Advanced Undergraduate Seminars
2014-2015

Fall 2014

7.341 The Metabolic Revolution: How New Discoveries Have Put Metabolism at the Center of Cancer and Other Diseases

Instructors: Caroline Lewis (lewisca@mit.edu, 5-4523; laboratory of Matthew Vander Heiden)
Lucas Sullivan (lucasbs@mit.edu, 5-4523; laboratory of Matthew Vander Heiden)
Fall 2014. Tuesdays, 11 am - 1 pm (Class time is flexible). Room 68-150.

Cellular metabolism is frequently considered to be a thoroughly understood process by which cells extract energy from nutrients to make adenosine triphosphate (ATP). For example, it is well known that cells will oxidize glucose by glycolysis and the tricarboxylic acid (TCA) cycle to produce ATP by electron transport chain activity and oxidative phosphorylation. However, while the foundations of cellular metabolism have been known for over 50 years, recent discoveries have shown that metabolism is more than just synthesizing ATP. Disease states such as diabetes, hypoxia and cancer have all been shown to display drastic differences in cellular metabolism. Cancer cells specifically display what is known as the "Warburg Effect," the increased uptake of glucose and excretion of lactate. In humans, lactate fermentation is typically thought of as occurring exclusively in low oxygen conditions, such as exercising muscle. Why cancer cells would forfeit so much potential ATP by excreting lactate is one of many fascinating questions that have arisen from a recent renaissance in metabolism research. New research has shown many conventional aspects of metabolism to be much more dynamic and malleable than previously recognized. This class will address several interesting phenomena related to metabolism research: How can a single mutation in a TCA cycle enzyme create a new metabolite to cause cancer? How does a diabetes drug decrease cancer incidence and death? Do antioxidants prevent disease, or increase it? How does adverse activation of cancer-associated genes rewire the metabolism of a cell? We will investigate these questions and other current topics in cellular and organismal metabolism. In addition, we will discuss current research methods and learn how to critically evaluate the experimental designs used in studies in this field.

7.342 Sweet Discoveries: Unraveling the Complex World of Sugars in Health and Disease

Instructors: Julie Silverman (silverjm@mit.edu, 617-253-1834, laboratory of Barbara Imperiali)
Marthe Walvoort (walvoort@mit.edu, 617-253-0206, laboratory of Barbara Imperiali)
Fall 2014. Tuesdays, 1 pm - 3 pm (Class time is flexible). Room 68-150.

Glycans, which are complex assemblies of sugars, are the most prevalent class of macromolecules, surpassing nucleic acids, proteins and lipids. Glycans are essential for life, as they are a required energy source, provide protection against cellular stresses and shape cellular structure. Glycans display vast chemical and structural diversity, which has hampered their discovery and characterization. For example, the molecular basis for organ rejection was not understood until the 1950s, when researchers discovered that glycans are a major component of blood group antigens. Over 50% of proteins in a human cell are modified with one or more glycans. Given the ubiquity of glycans, it comes as no surprise that alterations of glycan

metabolism and the cellular glycan profile can have drastic effects on cellular processes and can lead to a class of inborn diseases called congenital disorders of glycosylation. In addition, the surfaces of viruses and bacteria are extensively decorated with glycans, which can participate in both immunity recognition and evasion. During this course, we will explore the many roles glycans play in human health and disease. For example, we will learn about the healthy glycosylation patterns of many mammalian proteins and the dynamic changes that glycan structures undergo during early development and cancer metastasis, the influence of dietary carbohydrates on glycan metabolism, and the role of densely glycosylated proteins involved in HIV infectivity. Concurrently, we will learn about the chemical and biological techniques used to detect and visualize glycans by *in vitro* and whole-animal metabolic labeling approaches, how to profile protein-glycan interactions using high-throughput glycan arrays, and about the development of new carbohydrate-based therapeutics and vaccines to target HIV, influenza and bacterial pathogens. The course will focus on the primary research literature, and we will learn practical laboratory techniques, experimental design and how to interpret data and critique the conclusions offered by authors. Students will have the opportunity to visit a local research facility that studies glycosylation and attend a seminar related to the field of glycobiology.

7.343 Cell-material Crosstalk: Engineering Cell-instructive Biomaterials
Instructors: Danya Lavin (dlavin@mit.edu, 3-3443)
Matthew Webber (mwebber@mit.edu, 8-0468)
(Laboratories of Robert Langer and Dan Anderson)
Fall 2014. Wednesdays, 11 am - 1 pm. (Class time is flexible.) Room 68-150.

Biomaterials have been designed to direct the course of therapeutic or diagnostic procedures by controlling interactions with biological systems. A large toolbox of non-biological materials has been engineered to study cell behavior at the cell-material interface. In this course, we will examine how this interface can be leveraged both to study cellular systems and to generate novel therapeutics. A critical evaluation of the primary research literature will be used to frame discussions about the interactions between cells and biomaterials. In particular, we will discuss 1) how cell behavior can be altered by controlling biochemical and biophysical cues of substrate materials, 2) how new organs and tissues can be produced by the use of structured scaffolds that direct cells into organized forms, and 3) how specific patterning of materials can enable biological processes to be studied and altered at the single-cell level. We will also consider the applications at patterned cell-material interfaces to build artificial systems, such as organs-on-a-chip, which can be used to perform preclinical tests for the activities and toxicities of drug candidates. Also, we will discuss the combination of non-biological materials with genetic material (DNA and RNA), which can provide a robust approach to modifying gene expression at the level of cells, tissues, or organs. We hope that your introduction to the cell-materials interface will inspire you to work at the intersection of biology and engineering and that you will help pioneer new and improved strategies to engineer this interface for functional applications.

7.344 Unraveling the Molecular Mechanisms of Aging and Age-Related Diseases.
Instructor: Caitlin Ondracek (ondracek@mit.edu, 3-0809, laboratory of Leonard Guarente)
Fall 2014. Wednesdays 1 pm – 3 pm. (Class time and date flexible.) Room 68-150.

Biological aging is associated with a time-dependent decline in function. While everyone is familiar with the aging process, the mechanisms responsible for aging and age-related disease have yet to be fully elucidated. Did you know that Bama, a remote village in China, has the most active Centenarians (people at least 100 years old) living today? Why does Japan have the longest average lifespan expectancies in the world? Why does the average lifespan vary from species to species? Why do some breeds of dogs have lifespans of over 15 years, while others have lifespans of about seven years? Why do naked mole rats outlive other rodent species by more than 20 years? Why are older people more likely to experience diseases like cancer, stroke, and Alzheimer's disease? By studying the aging process, scientists hope to gain a mechanistic understanding of aging. In this course, we will explore the scientific discoveries that have led to revelations about the molecular and cellular biology of aging. We will discuss how different model organisms -- including yeast, the nematode *C. elegans*, naked mole rats and dwarf mice -- are used to study aging. Several cutting-edge technologies frequently used in the field of the biology of aging will be explored, including gene microarrays, nucleic acid sequencing, and computer modeling. We will address key questions in this field, such as: Is aging a result of or the cause of disease? Can we intervene to stop or reduce the aging process? We will discuss the connection between aging and several diseases, such as cancer and neurodegenerative disorders, including Alzheimer's and Huntington's diseases. Studies in the field of aging have led scientists to speculate that an "elixir of life" might prolong health span. During our discussion of potential pharmacological therapeutics with anti-aging properties, we will learn about two compounds – one found in red wine, called resveratrol, and another originally identified as an anti-fungal medication, rapamycin. We will also discuss how lifestyle and dietary regimens, such as calorie-restriction, can intervene in aging and age-related diseases. We will explore how new interventions might be designed to target the processes involved in aging. The class will attend a meeting of the Boston Area Aging Data Club, where we will meet the authors of some of the research papers that will be discussed in class. We will hear presentations by scientists actively working on exciting and novel topics in the field of aging. This class will be focused on learning to read, critique and effectively interpret the primary scientific literature. Students should be able to identify experimentally tractable interesting biological problems and design experimental approaches by the end of this course, while learning about important techniques in the field of aging.

7.345 The Science of Sperm: Fighting for Survival in a High-stakes World
Instructors: Bibi Lesch (leschb@wi.mit.edu, 646-319-0649; laboratory of David Page)
Renee George (rdg@wi.mit.edu, 314-750-0284; laboratory of David Page)
Fall 2014. Thursdays 11 am – 1 pm. (Class time is flexible.) Room 68-150.

Sperm are tiny, haploid cells with a supremely important job: they deliver the paternal genome to the egg, helping create a zygote that develops into a new individual. For a human male, however, only a small fraction of the sperm produced will ever fertilize an egg. Sperm thus experience intense selective pressure: they must compete against each other, navigate a foreign environment

in the female reproductive tract, and interact specifically and appropriately with the surface of the egg. These selective pressures can drive extreme changes in morphology and gene function over short evolutionary time scales, resulting in amazing diversity among species. In this course, we will explore the ways in which these unique evolutionary forces contribute to incredible specializations of sperm form and function, including hook-shaped heads and multiple tails. We will start with an overview of sperm development in mammals and discuss how selective forces during this process can lead to human disorders, such as dwarfism and webbing of the hands and feet. Next, we will discuss meiotic cell division in males, when major changes in chromosome structure and gene expression become a source of vulnerability in the developing sperm. We will then examine the molecular evolution of sperm-related proteins (*e.g.* protamines) and discuss why they might evolve faster than proteins in other cell types. Finally, we will discuss how sperm cooperate or compete against each other in the race to reach the egg, and how these processes affect sperm shape and testis size in different species. Students will learn from the primary research literature with an emphasis on rigorously interpreting experimental data and critiquing analyses and conclusions. Towards the end of this course, we will prepare and examine sperm specimens from several species to see first-hand how the evolutionary processes we discussed have contributed to their diverse morphologies and unique fertilization strategies.

7.346 Fine-Tuning the Synapse: Synaptic Functions and Dysfunction

Instructors: Abhishek Banerjee (abhi.synap@gmail.com; 3-8785; laboratory of Mriganka Sur)
Richard Cho (rcho@mit.edu; 617-452-2726; laboratory of Troy Littleton)

Fall 2014. Thursdays 1 pm - 3 pm. (Class day and time are flexible.) Room 68-150.

The synapse is the fundamental element by which neurons transmit, receive and transform information in the brain. Synapses are functionally diverse, and a single neuron in the brain receives up to 10,000 synapses. Given the enormous complexity of the nervous system, how does a neuron integrate, encode and retrieve information? How is information processed beyond a single cell within the context of a neuronal circuit? Fundamental synaptic mechanisms underlie expression of higher-order brain functions, such as learning and memory, and cognition. Conversely, the disruption of synaptic processes contributes to the development of neurological disorders. In this course, students will learn to critically analyze the primary research literature to explore how synapses are studied and to understand how synapses integrate information to perform higher-order behavior. We will begin with the molecular composition of the synapse and will discuss how these components are altered to change the structure and function of individual synapses in response to experience, a process called ‘plasticity’. We will explore the diversity of synapses by examining excitatory and inhibitory synapses, focusing on distinct and common rules for plasticity, developmental origins of neuronal cell-types, and mechanisms that govern their integration into neural circuits. Finally, we will study mechanisms that contribute to the disruption of excitation-inhibition balance that lead to neuropsychiatric disorders, such as autism and schizophrenia. With this knowledge, students will visit the Drug Discovery Unit at Pfizer to learn about strategies for drug design and discovery to treat neuropsychiatric disorders. Students will also have the opportunity to visit an MIT laboratory where they will be introduced to cutting-edge experimental techniques, such as high-resolution two-photon imaging and electrophysiology, as well as a demonstration of optogenetics to optically control the activity of specific neural circuit elements. From this course, students will learn how to read, critique,

summarize and present scientific results, and to understand advantages and disadvantages of various experimental approaches. By relying on the classic and current scientific literature, students will gain an appreciation of both the progress and the challenges ahead in understanding the contributions of synapses in normal and diseased brains.

Spring 2015

7.341 Of Mice and Men: Humanized Mice in Cancer Research

Instructor: Mandeep Kaur (mkaur@mit.edu, 4-5100, laboratory of Jianzhu Chen)
Spring 2015. Wednesdays 11 am – 1 pm (Class date and time are flexible.) Room 68-150.

Almost everyone knows someone whose life has been affected by cancer. This devastating disease, which still carries a social stigma in certain parts of the world, generally remains unbeatable despite numerous efforts to curb and curtail it since the inception of the War On Cancer in the 1970s. Why is cancer such a difficult disease to treat? Despite all the effort and money poured into developing new cancer treatments, why are there so few cancer therapies that specifically target tumor cells? What is the best system to model the development of a human tumor? How can novel therapies be tested in a system that mimics the human body by modeling the interaction between human tumor cells and a human immune system, which plays a role in the detection and elimination of tumor cells? Cancer is thought to develop and spread by escaping surveillance from human immune cells, which would otherwise eliminate it. How can new treatment modalities, especially immune-based therapies that harness the natural ability of immune cells to kill target cells, be developed to treat cancer? These and other questions will be addressed in this course. We will explore the concepts of mouse models for human cancer, humanized cancer mice and cancer immunotherapy by reading recent and classic research articles. Humanized mice, like Mouse Man from the comic world, are essentially mice on the outside and human in the inside because of the presence of an intact and functional human immune system after engraftment with human stem cells. In humanized cancer mice the development of a human tumor occurs alongside a normal human immune system. We will focus on analyzing and critiquing research papers describing the development of human cancer models using humanized mice, thus hopefully mirroring the situation in patients. A review of the literature and a dissection of experimental designs will serve as a framework to guide discussions about the strengths and weaknesses of humanized mice (also referred to as humice) in cancer research and their unique position as a platform for the testing of new therapies prior to use in the clinic. The course will end with the exploration of a tantalizing new concept: the development of "personalized mice" or mouse "avatars" for individual cancer patients to test drug toxicities prior to dosing the patient as an effort to improve therapeutic efficacy and minimize undesired side effects. Many believe that immunotherapies represent the future of cancer therapy and humanized mice are a recent addition to the cancer biologist's tool-kit for modeling human cancer, and this course will act as an introduction to the latest developments in the fields of cancer biology and immunotherapy. We will use the humice cancer field as a vehicle to fulfill the primary objective of this course -- the art and science of reading, analyzing and critiquing research articles. We will also have the opportunity to attend one or more seminars by experts in the field and visit a research laboratory actively involved in the generation of cancer humice.

7.342 Pluripotent Stem Cells and Genome Engineering for Modeling Human Diseases

Instructors: Malkiel Cohen (malkiel@wi.mit.edu, 617-852-5860, laboratory of Rudolf Jaenisch)
Katherine Wert (wert@wi.mit.edu, 425-922-9055, laboratory of Rudolf Jaenisch)

Spring 2015. Wednesdays, 1 pm – 3 pm. (Class day and time are flexible.) Room 68-150.

One of the major priorities in biomedical research is understanding the molecular events that establish the complex processes involved in human development and the relationships of these processes to human disease and disease progression. The role of stem cells as a tool to help reveal these processes has long been appreciated. During the 20th century, Mario Capecchi, Martin Evans, and Olivier Smithies made ground-breaking discoveries using mouse embryonic stem cells for gene targeting in mammals. Their efforts made it possible to modify DNA of specific genes within the genomes of living and fertile mice, allowing scientists to determine the roles of individual genes in health and disease. This approach of genome engineering has produced numerous non-human vertebrate models of human disorders, including diabetes, cancer, cardiovascular and neurodegenerative diseases. For their discoveries, Capecchi, Evans, and Smithies shared the 2007 Nobel Prize in Physiology or Medicine. In 2012, the Nobel Prize in Physiology or Medicine was received by Shinya Yamanaka and John Gurdon for their discovery that cells of mature humans and other animals can be reprogrammed to an early embryonic stage, known as pluripotency, which can then lead to various cell types of the adult organism. This work and many other studies have stimulated the stem cell field into generating pluripotent stem cells from human patients, and these patient-specific stem cells have been used to better model human diseases by reflecting the disorder in a cell culture system. In many cases, scientists can now induce patient-specific stem cells to become the cell type that is affected by the disease and can then study the diseased cells to understand the mechanisms underlying disease progression and to use these cells to test potential treatment options. In this class, we will explore stem cell biology and the ways in which this field has developed to shape our ability to study complex human disease. We will introduce the fields of stem cell biology and genome engineering through critical reading of both the classical and newest primary research literature. This course will focus on the methods used to study embryonic and induced pluripotent stem cells, genome editing to create transgenic animal models of human diseases, regenerative medicine such as the transplantation of stem cell-derived cell types to replace diseased tissues, and current hot topics in genome engineering, such as CRISPR/cas9, a novel method that can be used within living organisms or cells to delete or insert genes of interest. In addition, we will discuss specific disease model systems and their benefits and limitations for understanding the disease and treating human patients. Students will learn the principles of experimental design and the main concepts and questions concerning stem cell biology, become familiar with current research techniques used to model complex human diseases, and become able to critically evaluate the claims in this field.

7.343 Molecular Mechanisms of Cell Identity: Epigenetics

Instructors: Maja Klosinska (mklosins@wi.mit.edu, 8-6765; laboratory of Mary Gehring)
Brian Abraham (abraham@wi.mit.edu, 8-5236; laboratory of Richard Young)

Spring 2014. Thursdays, 11 am – 1 pm. (Class time is flexible.) Room 68-150.

Almost every one of the trillions of cells in a plant or animal inherits the same DNA sequence, which can be traced back to the original fertilized egg. Yet plants and animals can have hundreds of specialized cell types with widely ranging jobs. How can individual cells specialize if they all have the same set of DNA instructions that are passed down during cell division? The short answer is that not all DNA instructions are followed in all cells. Join us for the long

answer, which involves exploring the molecular mechanisms that govern cell identity, its establishment and maintenance, and its inheritance. Epigenetic inheritance plays a major role in these processes. Epigenetics is a fast-moving field with boundaries that are debated and are evolving. We will begin by discussing the definition of "epigenetics" and its importance in controlling the wheres and whens of gene transcription. We will cover a list of proposed epigenetic processes, including chemical modifications to DNA, DNA-packaging proteins, and the transcription apparatus, and show how all act together to specify gene expression profiles that dictate cell identity. The two daughter cells of a parent often share elements of the parent's identity, and at least some epigenetic factors are heritable across cell divisions, and perhaps across generations. Each cell division necessitates maintenance or reconstitution of epigenetic marks, sometimes at the scale of whole chromosomes. For instance, since, for many animals, female genomes inherit two X chromosomes, one must be silenced, lest expression of genes on this chromosome be twice as high as in males with only a single X chromosome. We will cover the elegant mechanisms by which this silencing is carried out and how it is maintained across cell lifetimes and divisions. Studies of mice (e.g., cells of Agouti mice share identical genomes but manifest in diet-dependent coat colors) as well as of humans (e.g., the offspring conceived during the Dutch Hongerwinter themselves produce fatter-than-average offspring, linked to epigenetic marks on specific metabolic genes) indicate that non-DNA-sequence information can be transmitted through generations, while molecular studies show how epigenetic profiles can be reestablished after cell division. Epigenetic mechanisms also have been implicated in memory formation and learning. Our discussions will extend to diseases in which disruption of factors involved in DNA packaging, chromatin modification, or transcription has been implicated, such as in cancer, diabetes, and numerous mental disorders. This incipient field of epigenetics has uncovered central principles of regulation of gene transcription, which establishes cell identity, and is involved in development, disease, and even —very possibly—how we think. This course will explore the primary research literature in the field of epigenetics, with a special focus on experimental design and the critical interpretation of data.

7.344 Treating Infertility – From Bench to Bedside and Bedside to Bench

Instructors: Michelle Carmell (carmell@wi.mit.edu, 617-258-5174; laboratory of David Page)
Jana Hersch (jhersch@alum.mit.edu, 617-710-3496, laboratory of Peter Reddien)

Spring 2015. Thursdays, 1 pm – 3 pm (Class date and time are flexible). Room 68-150.

In the western world, approximately 10-15% of couples suffer from subfertility. Consequently, over 5 million babies have been born thanks to assisted reproductive technologies, and more than half of those have been born in the past six years alone. In some countries, 3-5% of births are achieved with assisted reproductive technologies, and this number is projected to grow as societies are increasingly interested in beating the biological clock. This class will cover the basic biology behind fertility and explore the etiology of infertility. We will cover the latest developments in reproductive science and discuss the clinical challenges of translating research findings into medical treatments. We will discuss recent studies of gonadal stem cells and their use for rejuvenation of fertility, oocyte and embryo cryopreservation studies and usage, current diagnostic tools for common causes of male infertility, and key mouse models with reproductive phenotypes. This class will highlight open questions in reproductive biology, familiarize students with both tried-and-true and emerging reproductive technologies, and explore the

advantages and pitfalls of each. Students will have the opportunity to visit a Boston-area IVF clinic and speak with researchers who are on the front lines of reproductive technologies.

7.345 Synthetic Biology and Metabolic Engineering: How We Design Bacteria To Make Products of Societal Importance
Instructor: Jens Plassmeier (jplassme@mit.edu, 617-253-5106; laboratory of Tony Sinskey)
Spring 2015. Fridays, 11 am - 1 pm. (Class time is flexible.) Room 68-150.

Biotechnology is a rapidly growing field that offers alternative ways to produce substances that previously were either made by complex chemical syntheses or impossible to produce. What do the organisms of the biosphere, specifically microorganisms, have to offer to biotechnological endeavors? The advantages of using microbes include the use of carbonic waste streams (*e.g.* food and crop waste) or CO_2 for the production of products that are useful to us (biofuels, amino acids, etc.), fewer toxic waste byproducts than in chemical syntheses, and the possibility of producing highly complex molecules economically. Our ever-increasing repertoire of controllable biological functions (encoded by the genes present in an organism) allows for the efficient production of a broad variety of biomolecules. The number of possibilities grows as synthetic biology (the ability to synthesize DNA and design genes at will) progresses in its ability to alter microorganisms and enzymes to make chemical structures that have never existed. In this course we will focus on the production of biomolecules using microbial systems. We will discuss potential growth substrates (such as agricultural waste and CO_2) that can be used and learn about both established and cutting-edge manipulation techniques in the field of synthetic biology. This course will include the production of biofuels, amino acids (*e.g.* lysine), food additives (*e.g.* monosodium glutamate, MSG), specialty chemicals (*e.g.* succinate), and biopharmaceuticals (*e.g.* plasmids for gene therapy). We will learn how microbes have been used for several millennia to produce flavorings and alcoholic beverages (*e.g.* wine and beer) and discuss how biotechnology has been used to enhance the production capabilities of such microbial strains. We also will discuss the production of enzymes that can be purified and used in various applications: have you ever wondered why you can wash your clothes at low temperatures? In addition, we will consider the production of medically relevant substances, such as antibiotics and biocompatible materials (*e.g.* polymers for tissue implants and tissue-engineering scaffolds). A field trip to a biotech company in the Cambridge area should be part of this course to show how molecular biology and microbiology research can directly lead to the production of marketable compounds like plastics, medicines, and food additives. In this literature-based course, students will learn to read and critically evaluate primary research articles published in the field of microbial biotechnology.

7.346 Peptides as Biological Signaling Molecules and Novel Drugs
Instructor: Mohammed Shabab (shabab@mit.edu, 617-253-3745, laboratory of Graham Walker)
Spring 2015. Fridays, 1 pm- 3 pm. (Class date and time are flexible.) Room 68-150.

All living cells possess machinery for peptide synthesis, secretion, and posttranslational modifications. An enormous structural and functional diversity of peptides is generated by use of this cellular machinery. Peptides are broadly used as signal molecules for intercellular

communication in prokaryotes, plants, fungi, and animals. Peptide signals in animals include vast numbers of peptide hormones, growth factors and neuropeptides. Some of the best known examples are enkephalins (which help us sense pain) somatotropin (which helps us grow), and insulin and glucagon (both of which regulate our blood glucose levels). Similarly, in plants peptide signals such as CLAVATA3 play important roles in development. Peptides are also used by living organisms as components of their host defense systems. What determines the functional specificity of each peptide? How do these small polymers of amino acids survive hostile protein-digesting enzymes? How are they able to communicate with their specific peptide receptors or interacting proteins for proper functioning? In this course, we will learn about molecular bases of peptide signaling. In addition, peptides potentially can be used as potent broad-spectrum antibiotics and hence might define novel therapeutic agents. For example, antimicrobial peptides (AMPs) are low molecular weight proteins with broad spectrum antimicrobial activity against bacteria, viruses, and fungi and are found among all classes of life. The ability of these natural molecules to kill multidrug-resistant microorganisms has gained them considerable attention and clinical interest, since multidrug-resistant microorganisms have developed resistance to multiple antimicrobial agents and are difficult to treat with available antibiotics. One of most notorious examples is deadly strains of methicillin-resistant *Staphylococcus aureus*. Infections from these pathogenic bacteria are untreatable with known antibiotics like gentamicin, streptomycin and kanamycin**.** Some antimicrobial peptides can kill methicillin-resistant *Staphylococcus aureus* strains, making them as promising future drugs. In this class, we will discuss AMPs, their biological functions, mechanisms of action, and applicability as therapeutic agents. Students will learn about various human defense peptides, such as defensins, and about plant peptides involved in symbiosis, such as nodule-specific cysteine-rich peptides. We will consider techniques to detect, quantify and modify peptides. We will also discuss experimental methods such as high-performance liquid chromatography (HPLC) and liquid chromatography coupled with mass spectroscopy (LC-MS) used for quantification of small molecules such as peptides. We will focus on the primary research literature, and students will learn how to read and critique research papers. Additionally, we will visit Cubist Pharmaceuticals, a pharmaceutical company based in Lexington, which is developing peptides as drugs for various pathological conditions, such as complicated urinary tract infections.