2018 Biology I: Big Questions Module Summaries
Department of Biological Sciences

Blindness: Can We See Potential Gene and Stem Cell Therapies for Neurodegenerative Diseases? Dr. David Hyde

Over 300 million people worldwide suffer from a neurodegenerative disease, including 36 million people who are classified as legally blind due to a retinal degenerative disease, ranging from Retinitis Pigmentosa (affecting children) to age-related macular degeneration (primarily affecting the elderly). Nearly all neurodegenerative diseases are progressive and there is currently only one cure for a specific disease. However, there are a number of new and exciting therapies that are either recently developed or in clinical trials. In this module, we will focus on retinal degenerative diseases because the retina is an accessible part of the central nervous system and is leading the way in the development of therapies for neurological diseases. Using both classical research papers and recent publications, we will discuss retinal anatomy and physiology, genetics of various retinal degenerative diseases, a recently approved gene therapy for Leber's Congenital Amaurosis (a form of childhood blindness), stem cells and stem cell clinical trials for age-related macular degeneration, cellular reprogramming, and culturing of mini-retinas. At the end of this module, you should be able to understand how the anatomy/physiology/genetics of a neurodegenerative disease dictates different therapeutic strategies and what those strategies are, as well as how the science and ethical issues associated with these therapies will impact society in the future.

Is Everything in Biology a Compromise? Dr. Stuart Jones

It's likely that at least once in your life you've heard the quip "you can't be good at everything", but did you know that many consider this our only scientific law in Biology? Because time, space, or energy are often limiting, the behavior and evolution of biomolecules and organisms are often confronted with tradeoffs, in other words "they can't be good at everything". In fact biologists even have a name for the mythical creature that can do everything - a Darwinian Demon. In this module we will explore the physiological, ecological, and evolutionary basis of tradeoffs, and consider the implications of these tradeoffs for the organisms that face them and for humankind. The module will focus on active and structured learning through the use of conceptual models and examples from diverse areas of biology.

Hero or villain: How might Earth's ecosystems resolve the climate question?
Dr. David Medvigy

In his encyclical Laudato Si', Pope Francis teaches that "Climate is a common good", and that "Humanity is called … to combat this [climate] warming". Interestingly, because carbon is an important constituent of living things, biological processes are intimately tied up with the climate question. In fact, the atmosphere is exquisitely sensitive to the tiny imbalance between the biological processes of photosynthesis and respiration. In this module, we will track the fate of "heroes", such as the Amazon rainforest. Amazonia has been, on net, absorbing ever-increasing amounts of carbon from the atmosphere, but its long-term fate is uncertain due to increasingly strong droughts. We will also discuss "villains" such as the microbial decomposers of the Arctic. The Arctic holds a tremendous amount of ancient, fossil carbon lock in permafrost. As this permafrost melts, microbes have the potential to decompose this carbon and release it to the atmosphere: a so-called "carbon bomb". As we follow all of our heroes and villains, we will come to understand how fundamental concepts in biology, like evolution, genetics, and others, affect the ways that scientists understand climate.

Who's in control? The role of microbiomes in our world. Dr. Shaun Lee

You may have heard the astounding phrase "Bacteria outnumber us 10 to 1 on our own bodies" but what does this really mean? In this module, we explore the concept of the microbiome, defined as the sum community of microorganisms that inhabit the host body space. Studies to describe microbes and microbial communities span almost half a millennia-from the first discovery of microorganism as 'animalcules' by Antonie van Leeuwenhoek in 1673, to current, cutting edge genomic technologies that allow us to build 'catalogs' of microbiomes in high detail. Highlighted concepts include: prokaryotic vs. eukaryotic diversity, commensalism, pathogenesis, microbial multicellularity, microbial-host interactions, genetic mechanisms of antibiotic resistance, and the ecosystem of microbiomes. Emerging studies on the importance of the human microbiome in health, including the role of microbiomes in host immunity, behavior, and treatment of disease will be examined through discussion of several highlighted scientific publications.

The Power for Life. Dr. Jeanne Romero-Severson

The Power for Life module focuses on the power sources that enable all of life and the complex systems that human invented to provide food, the renewable power source for us. We will consider these questions: How did life start? What are fundamental biochemical innovations that provided enough power to support complex life forms? How did the transition to agriculture affect human health? How did the transition to industrial farming and food processing affect human health? Is our total dependence on agriculture really a catastrophe?

Harnessing Our Immune System to Fight Disease: To Be or Not to Be!
Dr. Jeffrey Schorey

It's an exciting time for scientists who study the immune system! There is a long history of pushing our immune system to better fight disease (think vaccines!) but only recently have we gained enough knowledge about our immune system that we can treat a large number of diseases by specifically enhancing or blocking our immune response. In this module we will explore the origin of our immune system, how it works and what makes it unique among the other systems in your body. The flu caused by the influenza virus will be used to illustrate the difficulty in developing vaccines and how we can potentially overcome these struggles. We will also discuss several recent success stories in the context of cancer immunotherapy and treatments for autoimmune diseases. During the course of our discussions we will touch upon the many layers of biology from the molecular to the cellular through the whole organism and finally to the population level; all centered around the common theme of immunity and disease prevention/treatment.

Humans: How did we get here? and Why are we like this? Dr. Michael Pfrender

The Earth's many ecosystems are home to an amazing diversity of organisms ranging from single-cell bacteria, to complex multicellular plants and animals. Among these organisms, Humans are perhaps the most intriguing of all. In this module, we will examine the evolutionary mechanisms that generate biological diversity by focusing on aspects of Human biology. In the first section of the module we will trace the major transitions in the history of life that gave rise to Modern Humans. Our understanding of Human evolution has increased enormously in the past decade revealing the surprising complexity of our history. In the second portion of the module we will explore the relationship between information in our genes and the traits that make us uniquely human. Where does the tremendous variation among people come from? What can we say about the variation in our own genomes? We will examine these topics through a combination of lectures, discussions and readings from recent scientific publications.

Natural Selection: The reason why we haven't cured cancer? Dr. Zachary Schafer

Cancer is a disease that afflicts millions of individuals around the world. It is currently the 2nd leading cause of death in the USA and according to the CDC will likely become the leading cause of death by 2020. Despite significant research advancements over the years, why is cancer such a difficult foe to combat? This module will focus on the relationship between natural selection (survival of the fittest), cancer progression, and challenges in cancer treatment. Over the course of the module, we will learn basic tenets of biology (e.g. evolution, structure and function, information flow, pathways/energy transformations, and systems) in the context of cancer as a disease of "misbehaving" cells. Highlights include discussion of the following topics: how cancer cells adapt to diverse environments, intercellular communication, utilization of nutrients by cancer cells, cellular suicide, and why resistance to cancer therapies is such a significant problem.