

UPGEN 778A-F Fall Term 2020

MWF 2-3:30p-All Modules will be Online

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 August 28 drop/add deadline will reflect a course withdrawal on a transcript- No Exceptions**

Module A Aug 24– Sept 4	Section 1 Nina Tsvetanova The CRISPR/Cas system and genome editing	Section 2 Kris Wood Tumor heterogeneity and evolution	Section 3 Greg Crawford “Epigenetic methodologies”	Section 4 John Rawls, Lawrence David and Neil Surana “Exploring the Microbiome”
Module B Sept 7– Sept 18	Section 1 Andy Alspaugh and Steve Taylor Genetics and genomics of infectious disease	Section 2 Danny Lew The Logic of Genetics	Section 3 John Willis Genomics of Adaptation	Section 4 Craig Lowe Genetics and genomics of ancient, ancestral, and extinct species
Module C Sept 21– Oct 2	Section 1 David Tobin Zebrafish genetics	Section 2 Danny Lew The Awesome Power of Yeast Genetics	Section 3 David Sherwood Basement membranes—formation, functions, and human disease	Section 4 Steve Haase Biological clocks
Module D Oct 7– Oct 19	Section 1 Allison Ashley-Koch Integrative Genomics	Section 2 David McClay Gene networks during development	Section 3 James Alvarez Animal Models of Cancer	Section 4 Blanche Capel Mouse Genetics and Genomics”
Module E Oct 21– Nov 2	Section 1 Hiro Matsunami Genetic switches	Section 2 Robin Smith Science Communication	Section 3 Marcy Uyenyoyama Population Genomics	Section 4 Philip Benfey “Entrepreneurship in the life sciences”
Module F Nov 4– Nov 16	Section 1 Ryan Baugh <i>C. elegans</i> Genetics and Genomics	Section 2 Don Fox and Jessica Sawyer Critical skills in scientific presentation	Section 3 Raphael Valdivia Bacterial genetics	Section 4 Raluca Gordan Modeling protein-DNA interactions in vitro and in vivo

Module Descriptions for Fall 2020:

Module A

The CRISPR/Cas system and genome editing (Nina Tsvetanova)

Genome editing with CRISPR (overview of the system and its applications in genome editing and functional genomics through lecture, group-led presentations and discussion of relevant primary literature and a short written proposal).

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.

“Epigenomic Methodologies” (Greg Crawford)

Many biological processes, such as tissue-specific gene expression, X inactivation, and development, are controlled 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.

“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 B

“Genetics and genomics of infectious disease” (Andy Alspaugh & Steve Taylor)

Microorganisms undergo dramatic cellular changes in order to adapt to the harsh environment of the infected host. These adaptations often require coordination of metabolism, stress responses, and the expression of specific “virulence factors”. Investigators have used many experimental techniques to define factors that favor microbial survival in this setting. This module will explore the use of classical and molecular genetics techniques to study the pathogenesis of human infectious diseases. We will also discuss genome-wide evaluative tools in microbial pathogens. Most class-time will involve group discussion of specific articles related to the topic of each session.

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

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

Genetics and genomics of ancient, ancestral, and extinct species (Craig Lowe)

Studying the molecular changes that underlie ancestral traits has long been in the realm of science fiction. However, recent advances, both technological and theoretical, have allowed us to begin rigorously dissecting the molecular basis of ancient phenotypic changes. We will cover these recent advances as well as discuss future research in this area.

Module C

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

The Awesome Power of Yeast Genetics (Danny Lew)

This module will focus on using genetic interactions to identify and dissect new players in a pathway (we use cell polarity as an example). Along the way, we will discuss the generation and utility of various kinds of mutants, genetic suppression, synthetic lethality, and newer genomic methodologies including synthetic genetic arrays. Prerequisite: The Logic of Genetics.

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.

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.

Module D

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.

Gene Networks During Development (Dave McClay)

This module focuses on early cell diversification. Production of the many cell types of an organism occurs through signaling and networks of transcription factors that collectively increase the complexity and number of cell types in a developing organism. The goal of the module is to gain an understanding of these networks and to learn how knowledge of them can be attained.

Animal Models of Cancer (James Alvarez)

Animal models have provided important insights into the development, progression, and treatment of cancer. This module will cover the fundamentals of animal models of cancer, with a particular focus on mice. We will describe methodological approaches to generating mouse models of cancer and discuss the advantages and limitations of different approaches. We will then focus on specific areas across tumor types in which mouse models have provided critical mechanistic insights into tumor biology. Each class will involve a discussion of primary research articles from the literature

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.

Module E

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.

“Science Communication” (Robin Smith)

In this six-part workshop, we'll share some techniques that will help you communicate your work more effectively with a variety of audiences beyond your colleagues. We will have you practice telling your scientific story in several ways, from tweets and radio interviews to science cafes, blog posts and crowdfunding campaigns. Effective communication can help you get noticed by potential mentors and search committees, earn higher marks on your job and postdoc applications and advance your academic career. This module will include hands-on, active learning, so please bring writing materials or a laptop.

Population Genomics (Marcy Uyenoyama)

This course presents an introduction to coalescence theory, the basis of modern population genomics. While summary statistics borrowed from classical population genetics have emerged among the most widely-used indices in genomic analyses, they are often used apart the transformative coalescence perspective.

A primary objective is to provide an intuitive basis for coalescence-based interpretation of patterns of variation. That interpretation includes Bayesian approaches to inferring the history of a sample from the pattern of variation observed in the sample.

“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.

Module F

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.

“Critical Skills in Scientific Presentations” (Don Fox & Jessica Sawyer)

Do you hope to obtain a job in science after graduate school? Are you terrified of public speaking? Are you tired of sitting through hard-to-follow seminars by your peers, but don't know how to help them give clearer talks? If you answered yes to any of these questions, this module is for you. The goal of this module is to help you to effectively and confidently communicate your science to other scientists. This course includes: a “speed dating” workshop of a 2-minute “elevator speech” to give to your colleagues, tips on designing effective presentation slides, an exercise on developing a talk narrative, and extensive peer feedback on a short scientific talk. This module is meant to complement the Solutions module on Science Communication (which focuses on communicating science to the public) by focusing on communicating science to your scientific peers. Each class is group discussion-based, and each student will have several speaking opportunities. **This module is for 2nd yr and above students.**

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.

Modeling Protein-DNA interactions In Vitro and In Vivo (Raluca Gordan)

In this module, the students will acquire Python programming skills through the use of computational models and methods for characterizing the DNA binding specificity of transcription factors. Topics will include: identification of DNA motifs from ChIP-seq data, alignment of DNA sequences, identification of transcription factor binding sites across the human genome, computing enrichment of DNA motifs in genomic data. (Basic coding skills are useful, but not required).