UPGEN 778A-F Fall Term 2021
MWF 2-3:30p-Format-In Person

UPGEN 778A-F consists of six mini-courses offered sequentially during the fall semester and together cover 24 topics. These courses are part of the core offerings of the University Program in Genetics and Genomics and allow maximum flexibility for a student-designed curriculum. Multiple topics are available during each mini-course and students choose one. The topics address everything from fundamentals of genetics to modern molecular genetic and genomic strategies for the analysis of a variety of biological systems.

*****Please Note: Any changes made after the September 3rd drop/add deadline will reflect a course withdrawal on a transcript-No Exceptions**

Module A Aug 23– Sept 3	**Section 1** **Ryan Baugh** *C. elegans* Genetics and Genomics 4219 French	**Section 2** **Greg Crawford** "Epigenomic methodologies" 1125 MSRB 3	**Section 3** **Matt Scaglione** Dictyostelium genetics/ development 415 Jones	**Section 4** **Kris Wood** Tumor heterogeneity and evolution 4002 GSRB 1
Module B Sept 6– Sept 17	**Section 1** **Jeremy Kay** "Genetic approaches to understand the nervous system" 384 Nanaline	**Section 2** **Craig Lowe** Writing Genomics Software for Fun and Productivity 4002 GSRB 1	**Section 3** **David Tobin** Zebrafish genetics 0010 CARL	**Section 4** **Raphael Valdivia** Bacterial genetics 1125 MSRB 3
Module C Sept 20– Oct 1	**Section 1** **Alex Ochoa** Genetic population structure and relatedness 384 Nanaline	**Section 2** **Craig Lowe** Misuses of Human Genetic and Phenotypic Data: Past, Present, and Future 1125 MSRB 3	**Section 3** **Nina Tsvetanova** The CRISPR/Cas system and genome editing C335 LSRC	**Section 4** **John Willis** Genomics of Adaptation 4002 GSRB 1
Module D Oct 6– Oct 18	**Section 1** **Raluca Gordan** Protein-DNA interactions 0010 CARL	**Section 2** **Simon Gregory** Genome Technologies 1125 MSRB 3	**Section 3** **David MacAlpine** Mechanisms of chromatin assembly 384 Nanaline	**Section 4** **David Sherwood** Basement membranes—formation, functions, and human disease 4002 GSRB 1
Module E Oct 20– Nov 1	**Section 1** **Steve Haase** Biological clocks 4002 GSRB 1	**Section 2** **Hiro Matsunami** Genetic switches 384 Nanaline	**Section 3** **Blanche Capel** Mouse Genetics and Genomics" 1125 MSRB 3	**Section 4** **John Rawls, Lawrence David and Neil Surana** **"**Exploring the Microbiome" 0010 CARL
Module F Nov 3– Nov 15	**Section 1** **Allison Ashley-Koch** Integrative Genomics 1125 MSRB 3	**Section 2** **Philip Benfey** "Entrepreneurship in the life sciences" 4219 French	**Section 3** **Ashley Chi** "Metabolism and death: Causes and Consequences" 0010 CARL	**Section 4** **Danny Lew** The Logic of Genetics 384 Nanaline

Module Descriptions for Fall 2021:

Module A

***C. elegans* Genetics and Genomics (Ryan Baugh)**
This module covers basic tools and emerging technologies that make the nematode *C. elegans* a powerful genetic and genomic model system. Students will learn how genetic technique like genome editing, RNAi, and mutant screens can be used together with genomic approaches to study genes and pathways that control animal development and behavior. Epigenetic inheritance, aging, and natural variation will be
covered as specific topics.

"Epigenomic Methodologies" (Greg Crawford)
Many biological processes, such as tissue-specific gene expression, X inactivation, and development, are control by sequence-independent (epigenetic) mechanisms that are heritable yet reprogrammable. Aberrant changes in chromatin structure that impact the function of genes or nuclear or developmental pathways can be the basis for many diseases. In this module, students will acquire a basic understanding of experimental chromatin-based techniques used to create functional maps of the genome. Topics will include identification and mapping of chromatin accessible sites, transcription factor binding sites, histone modifications, DNA methylation, long range chromatin looping, and tools to modify the epigenome to empirically test function.

Dictyostelium genetics/ development (Matt Scaglione)
We will explore the usefulness of *Dictyostelium discoideum* as a model organism for investigating a number of biological processes. We will also discuss genetic approaches and discuss fundamental findings that have led to novel insight into human biology. The class will consist of a mixture of lectures, manuscript discussions, and student led presentations.

Tumor heterogeneity and evolution (Kris Wood)
Genomic instability is a hallmark of cancer. Over time, this instability gives rise to heterogeneous, subclonal mutation patterns within tumors that serve as a reservoir for evolution. In this module, we will discuss the mechanisms governing intratumoral genetic heterogeneity and its implications for tumor evolution during disease progression and therapy resistance.

Module B

"Genetic approaches to understand the nervous system" (Jeremy Kay)
In this module we will delve into the link between genes, neural circuits, and behavior. How do genes influence nervous system function? And how do genetic mutations lead to neurological disease? Using examples from model organisms and from human studies, we will examine how genetic approaches are being used to address these two fundamental questions in neurobiology. We will cover classical forward/reverse genetics studies, as well as modern tools such as optogenetics and single-cell sequencing.

Writing Genomics Software for Fun and Productivity (Craig Lowe)
This module will focus on writing software for genomic sequence analysis. We will be covering data structures, unit testing, performance benchmarking, concurrency, and version control. During this course we will be using the Go programming language (golang.org). Experience with Go is not expected, but at least one short course in computer programming is recommended.

Zebrafish genetics (David Tobin)
We will explore the unique attributes of the zebrafish that make it a powerful and rapid system for understanding vertebrate biology. We will cover classic forward genetic screens and mapping, genome editing, transgenesis, cell transplants and chimera analysis, as well as newly emerging techniques and approaches. Finally, we will examine ways in which findings in model systems have been used to understand human biology. The class will also include problem sets that use the zebrafish to explore fundamental genetic principles

Bacterial genetics (Raphael Valdivia)
This module will cover basic aspects of bacterial genetics including mechanisms of DNA exchange by conjugation and phages and how these natural events have been harnessed to perform genotype-phenotype associations in bacteria. We will also review classic papers on the generation of molecular genetic tools and their application to generate complex mutant libraries and perform targeted screens based on reporter genes. Finally, we will revisit these techniques in the context of the post-genomic era.

Module C

Mouse Genetics & Genomics (Blanche Capel)
This module covers the history, nomenclature, basic tools, and emerging technologies of mouse genetics. Lectures cover the concept of inbred strains and their uses, experimental genetic approaches used to make and analyze models of human disease (including various forms of transgenesis and ES cell technology), quantitative trait loci, and emerging resources that facilitate the use of the mouse to study human variation, environmental impacts, and disease susceptibility.

Misuses of Human Genetic and Phenotypic Data: Past, Present, and Future (Craig Lowe)
This module will focus on reading and discussing specific case studies to better understand both historical misuses and present controversies regarding how genetic and phenotypic data sets from humans have been and are being used

The CRISPR/Cas system and genome editing (Nina Tsvetanova)
The goal of this module is to introduce you to the CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) system and its applications in genome editing. We will cover how the CRISPR-Cas microbial adaptive immunity works, the timeline of its discovery, how CRISPR was adapted for precise genome editing, and its *in vitro* and *in vivo* applications. We will go over the principles and workflow of CRISPR-based experiments: which Cas9 enzyme to use, how to design, clone and test gRNAs, and how to verify successful edits depending on the application. We will discuss primary research articles where your critical reading and participation is expected. Students will also work in groups to put together and present a proposal applying CRISPR to answer an outstanding biological question.

Genomics of Adaptation (John Willis)
Contemporary studies of how populations and species evolved adaptations to their ecological habitats. Focus on modern methods of genome mapping and sequence data and analysis in wild populations that can identify genetic changes that contributed to ecological adaptations. Emphasis on case studies of genomics of adaptation in plant and animal systems, including humans and our adaptations to environments that our ancestors encountered as they colonized diverse habitats throughout the world. Examples will also illustrate how speciation and hybridization can contribute to adaptive biodiversity.

Module D

Protein-DNA interactions (Raluca Gordan)
In this module, we will discuss high-throughput techniques for measuring protein-DNA interactions in vitro (e.g. HT-SELEX) and in vivo (e.g. ChIP-seq), focusing on transcription factors. The class will include didactic lectures, paper reading, and oral presentations. We will discuss in detail the advantages and disadvantages of each technique, including sources of noise and bias, and the potential for misinterpreting the data.

Genome Technologies (Simon Gregory)
In this module, students will learn about and discuss the practical and technical application of various state-of-the-art genomic tools. Class will include didactic lectures, paper reading, oral presentations in genomic technologies and online resources to uncover novel insights into biological processes and disease states.

Mechanisms of chromatin assembly (David MacAlpine)
Every time a cell proceeds through S-phase, the regulatory chromatin landscape is disassembled ahead of the replication fork and reassembled in its wake. This module will focus on the intersection of DNA replication and chromatin assembly to define the mechanisms that ensure epigenetic inheritance.

Basement membranes-formation, functions, and human disease (Dave Sherwood)
Basement membranes are a thin, dense, sheet-like extracellular matrix that underlies all epithelia and surrounds most tissues. Basement membranes emerged at the dawn of animal multicellularity and are thought to have been essential for the formation of tissues. Although generally thought of as a static scaffolding that supports and segregates tissues, recent studies are revealing dynamic, diverse, and crucial roles for basement membranes in nearly every aspect of tissue function. The course explores these diverse roles (e.g. differentiation, polarity, tissue shaping, tissue connection) and the growing evidence of basement membrane dysfunction in numerous human diseases as well as its important role in aging.

Module E

Biological Clocks (Steve Haase)
From sleep/wake cycles to flower opening to cell division, all organisms and cells display rhythmic behaviors. These behaviors are regulated by systems called biological oscillators. Specialized oscillators called circadian clocks, have the ability to keep time, so that events can be coordinated with diurnal cycles. In this module, we will examine the molecular mechanisms that comprise oscillators and clocks. We will discuss the common components of oscillating systems and the mechanisms that control the unique dynamics of the clocks and oscillators that regulate cell division and circadian rhythms. Quantitative models of these molecular oscillators will also be examined.

Genetic Switches (Hiro Matsunami)
Cells in our body are specialized; each cell expresses a specific set of genes. How do gene switches control expression in different cell types or even individual cells of the same cell type? This module will cover elements that regulate gene transcription including structure of genes, gene regulatory regions, epigenetic modifications and/or subnuclear localization of genes, all in concert guide the initiation of transcription of specific genes in eukaryotes. Various modes of gene expression controls will be discussed mainly based on careful readings of recent literatures.

Genetic population structure and relatedness (Alex Ochoa)
Population samples are "structured" when individuals do not mate randomly, often due to distance/geography or other constraints. Thus, individuals are related to different extents, and this correlation structure must be modeled, lest it be a problem, for many applications, while it can be informatively leveraged in other applications. We will review literature of approaches to model population structure, including FST, the PCA approach, kinship / genetic relatedness matrices, admixture models, and their use in genetic association studies and heritability estimation.

"Exploring the Microbiome" (John Rawls, Lawrence David and Neil Surana)
Recent advances in genomic technology have led to spectacular insights into the complexity and ubiquity of microbial communities (the microbiome) throughout our planet, including on and within the human body. The microbiome is now known to contribute significantly to human health and disease, regulate global biogeochemistry, and harbor much of our planet's genetic diversity. Consisting of lectures and reading of primary literature, this module is designed to provide students with a foundational understanding of microbiome science. Enrolling students are expected to have a background in general microbiology. For more information, please contact John Rawls john.rawls@duke.edu

Module F

Integrative Genomics (Allison Ashley-Koch)
The field of genomics is moving at a rapid pace with many 'omics technologies available (exome sequencing, transcriptomics, epigenetics, metabolomics, proteomics). Often, multiple 'omics data types are available on the same individuals, but also across studies through publically available data. Integration of these multiple data types should inform our knowledge of biology and disease. This course will focus on reading primary literature in the field and understanding approaches to integrate these various data types.

"Entrepreneurship in the life sciences" (Philip Benfey)
This module will cover various aspects of entrepreneurial activity in the life sciences. These include setting up, securing funding and working in a start-up company as well as protecting and licensing intellectual property. We will discuss how best to prepare for life in the start-up ecosystem. Students will be evaluated on class participation and will write an executive summary of a business plan for a start-up of their choice.

Metabolism and death: Causes and Consequences (Ashley Chi)
While metabolism was thought to play a supportive role, it is clear that metabolism is also critical for the signaling, epigenetic components of various biological processes. Dysregulation metabolisms lead to metabolic death that modulate tissue regeneration, inflammation and immune response. We are hoping to cover some logics of the metabolic signaling as well as the causes and consequences of cell death.

The Logic of Genetics (Danny Lew)
This module will focus on how to apply haploid/diploid genetics to solve a biological problem (we use signal transduction as an example). Yeast is used as the example system, and we discuss the design and implementation of genetic screens, complementation, linkage, and epistasis to order genes into pathways. The first week we will do problem sets covering classical genetics and the second week we will read papers covering molecular genetics and genomics approaches to understand the same pathway.