GENOMICS AND INFECTIOUS DISEASE DYNAMICS (FALL, 2016)

Course Number: BIOL 3128 (Undergraduate) and BIOL 5128 (Graduate)

Days and Times T & R from 14:00 to 15:20

Room BIOSCI 332

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Welcome to the course "Genomics and Infectious Disease Dynamics", I look forward to working with you. This syllabus provides essential and helpful information about this class, please read it carefully. This syllabus will be followed as closely as possible. However, the instructor reserves the right to modify, supplement, and make changes as the course progresses. Thus, specifics are subject to change with prior notification.

COURSE DESCRIPTION

Events such as the SARS epidemic and the emergence of avian flu have increased public awareness about the need for incorporating ecology and evolution in decision-making processes that involve infectious diseases. It is increasingly evident for the public health community that molecular information, together with concepts from ecology and evolutionary biology, allows for testing of hypotheses and exploration of scenarios that otherwise could not be investigated by traditional epidemiological approaches. Understanding the ecological and evolutionary dynamics of infectious diseases requires the integration of information across organizational levels at various temporal and/or spatial scales. This requirement, together with novel molecular evolution, genomics, and mathematical modeling approaches, has positioned research on Genomics and Infectious Diseases Dynamics at the forefront of Public Health Genomics.

The goal of this class is to discuss some of the biological processes leading to the emergence and re-emergence of infectious diseases stressing on evolutionary concepts within an epidemiological context. Basic concepts will be provided by the instructor as part of formal lectures. Our general objective (integrating evolutionary biology into epidemiology) will be fulfilled by discussing research articles stressing the role played by molecular data in modern epidemiologic surveillance and control programs. Such discussions will take place during the second half of the semester. "Emerging" perspectives such as One Health and Public Health Genomics will be integrated into the lectures and discussions.

STUDENT LEARNING OUTCOMES

Upon successful completion of this course:

- Students will have learned a variety of approaches used to study Emerging Infectious Diseases from epidemiological, ecological, and evolutionary biology frameworks.
- Students will have read primary literature and integrated concepts from epidemiology and evolution in order to solve specific problems related with EID.
- Students will have gained proficiency in writing scientific papers.
- Students will have gained proficiency in self-directed learning.

REQUIREMENTS AND COURSE PHILOSOPHY

Prerequisite Undergraduates:
BIOL 2112 or 2912 – Introduction to Biology with a grade of C or better
Biology 2227 - Principles of Ecology with a grade of C or better

Prerequisite Graduate Students: None.

This is an upper-level course intended for juniors, seniors, and beginning graduate students. Being curious and inquisitive is a requirement. This class relies on courses that are being taught regularly at the undergraduate and graduate level; it requires a general course in Biology, as well as basic concepts in molecular biology and evolution. Notice that students will need to refresh concepts from time to time.

This course integrates several fields, so students will need to research for their own sources. Review articles will be provided so the students can check concepts at their discretion; however, those reviews are not expected to be the only source. This class does not cover pathogenesis, clinical, or basic molecular-cell biology aspects but you may need them.

The epidemiological and evolutionary concepts will be discussed in class. Students **(you)** are responsible for checking concepts and reviewing information on your own as needed (e.g. characteristics of the HIV virus, genetic exchange in bacteria, the genetic code, etc.). **Taking responsibility for your own education is called "self-directed learning" and it is an essential skill in the real world**.

The evaluation is highly individualized: students choose the topics of the final paper; in addition, the questions in essays are open to more than one correct answer. **Students will practice how to search, synthesize and communicate information.**

It is expected that, at the end of this course, students will learn how systematically apply/compare concepts from epidemiology, ecology and evolutionary biology to address problems in emerging infectious diseases. Those concepts are: One Health, Parasite, Host, Host range, Host specificity, Disease, Causation and Association in Epidemiology, Case Definition vs Phenotype, Sensitivity and Specificity, Prevalence, Incidence, Morbidity, R_0, herd immunity, Virulence (in Epidemiology, Ecology, and Evolutionary Biology contexts), Fitness, Adaptation, Natural Selection, Genetic Drift, Population (in Epidemiology, Ecology, and Evolutionary Biology contexts), Genotype, Phenotype, and Genetic Structure. You may have seen many of them in previous courses, however, others likely are completely new.

Notice that this course does not replace classes on evolution, population genetics, disease ecology, or epidemiology. You will learn basic concepts that will facilitate the interpretation of evolutionary genetic analyses and appreciate their value. Unfortunately, there is no time to teach the skills needed to perform such analyses. However, students could use this course to identify needs regarding their training or to obtain some basic language that will allow them to interact with evolutionary biologists working on EID.

RESOURCES

TEXTBOOK: There is no specific textbook; however, the students **should have** access to a general microbiology book and a general evolutionary biology book to be used as references. Required readings will be posted in blackboard a week in advance.

BLACKBOARD: Information pertaining to this class will be listed on Blackboard. *Students are responsible for checking Blackboard regularly.* Please, check it for announcements, class notes, recommended readings, updates, etc. *Notice that this syllabus will be followed as closely as possible. However, the instructor reserves the right to modify, supplement, and make changes as the course progresses. Thus, specifics are subject to change with prior notification.*

VALUABLE ONLINE RESOURCES: Web of Science (available via Temple library). *Students are responsible for learning how to use library resources*.

OFFICE HOURS: BY APPPOITMENT. Please make your appointment by e-mail. Concise e-mails are encouraged. Please, give the instructor at least 24 hours during business days to answer e-mails. Notice that you can request an appointment that better fits your schedule.

CONTACTING THE INSTRUCTOR: E-mail is the preferred method of contact. Students are welcome to make appointments or address administrative issues using e-mail. Please identify yourself as student in this class and write a concise message. E-mails will be answered within regular hours. Academic questions are better addressed in person during office hours. **Do not expect answers on weekends or late at night**.

LECTURE POWERPOINTS: Lectures will be posted **AFTER** class, within 48 hours, in either Powerpoint or pdf format. These materials are originally intended to guide the flow of the lecture and to support the explanations with appropriate graphics. In this sense they can be useful as study-guides. However, they are not substitute for note-taking, reading of assigned research articles, or your own search (checking books, review articles, etc.) i.e. they will not suffice to write your assignments nor can they be cited as primary source. It is the student's responsibility to download these guides. Do NOT ask the instructor to send them to you.

Electronic databases: Temple has free access to several electronic databases. If you are not familiar with their use (PUBMED or WEB of SCIENCE), please go to the library and ask for assistance.

GRADING POLICIES (GRADE ALLOCATION)

The course involves two parts. First, there will be lectures where the instructor will discuss basic concepts from epidemiology, ecology, and evolution. The second part includes an overview of specific EIDs, usually one brief introduction and two discussion sessions per week. **Students are expected to use and integrate concepts learned during the first part of the class.** The use of molecular evolutionary biology will be emphasized; however, a basic understanding of the epidemiological and anthropological contexts is encouraged.

GRADING POLICIES AND PERCENTAGES: There are a total of 100 points. Your grade will be based on the following items/activities:

- Papers: 60 % (20% first paper and 40% second paper)
- Discussion and individual participation: 40%.

The final grades will be based on a 90-80-70-60 scale. Grades are not standardized; this means that it is possible that all the students could receive an A. Study/discussion groups are encouraged. The following shows the **exact** breakdown for the grades:

Numeric-To-Letter-Grade Scale: 93-100 A, 90-92 A-, 87-89 B+, 83-86 B, 80-82 B-, 77-79 C+, 73-76 C, 70-72 C-, 65-69 D+, 55-64 D, 50-54 D-, 0-49 F.

Expect that the grading policy will be strictly applied.

PAPERS: are worth 60% total (20% the first and 40% the second). They should be written following the guidelines provided by the EID journal (http://www.cdc.gov/ncidod/eid/). **PRIMARY SOURCES (SCIENTIFIC ARTICLES IN PEER REVIEWED JOURNALS) SHOULD BE USED IN BOTH PAPERS.** The First paper will be an extended "Commentary" for all students. This commentary should be between 900-1100 words excluding references, title and personal identification. Although the journal states that commentaries can be written without references, **THIS IS NOT AN OPTION:** all students have to discuss and cite few research articles (primary sources) in their commentaries (http://www.loc.gov/teachers/usingprimarysources/whyuse.html).

The second paper will be a "Synopses" in the case of undergraduate students and a "Perspective" in the case of graduate students. The use of primary references (scientific articles in peer reviewed journals) is a requirement**.** This final paper should be between 2000-3000 words in length excluding references, title, abstract, and personal identification**.** Please: read the journal guidelines before asking what "Perspectives" or "Synopses" are. Notice that the papers lengths are clearly specified in this paragraph, writing papers that are excessively long or too short will affect your grade. **You don't have to write a cover letter nor write the section about your biography.**

Graduate students are expected to discuss the topic of their "Perspective" paper with the instructor by week 3. Undergraduate students are welcome to discuss topics for their "Synopsis" paper. Notice that brevity and Standard English are characteristics of a well-written scientific paper. Please avoid using unnecessary adjectives, flowery language, excessive redundancy, or any sort of poetic-storytelling prose. Colloquial use of terms will not be accepted. Literal quotations from papers are not recommended; if you need to use quotations please identify the source and clearly identify the quotation since those words will not be considered in for the paper total length.

I suggest that you write your commentary and final papers on the same or similar topics, however, it is not a requirement. Writing papers in a rush is strongly discouraged. Writing a good commentary facilitates your final paper. However, notice that these two papers are different assignments, if your final paper is simply a larger version of your commentary your grade will be affected. The topic for writing your papers is open but it should be clearly related with the class. As examples, there have been papers on how global warming affects vector-borne diseases, how the use of recreational drugs could affect the origin of antimicrobial resistance, how changes in land use affect the origin of emerging infectious agents, the problem of applying epidemiological concepts while studying wildlife diseases, the origin and evolution of a particular pathogen, and how genomics can be used to understand mechanisms of immune evasion in pathogens.

Students are expected to integrate ecological and/or evolutionary concepts in their paper, your effort for integrating at least two of the three major areas (ecology, evolution, and epidemiology) **will account for 50% of your grade**. Papers focusing only on epidemiology, public health or conservation medicine (even well written papers) **will not get a good grade**. E-mail submissions are required together with a hard-copy in class, papers are due at 3:00 PM the due date. Do not leave papers in my mailbox. There are not make-up papers without a valid medical excuse.

ATTENDANCE: Attendance is required; however, up to two excused absences (e.g. medical excuses) will not affect your grade. Any excused absence should be notified to the instructor prior the day or within three business days after you missed your class (if possible). Students who wish or need to request more than two excused absences should talk with the instructor. Students with more than four unexcused absences will get an automatic "**D**" even if they turn their papers in.

DISCUSSION AND INDIVIDUAL PARTICIPATION (40% TOTAL GRADE): **Attending class and submitting your written assignments are necessary but not sufficient conditions for getting an A.** Questions are very important and welcome; however, they are not considered participation. There is a clear difference between a student raising/waiving his/her hand in order to be noticed and a student actively participating/contributing in a discussion that ask questions for getting more information. Let's define "participation" as: a) comments showing that you have read a specific paper, b) a reasonable attempt to

understand or highlight a problem, c) provide an alternative perspective about an issue, d) recommend, introduce or present a research article to the class, e) been "volunteered" to explain/introduce assigned research articles (that will be done routinely, so be prepare), and f) pop quizzes or short written assignments in class. The instructor will keep a record of your participation; you are welcome to check it.

A good effort invested in understanding a problem is highly appreciated and considered participation even when the arguments are not entirely correct. However, notice than been lost or giving a totally wrong answer is not considered participation. Students are expected to do their best and been actively engaged in the discussion. Everyone could have a bad day; there will be plenty of opportunities to participate and recover. Traditionally, as benchmark, a student that participates clearly below average cannot expect more than 50 % of the participation points. Please keep your readings up to date. You don't have to memorize them: take notes while reading, bring questions on tables and figures, and make comments.

EACH GRADUATE STUDENT HAS TO LEAD THE DISCUSSION OF AT LEAST ONE PAPER. UNDERGRADUATE STUDENTS COULD VOLUNTEER OR WILL BE CHOSEN AT RANDOM IN CLASS.

EXTRA CREDIT POLICY: EXTRA CREDITS ARE NEVER GIVEN TO SATISFY INDIVIDUAL NEEDS. IF THE INSTRUCTOR DECIDES TO ORGANIZE ACTIVITIES IN WHICH EXTRA CREDITS CAN BE EARNED, ALL STUDENTS WILL HAVE THE SAME OPPORTUNITY.

LATE ASSIGNMENTS: It is anything that is turned in after a dateline without medical excuse or previous authorization from the instructor. If the instructor decides to grade it, 25% will be taken off the final grade if received up to a day late (24 hours). After a day and up to a week, your grade will be penalized up to 50% off. No late assignment will be accepted after a week. Notice that is up to the instructor to grade a late assignment.

RE-GRADING POLICY: If you consider that the instructor has made a mistake (different than adding points), you can request a re-grade. **Re-grades, however, are not partial**. Notice that you cannot request a re-grade that only encompasses part of the assignment, a single paragraph or a sentence out of context. A re-grade can go in any direction (**your grade could go up, down or remain unchanged**). Your original grade is nullified at the moment that you ask for a re-grade, thus, if you end having fewer points you cannot retract. Re-grading, however, is a dynamic process. It is highly recommended that you set an appointment with the instructor to discuss your assignment. Be ready to discuss the content of your assignment. Been self critical is important, your answers during the interview will be part of the re-grade process. Re-grades cannot be appealed with the instructor; there is a formal grade grievance process that you can follow. Re-grades should be requested within two business days after the grade is posted. Thus, you cannot ask for re-grades after two business days.

"BORDERLINE" GRADES POLICY: Students should not expect to be "bumped up" automatically to the next letter grade even if they need a fraction of a point. **It is considered unethical to ask for points (even a fraction), you will automatically lose any chance of getting that "extra point or fraction" if you request them from the instructor**. The instructor will evaluate all the borderline cases before posting the final grades and then decide whether a student could receive that extra point or fraction considering the big picture (overall responsibility, pattern of improvement, etc.).

If you have problems or questions, please either send an e-mail, use the office hours, or make an appointment. IT IS NOT POSSIBLE FOR THE INSTRUCTOR TO ANSWER ALL YOUR QUESTIONS AFTER OR BEFORE CLASS OR JUST BEFORE AN ASSIGNMENT. IF YOU SEND AN E-MAIL, PLEASE BE COURTEOUS, CONCISE, USE PROPER LANGUAGE, AND DO NOT ATTACH UNNECESSARY FILES. NOTICE THAT E-MAILS ARE INAPPROPRIATE TO DISCUSS CONTENT. **Please include "EID" in the subject line when you email the instructor to insure that spam filters do not classify it as junk email and accidentally delete it.**

INTERNET OR COMPUTER PROBLEMS: These are not valid excuses for turning an assignment late. There are several computers on campus that can be used if an assignment is done in a timely manner. Please plan ahead and consider the possibility of having a last minute problem.

DISABILITY DISCLOSURE:

Any student who has a need for accommodation based on the impact of a documented disability, including special accommodations for access to technology resources and electronic instructional materials required for the course, should contact the instructor privately to discuss the specific situation by the end of the second week of classes or as soon as practical. If you have not done so already, please contact Disability Resources and Services (DRS) at 215-204-1280 in 100 Ritter Annex to learn more about the resources available to you. The instructor will work with DRS to coordinate reasonable accommodations for all students with documented disabilities. If there are circumstances that make our learning environment difficult, please contact the instructor.

STUDENT/FACULTY ACADEMIC RIGHTS AND RESPONSIBILITIES: The University has a policy on Student and Faculty Academic Rights and Responsibilities (Policy #03.70.02) which can be accessed through the following link: http://policies.temple.edu/PDF/99.pdf

CLASSROOM RULES OF CONDUCT:

1. Please arrive to class on time and plan to stay for the entire lecture/discussion. Notice that late arrivals are disrespectful and distracting.
2. All cell phones must be turned off and hidden from view during class time. No texting is allowed. If you are expecting an important call, please notify the instructor before class. You should keep the phone on vibrate and answer the call outside the classroom.
3. Laptop and tablet computers are allowed for note taking and read your assigned papers only: i.e., other activities such as checking personal e-mail or browsing the Internet are prohibited.
4. This is an upper division class so students are expected to talk to the class. Please avoid side conversations.

ACADEMIC DISHONESTY, INCLUDING INAPPROPRIATE COLLABORATION, WILL NOT BE TOLERATED. See below the Civility & Temple's Code of Conduct.

CIVILITY & TEMPLE'S CODE OF CONDUCT (COC): Violations of the CoC include, but are not limited to: academic dishonesty and impropriety, including plagiarism and academic cheating; interfering or attempting to interfere with or disrupting the conduct of classes or any other normal or regular activities of the University (see: http://policies.temple.edu/PDF/294.pdf).

LETTERS OF RECOMMENDATION: I get many requests for letters of recommendation. Unfortunately, I do not have the opportunity to get to know all students as individuals. You want a recommender who can write something like "I have personally observed in this student the creativity, dedication and perseverance required for…", rather than "The student demonstrated excellent knowledge of the subject, with a grade of "A" in my class." **Therefore, I likely will decline to write you a recommendation letter that is based solely on this class.**

PROGRAM: *This syllabus will be followed as closely as possible. However, the instructor reserves the right to modify, supplement, and make changes as the course progresses. Thus, specifics are subject to change with prior notification.*

Dates: **Topics (Lectures: L; Discussion: D; R: Readings):**

Week 1: L1: Introduction.

R: Lloyd-Smith J et al (2009). Epidemic dynamics at the human-animal interface. Science 326:1362-7. doi: 10.1126/science.1177345.

L2: Epidemiology of infectious diseases: Basic concepts: Population, Case Definition, Research Methods/Study Design (lecture).

R: Grimes DA and Schulz KF (2002). An overview of clinical research: the lay of the land. Lancet. 359(9300):57-61.

Week 2: L3: Epidemiology of infectious diseases: Research Methods/Study Design, Causality.

R: Grimes DA, Schulz KF. (2002). Cohort studies: marching towards outcomes. Lancet 359(9303):341-5.

R: Grimes DA, Schulz KF. (2005) Compared to what? Finding controls for case-control studies. Lancet 365:1429-33.

L4: From Epidemiology to Ecology: Introduction to Evolutionary Ecology of pathogens. R_0 and defining a population.

Week 3: L5: Transmission Dynamics - How to read a SIR model (an Introduction)

R: Wonham et al. (2004). An epidemiological model for West Nile virus: invasion analysis and control applications. Proc Biol Sci. 271(1538):501-7.

L6: Virulence versus pathogenesis/Contrasting perspectives.

R: Alizon S. et al. (2009) Virulence evolution and the trade-off hypothesis: history, current state of affairs and the future. J Evol Biol. 22(2):245-59. doi: 10.1111/j.1420-9101.2008.01658.x.

R: Schmid-Hempe P. (2009) Immune defence, parasite evasion strategies and their relevance for 'macroscopic phenomena' such as virulence. Philos Trans R Soc Lond B Biol Sci. 364(1513):85-98. doi: 10.1098/rstb.2008.0157.

Week 4: L7: Evolution: Genetic drift and Neutral Evolution.

L8: Evolution: Neutral Genetic Variation and Population Structure.

Week 5: L9: Evolution: Natural Selection: Fitness and Adaptive Genetic Variation.

R: Hurst LD. 2009. Fundamental concepts in genetics: genetics and the understanding of selection. Nat Rev Genet. 10(2):83-93. doi: 10.1038/nrg2506

L10: Basics on how to read phylogenetic trees.

R: Baum DA. et al. 2005. The tree-thinking challenge. Science. 310(5750):979-80.

R: Whelan S. et al. 2001. Molecular phylogenetics: state-of-the-art methods for looking into the past. Trends Genet. 17:262-72.

Week 6: L11: Basics on how to read phylogenetic trees.

R: Baldauf SL. 2003. Phylogeny for the faint of heart: a tutorial. Trends Genet. 19:345-51.

L12: Evolutionary Medicine: Comparing Phenotypes with Case Definition.

R: Stearns SC. 2012. Evolutionary medicine: its scope, interest and potential. Proc Biol Sci. 279(1746):4305-21

Week 7: L13: Evolutionary Medicine: Adaptation or neutral evolution?

R: Tibayrenc M. 2005. Bridging the gap between molecular epidemiologists and evolutionists. Trends Microbiol. 13(12):575-80.

L14: One Health and Evolutionary Medicine.

R: Coker R. et al. 2011. Towards a conceptual framework to support one-health research for policy on emerging zoonoses. Lancet Infect Dis. 11(4):326-31. doi: 10.1016/S1473-3099(10)70312-1.

R: Cleaveland S. et al. 2014. Ecology and conservation: contributions to One Health. Rev Sci Tech. 33(2):615-27.

Week 8: D1: Is there a "Molecular Epidemiology"?

R: Foxman B. 2007. Contributions of molecular epidemiology to the understanding of infectious disease transmission, pathogenesis, and evolution. Ann Epidemiol. 17(2):148-56

D2: Public Health Genomics.

R: Geller G. et al. 2014. Genomics and infectious disease: a call to identify the ethical, legal and social implications for public health and clinical practice. Genome Med..6(11):106. doi: 10.1186/s13073-014-0106-2.

Week 9: D3 and D4: Surveillance: Molecular typing.

R: Coscolla M. et al. 2015. Genomic epidemiology of multidrug-resistant Mycobacterium tuberculosis during transcontinental spread. J Infect Dis. 2015 Jul 15;212(2):302-10. doi: 10.1093/infdis/jiv025.

R: Didelot X. et al 2013. Genomic evolution and transmission of Helicobacter pylori in two South African families. Proc Natl Acad Sci U S A. 110(34):13880-5. doi: 10.1073/pnas.1304681110.

Week 10: D5 and D6: Phylodynamics: Influenza and Dengue (Discussion).

R: Pybus OG and Rambaut A. 2009. Evolutionary analysis of the dynamics of viral infectious disease. Nat Rev Genet. 10(8):540-50. doi: 10.1038/nrg2583.

R: Rasmussen DA. Et al. 2014. Reconciling phylodynamics with epidemiology: the case of dengue virus in southern Vietnam. Mol Biol Evol. 2014 Feb;31(2):258-71. doi: 10.1093/molbev/mst203.

Week 11: D7 and D8: Drug Resistance.

R: Wilson BA. et al. 2016. The population genetics of drug resistance evolution in natural populations of viral, bacterial and eukaryotic pathogens. Mol Ecol. 25:42-66. doi: 10.1111/mec.13474.

R: Nair S et al. 2007. Recurrent gene amplification and soft selective sweeps during evolution of multidrug resistance in malaria parasites. Mol Biol Evol. 24(2):562-73.

R: Osório NS. et al. 2013. Evidence for diversifying selection in a set of Mycobacterium tuberculosis genes in response to antibiotic- and nonantibiotic-related pressure. Mol Biol Evol. 30:1326-36. doi: 10.1093/molbev/mst038.

Week 12: D9 and D10: Pathogens variation and vaccines.

R: Neafsey DE. Et al 2015 Genetic Diversity and Protective Efficacy of the RTS,S/AS01 Malaria Vaccine. N Engl J Med. 373(21):2025-37. doi: 10.1056/NEJMoa1505819.

R: Merker M. et al. 2015. Evolutionary history and global spread of the Mycobacterium tuberculosis Beijing lineage. Nat Genet. 47(3):242-9. doi: 10.1038/ng.3195.

Week 13: D11 and D12: Wildlife diseases.

R: James TY. et al. 2009. Rapid global expansion of the fungal disease chytridiomycosis into declining and healthy amphibian populations. PLoS Pathog. 5(5):e1000458. doi: 10.1371/journal.ppat.1000458.

R: Kovaliski J. et al. 2014. Molecular epidemiology of Rabbit Haemorrhagic Disease Virus in Australia: when one became many. Mol Ecol. 23(2):408-20. doi: 10.1111/mec.12596.

R: Ferguson EA. et al. 2015. Heterogeneity in the spread and control of infectious disease: consequences for the elimination of canine rabies. Sci Rep. 5:18232. doi: 10.1038/srep18232.

Week 14: D13 and D14: Climate Change and Infectious Diseases.

R: Medlock JM and Leach SA. 2015. Effect of climate change on vector-borne disease risk in the UK. Lancet Infect Dis. 15(6):721-30. doi: 10.1016/S1473-3099(15)70091-5.

R: Rohr JR et al. 2011. Frontiers in climate change-disease research. Trends Ecol Evol. 26(6):270-7. doi: 10.1016/j.tree.2011.03.002.

Week 15: D15 and D16: Pathogens demographic history.

R: Comas I et al. 2013. Out-of-Africa migration and Neolithic coexpansion of Mycobacterium tuberculosis with modern humans. Nat Genet. 45(10):1176-82. doi: 10.1038/ng.2744.

R: Zhou Z et al. 2014. Transient Darwinian selection in Salmonella enterica serovar Paratyphi A during 450 years of global spread of enteric fever. Proc Natl Acad Sci U S A. 111(33):12199-204. doi: 10.1073/pnas.1411012111.

Week 16: D17 and D18: Virulence and Specificity

R: Fraser C. et al. 2014. Virulence and pathogenesis of HIV-1 infection: an evolutionary perspective. Science 343(6177):1243727. doi: 10.1126/science.1243727.

R: Kreuder Johnson C. et al. 2015. Spillover and pandemic properties of zoonotic viruses with high host plasticity. Sci Rep. 5:14830. doi: 10.1038/srep14830.