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BIOS 435/835: Evolutionary Medicine

Basic Course Information

Instructor:

Dr. Clay Cressler, Assistant Professor, School of Biological Sciences
424 Manter Hall (office)
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Office Hours and Email: Wednesday and Friday mornings from 9-10 and by appointment. I'm here to help - please use my email to communicate questions and concerns. I will respond to all emails within 24 hours of receipt during the week, and within 48 hours on the weekend.

Course Overview:

BIOS 435/835 Evolutionary Medicine, 3 credits

Description: Evolutionary perspective on human health. Emphasis on how human evolutionary history and the evolutionary histories of our parasites influences disease; evolution of aging; reproductive biology and mother-offspring conflict; parasite virulence evolution; evolution of drug resistance; hygiene hypothesis and autoimmune disease; mismatch to modernity and the diseases of civilization.

Prerequisites: LIFE 121 Fundamentals of Biology II

Class meeting times: Tuesdays and Thursdays 2:00-3:15pm

Class location: 401 Manter Hall

Textbook and Supplemental Resources:

There is no required textbook for this class. For each class period, students will read article(s) from the primary literature that are relevant to the learning goals for that day. These primary literature articles are paired with popular science articles, videos, or podcasts that deal with the same topic. This pairing is meant to improve understanding of the primary literature article and to provide examples of how scientific discoveries are communicated to the public.

Accompanying each paired set of readings are discussion questions that must be turned in at the beginning of each class period.

PDF files of lecture slides will also be posted on Canvas.

Course Description and Learning Goals

What does evolution have to teach us about human health and disease? While biomedical science has identified many of the proximate biochemical, physiological, and immunological mechanisms that underlie disease, the ultimate explanations for why we get sick are intimately tied to both our evolutionary history and the evolutionary histories of our parasites and pathogens. This course will provide students with an evolutionary perspective on human health and disease, showing how a consideration of features of the evolutionary process (like genetic variation, common descent, natural selection) can provide a complementary approach to the study of disease, helping to solve many of the complex health problems facing humans today. The course also emphasizes scientific communication. Evolutionary medicine is a rapidly developing field, with considerable appeal to the general public, and

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dozens of articles appear every year in popular science blogs, columns, and magazines that touch on course material. Students will engage with both the primary and popular science literatures to develop as effective communicators of science.

Learning Goals

By the end of this course, students will be able to:

- Explain how evolutionary processes like mutation, drift, natural selection, kin selection, and sexual selection can help us understand the ultimate causes of disease;
- Apply the tools of evolutionary biology, such as phylogenies, to biomedical problems, such as flu evolution;
- Explain how evolutionary trade-offs can arise at different levels of biological organization and evaluate the importance of trade-offs in shaping human life history evolution, the evolution of the immune system, and parasite evolution;
- Analyze human health problems and identify whether and how an evolutionary perspective can help with understanding the causes and/or treatment of disease;
- Apply an understanding of evolutionary processes to predict the response of humans and their parasites to changes in the environment;
- Analyze mathematical representations of biological systems to understand and critique the assumptions made in constructing the mathematical models;
- Critically read and synthesize biological literature in an area of science that is still very much under debate;
- Effectively communicate complicated scientific ideas using both written and oral presentations.

Key Dates

Feb. 7 – rough draft of research summary and synthesis due

Feb. 14 – topic statement for final project due

Feb. 19 – no class – meet with me to discuss final project

Feb. 21 - take-home essay #1 due

Feb. 28 – final draft of research summary and synthesis due

Mar. 7 – annotated bibliography due

Mar. 28 – take-home essay #2 due

Mar. 28 – rough draft of final paper due

Apr. 25 – final draft of final paper due

May 2 – take-home essay #3 due

Assessment

Pre-class Reading Assignments (30%)

Attendance and Participation (10%+5% Team assessment)

Research Summary and Synthesis (7%)

Take-home essays (13%)

Synthesis and Review Article (35%)

- Topic statement (2%)
- Annotated bibliography (7%)
- Rough draft (6%)
- Final draft (20%)

Pre-class Reading Assignments (30%): Prior to each class, students will read articles from the primary literature. **The purpose of these articles is two-fold.**

The articles highlight novel, non-intuitive, and important results that:

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- (a) Introduce key evolutionary concepts and processes that have implications for the study of medicine.
- (b) Demonstrate how the tools of evolutionary biology (e.g., phylogenies, genomics, mathematical models) are used to answer biomedical questions.
- (c) Inform our understanding of how evolution shapes traits related to disease.
- (d) Explore the frontier of our scientific understanding.

Reading these articles:

- (e) Improves your ability to process and understand the scientific literature.
- (f) Ensures that you come to class ready to engage in discussion and exploration of these topics (e.g., points (a)-(d) above) in more detail.

Typically, these articles will be complemented by popular science pieces (articles, videos, podcasts) that summarize the research findings of the primary literature article and put those findings into a broader context, using language that can be understood by the general public. These popular science pieces will make the primary literature more accessible, as well as to provide examples of how science journalists approach the task of making scientific research accessible.

You are required to submit three responses to the daily reading by 11:59pm the night before class. Your responses will be integrated into the class discussion each day, and I will use them to measure your engagement with the material. These responses should do three things:

- (1) *Highlight the result obtained or question provoked by the study* that you found most surprising, interesting, or otherwise compelling. You should include an explanation of how the authors came to that result or question, and explain why you found it compelling. This is an excellent way to demonstrate that you read the article carefully and thought about it.
- (2) *Propose one question that can be used to stimulate discussion.* Discussion questions should not address purely technical or methodological questions (see below). They should be open-ended questions that need not have a right or wrong answer, but should be answerable by other students (that is, don't write questions that you think only the instructor can answer). Example prompts for a good discussion question include, "What is the importance of...", "Compare...", "Contrast...", "What are the causes of...", "What connection is there between...", etc.
- (3) *Address technical or methodological questions.* These questions can be purely for clarification and comprehension, that is, they can have right or wrong answers. Note that a question about whether a particular experiment or method is actually appropriate for answering the study question is more of a discussion question.

These responses will be assessed on a simple 2 point scale: thoughtful responses that demonstrate clearly that you read the articles and thought about them will receive full credit; partial credit will be awarded to responses that are complete but superficial; no points will be awarded if the questions are missing or could have been written based only on reading the abstract. *The three lowest scores will be dropped.*

Attendance and Participation (10%+5% Team assessment): Class periods are structured around discussion and peer-to-peer interaction, so your attendance and participation is what makes the class successful. Each class is worth two points: one for attendance, and one for participation. Attendance is self-explanatory; your participation score is determined by whether you were engaged in the class, taking notes and talking to your classmates. If you notice you browsing the internet or texting, you will not receive the participation point for the day. *The two lowest scores will be dropped; this is how I accommodate absences for any reason. If you have to miss more than two classes, come talk to me.* At the end of the semester, you will evaluate the students you have been working with for the entire

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semester. These peer evaluations are entirely anonymous, but give you a chance to reward the outstanding efforts of your teammates, or not to do that.

Research Summary and Synthesis (7%): A two-page paper that summarizes and synthesizes two related primary literature articles. The purpose of this paper is to improve your ability to concisely, accurately, and informatively explain scientific research, and to integrate and synthesize information across multiple studies. This is an essential skill for success on the final project. You will turn in a draft of this research summary to the Writing Fellow (see below), who will provide detailed written and verbal feedback on the draft before the final draft is due to me. Turning in a complete draft, including an author's note (see below) is worth 1%; meeting with the Writing Fellow to discuss the rough draft is also worth 1%. The remaining 5% is based on the final draft.

Essays (13%): Three take-home essays. The essay questions will draw on previous course material and discussion. These essays may involve explaining an evolutionary concept, hypothesizing an evolutionary mechanism for observed data, analyzing a pattern in data, or other similar questions. These exams will be take-home to give you space to be reflective and to more fully communicate your thinking. *These essays will be self-graded.* In many ways, *you* are the best judge of your understanding of the material – you know how hard you worked on each question, and you know how well you understood the premise of the question and how able you were to answer it without resorting to hand-waving or obfuscation. However, I reserve the right to modify your self-assessed grade, either up or down.

Final Project (35%): The final project for this course will be a **3000-word synthetic review of the evolutionary considerations of any human health condition or other topic in evolutionary medicine.** The review must synthesize the current state of scientific knowledge in the topic, with at least 10 references, at least 7 of which must be from the primary literature. Don't be constrained to only thinking about infectious disease, as there are evolutionary factors that help explain our susceptibility to chronic diseases (obesity, mental illness, etc.) as well. To help you think about this topic starting early in the semester, there are several "mini-goals" along the way.

- **Topic statement (2%):** You must submit a topic statement by Feb. 14, and you must schedule a short (5-10 minute) meeting with me to discuss this topic to determine whether it is appropriate and likely to have enough information for being able to write a synthetic review. I provide a list of potential topics at the end of this syllabus. This list is not comprehensive, so don't feel constrained to choose something on the list.
- **Annotated bibliography (7%):** You are required to submit an annotated bibliography that identifies 12 articles that will be used in the synthetic review. At least 10 of these articles must be from the primary literature. In addition to providing a properly formatted citation, you must provide a three-sentence summary of the article that identifies the key result of the study and explains how the study fits into the theme of the review. This is due March 7.
- **Rough draft (6%):** A detailed rubric will be distributed later in the semester that details how the final draft will be evaluated. To earn full credit for this portion, you must do three things: (1) turn in the rough draft on time (1%); (2) meet with the Writing Fellow to discuss the rough draft (1%); (3) turn in a complete rough draft that meets the page and reference requirements and includes an author's note (4%). This is due March 28.
- **Final draft (20%):** Due April 25.

Author's Notes

You will turn in rough drafts of the Research Summary & Synthesis and Final Project to the Writing Fellows (see below). You are required to include a 1-2 paragraph author's note with your rough draft.

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You can put the author's note as a separate, single-spaced paragraph before the main part of your paper. Your author's note should address the following:

- How far along are you in your drafting process? Is this a pretty complete draft, or have you just started? Is there more you know you want to say?
- How confident are you in what you've written so far? What are your favorite/least favorite aspects of what you've written?
- What specific kinds of feedback would you like? What questions do you have?

Writing Fellows

Writing Fellows are undergraduate students themselves who enjoy talking with other students about writing. They work one-to-one with students in a specific course, giving written feedback on rough drafts and holding face-to-face conferences with students. The Writing Fellows will talk through ideas and problems with you and help you figure out how to express your own ideas as clearly and effectively as possible. They are not editors or proofreaders; rather, they are here to help you meet your writing goals in this course and become a stronger, more confident writer. *They will help with revision of the Research Summary and Synthesis and the Final Project.*

Note to Graduate Students

If you are taking this course at the 800-level (BIOS 835), the requirements are slightly different. The final project should, ideally, be something that is applicable to your own research, so that the writing is meaningful to you. It is fine if that means the topic is slightly adjacent to evolutionary medicine, though evolutionary medicine is a big umbrella that can accommodate a lot of topics! Also, you will lead the discussion during the last week of class, serving as the primary instructor. Most likely, you will end up crafting the discussion around whatever topic you are writing about for the final project. I will be available to help you with crafting these discussion sections, so don't hesitate to ask.

Course Policies

Deadlines

You are expected to be prepared to hand in assignments at the scheduled times. If there is a valid, verifiable reason why you will have to miss a deadline during the semester, please come speak to me right away. Circumstances that *might* induce me to give an extension include some outside events, illness or emergency. Please contact me as soon as possible to hand in the documentation for your absence and to arrange an alternate time to hand in the assignment. In the absence of any communication, I will deduct 20% per day for each day an assignment is late.

Academic Honesty:

I expect you to adhere to guidelines concerning academic dishonesty outlined in UNL's Student Code of Conduct (<http://stuafs.unl.edu/ja/code/>). Please contact me if you need clarification of these guidelines or if you have questions and/or potential concerns.

Students with Disabilities:

Students with disabilities are encouraged to contact me for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.

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Possible topics for the final writing project

- Evolution of virulence
- Evolution of drug/chemotherapy resistance by parasites/cancer
- Vaccine-driven evolution of a particular infectious disease
- Evolutionary causes of (re)emergence of a particular infectious disease
- Evolution of parasites with complex life cycles
- Host behavioral manipulation by parasites
- Phage therapy – using coevolving organisms as treatments for disease
- Human population genetics and disease
- The future of human life history evolution
- Parent-offspring conflict during pregnancy
- Parent-parent conflict during pregnancy
- Evolution of menstruation
- Evolution of menopause
- Cost of reproduction and lactation
- Evolutionary considerations in mate choice
- Chronic disease and the fetal origins hypothesis
- Energetics of immunity
- The adaptive value of disease symptoms
- Infection-induced anorexia - why do we lose our appetite when we get sick?
- The Hygiene Hypothesis for autoimmune disease
- The “Paleo” diet
- Evolutionary explanations of mental disorders
- Evolution of altruistic behavior
- CRISPR and the future of evolution