CMB 710 A - F
Cell & Molecular Biology Modules – Fall 2024
MWF 10:20 -11:40
Course Directors: Craig Lowe & Lucia Strader

Topic Offering Overview:

FALL 2024	Section 1	Section 2	Section 3	Section 4
Module I: CMB 710A 8/26 - 9/9	MECHANISMS EARLY DEVELOPMENT (Lechler & Silver) ND 384	PHASE SEPARATION IN CELL BIOLOGY: STRESS GRANULES AND mRNA TRANSLATION (Nicchitta) ND 437	T CELL BIOLOGY (Hemmers) MSRB-3 1125	CANCER IMMUNOLOGY (Hartman) GSRB I 4002
Module II: CMB 710B 9/11 - 9/23	RECEPTOR SIGNALING NETWORKS (Rajagopal) MSRB-3 1125	CELL MIGRATION/INV DEV CANCER (Sherwood) GSRB-1 4002	QUANTATIVE APPROACHES FOR STUDYING PRINCIPLES OF TISSUE MORPHOGENESIS (Munjal) ND 384	STEM CELL AGING (Chakkalakal) LSRC C335
Module III: CMB 710C 9/25 - 10/7	MICROSCOPY OF CELL BIOLOGY (Carlson & Cameron) MSRB-3 1125	DIVERSITY & EVOL OF CYTOSKELETAL SYSTEM (Onishi) GSRB I 4002	EYE AS DIGITAL CAMERA (Arshavsky) ND384	CELL BIOLOGY OF NEURO DISORDERS (Goetz) 437 ND
Module IV: CMB 710D 10/11 - 10/25	Intersec Signaling/Ther apeutic (Wood) GSRB I 4002	Epithelial Biology from Morphogenesis to Disease (Lechler) ND384	ADVANCED MICROSCOPY (Pre-Requisite – Microscopy in CB) (Cameron & Carslon) MSRB-3 1125	From Genes to Treatments in Cardiovascular Disease (Ravi Karra) 437ND
Module V: CMB 710E 10/28 - 11/8	PROTEOSTASIS (Scaglione) GSRB I 4002	REGNERATION (Diao & Poss) 437 ND	Tidybiology: An Intro to Bio Data Sci in R (Hirschey) MSRB-3 1125	AXON REGENERATION (Yan) ND 384
Module VI: CMB 710F 11/11 - 11/22	Germ Cells Sex Determination (Capel) 437 ND	SNGL Cell APPR to Stem Cell Bio (Tata) 384 ND	PROTEIN-PROTEIN INTERACTION (Oas) GSRB-3 1125	Glycobiology (Boyce) MSRB-3 1125

Module I: CMB 710A
8/26 - 9/9

Section 1
MECHANISMS EARLY DEVELOPMENT

(Lechler/Silver)
384 Nanaline Duke

Description: *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.*

Section 2
PHASE SEPARATION IN CELL BIOLOGY: STRESS GRANULES AND mRNA Translation
(Nicchitta)
ND 437

Description: *Phase separation in cell biology: Stress granules and mRNA translation*

Over the past decade, research into the higher order organization of biological processes has become a prominent frontier in cell biology. A common theme throughout is the finding that biomolecular condensates, defined as liquid-liquid phase separated, membrane-less assemblies of biomolecules, are critical for the organization and regulation of diverse cellular processes. Stress granules (SGs), which are biomolecular condensates of mRNAs and proteins, are a prominent example of liquid-liquid phase separation. SGs form during cell stress, specifically under conditions where protein synthesis undergoes signal-mediated inhibition. The mechanism of SG formation, where in the cell SGs form, how and why mRNAs are selected for recruitment into SGs, and the broader biological function of SGs are all questions are all questions under very active investigation in the field. In this module, we will critically evaluate past and current literature on SG biology, with a focus on experimental design and data interpretation. A short (1 page) mini-grant proposal assignment developing a theme from the literature discussed in class will be required.

Section 3
T CELL BIOLOGY
(Hemmers)
MSRB-3 1125

Description:

We will cover the basics of T cell biology from their development in the thymus, the unique features of the T cell receptor and the establishment of tolerance to self, to T cell activation and effector function in infectious settings. In addition, the module will include student-led discussions on common immunological techniques to study T cell function (TCR-transgenic mouse strains; tetramer-based cell analysis; flow cytometry) and T cells as therapeutic targets or cellular therapies (immune checkpoint blockade, CAR T cells).

Section 4
CANCER IMMUNOLOGY
(Hartman)
GSRB-3 4002

Description:

In this module we will explore the fundamental principles of immunology and how they intersect with oncology to understand the immune mechanisms involved in cancer recognition, evasion, and elimination. Through a combination of lectures, journal presentation, and interactive discussions, students will explore topics such as tumor immunogenicity, immune surveillance, tumor microenvironment, immune checkpoint pathways, and immunotherapy approaches. This module will also cover cutting-edge research and therapeutic strategies aimed at harnessing the power of the immune system to combat cancer, including immune checkpoint inhibitors, adoptive cell therapy, cancer vaccines, and cytokine therapy. Students will critically evaluate the challenges and opportunities in translating basic immunological concepts into clinical applications for cancer treatment.

Module II: CMB 710B
9/11 - 9/23

Section 1
RECEPTOR SIGNALING NETWORKS
(Ragjagopal)
MSRB-3 1125

Description:

Receptor Signaling Networks – We will discuss signaling pathways that are activated upon drug binding to transmembrane receptors. The primary focus will be on G protein-coupled receptors, but we will also discuss other receptors, such as receptor tyrosine kinases and cytokine receptors.

Section 2
CELL MIGRATION/INV DEV CANCER
(Sherwood)
GSRB-1 4002

Description:

Cell migration plays crucial roles in the development, maintenance, and regeneration of animals. Inappropriate and defective cell migrations also underlie 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 is a major limitation. Cell migration takes on a variety of forms, and this module covers how cells migrate as individuals, in groups, and the mechanical, metabolic, and signaling regulation of cell migration. This course has no prerequisites and would benefit students interested in cancer, immunology, development, and regeneration.

Section 3
QUANTATIVE APPROACHES FOR STUDYING PRINCIPLES OF TISSUE MORPHOGENESIS
(Munjal)
ND 384
Description:

Or current knowledge of tissue morphogenesis relies on a framework that explains how genetic and biochemical information drive cellular mechanics and thereby tissue dynamics. This framework, however, fails to account for: 1) Self-organized emerging behaviors that cannot be explained by upstream genetic information; 2) Cell extrinsic information, including external forces; and 3) Multi-scale feedback interactions. In this module, we will review and discuss recent findings that address these gaps, with an emphasis on the state-of-the-art quantitative approaches in the field.

Section 4
STEM CELL AGING
(Chakkalakal)
LSRC C335

Description:
In most organisms, aging is associated with a progressive loss of regenerative potential. Adult stem cells contribute to tissue maintenance and repair; however, age-related changes in stem cell number and function, and the stem cell niche are associated with tissue deterioration. Therefore, considerable effort is being invested in restoring stem cell function and/or their environment(s) to counter age-related tissue dysfunction and degeneration. In this module, we will focus on skeletal muscle as a model system to study stem cell aging. We will review studies that have significantly contributed to our understanding of age-related declines in stem cell integrity and tissue regenerative potential. We will also examine strategies that have been proposed to restore stem cell function and tissue regenerative capacity.

Module III: CMB 710C
9/25 - 10/7

Section 1
MICROSCOPY IN CELL BIOLOGY
(Cameron/ Carlson)
MSRB III 1125

Description:

Light 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 microscopy 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.

Section 2
DIVERSITY & EVOL OF CYTOSKELETAL SYSTEM
(Onishi)
GRRB I 4002

Description:

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*

Section 3
EYE AS DIGITAL CAMERA
(Arshavsky)
384 Nanaline Duke

Description:

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 biochemical, molecular, cellular and electrophysiological studies into a single big picture of how the retina works.

Section 4
CELL BIOLOGY OF NEURO DISORDERS
(Goetz)
437 Nanaline Duke

Description:

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.

Module IV: CMB 710D
10/11 - 10/25

Section 1
INTERSEC SIGNALING/ THERAPEUTIC
(Wood)
GSRB I 4002

Description:
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.

Section 2
EPITHELIAL BIOLOGY – FROM MORPHOGENESIS TO DISEASE
(Lechler)
ND 384

Description:
Epithelial Biology – From Morphogenesis to Disease
This class will be focused on journal article discussions that highlight aspects of epithelial morphogenesis, function, and disease. Topics will vary by year but include, apical-basal polarity, planar cell polarity, cell-cell contacts, integrin-based adhesions, folding of epithelia, barrier/absorptive functions, growth control in epithelia and its dysregulation in cancer. We will cover a diverse set of papers using different organisms and tissue types.

Section 3
ADVANCED MICROSCOPY
(Cameron)
MSRB-3 1125

Description:
Over the last ten years or so, 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.
Pre-requisite: completion of Microscopy in Cell Biology module

Section 4
From Genes to Treatments in Cardiovascular
Disease
(Karra)

Treatment strategies rooted in human genetics are more likely to result in approved therapeutics. In this course, we will review several cardiovascular therapeutics, charting their map from discovery to mechanisms to clinical approval. We will also review resources for genetically simulating human clinical trials.

Module V: CMB 710E
10/28 - 11/8

Section 1
PROTEOSTASIS
(Scaglione)
GSRB I - 4002

Description:

Maintenance of cellular protein homeostasis (proteostasis) is essential for cellular health. To maintain proteostasis cells have developed a network of cellular pathways to respond to cellular stress and protein misfolding. In this module we will discuss seminal papers in the field of proteostasis. This will include a discussion of identification of protein folding and degradation pathways and expand to discuss how these pathways counteract human disease.

Section 2
REGENERATION
(Diao/Poss)
437 Nanaline Duke

Description:

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 the 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.

Section 3
TIDYBIOLOGY: AN INTRO TO BIOLOGICAL DATA SCIENCE IN R
(Hirschey)
MSRB III 1125

Description:

This workshop will be a comprehensive introduction to the emerging field of Data Science using the R programming language, including data analysis and visualization, with a particular focus on its utility for biological insight. You will be provided with biological datasets, and introduced to R packages and code used to examine data. In the first half of each class, participants will be lectured on methods and shown demonstrations; in the second half of each class, students 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, each participant will be given datasets 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.

Section 4
AXON REGENERATION
(Yan)
ND 384

Description:
Neurons are fragile and can be damaged in stroke, spinal cord injury, or neurodegenerative diseases. Axon injury in mature neurons triggers injury responses and repair pathways. These pathways activate regrowth programs whose effectiveness depends on both the intrinsic growth competence of the neuron and the local extracellular environment. In this module we will discuss major signals involved in axon regeneration in multiple species including C. elegans, Drosophila, fish and mammals, and the difference between PNS and CNS in axon

regeneration. We will also discuss the function of glial cells in this process.

Reading:

1. Axon Regeneration in the Central Nervous System: Facing the Challenges from the Inside. Michele Curcio and Frank Bradke. Annual Review of Cell and Developmental Biology Vol. 34:495-521 (Volume publication date October 2018)
2. Functions of Nogo proteins and their receptors in the nervous system. Martin E. Schwab. Nature Reviews Neuroscience volume 11, pages 799–811 (2010)

Module VI: CMB 710F
11/11- 11/22

Section 1
GERM CELLS/ SEX DETERMINATION
(Capel)
ND 437

Description:
This is a module offered to introduce students to sex determination across species and to early germ cell biology. Both sex determination and germ cell development are classic model systems for the study of development, evolution, and stem cell biology.

Section 2
SNGL CELL APPROACHES TO STEM CELL BIOLOGY
(Tata)
384 Nanaline Duke

Description:

Most tissues rely on specialized cells called stem/progenitor cells for their day-to-day turn over. 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.

Section 3

PROTEIN-PROTEIN INTERACTION
(Oas)
ND437

Description:

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?

Section 4

GLYCOBIOLOGY
(Boyce)
MSRB-3 1125

Description:

Glycobiology is the study of the biosynthesis, structures, functions and evolution of carbohydrates (glycans) that are often attached to other biomolecules, such as proteins and lipids. Glycosylation is found in all kingdoms of life and underlies every aspect of cell biology. In addition, glycobiology has major implications for an enormous range of fields, from human health to renewable energy to materials science. Recently, new technologies and experimental approaches have triggered explosive progress in the modern glycosciences. This module will sample some very recent papers – all published in 2024 – on a range of glycobiology topics, with an emphasis on protein glycosylation in mammalian health and disease. Our two main goals are to get an overview perspective on current research in glycobiology and to hone our critical reading skills.

***Optional background reading**: Chapter 1 of Varki et al., Essentials of Glycobiology, available at https://www.ncbi.nlm.nih.gov/books/NBK579927/*