**Course Overview & Requirements:** Modules in the CMB 710 series (A – F) are offered sequentially during the Fall semester and together cover 24 topics. These are the core offerings of the Cell & Molecular Biology Program and allow maximum flexibility for a student-designed curriculum. Four different topics are available during each module and students select one. Topics reflect the expertise of the corresponding faculty and emphasize either in-depth critical discussion of the primary literature or quantitative/mathematical approaches to addressing biological questions. Each module lasts 2 weeks, with 3 meetings per week. Students entering through CMB are required to take 6 modules in fall semester of their first year and at least 4 of these modules must be in the CMB 710 series. The other two may be from the UPGEN 778 series. A total of 12 modules are required for the CMB certificate, and 8 of these must be from CMB710. **Check prerequisites before signing up.**

**Special Note:** The Drop/Add deadline for Fall 2020, Friday, August 28th is the LAST day to make any modifications. Changes after August 28th will display as a withdrawal on your transcript.

**Topic Offering Overview:** (click on title hyperlink, below, to be taken to course description overview)

<table>
<thead>
<tr>
<th>FALL 2020</th>
<th>Section 1</th>
<th>Section 2</th>
<th>Section 3</th>
<th>Section 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I: CMB 710A 8/24 - 9/4</td>
<td>INTRO TO EXPERIMENTAL DESIGN &amp; STATISTICS (Lew) (first yr only)</td>
<td>MECHANISMS EARLY DEVELOPMENT (McClay)</td>
<td>CELL BIOLOGY OF NEURO DISORDERS (Goetz)</td>
<td>REGENERATION (Diao)</td>
</tr>
<tr>
<td>Module II: CMB 710B 9/7 - 9/18</td>
<td>CYTOSKELETON: DYNAM/FUNCTIONS (Lechler)</td>
<td>STRESS SIGNALING: RESPONSES ENV (Nicchitta)</td>
<td>CONTROLLING THE CELL CYCLE (Lew)</td>
<td>CELL MIGRATION/INV DEV CANCER (Sherwood)</td>
</tr>
<tr>
<td>Module III: CMB 710C 9/21 - 10/2</td>
<td>MITOCHONDRIA IN HEALTH/DISEASE (Cartoni)</td>
<td>EYE AS DIGITAL CAMERA (Arshavsky)</td>
<td>MAMMARY GLAND DEVELOPMENT (Alvarez)</td>
<td>PROTEOSTASIS (Scaglione)</td>
</tr>
<tr>
<td>Module IV: CMB 710D 10/7 - 10/19</td>
<td>MECH SKELETAL DEV AND DISEASE (Karner)</td>
<td>QUANTITATIVE CELL &amp; DEV BIO (Di Talia)</td>
<td>SNGL CELL APCHS/STEM CELL BIO (Tata)</td>
<td>MICROSCOPY IN CELL BIOLOGY (Cameron/Carlson)</td>
</tr>
<tr>
<td>Module V: CMB 710E 10/21 - 11/2</td>
<td>PROTEIN-PROTEIN INTERACTION (Erickson)</td>
<td>INTERSEC SIGNALING/ THERAPEUTIC (Wood)</td>
<td>GERM CELLS/SEX DETERMINATION (Capel)</td>
<td>ADVANCED MICROSCOPY APPS (Cameron) (pre-req Microscopy)</td>
</tr>
<tr>
<td>Module VI: CMB 710F 11/4 - 11/16</td>
<td>DIV &amp; EVOL OF CYTOSKELETAL SYSTEM (Onishi)</td>
<td>TIDYBIOLOGY: AN INTRO TO BIO DATA SCI IN R (Hirschey)</td>
<td>BIOINFO/GENOMICS FOR BIOLOGIST (MacAlpine)</td>
<td>HUMANS AS MODEL ORGANISMS (Bennett)</td>
</tr>
</tbody>
</table>
TOPIC DESCRIPTIONS:
CELL & MOLEC BIO MODULE I:

CMB 710A-01 / INTRODUCTION TO EXPERIMENTAL DESIGN AND STATISTICS
Instructor: Lew, Daniel J
Summary: What is a good experiment and what isn't? What controls should be present in the experiment, and why? How can we avoid being misled? How much data do we need to persuade someone of our conclusions? This class will use problem sets and group learning to address these questions. No prior readings required.
Prerequisite: First year students only

CMB 710A-02 / MECHANISMS OF EARLY DEVELOPMENT
Instructor: McClay, David R
Summary: This module will cover the maternal to zygotic transition, initial asymmetries that launch cellular diversity, onset of signaling, mechanisms of specification, and control mechanisms necessary for morphogenesis. It will emphasize the means by which genomic information is used to drive development. Each class period will be a combination of primary literature review, lecture and discussion. Animal examples will be drawn from across the animal kingdom.

CMB 710A-03 / THE CELL BIOLOGY OF NEURODEVELOPMENTAL DISORDERS
Instructor: Goetz, Sarah
Summary: This module will cover the cell biology of pediatric brain and neurodevelopmental disorders. Topics of discussion will include the basis of neural tube closure defects, the role of mitosis/cell divisions, centrioles, and ciliary signaling in neurological development. We will also discuss new findings relating neurological disorders to defects in metabolism, infectious diseases, somatic mutations, and other emerging areas. This module will be literature based, with students presenting and discussing new and classic primary papers.
Reading: N/A

CMB 710A-04 / REGENERATION
Instructor: Diao, Yarui
Summary: Regeneration means the regrowth of a damaged or missing organ part from the remaining tissue. Humans can regenerate some organs, including the skin, liver, bone, and skeletal muscle. However, many other human tissues, such as heart and brain, only have very limited regeneration capacity. Questions of how and why tissue regeneration occurs or not in health and pathology have captured the attention of countless biologists, biomedical engineers, and clinicians. In this module, we will focus on skeletal muscle as the model system, to cover key concepts and mechanisms of tissue regeneration. We will also discuss the different regenerative strategies and mechanisms that are used by a variety of model organisms, including salamanders, planarians, and zebrafish, to understand regeneration.
Reading:

**CELL & MOLEC BIO MODULE II**

**CMB 710B-01 / THE CYTOSKELETON: DYNAMICS & FUNCTIONS**
**Instructor:** Lechler, Terry
**Summary:** This is a primary literature reading intensive course that will cover aspects of cytoskeletal dynamics and functions in reconstituted systems, cultured cells and intact organisms. Diverse topics will be discussed, which may include: the role of cytoskeleton in mitosis/cytokinesis, cell migration, cell adhesion, cell signaling, cell shape control and mechanotransduction. Preparation and active participation required.
**Reading:** Molecular Biology of the Cell, Alberts et al. Chapter 16 (Cytoskeleton)

**CMB 710B-02 / STRESS SIGNALING: TRANSCRIPTIONAL AND TRANSLATIONAL RESPONSES TO ENVIRONMENTAL STRESS**
**Instructor:** Nicchitta, Christopher
**Summary:** In this module we will trace the path of research leading to the discovery of the unfolded protein response (UPR), a critical signaling pathway ubiquitously expressed in all eukaryotes. The UPR couples translational and transcriptional regulatory pathways to environmental stressors, such as glucose and/or amino acid deprivation or oxidative stress, and provides a common mechanism for sensing and adapting to cell stress. In this module, we will read, discuss, and critique the primary literature reporting the discovery of the UPR, the molecular components that comprise it, and its mechanism and regulation.
A basic knowledge and understanding of the secretory pathway and the protein synthesis and processing functions of the endoplasmic reticulum (ER) is necessary for this module.

**CMB 710B-03 / CONTROLLING THE CELL CYCLE**
**Instructor:** Lew, Daniel
**Summary:** The accurate copying of a cell’s contents and their distribution to produce two daughter cells is a stunning feat requiring exquisite coordination. The set of carefully orchestrated steps by which proliferating cells make copies of themselves constitutes the cell cycle. In this module, we will discuss landmark papers that established the conserved mechanisms underlying cell cycle control, as well as recent papers dissecting the control circuitry.
In addition to learning about a fundamental process, we will explicitly deal with strategies for reading primary Journal articles to critically assess the validity of their conclusions. We will also discuss how to turn cartoon diagrams of regulatory pathways into equations and graphs producing quantitative predictions of pathway behavior, and address the importance of feedback pathways and bistable systems in generating sharp transitions in cell behavior.
**Reading:**

**CMB 710B-04 / CELL MIGRATION/INVASION IN DEVELOPMENT & CANCER**

**Instructor:** Sherwood, David R

**Summary:** Cell migration/invasion through extracellular matrix and tissues play crucial roles in the development, maintenance and regeneration of multicellular organisms. Inappropriate and defective cell migration also underlies numerous diseases, including inflammatory diseases (i.e. asthma, rheumatoid arthritis, multiple sclerosis, psoriasis and Crohn's disease), developmental disorders, and tumor spread. Understanding cell migration is also important for regenerative therapies, including stem-cell grafting, where defective migration/invasion is a major limitation. Cell migration takes on a variety of forms, and this course covers how cells migrate and invade as individuals, in groups as well as the plasticity of migration modes in development and cancer.

**Reading:**

**CELL & MOLEC BIO MODULE III**

**CMB 710C-01 / MITOCHONDRIA IN HEALTH AND DISEASES**

**Instructor:** Cartoni, Romain

**Summary:** Mitochondria are responsible for key cellular functions such as energy production, reactive oxygen species regulation and calcium buffering. Moreover, it is an extremely dynamic organelle that is able to divide, fuse and move along microtubule track. The importance of mitochondrial functions and dynamics is evidenced by the numerous diseases such as cancer, diabetes and neurodegenerative diseases that have been linked to mitochondrial dysfunction. Therefore it is more important than ever to better understand the physiology of this multifaceted organelle. Through a series a classic, provocative and recent papers, this course will provide an overview of mitochondrial biology and its role in pathophysiological conditions with a special emphasis on mitochondrial dynamics and neurodegeneration.

**Reading:**
2. Cold Spring Harb Perspect Biol 2013 Schwarz

**CMB 710C-02 / THE EYE AS A DIGITAL CAMERA**

**Instructor:** Arshavsky, Vadim Y

**Summary:** We are well familiar with the metaphor comparing the eye with a photographic camera. Indeed, both rely on refraction and lenses to form images. What is perhaps less appreciated is that the eye functions as a digital camera. Information about the surrounding world reaches the back of the eye in the form of photons of variable wavelength, which are absorbed by rod and cone photoreceptor cells of the retina. The light-evoked electrical signals produced by photoreceptors are next processed by a network of retinal neurons, so that information about each point in visual space becomes digitized and reaches the brain through multiple channels, each reporting a different feature of the visual world (brightness, contrast, color, motion, etc.).
In this module, we will follow each step of this analog-to-digital transition by discussing critical experimental papers in three areas: phototransduction (the transformation of a light signal into an electrical signal); the functioning of the first synapse in the retina; and the split of visual information into multiple channels each carried by a highly-specialized type of the retinal ganglion cells. Our goal would be to integrate the findings of molecular, cellular and electrophysiological studies into a single big picture of how the retina works.

Reading:

CMB 710C-03 / MAMMARY GLAND DEVELOPMENT
Instructor: Alvarez, James
Summary: The mammary gland is a secretory organ that mammals use to produce milk to feed their young. The majority of mammary gland development occurs postnatally, and the mammary gland undergoes dramatic morphological and functional changes during pregnancy and lactation. Studies of mammary gland development have provided important insights into organizing principles of tissue development, including the organization of stem cell hierarchies, crosstalk between epithelial and stromal cells, the importance of immune cells in epithelial tissue development, and how tissues can integrate both local and systemic signals to control development. Furthermore, dysfunction of mammary gland development is intimately linked to the risk of developing breast cancer. In this class we will cover the fundamentals of mammary gland development — including the current intense interest in mammary stem cells — and discuss the implications of these topics for breast cancer.

Reading:

CMB 710C-04 / PROTEOSTASIS
Instructor: Scaglione, K Matthew
Summary: Maintenance of protein homeostasis (proteostasis) is essential for cellular health. In a number of diseases proteostatic pathways are altered and contribute to disease pathogenesis. This ranges from an increase in proteostatic capacity in cancer to a dysregulation of protein folding in most neurodegenerative diseases. In this module we will read and discuss key papers that cover the regulation of proteostasis in health and disease.
Reading: N/A

CELL & MOLEC BIO MODULE IV

CMB 710D-01 / MECHANISMS OF SKELETAL DEVELOPMENT & DISEASE
Instructor: Karner, Courtney
Summary: This module will cover the embryonic and postnatal development of the skeleton. It will focus on the major signaling pathways and transcriptional regulation controlling the specification, commitment and differentiation of mesenchymal cells into chondrocytes and osteoblasts. Attention
will also be given to these events in human skeletal diseases. Examples will be drawn from multiple species. This will primarily be a literature review course with some lecture and discussion.

**Reading:**

**CMB 710D-02 / QUANTITATIVE CELL & DEVELOPMENTAL BIOLOGY**

**Instructor:** Di Talia, Stefano  
**Summary:** It is a common belief that biology is the least quantitative and theoretical of the natural sciences. However, many fundamental discoveries in biology (e.g. membrane excitability, spikes, proofreading) have come from the use of modeling and theoretical ideas. The goal of this module is to show how theoretical and mathematical ideas can contribute to develop deeper insights on biological problems. Focusing on primary literature, we will discuss how recent advancements in imaging technologies are improving our understanding of cell and developmental biology. Ideally by the end of this module, students will be able to distinguish good informative mathematical models from less informative models.

**Reading:**

**CMB 710D-03 / SINGLE CELL APPROACHES TO STEM CELL BIOLOGY**

**Instructor:** Tata, Purushothama Rao  
**Summary:** Most tissues rely on specialized cells called stem/progenitor cells for their day-to-day turnover. Stem cells in some tissues directly differentiate into mature cells whereas in some cases they undergo replication and generate intermediate cells which then differentiate into mature cell types. Both systemic and micro-environmental factors dynamically control the behavior of stem cells in a context dependent manner. In this module we will be discussing how different factors such as microenvironment, cell-cell communication and cell plasticity influence stem cell behavior to control tissue homeostasis, regeneration and tumorigenesis. We will also discuss some of the new tools developed to unravel emerging concepts that are put forward in the recent years in stem cell biology.

**Categories:**
1. Stem cells, development & regeneration  
2. Physiology & disease

**Reading:**
1. Developmental Biology by Scott F. Gilbert; 9th or 10th or 11th edition; Chapters- 2, 4 and 5.  

**CMB 710D-04 / MICROSCOPY IN CELL BIOLOGY**

**Instructor:** Cameron, Lisa and Carlson, Benjamin  
**Summary:** Microscopy has been revolutionized by fluorescence and now provides a vast array of tools with which to investigate biology. This module will cover the principles and techniques of light
microscopy – how microscopes and photon-based imaging systems work and what you can do with them. We will discuss a range of techniques emphasizing the most common applications encountered in biological research - widefield imaging, optical sectioning by confocals, multi-photon excitation and TIRF microscopy. The theory and physical principles of the imaging systems will be explained in the first half of the module in a lecture based setting to a level giving understanding of how they work and guidance for optimal use. The second part of the module will be a mixture of theory and exercises in FIJI/ImageJ covering the processing, visualization and quantification of microscopy data. This is the prerequisite to the Advanced Microscopy Applications module.

Reading:
Molecular Biology of the Cell, Alberts, et al., - Chapter 9 (focus on the sections discussing light/fluorescence microscopy)

CELL & MOLEC BIO MODULE V

CMB 710E-01 / PROTEIN-PROTEIN INTERACTION
Instructor: Erickson, Harold P
Summary: Proteins are the machines of the cells. A few enzymes operate alone, but most proteins interact with others to form more complex machines. In this unit we will learn the basic principles of protein-protein interaction and bonding and address the following questions.

- How big is a protein molecule; how do you determine if it is a monomer or tetramer; how do you determine its shape? What is the structure of a protein-protein bond? How many amino acids are in contact? How does the dissociation constant relate to the strength of the bond? How fast do two proteins form a bond, and once formed how long does the complex last before it dissociates? If you want to eliminate or reduce a protein-protein bond by mutagenesis, how many amino acids to you need to change? How do you decide which ones?

Reading:
Molecular Biology of the Cell", Alberts et al., Chapter 3 - Proteins.
Chapter 2 (to review basic biochemistry. Most important is to know the amino acids, which ones are hydrophobic, hydrophilic, charged)

CMB 710E-02 / INTERSECTION OF SIGNALING & THERAPEUTICS
Instructor: Wood, Kris C
Summary: It is now possible to comprehensively map the numerous genomic alterations present in individual human tumors. As a result of this stunning technological advance, we can now begin to design therapeutic strategies that function by “targeting” these alterations. However, identifying the optimal therapeutic targets for a given tumor is challenging, and this challenge is further exacerbated by the problem of drug resistance, which commonly emerges as tumors evolve under pharmacological selection pressures. In this module, we will construct a framework for understanding the related topics of pharmacogenomics and drug resistance in cancer, discussing landmark papers that established the guiding principles in each field.

Reading:
CMB 710E-03 / GERM CELLS / SEX DETERMINATION
Instructor: Capel, Blanche  
Summary: This module will cover the formation, pluripotent characteristics, and male vs. female development of primordial germ cells in multiple species including Drosophila, C. elegans, fish and mammals. It will also cover sex determination and cell fate commitment in somatic cells of the gonad, including genetic and temperature/hormone-dependent mechanisms. We will likely also consider how sex chromosomes evolve and how species transition between sex determining mechanisms.  
Reading:  
Developmental Biology, Gilbert:  
Chapter 15 - Sex Determination  
Chapter 17 - The Saga of the Germ Line

CMB 710E-04 / ADVANCED MICROSCOPY APPLICATIONS
Instructor: Cameron, Lisa  
Summary: Over the last ten years, advancements in hardware and development of various probes have fueled higher resolution imaging techniques dubbed “super-resolution” along with other related methods. This module will build on the information from the “Microscopy in Cell Biology” module to cover specifics of ways to resolve beyond the diffraction limit and collect images in 3D with greater speed than typical optical sectioning. The format will be mostly lecture style with some opportunity for demonstration or tour – this will be discussed in class. We will discuss how these techniques may benefit your research and the practical limitations and factors to achieve optimal imaging.  
Prerequisite: MICROSCOPY IN CELL BIOLOGY module  
Reading:  
Toomre and Bewersdorf 2010 Annual Reviews in Cell and Developmental Biology 26:285-314 “A New Wave of Cellular Imaging”.  
Lambert, TJ and JC Waters 2017 Journal of Cell Biology Jan 2; 216(1):53-63 “Navigating challenges in the application of superresolution microscopy”

CELL & MOLEC BIO MODULE VI

CMB 710F-01/ DIVERSITY AND EVOLUTION OF CYTOSKELETAL SYSTEMS  
Instructor: Onishi, Masayuki  
Summary: Three classes of cytoskeletal proteins, actin, tubulin, and septin, are conserved in the majority of eukaryotes and appear to have been inherited from the last eukaryotic common ancestor (LECA). This module will briefly review the cytoskeletal systems made of these proteins in established model organisms, and then study the primary literature on their roles in a diverse range of organisms in which they are regulated in non-canonical ways. We will also discuss how these proteins may have evolved from their ancestral precursors related to prokaryotic proteins.  
Reading:  
Molecular Biology of the Cell, Alberts et al., Chapter 16: The Cytoskeleton

CMB 710F-02 / TIDYBIOLOGY: AN INTRODUCTION TO BIOLOGICAL DATA SCIENCE IN R 
Instructor: Hirschey, Matthew  
Summary: This workshop-style module provides an introduction to the emerging field of Data Science in R, including data analysis and visualization, with a particular focus on its utility for biological insight.
Students will be provided with biological datasets, and introduced to R packages and code used to examine data. In the first half of each class, students will be lectured on methods and shown demonstrations; in the second half of each class, studies will use tools to analyze real data; laptop computers are required. Methods for filtering, sorting, and transforming data will be discussed along with visualization tools and options. Particular attention will be paid to code interpretation and data provenance methods by learning to generate reproducible data output files. For a final project, students will be given a new dataset to analyze using the tools learned during the course, and will share findings with the class in a short oral presentation. Although specific datasets will be used for analysis in class, this workshop will provide broadly applicable tools to reproducibly analyze and visualize data across the biological sciences.

CMB 710F-03 / BIOINFORMATICS & GENOMICS FOR THE BIOLOGIST
Instructor: MacAlpine, David M
Summary: Computational biology and genomics are a mainstay of modern biology. For example, sequence alignments, identification of gene orthologs and paralogs by blast searches, and motif identification are now routine practices in the laboratory. In addition, the explosion of whole genome sequencing in the last decade has led to a variety of genomic approaches (many based on microarray technology and next-generation sequencing) to phenotype the cell at the level of gene expression and identify networks of co-regulated genes. These computational tools and genomic approaches are likely to be integral components of many research projects.

In this module, we will explore the tools and approaches to analyze next-generation sequencing data. We will make extensive use of Unix, bash scripting, and the R environment for statistical computing. The student will not only learn to critically evaluate these complex genomic experiments but will also gain first-hand experience at analyzing primary data.

Reading:
Unix Tutorial, http://www.ee.surrey.ac.uk/Teaching/Unix/

CMB 710F-04 / HUMANS AS MODEL ORGANISMS
Instructor: Bennett, G Vann
Summary: Translational research is frequently viewed as the application of established principles of basic science to promote human health. This section will develop the theme that deciphering the molecular basis for human disease can be far from straightforward, and both require and contribute to elucidation of new fundamental biology. We will focus this year on nervous system-related diseases, beginning with Creutzfeldt-Jacob and related neurodegenerative disorders where molecular breakthroughs have led to the prion concept. We will then consider Alzheimer's disease, where genetic mutations and risk factors are known, but the pathophysiology is still unresolved. We will end with discussion of autism, which since 1980 has transitioned from a rare disorder to one affecting 1% of the population. Autism is heritable and autism susceptibility genes are known. However, autism still lacks a unifying concept and is an attractive target for future research.

Reading: Pruisner's Nobel Lecture