Why a course on disease ecology and evolution?

In recent years there has been an unprecedented rise in the global incidence and severity of infectious diseases in human, animal, and plant populations across nearly all of the world's terrestrial, aquatic, and marine ecosystems. It is believed that such an intensification of diseases around the world is due to human activity, which has brought about habitat transformation, biological invasions, environmental contamination, climate change, and ensuing losses of biodiversity. Although disease outbreaks have historically been studied in relative isolation, the ecological and evolutionary complexities of disease development and spread have been clearly illustrated by such famous examples as the plague and flu epidemics, the Irish potato famine, and more recently, the swine flu pandemic, amphibian declines, white nose disease of bats, various forest declines, SARS, Lyme disease, and West Nile virus. We are now beginning to understand some of the basic ecological and evolutionary principles that may regulate disease emergence and transmission. These ecological and evolutionary principles are essential to our ability to understand new emerging disease outbreaks and spread and also to develop more comprehensive disease surveillance, prediction, and management systems.

Course goals

Most students emerging from introductory biology have often had little exposure to the ecological processes that influence and are influenced by infectious diseases. Furthermore, the typical preparation for medical and veterinary students focuses more heavily on the molecular, cellular, and organismal aspects of disease and rarely includes a broader scale focus on disease causation and management.

An important aim of this course is to provide students with a broad and basic understanding of infectious disease ecology and evolution, and to provide that understanding within the context of a science-based learning format that will hopefully foster scientific curiosity, critical thinking, and an appreciation of scientific inquiry. An overarching goal in the course is to integrate principles of disease ecology and evolution across human, animal, and plant hosts and to highlight the commonalities and differences and explore the linkages among the three types of hosts.

An additional aim of the course is to foster continued learning once you leave the university. To that end, we will try to provide you with the skills to not only ask good questions about the world around you, but to also develop the skills to effectively answer questions about diseases and any other subject with which you are curious.

This course is appropriate for a wide variety of biology students, with interests ranging from ecology, environmental biology, plant, animal, and human biology to microbiology, pre-vet and pre-med. A basic understanding of infectious agents and host responses is assumed. Therefore, **previous enrollment in PlPa 2950, "Biology of Infectious Diseases: From Molecules to Ecosystems" is highly recommended but not required.**

Syllabus contents

Course format

The course will be structured largely in a discussion-based format where we will explore contemporary topics in disease ecology and evolution through focused reading, analysis, and brainstorming. We will first explore concepts of health and disease. You will learn to think about diseases at different spatial and temporal scales and levels of biological

Course Details

Meeting Times:	**TR, 10:10-11:25, 336 Plant Science Building**
Instructors:	**Eric B. Nelson –** 323 Plant Science Building, ebn1@cornell.edu, 255-7841 **Michael G. Milgroom** – 222 Plant Science Bldg., mgm5@cornell.edu, 255-7872
Office Hours:	No set office hours. Contact us any time to set up a mutually convenient time to meet
Grading:	Letter only (3 credits)
Course website:	http://www.blackboard.cornell.edu

What will you learn in this course?

After completing this course you will be able to:

1) Ask good questions and be able to find the answers to those questions.
2) Identify and analyze the ecological and evolutionary processes that influence the dynamics of infectious diseases of humans, animals, and plants.
3) Compare and contrast the ecological and evolutionary dynamics of human, animals, and plant diseases.
4) Identify and analyze the ecological and evolutionary processes that influence disease dynamics at difference temporal and spatial scales.
5) Apply sound reasoning skills to identify the logical causes and regulators of disease development.
6) Analyze disease scenarios to effectively identify the ecological and evolutionary factors that may regulate disease emergence and transmission.
7) Apply ecological and evolutionary concepts to predict how new diseases might emerge.
8) Apply ecological and evolutionary concepts to develop sound management strategies for various diseases.
9) Apply knowledge, skills, and understanding to communicate principles of disease ecology and evolution to others.

organization and how to begin to ask and answer questions related to disease ecology and evolution. You will also learn how we gain new knowledge and understanding in disease ecology and how scientists communicate that knowledge and understanding to others. Most importantly, you will learn how to ask good questions and critically weigh evidence. This will help prepare you to learn about disease ecology and evolution more effectively.

Next, we will explore the basic aspects of population biology as it impacts infectious disease dynamics and evolution. You will explore topics such as the nature of populations, population interactions, metapopulations, microbial population genetics, the nature and evolution of virulence, and epidemic modeling, which will enable you to learn more about the mechanisms that facilitate disease transmission among and between populations of hosts.

We will next explore disease dynamics in complex assemblages of hosts, including interactions among plant, animal, and human hosts. You'll learn about the impacts of disease on ecosystems and the impacts of ecosystem changes on human, plant, and animal disease dynamics.

Presentation of proposal ideas

You will have the opportunity to educate us and the rest of your classmates on specific disease ecology and evolution topics that are of special interest to you. The topic for your presentation is also the topic of your disease ecology and evolution proposal. This is our favorite part of the course!

Integration and course wrap-up

For this last part we will all try to tie everything together in a meaningful framework for understanding the complexity of factors that influence disease dynamics at multiple temporal and spatial scales.

Accommodation of Students with Disabilities

In compliance with the Cornell University policy and equal access laws, we are available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first three weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.

Course requirements

We are assuming that you have an understanding of basic biology (i.e., has taken at least two semesters of introductory biology here at Cornell or has had the equivalent either here or elsewhere) and possibly also been exposed to basic microbiology. We also assume that you have a preconceived notion of what infectious diseases are all about.

This course will require that you read a significant number of primary research papers and review articles as well as popular magazine, newspaper, and web articles coving all aspects of infectious diseases of humans, animals, and plants. Don't worry if you feel like you don't know much about diseases of any particular host group. By the end of the course, you'll have a new appreciation for them. This course will also require that you come to class each and every day, prepared to discuss your thoughts and opinions of the papers you read and express your ideas during class discussions and journal entries. Learning is an active process, not a passive one, so the interactive nature of this class requires your commitment and continued participation.

Readings and Reading Discussions. There is no required or suggested textbook for this course. All of the course readings will come from primary research papers and review articles, as well as articles from the popular press. These readings will be available as PDFs on the class website. Students will be required to read numerous research papers throughout the semester. These papers will be used to illustrate important concepts and to underscore how science is performed and communicated. In-class discussions will center on interpreting data presented in research papers and how we might incorporate research results into new models of disease development.

To better facilitate the discussion and understanding of primary research papers, we will break up into small, structured reading groups. Students will be assigned to groups of six students. Each student within the group will be assigned a specific discussion “role” each week; these roles will be described in detaill in a handout later. Each student will be required to read the paper thoroughly prior to class, taking notes where appropriate, and perhaps doing some research to prepare with the necessary background and important details related to your specific role. You will write a “prep sheet” demonstrating your preparation for your assigned role; prep sheets will be turned in before class and will be used for evaluating your performance in this exercise. On reading group days, students will meet in small groups for approximately 25 minutes. This will be followed by a whole-class discussion for about 20 minutes. Roles will rotate each week so that everyone will experience each role a couple of times throughout the semester.

Journals. You will be required to write about your thoughts and reflections on the week’s major ideas, activities, discussions, and remaining questions or controversies that came up in class. These journals are mainly for you to review and reinforce what you learned each week. They have the added benefit of providing feedback to the instructors about the effectiveness of the classroom activities and readings for teaching you about infectious diseases. Concepts identified in journals as causing confusion will be discussed further in subsequent classes.

There are two main purposes of these journals: 1) to ensure that you understand the main points covered that week, and 2) to help you establish and work through some of your learning ideas without worrying about a grade. You can write as much or as little as you choose each week in your journal. However, we would like you to at least address the following questions in your journals: 1) What question(s) do you most wish had been answered this week?, 2) What was the most important new understanding for you this week?, and 3) What was the least clear about what material and experiences in class this week? You may do this either explicitly or implicitly. You are certainly encouraged to offer any other thoughts or ideas that you have each week. You should submit journal entries to us through the journals link on the class website **no later than 9:00 pm on Saturday of each week**. We will grade journals only on a complete/not complete basis. We will read journals to get a sense of what and how students in the class are thinking and understanding and comment appropriately in class the following Monday.

Here are the due dates for journals (please mark your calendars!):

Journal 1	Aug 30
Journal 2	Sep 6
Journal 3	Sep 13
Journal 4	Sep 20
Journal 5	Sep 27
Journal 6	Oct 4
Journal 7	Oct 11
Journal 8	Oct 18
Journal 9	Oct 25
Journal 10	Nov 1
Journal 11	Nov 8
Journal 12	Nov 15
Journal 13	Nov 22
Journal 14	Dec 6

Course assessments that contribute to your final grade

Grades will NOT be based on any kind of curve or forced distribution. Your instructors are very understanding guys and will do everything to be as fair as possible. The final letter grade will be assigned based on the following mean numerical scores from all the combined and weighted metrics:

Journals (14)	98 pts (9%)
Proposal Peer Review (2)	100 pts (9%)
Prep sheets (9)	150 pts (14%)
Investigative exercise 1	200 pts (18%)
Investigative exercise 2	250 pts (23%)
Proposal	300 pts (27%)
Total	1100 pts (100%)

Grade	+	0	-
A	≥98	92-97	88-91
B	85-87	82-84	79-81
C	76-78	73-75	70-72
D	67-69	64-66	60-63
F		<60	

You will be able to follow your grades on the class website so you can always know how you're doing in the class.

A general note on class attendance and participation. This class relies heavily on in-class activities and discussions, requiring you to attend class and participate in reading discussions and whole-class discussions. You'll be expected to attend every class unless you've made prior arrangements with the instructor. You've paid for it so you should get your money's worth! **You will also be expected to arrive at class on time and prepared for active engagement in class activities. This necessitates doing all of the assigned homework and readings BEFORE coming to class. We will do our best to start and end every class on time.** Remember – this course is for YOU and you need to get out of it what you came here for.

We realize that some students are more introverted than others and consequently do not participate much in class even though they are prepared. It would be unfair for us to penalize you for this and we would not want to favor only the more extroverted students. However, even though you may be introverted, we and others would certainly appreciate your ideas, insights, and opinions. We would hope that this class will be comfortable enough for everyone to freely express their opinions and ask questions. Your ideas will always be treated with respect and we will do everything possible to create a class environment in which you will feel comfortable participating in discussions.

Investigative Exercises. There will be two investigative exercises over the course of the semester. The purpose of these exercises will be to assess your abilities to apply your analytical reasoning skills to new and potentially unfamiliar aspects of infectious disease ecology and evolution. Each exercise will draw from the elements of disease ecology and evolution we have learned up to that point.

These exercises will typically be composed of two parts and involve three separate classroom activities

Part 1 will consist of a scenario for which **YOU** will be required to raise pertinent questions upon thinking about the disease scenario. You will then be required to provide a plan for answering the questions you posed, including the assumptions underlying your questions and the evidence needed to answer your questions clearly.

Part 2 of the exercise will take place out of class and will consist of your answers to the questions you raised, utilizing the evidence you outlined in Part 1. The evidence should be well referenced and pertinent. You will be expected to utilize all of what you've learned, read, and discussed up to that point to answer your questions. Exercises will be evaluated on the following criteria: 1) the quality and insightfulness of the questions posed; 2) the thoroughness of assumptions essential to answering the questions; 3) the logic, likelihood, and thoroughness of possible hypotheses; 4) the thoroughness of confirmatory and refuting evidence; and 5) a retrospective self-analysis of the soundness of your proposed plan for answering your questions. We will go over an example exercise prior to the first one.

Part 3: Once an exercise has been evaluated, we will devote a large part of a class period to discussing it, including the types and quality of questions asked and the strategies and resources employed for answering the questions, and the quality of the evidence used to answer the questions.

Disease ecology and evolution proposal. This proposal will serve as a proxy for a final exam for the course. You will complete a proposal on an aspect of disease ecology and evolution that interests you. The purpose of the proposal will be to serve as a vehicle for you to explore your own curiosities in new frontier areas of disease ecology and evolution, providing a **plan** for answering some of the bigger remaining questions in disease ecology and evolution, and communicating the findings to others. This will require you to explore your chosen topic in considerable depth so that the current level of our understanding is clear and the plan for filling our gaps in understanding, implementation, or societal need is well planned and articulated. The format for the proposal will be discussed early in the semester and the planning and work on the proposal will progress throughout the semester. Each of you will be expected to meet a series of milestones to ensure the timely completion of the proposal.

Proposals may outline a plan for laboratory or field research, disease management decision making, conservation, or any other aspect of disease ecology and evolution of interest to you. As examples, your proposal may focus on one particular disease or infectious agent or classes of diseases or infectious agents. Proposals may also focus on public or environmental health issues, conservation efforts, or policy making issues. Again, the topic should be of interest to YOU!

Please note: The proposal is NOT the same as a term paper. The proposal is a focused plan for answering YOUR important question in disease ecology and evolution.

Proposals will be evaluated by us and a panel of your peers. Although we will have final say on the proposal grade, the peer evaluations will be used to inform us of how well others understand what you are trying to propose.

Newly emerging fungal and oomycete diseases with complex ecologies are threatening forest ecosystems worldwide. These diseases lead to deforestation impacting human and wildlife diseases.

(From left to bottom right: Chestnut trees before the blight epidemic, Jarrah dieback, and Sudden oak death – one of the more devastating contemporary plant diseases)

Tentative Course Schedule (we will modify as needed as we go through the semester)

Class	Date	Topic Menu	Concept (s)
01	**Tue Aug 26**	Thoughts about the Ebola outbreak in west Africa Conceptual preview for the semester The discipline of disease ecology & evolution	
02	**Thr Aug 28**	Infectious diseases: players and processes Impacts of pathogens on hosts Important diseases to know	Disease triangle Infectious disease as an ecological and evolutionary process
03	**Tue Sep 2**	**Introduction to reading groups** Thinking about disease across temporal and spatial scales Disease "hotspots"	Reading scientific papers Scale and scaling
04	**Thr Sep 4**	Asking questions in disease ecology and evolution	Disease emergence Hypothesis space Scientific inference
05	**Tue Sep 9**	Introduction to disease ecology proposal **Reading group discussion 1**	The nature of science
06	**Thr Sep 11**	What are populations? Basic principles of population ecology Metapopulations	Logistic growth Density and frequency-dependent phenomena
07	**Tue Sep 16**	Thinking about pathogen transmission within and between populations; SIR epidemiological models **Reading group discussion 2**	Compartmental epidemiological models Concepts of R_0
08	**Thr Sep 18**	Genetic variation within and among populations: ecological interactions and evolutionary processes **Introduction to investigative exercises**	Population genetic concepts Basic mechanisms of evolution Phylogenomics

09	**Tue Sep 23**	Interacting populations of pathogens and hosts: ecological and coevolutionary processes Pathogen evolution Phylodynamics of influenza **Reading group discussion 3**	Coevolution HGT Pangenomes, and more
10	**Thr Sep 25**	**Investigative Exercise 1 (bring laptops to class)**	
11	**Tue Sep 30**	The nature of virulence: ecology and evolution; Virulence-transmission trade-offs **Reading group discussion 4**	Virulence evolution
12	**Thr Oct 2**	Multiple hosts and multiple infections: impacts on the ecology and evolution of virulence **Reponses to Exercise 1 due @ midnight on Sunday Oct 5**	Virulence evolution
13	**Tue Oct 7**	Ecology of host defenses (Eco-immunology); Ecology of host microbiomes; Immunity trade-offs **Reading group discussion 5**	Ecoimmunology Herd immunity Host microbiomes
14	**Thr Oct 9**	Multiple hosts revisited: The nature of zoonoses, reverse zoonoses, and host jumps **Class discussion of Exercise 1**	The nature of reservoirs and vectors Pathogen spillover and spillback
	Tue Oct 14	**Fall Break – No Class**	
15	**Thr Oct 16**	Biodiversity and infectious diseases: the issues	Disease dynamics in communities
16	**Tue Oct 21**	Biodiversity and infectious diseases: the controversy **Reading group discussion 6**	Reservoir competence Dilution effect

17	**Thr Oct 23**	**Investigative Exercise 2 (bring laptops to class)**	
18	**Tue Oct 28**	Thinking more about pathogen dynamics across multiple hosts and environmental reservoirs – connecting hosts, pathogens, and the environment Plants and human pathogens? **Reading group discussion 7**	Biodiversity and disease issues
19	**Thr Oct 30**	Emerging diseases in a changing world: Climate drivers **Reponses to Exercise 2 due @ midnight on Saturday Nov 1**	Drivers of disease emergence
20	**Tue Nov 4**	Emerging diseases in a changing world: Land use and biotic homogenization drivers **Reading group discussion 8**	Drivers of disease emergence
21	**Thr Nov 6**	Ecological and evolutionary mechanisms of antibiotic resistance **Class discussion of Exercise 2**	Antibiotic resistance
22	**Tue Nov 11**	Ecological and evolutionary mechanisms of antibiotic resistance (cont'd) **Reading group discussion 9**	Antibiotic resistance
23	**Thr Nov 13**	**Student proposal presentations**	
24	**Tue Nov 18**	**Student proposal presentations**	
25	**Thr Nov 20**	**Student proposal presentations (as needed)**	

26	**Tue Nov 25**	The problem of surveillance Emerging disease hotspots **Proposal draft due by midnight on Wed Nov 26th**	
	Thr Nov 27	**Thanksgiving Break – No Class**	
27	**Tue Dec 2**	Beyond OneHealth: Connecting humans, animals, AND plants	One Health Initiative
28	**Thr Dec 4**	Course wrap-up	What have we learned this semester?
Final Disease Ecology Proposals Due sometime between Wednesday Dec 10 and Thursday, Dec 18 **Due date and time will correspond to the end time for the scheduled final exam for the course**			

Academic integrity

Each student in this course is expected to abide by the Cornell University Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work. For this course, collaboration is allowed and encouraged for group projects, group discussions, take-home exams, brainstorming sessions, and exam preparation.

You are encouraged to study together and to discuss information and concepts covered in class sessions with other students. You can provide "consulting" help to or receive "consulting" help from other classmates. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of any electronic or print media. Should copying occur, both the student who copied work from another student and the student who gave material to be copied will both automatically receive a zero for the assignment. Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations. You may not compare papers, copy from others, or collaborate in any way during in-class examination periods. Any collaborative behavior (unless explicitly permitted by the instructor) during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.