Expected outcome:
The expected outcome of this course would be a comprehensive understanding of the signaling pathways and molecular mechanisms involved in cancer biology, including how these pathways contribute to cancer initiation, progression, and metastasis. Students would gain knowledge about the interplay between genetic, epigenetic, and signaling factors that drive cancer development, as well as the latest advances in cancer research and therapeutic approaches. Upon completion of the course, students should be equipped with the skills and knowledge necessary to critically evaluate and design experiments aimed at unraveling the complexities of cancer signaling and mechanisms.

PREREQUISITES:
Undergraduate course in Molecular Biology at the level of Alberts “Molecular Biology of the Cell”.

Students should be familiar with college-level molecular biology, cell biology, and basic knowledge of gene structure and cancer.

REQUIRED MATERIALS:
Computer.

Recommended readings (not required):

- The Biology of Cancer 3rd Edition 2023 by Robert Weinberg. ISBN-13: 978-0393887655
- The Biology of Cancer, Third Edition Ebook, Interactive Online Textbook
- Cell Signaling: Principles and mechanisms 2014 by Lim, Mayer and Pawson. ISBN-13: 978-0815342441
- Molecular Cell Biology, Lodish et al. ISBN-13: 978-0716776017

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
10% participation in TBL exercises; 30% each of three exams.

Exams: There will be three exams to access students' understanding of key concepts and their ability to apply their knowledge to solve problems related to cancer biology. Exams are in take away format to be completed in a week's time, submitted electronically on canvas. Exam questions will be a combination of objective and subjective to cover the topics from the lecture.
Team-based learning exercises: These exercises, which are incorporated throughout the course, will assess students' ability to work collaboratively and effectively as part of a team. In each discussion session, a cutting-edge research article will be discussed to develop analytical and conceptual skills to critically discuss and present data from the research articles in a group setting.

CREDIT HOURS: 3.0

BIOS 5016 – MSTP Thesis Mentor Reading Elective

COURSE LEADER:
Matthew Gamble, PhD

COURSE DESCRIPTION:
This reading elective course provides MSTP students with the opportunity to read the relevant background literature for their planned PhD thesis projects and discuss the papers with their thesis mentor prior to starting in the lab. MSTP students complete their three lab rotations by the end of the summer between their first and second year. The second year in the MSTP is largely devoted to completion of their MD coursework, the Transition to Clerkship course, a single clinical clerkship, and study time to prepare for and take the USMLE Step 1 exam. They do not start in their thesis research lab until the summer between the second and third years. This course would provide them the opportunity to enter the lab with a more solid knowledge of the foundational literature for their thesis research.

COURSE OBJECTIVES:
The objective of this course is for the MSTP students to read the background literature relevant to their planned thesis research and discuss it with their mentors. This will allow them to enter the lab with a deeper knowledge base of the relevant background literature as they begin to conceptualize and develop their experimental plans. It will also provide them with the opportunity to develop a relationship with their mentor while they complete their MD coursework.

PREREQUISITES:
Students should have taken the graduate courses relevant to their planned thesis research projects so that they can understand the literature they are reading.

REQUIRED MATERIALS:
Access to the relevant publications via the Library.

SUITABLE FOR 1ST YEAR STUDENTS:
No. For 2nd year MD-PhD students only.

STUDENT ASSESSMENTS:
Students will write a five page double spaced paper summarizing the background literature they read. The mentor will read the document and provide feedback to the student. The mentor will inform the course director if the student's performance was acceptable. Students will prepare a 5-10 minute talk summarizing the literature and the field and present these to the entire MSTP class cohort with the course director. There will be 2-3 group sessions in November/December for the oral presentations. Otherwise the students will be expected to meet with their mentors on a weekly basis for 1-2 hours to discuss the papers.

Assessment of performance will be by the mentor (70%). They will assess student's ability to critically read the scientific literature and to write a cogent summary of the papers they have read. Students will be expected to read

2-3 papers per week which may include primary literature and/or reviews. The student oral presentations will count for 30% of the grade.

Final grades will be pass if the student has done the assigned readings, discussed them with the faculty mentor, and written and acceptable document summarizing the field and made a cogent oral presentation to the class.

CREDIT HOURS: 2.0

BIOS 7006 – Molecular Genetics

COURSE LEADER:
Julie Secombe, PhD | Meelad Dawlaty, PhD

COURSE DESCRIPTION:
The course is designed to convey genetic concepts and their application in a diverse set of model systems. It will allow students to understand and critically evaluate the literature. The course is divided into three sections. In the first section, students will briefly review basic genetic concepts. This part is followed by sections on individual genetic systems. In the second section, students will learn about major multicellular systems, including mouse, stem cells, zebrafish, *C. elegans* and *Drosophila*. The third section includes yeast and bacterial genetics, and concludes with human genetics and cancer genetics, with their necessarily different approaches. Overall, this course should convey graduate level in all its modern facets and constitute the foundation for more advanced studies.

COURSE OBJECTIVES:
The goal of this course is to provide an overview of modern genetic methods and approaches using a range of organisms. Both classic and modern examples will be used to convey the possibilities and contributions of the field of Genetics to the understanding of biological processes.

PREREQUISITES:
Undergraduate genetics or equivalent is required.

REQUIRED MATERIALS:
Computer.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Minimum passing grade is 65%. There are exams after each section of the course. The first and second exams count for 33% each and the third exam for 34%. Students must attain a passing grade (65%) in two of the three exams to pass the course.

Attendance:
Students are encouraged to attend lectures in person. The course leaders will make every effort to record classes and make them available after each class, subject to the lecturer allowing recording of their class. Students are required to attend TBLs in person.

CREDIT HOURS: 5.0

BIOS 7406 – Principles of Neuroscience I

COURSE LEADER:
Bryen A. Jordan, PhD | Alberto E. Pereda, MD, PhD

COURSE DESCRIPTION:
Principles of Neuroscience I is a 13-week course required for students in the Department of Neuroscience. The course covers the cellular and molecular properties of neurons and glia, including neuronal excitability and synaptic transmission, as well as the cell biological aspects of brain function. From the organizational point of view, the course aims to be an interactive experience centered on understanding basic principles of brain cell function that will be used to navigate the course material during paper presentations and group discussions. Ultimately, the course aims to provide students with a toolkit of basic knowledge that will allow them to incorporate new knowledge during the development of their research projects.

Expectations: The course does not follow the traditional college course structure, where exams and homework assignments numerically add to the final grade. Consistent with the goals of graduate education, the class format consists of a combination of formal and informal lectures, daily questions, and student presentations, with a major emphasis placed on interactive class discussions. Feedback, participation, and discussions are important for the learning experience and final evaluation. Moreover, because the basic principles of cellular neuroscience are too numerous and complex to fully cover in class, significant learning outside of the classroom will be expected through provided reading materials, teaching assistants, and the Canvas online discussion forum. In addition to normal course scheduled lectures, the course requires students to attend the weekly Neuroscience Seminar Series and includes lab visits for first-hand learning experiences.

COURSE OBJECTIVES:
1- Understand the chemical and electrical principles that lead to neuronal excitability
2- Understand the principles that underlie neurotransmission, and understand how non-neuronal cells support this process
3- Understand the molecular and cellular mechanisms the give rise to neurotransmission, and how input leads to short and long-term changes in neuronal function

PREREQUISITES:
A basic understanding of general cellular theory, organelles, and the central dogma of molecular biology (from DNA to RNA to protein), as well as a basic understanding of basic electrical concepts, such as Ohms law (V=IR), ions, batteries, resistors, and capacitors is needed. Students should read and review chapter 7-9 of “Principles of Neuroscience 6th Edition (2021), Kandel ER” available from the Einstein Library prior to the start of the class.

If unsure about your preparedness for the course, please reach out to course instructors who may recommend certain readings to resolve any deficits in knowledge.

REQUIRED MATERIALS:
Textbooks are provided as additional learning resources:

- Kandel, E., et al. - Principles of Neuroscience 6th Ed. ISBN-10: 1259642232. ISBN-13: 978-1259642234.
- Johnston, D. - Foundations of Cellular Neurophysiology (excitability is well covered). ISBN-10: 0262100533. ISBN-13: 978-0262100533.
- Raman, I. and Ferster, D. - The Annotated Hodgkin and Huxley: A Reader's Guide. ISBN-10: 0691220638. ISBN-13: 978-0691220635.
- Bear, M., Connors, B., and Paradiso, M. - Neuroscience Exploring the Brain 4th Ed. ISBN-10: 0781778174. ISBN-13: 978-0781778176.
- Byrne, J.- From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience. ISBN 10: 0123971799. ISBN-13: 978-0123971791.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Attendance and class participation: 25%
Presentations 25%
Final exam 50%.
The Final Exam must be passed to pass the course. However, this is not sufficient. Active participation in class and well-prepared presentations will also be assessed and considered for passing. Students who are not sufficiently participating will be informed by the course leaders to provide them with the opportunity to increase their class participation.

CREDIT HOURS: 6.0

BIOS 7010A – Quantitative Skills for the Biomedical Researcher I

COURSE LEADER:
Mimi Kim, ScD | Kith Pradhan, PhD | Jee-Young Moon, PhD

COURSE DESCRIPTION:
Students will be introduced to principles of scientific rigor and reproducibility, descriptive statistics, estimation, statistical inference and study design. Specific topics covered include hypothesis testing (one and two-sample tests with continuous and binary outcomes), non-parametric tests, power calculations, and methods for multiple testing adjustments. The students will learn to explore and visualize data as well as perform statistical tests using the R programming language.

Topics:
- Overview of statistics in research
- Visualizing and summarizing data
- Statistical estimation and inference 1: Continuous data
- Statistical estimation and inference 2: Categorical data
- Non-parametric methods, multiple testing
- Study design, power, rigor and reproducibility

COURSE OBJECTIVES:
This 3-week course aims to acquaint students with the fundamental concepts of biostatistics, applications of basic methods, and their interpretation.

PREREQUISITES:
All students are expected to have college-level mathematics and basic computer skills.

Recommended prerequisites:
The Introduction to R Programming course offered in the summer or the R-coding bootcamp given the week prior to the start of this course are strongly recommended prerequisites for this course.

REQUIRED MATERIALS:
Statistical Software: The statistical software R will be used.
Recommended Textbooks:
- Ann McDonnell Sill, *Statistics for Laboratory Scientists and Clinicians*, (1st Edition). ISBN-13: 978-1108708500, ISBN-10: 1108708501.

Textbooks are not required, and lecture notes will be posted. It is not necessary for the course but may be a helpful resource for your research.

SUITABLE FOR 1ST YEAR STUDENTS:
Not recommended; permission from course leader required if seeking to take this course in the first year.

STUDENT ASSESSMENTS:
Course grade will be based on homework (20%), and an in-class final exam (80%).

CREDIT HOURS: 1.0

BIOS 7010B – Quantitative Skills for the Biomedical Researcher II

COURSE LEADER:
Kenny Q. Ye, PhD

COURSE DESCRIPTION:
In QSBR I, the focus is on the basic concepts of statistical inference, especial the idea of quantifying the uncertainty of estimation and reasoning of hypothesis testing. In QSBR II, we will apply the basic concepts of statistical inference to explore relations between two or more variables, and the focus of the teaching will shift from basic concepts towards the art of data analysis. Below are a few things that might help you do well in learning statistics. The best way to learn statistics is to apply your own common sense and reasoning, and applying statistical methods to real problems encountered in your research.
Although math plays an important role in statistics, for the vast majority of biomedical researchers, it is more important to understand what a particular statistical method tries to do than to know the details of the mathematical formula and computational algorithms. In other words, you want to have the big pictures before getting into the details. Mathematics mostly serves the purpose of justifying our common sense and enabling us to handle complicated problems.

For data analysis, it is often much more important to make sense of the data using a variety of visualization tools before describing them with numbers and statistical models.
We will also use software R in this module. It is used mainly for
1. visualizing the data
2. numerical simulation to help understand statistical methods
3. perform some modern statistical computational methods.

Topics to be covered:
Fisher Exact Test and Hypothesis Testing
Chi-square Tests + R session
Correlation and Linear Regression
Regression Diagnostics
One-Way ANOVA + R session
Two-Way ANOVA and Statistical Interactions
Permutation tests (Bring your laptops to the classroom)
Logistic Regression + Extra R session
(Possibly) Repeated Measure and Random Effect Model

COURSE OBJECTIVES:
To build student confidence in understanding and using at least some statistical methods that are not taught in this course when students need them in their future research.

PREREQUISITES:
Quantitative Skills for the Biomedical Researcher I.

RECOMMENDED MATERIALS:

- Peter Dalgaard: *Introductory Statistics with R*. ISBN-13 978-0387790534
- Robert Elston: *Basic Biostatistics for Geneticists and Epidemiologists.* ISBN-13: 978-0470024904; ISBN-10: 0470024909

SUITABLE FOR 1ST YEAR STUDENTS:

Not recommended; permission from course leader required if seeking to take this course in the first year.

STUDENT ASSESSMENTS:

The grade of this course is pass/fail, and usually 10-15% will get pass with honors. The grade will be based on the quality and effort of the homework (67%) and final projects (33%).

CREDIT HOURS: 1.0

BIOS 7010C – Quantitative Skills for the Biomedical Researcher III

COURSE LEADER:
Kith Pradhan, PhD

COURSE DESCRIPTION:
This course will cover the statistical principles that are pertinent to the study of big–omic data sets being collected in biology. Students will learn about current statistical approaches, issues related to experimental design and reproducible research, and important case studies that illuminate some of the challenges of analyzing big data. This course is the third module of the Quantitative Skills for the Biomedical Researcher series, and builds upon the material covered in the first two modules. As part of the assessment, students will gain practical experience by conducting a mini big data research project while working in small teams.

COURSE OBJECTIVES:
Students are expected to acquire the following learning outcomes by the conclusion of the course:

- An understanding of statistical and computational approaches to analyzing big data sets in the form of gene expression data.
- Practical skills in R programming to process, analyze, and visualize gene expression data.
- Be able to extract published datasets from the literature and re-analyze this data either to reproduce basic analyses or ask new questions of the data.

PREREQUISITES:
Required courses: Quantitative Skills for the Biomedical Researcher I, and Quantitative Skills for the Biomedical Researcher II, or the equivalent in background knowledge.
This course draws upon practical programming skills in R and basic statistics.

REQUIRED MATERIALS:
Statistical Software: The open source, freeware statistical software R will be used.
Recommended Textbook:

- Pagano, M., Gauvreau, K. Principles of Biostatistics, 2nd Edition, ISBN-10: 1138593141.

SUITABLE FOR 1ST YEAR STUDENTS:
Not recommended; permission from course leader required if seeking to take this course in the first year.

STUDENT ASSESSMENTS:
Final project (100%).

CREDIT HOURS: 1.0

BIOS 7020A – Responsible Conduct of Research - Advanced

COURSE LEADER:
Victoria H. Freedman, PhD | Diane Safer, PhD

COURSE DESCRIPTION:
This advanced course in the responsible conduct of research is for the more experienced (5th year) graduate students and postdocs. The National Institutes of Health (NIH) requires that all pre-doctoral and post-doctoral trainees receive training in the responsible conduct of research at a frequency of every four years. (All pre-doctoral and post-doctoral trainees are required to take the first instance of the RCR course in year one of training.)

This advanced course will cover the following topics:

- Overview of RCR and Policies
- Data Management Practices and Problems; Rigor and Reproducibility
- Authorship and Publication – Pitfalls and Problems; Strategies for Success
- Mentor and Trainee Responsibilities and Relationship Issues; AToRT
- Effective Communication for Success in Inclusive and Diverse Teams
- Becoming a Resilient Scientist; Balancing Expectation and Reality

The first session will be a general overview and review of institutional, professional and national policies, as well as reporting practices and discussion of some problems in the conduct of science. The following sessions will consist of a mixture of didactic material and small group work to review common scenarios and work together on problem-based case studies.

This course fulfills the NIH retraining in RCR requirement and is *required for PhD students and post-doctoral fellows in the 5th year of training.*

PREREQUISITES:
1st year Responsible Conduct of Research

REQUIRED MATERIALS:
Course readings will be distributed or made available as pdf files on CANVAS.

SUITABLE FOR 1ST YEAR STUDENTS: No.

STUDENT ASSESSMENTS:
To satisfy this advanced course, attendance at every session for the full session is required. Missing a session (due to illness or professional travel) will require the submission of a make-up assignment in order to complete the course. Students who miss more than one session will be dropped from the course and will be required to re-take the full course.

CREDIT HOURS: 1.0

CLRM 5820 – Epidemiologic Research Methods

COURSE LEADER:
H. Dean Hosgood, PhD

COURSE DESCRIPTION:
This course focuses on the analytical issues of epidemiological studies: biases, confounding, interaction, and statistical methods used in case-control and longitudinal studies. In-class exercises will reinforce these concepts. Students are expected to know the basic design issues of retrospective and prospective studies as well as clinical trials from the Clinical Research Intensive course.

PREREQUISITES:
Clinical Research Intensive (summer course).
Students are expected to know the basic design issues of retrospective and prospective studies as well as clinical trials from the Clinical Research Intensive course.

REQUIRED MATERIALS:
Moyses Szklo & F. Javier Nieto: Epidemiology: Beyond the Basics. 3rd Edition, Jones & Bartlett Publishers, Sudbury, Massachusetts, 2012. ISBN-13: 9781449604691; ISBN-10: 1449604692. Available online through the Einstein Library. To access the e-book you must be at Einstein or have remote access to the Library.

SUITABLE FOR 1ST YEAR STUDENTS:
No.

STUDENT ASSESSMENTS:
In-class exercises/class participation 50%, Mid-term test 25%, Final Exam 25%.

(CLOSED REGISTRATION) LIMITED TO 15 STUDENTS NEED APPROVAL FROM PROGRAM DIRECTOR-DR. AILEEN MCGINN (PICK UP COURSE REGISTRATION FORM IN THE GRADUATE OFFICE)

CREDIT HOURS: 3.0

CLRM 5860 – Multivariable Regression

COURSE LEADER:
Aileen P. McGinn, PhD

COURSE DESCRIPTION:
Multivariable Regression builds on the knowledge of univariate and bivariate analyses that were learned in the Clinical Research Intensive course and introduces concepts related to multivariable model building for multiple linear regression, logistic regression and survival analysis. Both the lecture and the lab will focus on multiple regression model building, interpretation and diagnostic tests, assessing for interaction, and statistical adjustment for confounding.

COURSE OBJECTIVES:

- To learn the basics and applications of multivariable regression in assessing associations between exposure/explanatory variables and various forms of outcome variables.
- To use Stata software to conduct multivariable regression and be able to interpret results from the application of these modeling techniques.

PREREQUISITES:
Clinical Research Intensive; Students are expected to know the material covered in Clinical Research Intensive, including univariate and bivariate statistical analyses and basic epidemiological study designs.

REQUIRED MATERIALS:

- Regression Methods in Biostatistics. *Vittinghoff et al*: ISBN-13: 9781461413523; ISBN-10: 1461413524

NOTE: this textbook is available online via the Einstein Library as a pdf

- *Primer of Applied Regression and Analysis of Variance*. *Glantz & Slinker*. ISBN-13: 9780071360869; ISBN-10: 0071360867. NOTE: available for loan via the CRTP Library—please see Nancy Marte in Block 506
- Applied Logistic Regression by David W. Hosmer, Stanley Lemeshow & Rodney X. Sturdivant (3rd edition). ISBN-13: 9781118548356; ISBN-10: 1118548353. NOTE: this textbook is available online via the Einstein Library as a pdf
- Survival Analysis: A Self-learning Text by David Kleinbaum and Mitchel Klein (3rd edition). ISBN-13: 9781493950188; ISBN-10: 1493950185. NOTE: this textbook is available online via the Einstein Library as a pdf

SUITABLE FOR 1ST YEAR STUDENTS:
No. Closed registration: limited to students on the PCI track.

STUDENT ASSESSMENTS: Class Participation 10%, Homework 30%, In-class quizzes 15%, Take home exams 45%.

CREDIT HOURS: 5.5

Block II

BIOS 8006 – Biology of Aging

COURSE LEADER:
Ana Maria Cuervo, MD, PhD | Nir Barzilai, MD | Derek Huffman, PhD

COURSE DESCRIPTION:
Why do we get old? Is aging a disease or a physiological stage in life? As the percentage of aging population grows, under what has been termed as "global aging", the need to understand the peculiarities of the aging process increases and has become a priority for public health. The common goal of aging researchers is being able to extend the healthy active years of life. Research in Biology of Aging is in exponential expansion because this field has benefit in recent years from the advances in many other areas of research going from genetics to cell biology, biochemistry of proteins, systems biology, etc. Furthermore, classical studies of genetics of longevity in laboratory species are now escalating to humans, thus making possible a better understanding of both physiological aging and age-related diseases.

This course presents an in-depth analysis of the biology of aging, building up from changes occurring at the molecular and cellular level and analyzing the consequences at the organism level. In addition, the influence of these age-related changes in what are commonly considered a disease of aging, such as neurodegeneration, diabetes, etc., will also be discussed. Topics will include: theories of aging, experimental models used to study of aging and longevity, impact of oxidative stress in cell and organ function, the metabolic syndrome of aging, functional changes in the immune and central nervous systems, genetic instability and genetics of aging and longevity.

COURSE OBJECTIVES:

- To learn about the basic cellular and molecular processes that contribute to aging.
- To understand the impact that modulating aging may have in the course of age-related disorders.
- To gain a better understanding of ongoing interventions aiming at modulating aging.

PREREQUISITES:
Undergraduate courses in Biochemistry, Cell Biology, Genetics and Statistics highly advisable. Students who have taken graduate Cell Biology and Genetics will be able to get the most out of this course.

REQUIRED MATERIALS:
Vijg, J., Campisi, J., Lithgow, G. 2015. Molecular and Cellular Biology of Aging Published by the Gerontological Society of America (Text book available here: https://www.geron.org/publications/molecular-and-cellular-biology-of-aging.)

Other resources (selected chapters): The Encyclopedia of Aging (Schulz,R, Noelker LS, Rockwood K and Sprott R.), 2006*; Aging and age-related diseases: the basics (Karasek, M), 2006*; ISBN-10: 0826148433; ISBN-13: 9780826148438.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Grade will be combination of attendance, participation and presentations in Journal Club.

CREDIT HOURS: 2.0

BIOS 7024 – Chemical Biology

COURSE LEADER:
Jonathan Lai, PhD

COURSE DESCRIPTION:
This class will examine fundamental principles and current techniques for the use of chemical methods to manipulate and study biological processes. Topics include synthesis and screening of chemical and protein libraries, methods for modification of proteins, display technologies, enzymology, and ProTAC/LysoTAC design. Instruction will take the form of two 50-min lectures per week by topic experts, and four graded team-based learning sessions based on primary literature. In addition, there will be two examinations. In-class learning will be supplemented by TA-led discussion sessions once every two weeks.

COURSE OBJECTIVES:
The goal of this course is to provide students with a foundational framework of concepts in Chemical Biology that can be applied to drug discovery or basic research on biological systems. Upon completion of this course, successful students will:

- Critically assess Chemical Biology primary literature and communicate methods and conclusions to their peers.
- Demonstrate knowledge of fundamental principles of Chemical Biology and how those may be applied to biological systems.
- Demonstrate the ability to select Chemical Biology methods to solve problems in a biological system.

PREREQUISITES:
Required course: Biochemistry (Block I)

REQUIRED MATERIALS: Laptop.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
Two presentations (20% each): Students will be assigned into teams and will be responsible for reading assigned literature, providing critical analysis, and then presenting to the rest of the class. Evaluations will be performed by the Course Director in conjunction with contributing lecturers and be based on clarity, accuracy, composition of slides, and critical dialogue.
Discussant on two presentations (5% each): Students will listen to other student presentations and provide commentary or ask questions. Participation is expected.
Two in-class examinations (25% each): Students will be expected to demonstrate knowledge of the assigned topics, and to critically analyze methodologies and formulate experimental strategies to apply them to biological problems.

CREDIT HOURS: 3.0

BIOS 7018 – Computational Biology of Proteins and Python

COURSE LEADER:
Andras Fiser, PhD

COURSE DESCRIPTION:
An introductory course to Protein Bioinformatics. We provide a systematic introduction to the major techniques, algorithms and tools used in Bioinformatics (for sequence alignments, classifications, secondary and tertiary structure predictions, modeling, sampling of conformations, energy functions, prediction of various functional and structural features of proteins, docking etc.).

We also devote about one third of the lectures to provide an introductory Python programming course with practical applications in bioinformatics.

COURSE OBJECTIVES:

- To learn fundamentals of bioinformatics algorithms and most frequent applications in protein science research
- To learn python programming

PREREQUISITES:
None.

REQUIRED MATERIALS:
Not required, but suggested:

- Dekker, M., Computational Biochemistry and Biophysics. New York, NY. ISBN-13 978-0824704551.
- Durbin, R., Eddy, S.R., Krogh, A., Mitchison, G., Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. ISBN-13 978-0521629713.
- Baldi, P., Bioinformatics: The Machine Learning Approach, Second Edition. ISBN-13 978-0262025065.
- Sternberg, M.J.E., Protein Structure Prediction: A Practical Approach. ISBN-13 978-0199634965.
- Rigden, D.J., From Protein Structure to Function with Bioinformatics. 2009. ISBN-13: 978-1402090578.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
25% Midterm exam
25% Python programming exam
25% Final exam
25% Attendance
A pass requires 75%

CREDIT HOURS: 3.0

BIOS 7007 – Gene Expression: Beyond the Double Helix

COURSE LEADER:
David Shechter, PhD | Matthew Gamble, PhD | Kristy Stengel, PhD

COURSE DESCRIPTION:
This course deals with molecular mechanisms of biological information content. Specifically, the course will tackle the question of how the information contained within DNA, RNA, and chromatin is stored and used in different biological contexts. The major focus is on the molecular mechanisms of the regulation of gene expression and their impact on cellular functions. Students will learn how to critically think about interpreting and designing experiments. Topics include: the genome and DNA, the biochemistry of DNA transcription into RNA, biochemistry of chromatin and the histone code, regulation of transcription and of chromatin structure, its modification and role in epigenetic phenomena; metabolism of the major cellular classes of RNA, emphasizing transcription, processing, stability/degradation, and translation of messenger RNA into protein and control at each of these steps; the role of RNA-mediated catalysis in biology and evolution; the biology and biochemistry of non-coding RNA and the use of RNAi as an experimental and therapeutic tool.

COURSE OBJECTIVES:
Biological Information, i.e. DNA, RNA, Chromatin, Translation, other information stores.

PREREQUISITES:
Undergraduate course in molecular biology at the level of Alberts “Molecular Biology of the Cell” and 1st Block Biochemistry.
Students should be familiar with nucleic acid structure, college-level genetics, graduate biochemistry level protein structure/function.

REQUIRED MATERIALS:
Computer.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
There will be three exams. The first will be an oral exam, and the final two exams will be take-home, open book exams. These exams will cover content from lectures, discussion sections, and readings. Critical thinking and experimental design and interpretation are key parts of the grading. Grades and constructive feedback will be returned. The exams will count for 80% of the final grade. Discussion section participation (attendance and oral contributions) will count for 20% of the final grade.

Attendance at all lectures is expected. If a student will be absent for a lecture, they must inform the course leaders. Unexcused absence from a TBL will result in a "0" grade for that session.

CREDIT HOURS: 5.0

BIOS 7022 – Immunology

COURSE LEADER:
Gregoire Lauvau, PhD | Teresa DiLorenzo, PhD

COURSE DESCRIPTION:
This course will consider both innate and adaptive immunity and include the structure and function of key receptors including innate Pattern Recognition Receptors, Major Histocompatibility Complex, Immunoglobulins and T Cell Receptors. The mechanisms of innate immune responses, antibody formation and molecular aspects of cellular immunity, including T and B cell interactions and memory lymphocyte formation, will be emphasized, and connections to modern biomedical science will be highlighted. These will include presentations and discussions on autoimmunity, immunity against microbial pathogens, transplantation, and tumor immunology. The course will rely on multiple materials, including formal lectures (by sixteen Einstein faculty), seminal paper discussions, immunological methods and mouse model lectures, assigned reading (selected textbook chapters and cutting-edge review articles), didactic videos, and data-driven learning sessions ("hands-on" data analysis and interpretation).

COURSE OBJECTIVES:
The goal of the course is to provide students with a broad overview of basic immunology, while also delving deeply into cellular and molecular details in areas of central importance to the field. Successful completion of the course will provide students with strong fundamental knowledge in basic immunology, and assist them in deepening their knowledge of current research and developments in modern immunology.

PREREQUISITES:
Although there are no formal prerequisites, students who are completely new to immunology are especially advised to do some preparation in advance to become familiar with the basics.

REQUIRED MATERIALS:
Textbook: Janeway's Immunobiology 10th edition, Murphy, Weaver, and Berg, ISBN-13: 978-0393884906, ISBN-10: 0393884902
Computer access; internet access.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:

First-quarter exam	15 points
Participation	10 points
Midterm exam	30 points
Final exam	45 points
	100 points

Students earning a total of 70 points or greater will receive a passing grade for the course. Lower point totals may also qualify as passing, but this will need to be determined once the grade distribution has been evaluated.

The participation grade will be determined based on attendance and contributions to class discussions, including seminal paper and data sessions.

CREDIT HOURS: 4.0

BIOS 7005 – Molecular Cell Biology

COURSE LEADER:
Arne Gennerich, PhD | Rebeca San Martin, PhD

COURSE DESCRIPTION:
This advanced course provides an in-depth exploration of eukaryotic cell biology, spanning from molecular mechanisms to cellular architecture and function. Emphasis is placed on current, actively researched topics, including intracellular protein transport, nuclear dynamics, and cytoskeletal organization.

Key Topics

- **Membrane Structure & Biogenesis**: Lipid and protein organization; membrane compartmentalization; signal hypothesis and protein targeting
- **Intracellular Membrane Function**: Vesicle trafficking, intracellular sorting, exocytosis, endocytosis, and membrane fusion
- **Nuclear Structure & Function**: Nuclear envelope organization, chromatin architecture, nucleocytoplasmic transport, mRNA localization
- **Cytoskeletal Dynamics**: Self-assembly and organization of actin, microtubules, and intermediate filaments; molecular motors; roles in mitosis, cell shape, and motility
- **Cell Cycle & Mitosis**: Molecular regulation of checkpoints, cyclins/CDKs, checkpoint signaling, and cancer-related dysregulation
- **Cell Interactions & Signaling**: Cell junctions, extracellular matrix (ECM), integrin dynamics; small GTPases and downstream signal transduction pathways

COURSE OBJECTIVES:
At the end of this course, you will understand the structures and functions of most cell components and how they communicate and interact with each other. It will make scientific literature and seminars more accessible to you. You will develop an overall sense and feel for life on a cellular level.

By the end of the course, students will be able to:

1. Identify major cellular components and explain how their structures relate to function across organelles, membranes, and the cytoskeleton.
2. Describe and compare pathways of intracellular trafficking, signal transduction, and cell cycle control, and predict how their perturbation may affect cellular behavior or disease states.
3. Integrate knowledge of subcellular processes to formulate mechanistic hypotheses and design logical experimental approaches.
4. Interpret, analyze, and critically evaluate data from primary research articles.
5. Gain fluency in scientific literature and seminars, building intuition for how cells work as dynamic, integrated systems.

PREREQUISITES:
Some background in biochemistry, molecular biology, and cell biology is helpful but not required.

REQUIRED MATERIALS:

- Alberts, B., Molecular Biology of the Cell, 7th Edition. https://digital.wwnorton.com/mboc7 ISBN-10: 0393884821; ISBN-13: 978-0393884821.

Reading the relevant chapter(s) prior to the lecture is required and essential for understanding the lectures. Additional required reading material will be provided by each lecturer consisting of review articles and original research articles.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:

Student performance will be evaluated based on three in-class exams, which will form the primary basis for the final grade. In addition, participation and performance in three Team-Based Learning (TBL) sessions will contribute to the final grade to a lesser extent.

Grading will be curved, rather than based on fixed percentage thresholds. The curve and grade distribution will be discussed with the class following each exam to ensure transparency.

Attendance is expected.

CREDIT HOURS: 5.0

BIOS 7011 – NMR for Chemistry and Biochemistry

COURSE LEADER:
David Cowburn, PhD | Sean Cahill, PhD

COURSE DESCRIPTION:
The course will provide a gentle but thorough introduction to basic NMR theory and principles followed by application of NMR to solving various chemical and biochemical problems. Topics will include one-, two-, and 3-dimensional NMR methods applied to: the covalent structure and conformation of small molecules and macromolecules, ligand binding and exchange rates, pKa values, and enzyme mechanisms. Lectures will be combined with hands-on sessions in the NMR lab, where students will be assigned projects to be completed on the NMR spectrometers.
NOTE: there are approximately 7 labs that will require some time outside of the assigned block to complete - prepare to spend 1-2 hours for each lab to run experiments and/or analyze data on your own time.

COURSE OBJECTIVES:
Students will acquire the basic skills for running NMR experiments and interpreting NMR data from a variety of applications in chemistry and structural biology.

PREREQUISITES:
A general familiarity with organic chemistry and biochemistry.

REQUIRED MATERIALS:
Computer or laptop.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
Lab reports and problem sets: 75%
Scores on late reports/problem sets are discounted 10%/day; lowest score will be dropped

Presentation: 25%
Score based on

- Introduction to paper and problem studied
- NMR methods and details of experiments performed
- Summary and discussion of results
- Conclusions, future directions and timing of talk

Grade required to pass: 65/100; w/ Honors: 93

CREDIT HOURS: 2.5

BIOS 7407 – Principles of Neuroscience II

COURSE LEADER:
Anita Autry, PhD | J. Tiago Goncalves, PhD

COURSE DESCRIPTION:
Principles of Neuroscience II is a 13-week course required for students in the Department of Neuroscience. In this course, students will explore how complex neural systems integrate afferent information and direct efferent outflow, and the mechanisms underlying the development of these neural systems. The overall goal will be to explore higher order functions, such as the structure and function of neural systems underlying sensation and movement, learning and memory at the sensory and motor levels, as well as higher-level cognitive processes, followed by investigation of the developmental mechanisms driving the structure and function of neural networks. Student knowledge in these areas will be built on a firm understanding of the underlying physiology and anatomical structure. Principal areas of interest will be on hierarchical neural systems, the plasticity of neural networks, serial and parallel neural processing, cognition and computational modeling.

COURSE OBJECTIVES:
- To learn the role of neural networks in high-order perceptual, motor and behavioral states functions.
- To learn computational approaches explaining brain functions.
- To learn how to write a research grant.

PREREQUISITES:
Required course: Principles of Neuroscience I (Block I).

REQUIRED MATERIALS:
Online access to Zoom lectures, books and journals available at Einstein's library.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
The grade in this course will be based on participation in class (25%), proposed research project, midterm projects critiques (25%), and final proposed research project (50%).

CREDIT HOURS: 6.0

BIOS 8002 – Quantitative Imaging of Cells

COURSE LEADER:
Vera DesMarais, PhD | David Entenberg, PhD | Frank Macaluso, MS

COURSE DESCRIPTION:
The class Quantitative Imaging of Cells is given as interactive lectures with weekly lab sessions and will introduce students to the physical concepts of optical and electron microscopy and their practical applications to biomedical research. Lectures will cover the properties of light, hardware components and applications of standard and advanced microscopes, such as basic light and fluorescence, confocal, TIRF, light-sheet, multiphoton, and superresolution. There will be additional focus on image processing and image presentation, as well as specialty applications including an overview of fluorescent molecules and photomanipulation techniques, FRET, and Optical Tweezers. Subsequent lectures will cover transmission, scanning and cryo electron microscopy. Lab sessions will include hands-on demonstration sessions on microscopes.

COURSE OBJECTIVES:
To give students an overview of modern light and electron microscopy technology and how to apply it to biomedical research.

PREREQUISITES:
None.

REQUIRED MATERIALS:
None.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
3 exams spaced throughout the Block and a final presentation, each 25% of the overall grade, passing level at 80% overall.

CREDIT HOURS: 5.0

BIOS 7020 – Responsible Conduct of Research

COURSE LEADER:
Victoria Freedman, PhD | Anne Bresnick, PhD | Diane Safer, PhD

COURSE DESCRIPTION:
This course fulfills an NIH mandated training requirement and is required for all 1st year pre-and post-doctoral trainees.

Topics:
- Overview of RCR
- Research Misconduct
- Protection of Human Subjects
- Welfare of Laboratory Animals
- Conflicts of Interest
- Data Management Practices
- Collaborative Research
- Mentor and Trainee Responsibilities
- Resilience and Self-Efficacy
- Responsible Scientist
- Safe Research Environments
- Authorship and Publication
- Peer Review

COURSE OBJECTIVES:
The Responsible Conduct of Research course is designed to introduce key issues in the responsible conduct of research (RCR), by following the research process from inception to planning, conducting, reporting, and reviewing biomedical research. The course will provide an overview of the rules, regulations, and professional practices that define the responsible conduct of research. In addition, the course aims to provide a practical framework for ethical decision making when faced with difficult situations in the research and training environment.

PREREQUISITES:
None.

REQUIRED MATERIALS:
The textbook "ORI Introduction to the Responsible Conduct of Research" by Nicholas H. Steneck (Department of Health & Human Services) features case studies, text-box inserts, discussion questions and electronic and printed resources. The text is available online as a PDF document (http://ori.hhs.gov/documents/rcrintro.pdf). Each session of the course is associated with one or more chapters from the text.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes. Required for 1st year students and PREP scholars.

STUDENT ASSESSMENTS:

No class session may be missed in order to receive credit. An incomplete grade for the course will require retaking missed sessions the following semester.

CREDIT HOURS: 1.5

BIOS 7015 – Viruses

COURSE LEADER:
Vinayaka Prasad, PhD | Kartik Chandran, PhD | Ganjam Kalpana, PhD

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.

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.

REQUIRED MATERIALS:

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

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

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

CREDIT HOURS: 3.0

CLR 5000 – Design and Conduct of Clinical Research

COURSE LEADER:
H. Dean Hosgood, PhD

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:

- Hulley S.B., Cummings S.R., Browner W.S., Grady D.G., Newman T.B., 2013. Designing Clinical Research, 4th Ed. Lippincott Williams & Wilkins; Philadelphia. 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

Block III

BIOS 7409 – Approaches to Study Neural Circuits in Behaving Animals

COURSE LEADER:
Anita Autry, PhD | Lucas Sjulson, MD, PhD

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 of 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 on 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.

STUDENT ASSESSMENTS:

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.

Attendance:
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

BIOS 8013 – Course Design and Teaching in the Age of Artificial Intelligence

COURSE LEADER:
Michael Risley, PhD

COURSE DESCRIPTION:
Research and teaching are two major spheres of scholarship and responsibility for most faculty in academic science. Although we are often expected to teach and show evidence of good teaching, our training in teaching and learning is frequently weak, and research training does not substitute for training to teach. Training in the science and art of teaching is uncommon, particularly in the research-intensive environment of a medical school.

This course will educate students in fundamental concepts and principles widely used in the design and execution of courses for adult learners (college and postgrad). Topics will include cognitive hierarchies and multiple intelligences in adult learning, course, lesson and syllabus design, lecture hall strategies, active learning strategies, formative and summative assessment techniques.

Since the advances in artificial intelligence (AI), educational strategies are undergoing rapid substantive changes. This course will teach the application of AI in syllabus and lesson plan design and writing, the design of student learning assignments, and the design and grading of assessments discussed in class.

COURSE OBJECTIVES:

- Participants who complete the full course will be able to:
- Describe the traits most common to highly successful teachers and courses.
- Identify the varied characteristics of adult students as a basis for designing courses, learning environments and activities.
- Differentiate significant (deep) from superficial learning.
- Define cognitive hierarchies and backward design as fundamental principles for course and lesson planning.
- Design lessons, courses and syllabi consistent with defined learning objectives, learning hierarchies and diversity in learning preferences.
- Describe the importance of active learning theory and varied instructional modalities to achieve active learning in diverse settings, including the lecture hall.
- Design formative and summative assessments of student learning, teaching and course effectiveness.
- Apply artificial intelligence models to design and write course syllabi, lesson plans and learning activities.

PREREQUISITES:
No prerequisite course, however, graduate students interested in taking this course must have completed the Qualifying Exam.

REQUIRED MATERIALS:
Computer access; readings from diverse sources will be provided via Canvas.

SUITABLE FOR 1ST YEAR STUDENTS:

No. This course is for graduate students who have completed the Qualifying Exam; postdocs; required of postdocs in NIH IRACDA program; faculty.

STUDENT ASSESSMENTS:

15% quiz 1
15% quiz 2
10% Report on a single AI supported learning activity
30% syllabus design report
30% lesson plan design report; passing will require 65% grade

Attendance:
No more than three absences.

CREDIT HOURS: 2.0

BIOS 7414 – Glial Biology and Pathobiology

COURSE LEADER:
David Spray, PhD

COURSE DESCRIPTION:
Glia are the most abundant cells in the brain, where they are specialized for certain functions and play major roles in nervous system physiology and pathology through their many types of interactions with neurons. Like neurons, glia possess ion channels and receptors for neurotransmitter and modulatory molecules and they communicate with one another and with neurons through gliotransmitter release and gap junction mediated spread of intercellular signals. Astrocytes contact neuronal synapses, providing a third element ("the tripartite synapse") to the pre- and postsynaptic neurons and also form endfeet upon cerebral vessels by which they control blood flow and the delivery and removal of nutrients and metabolites to and from the brain parenchyma. Together with microglia, astrocytes release and respond to inflammatory signals and remodel extracellular space. Microglia are the neural equivalent of macrophages, with primary functions of debris clearance and immune responses. They also remodel neuronal structure, playing a major role in synaptic plasticity during development and in learning processes. The third glial subtype, oligodendrocytes (and their peripheral counterparts, the Schwann cells) are responsible for axon myelination and have recently been implicated in neural developmental disabilities.

As a 6-week elective, this course will offer students a unique opportunity to focus on the cell biology and pathobiology of the cells that are most abundant in brain and perform highly specialized functions in the nervous system and behavior.

COURSE OBJECTIVES:
This nano course, with lectures delivered by Einstein faculty working on each of the glial subtypes, is designed to familiarize students with glial biology and pathobiology. While the coverage will be broad, it will emphasize the frontiers of research methods and questions and will highlight current controversies in the field. Specific objectives include:
1. To learn fundamental properties of the various types of glia in the central and peripheral nervous system
2. To learn current methods to study glial physiology in vivo and ex vivo
3. To learn the precise roles that glia play in neurological disease

PREREQUISITES:
None. Undergraduate neuroscience recommended.

REQUIRED MATERIALS:
Although not required, new textbooks provide additional material that may be of interest:

- Monk, K., Freeman, M., Stevens, B., Glia, Second Edition, Cold Spring Harbor Press 2024 ISBN-13: 978-1-621824-64-0
- Scemes, E., Spray, D., Astrocytes, Wiring the Brain, Second Edition CRC Press, 2025, ISBN 9781032756165

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:

The final grade will be reported as Pass (P) or Fail (F), based on a mid-course exam and a final brief presentation by each student. The exam will consist of one or two general questions about each of the first six course lectures, and the brief (10 min) presentation will deal with any topic relevant to glial pathobiology. Lecturers will submit questions and grade exams and judge presentations for content and clarity. Participation in class discussion will be encouraged and if students are apparently not engaged, the course director will discuss the concerns.

25% mid-course exam, 25% participation, 50% final presentation

Attendance:

Physical attendance is expected, as there will be no Zoom and there will be no posted recordings of lectures. Presentations will be available for view on Canvas, and any student not in attendance will be expected to review the presentations and ask faculty or other students for explanations of material that is unclear. Multiple absences will affect final grade.

CREDIT HOURS: 1.25

BIOS 7002 – Human Metabolism: Regulation and Disease

COURSE LEADER:
Maureen Charron, PhD

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:

- Devlin, T.M. (ed) Textbook of Biochemistry with Clinical Correlations, 6th Edition. ISBN-13: 978-0471678083.

SUITABLE FOR 1ST YEAR STUDENTS: Yes.

STUDENT ASSESSMENTS:
- 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%

CREDIT HOURS: 4.0

BIOS 7026 – Introduction to Systems Biology

COURSE LEADER:
Yinghao Wu, PhD | Aviv Bergman, PhD

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.

Attendance:
Students are expected to attend all classes regularly. Absence should be reported to the corresponding lecturers with acceptable excuses ahead of the lectures.

CREDIT HOURS: 3.0

BIOS 7013 – Mechanisms of Disease

COURSE LEADER:
David Fooksman, PhD

COURSE DESCRIPTION:
This multidisciplinary survey 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), and Cardiovascular disease. The course will focus on molecular, biochemical, cellular mechanisms of disease, as well as risk factors such as aging, environmental, societal, and 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, which will culminate in a study section-like discussion of some of the proposals.

COURSE OBJECTIVES:
The course will provide introduction to numerous pathologic diseases and underlying disease processes, at the genetic, biochemical, cellular, and system level. The goal of the class will be to understand the basic disease-causing processes, and to be able to compare and contrast how different diseases may utilize similar or different mechanisms. All students will learn how to critically read and analyze wide-ranging, cutting-edge journal articles across biomedical fields, ask questions and participate in a journal-club discussion. Individually, students will also develop and present the paper and background to their peers, teach a topic, lead a discussion. In addition, students will have a chance to envision future research plans by writing their own specific aims page to follow-up on their topic, which will undergo revisions in consultation with Dr. Fooksman. Some of the proposals will be selected for an NIH-like study section to discuss the merits and weaknesses of the proposals, and to have them scored.

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.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Grading will be based on class participation (33%), two oral presentations (33%) and a follow-up assignment and study section (33%).

For class participation, students will be expected to come prepared for class, having read all 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 initial oral presentations, 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, quality of the follow-up assignment, and participation in study section.

Attendance:

Attendance is mandatory for all lectures. No unexcused absences are permitted.

CREDIT HOURS: 3.0

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

COURSE LEADER:
Ruben Coen-Cagli, PhD

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.

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).
• 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 ASSESSMENTS:
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.

Attendance:
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

COURSE LEADER:
Ruben Coen-Cagli, PhD

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 learning 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 7 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).

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 ASSESSMENTS:
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 the exercises.

Attendance:
Students are expected to attend all classes. If missing a workshop class, they 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

COURSE LEADER:
Derek Huffman, PhD | Hayley McDaid, PhD

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.

STUDENT ASSESSMENTS:
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.

Attendance:
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

COURSE LEADER:
Mark Wagshul, PhD | David C. Zhu, PhD | Qi (Chris) Peng, PhD

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. An important component of the course will be hands-on experience on a 3T MRI scanner, which will take place every other week to help solidify the information covered in the lectures.

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:
Haacke, E.M., Magnetic Resonance Imaging: Physical Principles and Sequence Design. ISBN-10: 0471351288.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

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

The final project will be in the form of a critical review of a peer-reviewed MRI methods paper. The student will present paper review in an oral presentation (15-20 min) to be delivered during the last week of classes.

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).

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.

Attendance:
Attendance is mandatory. In the event of occasional, valid reasons for missed classes, students can discuss with the course instructors to make up missed material.

CREDIT HOURS: 3.0

BIOS 7029 – Stem Cells, Development and Disease

COURSE LEADER:
Andreas Jenny, PhD | Teresa Bowman, PhD

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 ASSESSMENTS:
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. 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.

Attendance:
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 7033 – Survey of Medical Imaging and Applications

COURSE LEADER:
Mark Wagshul, PhD | Tim Duong, PhD

COURSE DESCRIPTION:
The course will cover the basic principles of biomedical imaging, including fundamentals of x-ray, nuclear medicine and magnetic resonance imaging. For each imaging modality, we will use case studies to highlight the underlying principles and particular strengths of the specific modality. Throughout the course, examples will draw from both clinical and pre-clinical (animal) examples, and how they may relate to students' own research questions.

COURSE OBJECTIVES:
This course is designed as a survey of medical imaging, both to introduce students to what medical imaging can do, as well as how they might be able to apply it within the context of their own research questions. It will introduce the primary state-of-the-art imaging modalities (x-ray, CT, MRI, nuclear medicine, PET and ultrasound), including instrumentation and the unique imaging methodologies for each of the modalities. The course will focus on applications of each of the modalities in specific diseases.

PREREQUISITES:
None.

REQUIRED MATERIALS:

- Suetens, P., Fundamentals of Medical Imaging, 2nd Edition. 2009. ISBN-13: 978-0521519151.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
50% final project, 25% problem sets (4-5 per block), 10% attendance, 15% participation

CREDIT HOURS: 1.25

BIOS 7027 – Systems Biology Seminar

COURSE LEADER:
Aviv Bergman, PhD

COURSE DESCRIPTION:
It has long been recognized that scientific breakthroughs and groundbreaking research in the coming century requires multidisciplinary approaches to many areas of research. By means of critical reading of classical and contemporary articles the course will cover a broad range of relevant techniques from mathematical, statistical and computational sciences, and their relations to the specific scientific questions in each of the articles discussed. The course will cover 26 articles on biological questions that have been addressed both theoretically and experimentally. These articles will cover a broad range of biological topics from molecular biology, evolutionary biology, geonomics and neuroscience.

COURSE OBJECTIVES:
The goal is for students to understand each paper.

PREREQUISITES:
None.

REQUIRED MATERIALS:
None.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Grading for this unit will be made up of a combination of both participation within the class setting and papers' presentations. Depending on the number of students participating, each student will present and discuss 3-5 assigned papers which together will be worth 50-75%. Class participation will make up the remaining % will be class participation.

Attendance:
In-person attendance is mandatory for all classes.

CREDIT HOURS: 3.0

BIOS 7410 – Techniques in Human Neuroscience

COURSE LEADER:
Sophie Molholm, PhD | Elyse Sussman, PhD

COURSE DESCRIPTION:
This course will provide a survey of current methodologies used in the study of human neuroscience and behavior. These include functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), functional near-infrared spectroscopy (fNIRS), event-related brain potentials, mobile brain/body imaging (MOBI), and clinical assessments. Lectures will focus on the tools and techniques used to understand brain systems that enable memory, attention, language, scene perception, and executive functions, and the development of these processes across the lifespan.

COURSE OBJECTIVES:
- Learn the range of methodologies used to investigate the brain basis of human cognition.
- Identify strengths and limitations in the study of complex brain functions.

PREREQUISITES:
None

REQUIRED MATERIALS:
Suggested reading: Eds: Gazzaniga, M.S., Mangun, G. R., The Cognitive Neurosciences, 5th Edition. 2014. MIT press, Cambridge MA. ISBN-13: 978-0262027779.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
Grades will be based on attendance (10%) class participation (30%) and presentation of a paper that includes the strengths and weaknesses of the technique for answering questions about human behavior (60%). Participation will be assessed by daily or weekly reflections on Canvas, that will include short summaries of the main points covered in that week.

Attendance:
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: 1.25

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

COURSE LEADER:
Herbert Lachman, MD

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 PhD 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.

STUDENT ASSESSMENTS:

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.

Attendance:
Only one unexcused absence will be allowed.

CREDIT HOURS: 1.25

CLRM 5821 – Advanced Epidemiologic Research

COURSE LEADER:
Ilir Agalliu, MD, ScD

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.

PREREQUISITES:
Required courses:

- Clinical Research Intensive
- Epidemiologic Research Methods

REQUIRED MATERIALS:

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

SUITABLE FOR 1ST YEAR STUDENTS:
No.

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

CREDIT HOURS: 2.0

CLRM 5861 – Design & Analysis of Longitudinal Data Studies

COURSE LEADER:
Shankar Viswanathan, DrPH

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:
None.

REQUIRED MATERIALS:
Recommended Materials:

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

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
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

Summer

BIOS 7039 – Introduction to R Programming

COURSE LEADER:
Ariel Fishman, PhD

COURSE DESCRIPTION:
This course introduces students to R, a powerful and versatile programming language used extensively in data analysis and statistical computing. The course will cover basic programming concepts, data manipulation and wrangling, documentation, visualization, and the use of AI (ChatGPT) as a tool to help write your R code. This course is designed for students with little to no programming background.
Most sessions will take place in person, but a few will be held virtually. Students are expected to bring a laptop to all sessions as many classes will serve more as "workshops" than lectures. Students are very much encouraged (but not required) to bring, with permission, data sets from their lab, from the public domain, from other courses, and/or those of personal interest.

COURSE OBJECTIVES:

- To learn fundamental R programming, as well as how to write, execute, debug, and annotate R syntaxes.
- To learn different data types, programming concepts, and toolsets, and apply that knowledge to develop good programming habits for tidying, manipulating, and visualizing data.
- To learn data management skills as well as appropriate tools for continuing learning long after the course has completed.

PREREQUISITES:
None.

REQUIRED MATERIALS:
Students must own a laptop computer with administrative rights to be able to install R and R-Studio. (Program installation will be covered in the first session for students who need assistance.)

SUITABLE FOR 1ST YEAR STUDENTS:
Yes.

STUDENT ASSESSMENTS:
The course will be graded on a pass/fail basis. 50% completion of all assignments.
50% attendance and participation in in-class exercises and workshops.

CREDIT HOURS: 1.0

BIOS 5010 – Physiology: Membranes and Transport

COURSE LEADER:
Myles Akabas, MD, PhD

COURSE DESCRIPTION:
Physiology is the study of normal function at the molecular, cellular, organ, and whole organism levels. This course will focus on the role of membranes in the physiology of cells and tissues. Membranes form essential barriers that separate the cytoplasm from the external world and from subcellular compartments such as mitochondria, endosomes, lysosomes, etc. Lipid bilayers are a major component of cellular membranes. They create a barrier to the transport of ions and hydrophilic solutes across cell membranes. Transporters and channels create pathways for the regulated movement of solutes across cell membranes and for the creation of transmembrane electrical potentials. Membrane receptors create pathways for information transfer across cell membranes. Membrane proteins constitute about 25% of the genomes of most organisms.
This course will discuss:
1) the fundamentals of solute transport across cell membranes
2) the role of ion movement in the creation of membrane potentials
3) membrane receptors and second messenger signaling pathways
4) the role and regulation of these transport processes in the physiology of nerves, heart, and epithelia

COURSE OBJECTIVES:
By the end of the course students will be able to explain the structure and functions of membranes and membrane proteins, the mechanisms of solute and ion movement across membranes, the origins of passive and active membrane potentials, membrane receptors and second messenger pathways, and the process of cardiac electrical excitability and epithelial transport.
1) Be able to describe complex, interacting systems starting at the molecular level all the way up to the whole organ and whole organism level.
2) Be able to think about how physiological systems maintain homeostasis. They will be able to describe how systems establish set points and how they respond to perturbations from the set point.

PREREQUISITES:
Prerequisites include one year of general chemistry, physics, and biology, and preferably at least a semester of biochemistry. Students should be familiar with the structure of ions and non-electrolytes in solution, elementary thermodynamics and Gibbs free energy, acid-base chemistry, structure of biological membranes and membrane proteins, electrical potentials, resistance, conductance, and current.

REQUIRED MATERIALS:
Course readings will be made available as pdf files.

SUITABLE FOR 1ST YEAR STUDENTS:
Yes; required for 1st year MSTP students.

STUDENT ASSESSMENTS:

There will be six quizzes and a comprehensive final exam. Class participation in TBL and other sessions will contribute to the grade. Each quiz is worth about 10%. The final exam is worth about 30%. Class participation is worth about 10%. These percentages are somewhat arbitrary and depend on the number of questions on each quiz, which varies. Everyone who makes a reasonable effort to learn the material will pass the course.

CREDIT HOURS: 3.0

CLRM 5840 – Clinical Research Intensive

COURSE LEADER:
Aileen McGinn, PhD

COURSE DESCRIPTION:
This is an intensive introduction to clinical research which provides the fundamental concepts of epidemiology and biostatistics that will provide the foundation for more advanced work in these areas. Additionally, students will learn how to critically evaluate the clinical research literature, understand how to develop a research question, and use statistical software to complete basic data management and statistical analyses.

COURSE OBJECTIVES:
The overall goals of the summer course include:

- Identify and comprehend the fundamental concepts of epidemiology and biostatistics in clinical research that will provide the foundation for more advanced work in these areas
- Be able to use statistical software to complete basic data management and statistical analyses
- Conduct critical evaluation of the clinical research literature
- Understand how to develop a research question and formulate clear and concise specific aims
- Use a simulated sample data set to produce a paper that would (if the data were real) be publishable in a respectable journal

PREREQUISITES:
None.

REQUIRED MATERIALS:
Required Software: STATA 17 BE* perpetual license
Cost $225 purchased via student pricing

Required Textbooks:
You can order the required textbooks at any online bookstore (amazon.com; barnesandnoble.com, etc.)

Basic Statistics and Pharmaceutical Statistical Applications by James E. De Muth, 3rd edition, CRC Press - Taylor Francis Group
ISBN-13: 9781466596733 Available via Ebook @ Einstein Library

Gordis Epidemiology by David Celentatno and Moyses Szklo, 6th edition, (2019)
ISBN: 978-0-323-55229-5 Available via Ebook @ Einstein Library

Designing Clinical Research by Stephen B. Hulley, Steven R. Cummings, Warren S. Browner, Deborah Grady, Thomas B. Newman, 4th edition, LWW (2013)
ISBN-10: 1608318044: Available via Ebook @ Einstein Library

ISBN-13: 978-1608318049

Optional Textbooks:

Designing Clinical Research by Stephen B. Hulley, Steven R. Cummings, Warren S. Browner, Deborah Grady, Thomas B. Newman, 4th edition, LWW (2013)
ISBN-10: 1608318044: Available via Ebook @ Einstein Library
ISBN-13: 978-1608318049

A Gentle Introduction to STATA by Alan C Acock, 6th Edition (2018)
ISBN-13: 978-1597182690
ISBN-10: 1597182699

Practical Statistics for Medical Research by Douglas G. Altman, Chapman & Hall/CRC
ISBN-10: 0412276305
ISBN-13: 9780412276309

SUITABLE FOR 1ST YEAR STUDENTS:

No.

STUDENT ASSESSMENTS:

There will be an in-class final examination for Epidemiology with multiple choice and short answer questions. For Biostatistics, Data Analysis and Developing Your Research Question there will be a take-home, comprehensive final examination. This take-home final will include an analysis and interpretation of a dataset students will be given; the format of this exam will mirror the writing of a peer-reviewed manuscript. The final examinations will count for 2/3 of the grade. Homework, in-class quizzes/exams and class participation will count for 1/3 of the final grade.

CREDIT HOURS: 7.0