

Biology of Infectious Disease

From Molecules to Ecosystems

Course description

In this course we will examine and discuss current concepts and trends in infectious disease biology, assessing our basic understanding of human, animal, and plant diseases and their impacts on one another. The nature of disease, the causal agents, host defense, mechanisms of transmission and strategies for management are remarkably similar among humans, animals, and plants. These basic principles that underpin all of disease biology are rarely integrated into a formal undergraduate or graduate course. You will think about and discuss infectious diseases in ways you have likely not thought about before and will hopefully come to appreciate the importance of a pathogen-centric view of disease in understanding human and environmental health.

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. At the same time, the ways in which we approach the prevention and management of diseases have changed little in the past 50-100 years. It is becoming increasingly clear that the intensification of diseases around the world is, in part, due to human activities, which have 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 complexities of disease development and spread have been clearly illustrated by such famous examples as the plague, smallpox and flu epidemics, the Irish potato famine, and more

Human activities are increasingly altering ecosystems in ways that influence disease dynamics in wildlife, plants, and ultimately humans whether it is through deforestation, environmental pollution, or invasive species.



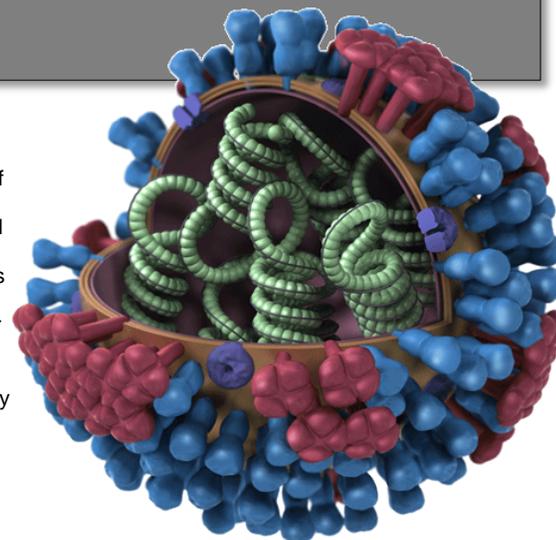
recently, the swine flu pandemic, amphibian declines, white nose disease of bats, colony collapse disease, various forest declines, SARS, Lyme disease, and West Nile virus. The interconnectedness among human, animal, and plant diseases and the infectious agents that cause them make it more important than ever to better understand these linkages, examine the basic principles that drive disease emergence and development, and critically reappraise contemporary approaches to disease mitigation and management.

Course goals

The typical preparation for medical and veterinary students does not include the broad treatment of disease processes that we'll cover in this course. Therefore, a basic goal of this course is to provide students with a comprehensive understanding of infectious disease biology, 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. We will critically examine the commonalities and differences in infectious diseases of humans, animals, and plants and explore the linkages among the three. In the end, we want you to leave the course thinking like a scientist and thinking about infectious diseases as a broadly trained scientist would.

We are assuming that every student in the course has some understanding of basic biology (either from an AP high school course, through the introductory biology curriculum at Cornell, or the equivalent either here or elsewhere) and has a curiosity to learn more about infectious diseases.

A key element of the success in this course will be your active engagement in each and every class as well as your commitment to and active involvement in your own learning. You will be expected to offer your thoughts, perceptions, and opinions about what you already know and believe, along with what you are learning and hope to learn. Most importantly, you will be



Graphical Representations of a Generic Influenza Virus (from CDC)

expected to actively explore your curiosity about disease biology.

This course will require that you read a fair number of primary research papers and review articles as well as popular magazine, newspaper, and web articles covering many aspects of infectious diseases of humans, animals, and plants. Don't worry if you feel like you don't know much about plant diseases. By

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Course Details

Meeting Times:	MWF, 11:15-12:05, 135B Plant Science Building
Instructors:	Eric B. Nelson – 323 Plant Science Building, ebn1@cornell.edu 255-7841 Michael Milgroom – 222 Plant Science Building, mam5@cornell.edu 255-7872
Graduate TA:	Katie Wilkins – 335 Plant Science Building, kew226@cornell.edu , 255-5652
Office Hours:	No set office hours. Contact us anytime to set up a mutually convenient time to meet
Grading:	Letter only (3 credits)
Course website:	http://www.blackboard.cornell.edu

How to approach this course	Newbies	Accomplished Novices	Experts
<p>It's not your course grade that reflects your success this course but rather what long-term understanding and insight you take away from it and how you ultimately want to use it. This is a function of how deeply you immerse yourself in the subject. Each of you is undoubtedly taking this course for different reasons. And, because this course is not required of any program, each of you is motivated to get different things out of it. You should focus on why you've decided that learning this material might be essential to your college experience, and what that means for you personally. It is entirely possible to do well in the class without being transformed by your newfound knowledge and understanding of infectious diseases, but it would be a shame if that didn't happen. This course can be different things for different people and you'll have the opportunity to dig as deeply into the subject as you wish, whether you are new to infectious diseases or whether you view yourself as expert.</p>	<p>Newbies need the basic foundations of disease biology, who the players are and how they behave, and how we might manage diseases, you want the surface-level knowledge. You may be considering a career in public health and are more focused on the social side of infectious diseases and less on the biology.</p>	<p>Accomplished novices have a grasp of the basics and are ready to think more deeply about health and disease, you want to know more about diseases as a biological phenomenon and want to know more details of their basic biology, ecology, and epidemiology.</p>	<p>Experts want to go deeper into the basic behavior and impact of infectious diseases, using the skills of scientists to ask critical questions and to think deeply about infectious diseases across all life forms and the importance of diseases to life on Earth.</p>
	<p>There's nothing wrong with just wanting the surface-level knowledge; this approach is appropriate if this is likely to be the only infectious disease course you are likely to take, or if you've never taken one before & it's all new. You will have new insights and understandings that you'll take away from the course.</p>	<p>Perhaps you've taken a course in biology, public health, or infectious diseases before, and are a pre-med or pre-vet student. You already know a fair amount about human diseases but have never really thought about diseases of all life forms, you are looking for patterns that characterize disease and how we might better humanity by understanding disease more deeply.</p>	<p>You are well aware of advances in infectious diseases and where some of the knowledge gaps exist. You actively seek the latest research findings and look for ways of synthesizing this knowledge into our current ways of thinking about disease. You look for alternative viewpoints, explanations, and applications.</p>
	<p>Newbies are often concerned mainly with the facts and figures: WHAT are diseases are most important and what are their distinguishing features. You tend to think less in mechanisms and syntheses. Newbies tend not to probe as deeply into the subject as accomplished novices and experts.</p>	<p>Accomplished novices notice inconsistencies and respectfully challenge assumptions through lively debate. You are interested in HOW & WHY things happen and what this means for how we approach and manage diseases. You tend to see a bigger picture and can connect detailed knowledge with larger concepts.</p>	<p>Experts don't take any of the course's structure or content as comprehensive or the end-all. They recognize the course's gaps. They are curious, passionate, and concerned with WHY the study of infectious diseases across all life forms, and not just humans, is important for understanding human and environmental health.</p>

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 actively express your ideas during class discussions. Learning is an active process, not a passive one, so the interactive nature of this class requires your commitment and continued participation. Below are more

specific guidelines for some of the course requirements:

Specific course requirements

Readings and Reading Groups.

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 PDF

files 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 conducted 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.

Course assessments contributing to your final grade

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

Reading group prep & participation (10@40 pts ea.)	400 pts (30%)
Disease management plan	400 pts (30%)
Weekly Quizzes (13 @ 30 pts ea.)	390 pts (29%)
Journals (14@10 pts ea.)	140 pts (11%)
Total	1330 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.

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. Except for unusual circumstances, requests for academic accommodations are to be made during the first three weeks of the semester so we can make mutually-agreeable arrangements. Students are encouraged to register with Student Disability Services to verify their eligibility for appropriate accommodations.

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 detail 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 25-30 minutes. This will be followed by a whole-class discussion for about 20 minutes. Roles will rotate each week so that everyone will have a chance to experience each role a couple of times throughout the course of the semester.

Journals

You will be required to write about your thoughts and reflections of the week's major ideas, activities, discussions, and remaining questions or controversies that came up either in or outside of 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



Electron micrograph of *E. coli* cells on contaminated food

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 at least to address the following questions in your journals: 1) What was the most important new understanding for you personally this week?, 2) What question(s) do you most wish had been answered this week?, and 3) What was the least clear about material and experiences in class this week? You are encouraged to offer any other thoughts or ideas that you have each week. You should submit journal entries through the "journals" link on the class website no later than 9:00 pm on Saturday of each week. We will not grade journals on content and quality but by whether you turned them in or not (**10 points each**). We will read journals to get a sense of what and how students in the class are thinking and understanding, and comment about them in class the following Monday. You should know that we're always excited to hear what you have to say and look forward to reading your journals every week.

Weekly Quizzes

There will be no traditional exams or final exam in this course. Weekly quizzes will consist of online responses to questions that come from concepts discussed that week. The purpose of these quizzes will be to assess your abilities to apply critical thinking and reasoning skills in which you utilize your current understanding of disease biology concepts to apply them to new and potentially unfamiliar aspects of infectious diseases. Once started, you will have 1 hr to complete each quiz. There will be a total of 13 quizzes with each comprise of 30 points, so any one quiz will not make or break your grade. Instead of a final exam, the disease management plan (see below) will serve as your final assessment.

Disease Management Plan

The disease management plan is an opportunity for you to integrate much of the knowledge you gain about infectious disease biology this semester in the context of disease management. This assignment will allow you to dig deeply into the biology of a disease system in which YOU are especially interested and to use that biology to formulate a plan to manage your disease of choice. Your choice of disease system may involve humans, domestic or wild animals, domestic or wild plants, or combinations of these and other hosts. You may also choose to focus on a group of

pathogens that have a multitude of diverse hosts. In the end, we want you to choose a disease system that you are especially interested in. Students will be required to meet individually with either Eric or Michael by early October to choose a disease system.

The disease management plan should consist of three parts: the first in which the biology of the pathogen and its interactions with its host(s) is extensively reviewed and disparate findings are synthesized into a coherent body of current understanding for that disease system. In the second part, you will describe and justify a plan for managing your particular disease. The management plan should be based explicitly on the biology of the system and not simply on the utilization of drugs or vaccines. Finally, in the third part you will summarize and synthesize the salient points in your plan and critically evaluate its potential for success.

This assignment will be due on November 25. A preliminary grade will be given on this version, but students will have the opportunity to revise their plans and resubmit for a final grade during final exam week. The two grades will be averaged for a final grade. Additional details about the structure and format of the plan, a suggested schedule and grading system will be provided at a later date.

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 group 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 be 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 never 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.

Course schedule (this will be updated throughout the semester)

Week	Concept(s)	Class Session	Date	Topic Menu
Week 1	Overview of infectious diseases, Ebola virus case study	01	8-27	Introductions, teaching philosophies; Discussion of the ongoing Ebola outbreak in West Africa
		02	8-29	Continue Ebola discussion: What questions emerge?
Week 2	Nature of pathogens and hosts, Disease-causing agents, Concept of pathogenicity and virulence			Labor Day Holiday – No Class
		03	9-3	Changing views of health and disease: from germ theory to the present day
		04	9-5	Overview of infectious agents, pathogens of humans, animals, and plants; What is a pathogen?; Damage-response framework
Week 3	Host defenses and immune responses, vaccines	05	9-8	Introduction to reading groups; Overview of host defense responses; innate and adaptive immunity
		06	9-10	Demonstration of reading group method; Vaccines
		07	9-12	Reading group 1
Week 4	Disease cycles, pathogen transmission, viral pathogens, influenza	08	9-15	Cyclic nature of disease, virus transmission
		09	9-17	Antigenic shift in influenza, host specificity, species jumps; concept of zoonosis
		10	9-19	Reading group 2
Week 5	Disease triangle, Pathogen dispersal, bacterial pathogens, Cholera	11	9-22	The nature of cholera and <i>Vibrio</i> species as pathogens, environment and disease, disease triangle
		12	9-24	Case study: Haitian cholera epidemic
		13	9-26	Reading group 3
Week 6	Horizontal gene transfer, pangenomes, antibiotic resistance	14	9-29	Bacterial pangenome concept, horizontal gene transfer and bacterial evolution
		15	10-1	Antibiotics and antibiotic resistance
		16	10-3	Reading group 4
Week 7	Antigenic variation, malaria	17	10-6	Introduction to malaria
		18	10-8	<i>Plasmodium</i> biology; antigenic variation
		19	10-10	Reading group 5
Week 8	Fungal and oomycete diseases; environmental impacts on disease			Fall Break – No Class
		20	10-15	The nature of fungal and oomycete diseases; chytridiomycosis and white nose syndrome
Week 9	Host microbiomes	21	10-17	Reading group 6
		22	10-20	Introduction to host microbiomes and disease
		23	10-22	Gut microbiota in health and disease; sepsis
Week 10	Host microbiomes and their interactions with immune systems	24	10-24	Reading group 7
		25	10-27	Host defense responses; innate and adaptive immunity revisited
		26	10-29	Cells and molecules in host immune responses
Week 11	Disease ecology, reservoirs and reservoir competence, silent carriers	27	10-31	Reading group 8
		28	11-3	Variation in defense responses among individuals and populations, concept of a reservoir
		29	11-5	Reservoir competence, Typhoid Mary, transmission networks
Week 12	Epidemiological modeling, SIR models, spillover, Hendra virus	30	11-7	Reading group 9
		31	11-10	Introduction to epidemiological modeling
		32	11-12	SIR models, threshold populations, R_0 , Hendra virus

		33	11-14	Reading group 10
Week 13	Disease emergence, SEIR models, Nipah virus	34	11-17	Emergence of pathogens, causal inference, return to antibiotic resistance
		35	11-19	Emergence drivers, concepts of scale, Nipah virus
		36	11-21	Reading group 11
Week 14	Review	37	11-24	Continue discussion of emerging diseases; Revisiting influenza and disease management
		38	11-26	Continue discussion of influenza and disease management
				Thanksgiving Holiday – No Class
Week 15	Communicating science, course wrap-up	39	12-1	The nature of science, science communication
		40	12-3	Prominent people in infectious disease history
		41	12-5	What did we learn this semester?

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.