INTEGBI 114 – Infectious disease dynamics (4 units)

INSTRUCTOR: Prof Mike Boots and Britt Koskella

Boots Email: mboots@berkeley.edu

Koskella Email: bkoskella@berkeley.edu

Webpage: https://bootslab.org and https://naturesmicrocosm.com

INSTRUCTOR INFORMATION

Prof Boots is a quantitative disease ecologist with broad training in ecological, epidemiological and evolutionary theory, and laboratory and field disease biology. He develops ecological evolutionary theory on host defense and parasite virulence, test this theory in model systems and apply ecological and epidemiological models to specific infectious diseases of humans and wildlife. Currently he is working on honeybee viruses, an insect virus model laboratory system, the spatial spread of plant disease in the field and models of TB in Badgers and Wildboar in addition to Dengue and Zika in human populations and more recently zoonotic Bat viral interactions. Since the pandemic he has been working on the pandemic response developing models of optimal testing protocols for university and other settings. Prof Boots believes that a quantitative understanding of the ecology and evolution infectious disease is critical in their management and that infectious disease provides a uniquely well-understood context to teach these quantitative approaches.

Prof Koskella has broad training in Ecology and Evolution, with a particular focus on host-pathogen interactions. Her research began as an undergraduate student examining the genetics of a fungal 'smut' pathogen that sterilizes flowers, then continued during her PhD where she used a snail-trematode interaction to test for the importance of host-parasite coevolution in driving diversity, and most recently has been focused on how bacteriophage viruses influence their bacterial hosts, and what effects this might have on the eukaryotic hosts in which these bacteria live.

Profs Boots and Koskella believe in the need for increased diversity in science, and work to foster a classroom and research environment in which all opinions and ideas are valued, and where each student feels empowered to offer new insight to a rapidly developing field.

COURSE FORMAT

The course will be completely remote during the 2021 spring semester –

The in person format was 3 lectures (Mon, Wed, Fri 10-11) and one hour of study section per week, but given that the course has such a large enrollment, we will cover the same material in a mix of pre-recorded and live lectures that are recorded so that you can take the course asynchronously.

We will have live lectures most weeks that apply the general concepts and approaches that we are learning about to the COVID-19 pandemics.

We will also have guest lectures from leading infectious disease researchers from across the US and around the world – many of which will focus on their COVID-19 work.

We will use the other lecture slots to run interactive sections with the recorded material and epidemiological modeling session.

We will also hold live discussion sections with smaller groups at times that work for students in different time zones.

Our aim is to have as much small group discussion time as possible.

There will be a major individual project of research on a particular disease leading to the production of a poster alongside mid terms and final exams.

PREREQUISITES

Bio 1A and Bio 1B or equivalent required, Ecology or Evolution course suggested.

FULL COURSE DESCRIPTION AND AIMS

The COVID-19 pandemic is a very stark reminder of the importance of infectious disease to human health and science. Even before COVID-19 infectious diseases remain as major public health problem, alongside their widespread impacts to agricultural and their major role in wildlife disease. Many of the challenges of managing infectious disease are essentially ecological and evolutionary problems. Disease follows the rules of species interactions as it spreads through host populations while resistance to antibiotics occurs through the rules of evolutionary biology. The key aim of the module is to teach ecological and evolutionary principles in the light of infectious diseases affecting human populations and societies as well as agriculture and wildlife. This is applied ecology and applied evolution writ large.

There is a large body of successful theory and more data in disease interactions than in any other ecological interaction. We aim to show how this combination of theory and data has been used to understand (1) the processes that determine population dynamics, (2) how we can successfully intervene in medical and conservation contexts (for example how many individuals should we vaccinate?), (3) how we can understand parasite virulence in the light of evolution and (4) how we can manage the impact of evolution on medical interventions. We begin by an introduction to the diversity of infectious disease but focus on key concepts using case studies and primary research literature to illustrate the fundamental concepts of disease ecology and evolution.

INTENDED LEARNING OUTCOME

- Understanding the role of infectious disease in natural populations and communities

- Understand the role of disease in shaping human agriculture and societies

- Describe how infectious disease may be important in conservation

- Discuss when parasite virulence makes sense in the light of evolution

- Explain how to apply ecological and evolutionary principles to the treatment and control of infectious

- Present a scientific poster on the evidence for coevolution between a pair of species.

- Apply this knowledge to our understanding COVID-19

TEXTBOOK

No required textbook

ASSESSMENT: (% of Final Grade)

Midterm 1 (15%):

Midterm 2 (15%)

Quizes, Assignments and participation throughout the semester (40%)

Poster (on assigned disease; 10%)

Final exam (20%, Finals week):

.

COURSE SCHEDULE

Classes will consist of online posting of lectures that will be three 40 or six 20 minute lectures per week generally focussing on a major conceptual topic in the dynamics of infectious disease.

In addition to your self study of these lectures will have live sessions where we play lectures and answer questions in real time.

In addition, we will have a series of live recorded lectures on the application of these ideas to the COVID-19 pandemic and have live recorded guest lectures from leading disease researchers.

We will teach a familiarity with disease modeling and forecasting techniques using hands on web-based modeling tools.

Discussion sections will (1) go over questions about the lectures, esp. as there is no text, (2) discuss the readings that will be presented in the last lecture of the week, and (3) later in the course it will help you with the major project (research on a particular disease to produce a poster). Instructions on all these things will be given during discussion. Later in the semester, the discussion sections will introduce you to how to conduct library and data base searches on a specific disease, and how to present the results as posters.

If you e-mail questions, we may share answers by e-mail with the rest of the class – rarely is something you are uncertain about unique to you. Nor is uncertainty or curiosity any kind of indictment of your abilities – quite the reverse – it means you are thinking and participating!!

SYLLABUS

During the course we will address the following topics:

The historic importance of infectious disease, The current importance of infectious disease, Introduction to the diversity of disease, Complex life cycles, Infectious disease transmission, Infectious disease dynamics, Modeling infectious disease, Contact networks, Heterogeneities, Vaccination, Population regulation, Zoonosis and disease emergence, Wildlife disease, Plant disease, Climate change and disease, Microbiomes, Disease intervention and control, Society and disease, Equity and disease.

We will illustrate general principles as they apply to COVID-19