

Evolutionary Medicine

Biol. 402-027 Biol. 502-027

UNM Department of Biology Fall 2009

Castetter Room 258

4:00pm-5:15pm (Tues-Thurs)

Joe Alcock MD MS (JA)

Blair Wolf PhD (BW)

Melissa Franklin MS (MF)

Course description:

The goal of this course is to understand how evolutionary biology provides insights into human health and disease. For most of the 20th century, the health sciences and evolutionary biology progressed along different paths, with neither discipline having much impact on the other. The last 15 years have seen increased exchange of information between the two fields of study. For instance, medical science has embraced evolutionary concepts that relate to pathogen antibiotic resistance. This course is a broader overview of evolutionary medicine. We will explore how natural selection influences pathogen-host interactions, human genetics, immunology, development, cancer, and diseases of senescence.

Evolutionary biology has important implications for the medical concepts of health, "normal" physiology and illness. One is the recognition of tradeoffs that sometimes promote health and other times result in illness. Many of these ideas challenge the conventional wisdom of the health sciences. During this course we will consider controversies and questions regarding health and evolution. A lecture will be given each tuesday on a topic, and alternative hypotheses will be presented. The thursday time slot will be reserved for discussion, "journal club" presentations, and critique of ideas in evolutionary medicine.

Required Readings:

A syllabus of required readings will be distributed on the first day of the course.

Course Requirements & Grading:

Students will be expected to attend all lectures. Students should complete assigned readings prior to that week's lecture and contribute to discussions. Each week, following lectures and discussions, students will be asked to complete a written summary of that week's topic. As a one-time assignment, students will be asked to evaluate the strengths and weaknesses of journal articles in evolutionary medicine. For this "Journal Club", a small group will be assigned a journal article to present to

the group and provide commentary. Finally, each student will make a presentation during the last two weeks of the course. Students should choose an area that interests them and produce a brief talk (powerpoint or equivalent) to present to the group.

Attendance and Participation. (35%)

Journal Club (10%)

Weekly Writing Project (20%)

Final Presentation (35%)

Course Outline:

Week 1 - 8/24/09 - Introduction. (JA)

4:00pm - 5:15pm Evolution in Health and Disease– a new synthesis of medical science and evolutionary biology. (JA)

Levels of Analysis – differentiating between proximate “how” questions and ultimate “why” questions of human diseases.

Readings:

1. Introduction and Overview of Evolutionary Medicine. Chapter 1 in: Evolutionary Medicine and Health. 2008. Trevathan WR, Smith EO, McKenna JJ. Page 1-54.

2. The Great Opportunity: Evolutionary applications to medicine and public health. Nesse, RM and Stearns SC. Evolutionary Applications 1 (2008) 28-48.

Writing project (due next tuesday). Pick one:

1. How do novel environments cause illness?
2. Give an example of benefits to patients (or lack of benefit) if doctors are taught evolutionary biology.

8/27/09 - Discussion

Topics for discussion:

What is an example of a constraint in human physiology?

Give an example of how evolutionary conflict between host and pathogens can cause disease?

Week 2 - 9/1/09 - Sickle Cell Disease and Malaria (MF) – Balancing selection for sickle cell allele is one of the first evolutionary medicine hypotheses.

Reading: Two Lessons from the Interface of Genetics and Medicine. Allison A.

Genetics 166: 1591–1599 (April 2004) (Read page 1-5)

Writing project (due next tuesday).

Explain why the incidence of sickle cell trait matches the geographic distribution of plasmodium falciparum. Since sickle cell trait is common in the US and there is no malaria, what do you think will happen its incidence over time?

9/3/09. - Evolutionary Biology Review - Background, Terminology and Concepts. (MF)

Week 3 - - 9/8/09 - Mismatch (JA)

From a genetic point of view, are we cavemen (and cavewomen)? How do our caveman genes interact with the radically changed modern environment to cause illness?

Readings:

1. Evolution and the Origin of Disease. Nesse, RM. Scientific American November 1998: 86-93.

2. [Collins 2007. Stroke Rainforests and Evolution. Nursing Forum Vol 42 \(1\) Jan-Mar.](#)

Writing project: (due next session), pick one:

How do psychoactive drugs cause disease by gene-environment mismatch? Do casinos exploit human neurobiology to extract money from your wallet? How is this gene-environment mismatch?

9/10/09 Discussion

Week 4 - 9/15/09 - Mismatch and Extreme Environments: Altitude Illness & Diving Accidents (JA)

Diving accidents and Mountain Sickness as diseases caused by new circumstances.

How does wound healing physiology and innate immunity play a role in decompression illness.

Writing Project.

a) Explain what scuba diving and high altitude mountaineers have in common? Describe how gene-environment mismatch causes disease in the following: decompression illness, high altitude pulmonary edema.

Readings: TBA.

Journal Club Assignments.

4:40pm Journal Articles for next weeks session will be assigned at this time. Journal

article critique will take the place of the writing project for this week.

1. Carriership of Factor V Leiden and Evolutionary Selection Advantage. Lindqvist PG, Dahlback B. *Cur Med Chem* 2008. 15: 1541-1544.

2. Evolution and Hypertension. Weder AB. 2007; 49; 260-265.

3. Artificial lighting in the industrialized world: circadian disruption and breast cancer. Stevens RG. *Cancer Causes Control* (2006) 17:501-507

4. The adaptive value of fever. Kluger, MJ. et al. *Infectious Disease Clinics North America*. 1996.

9/17/09

Discussion (MF)

2) How best to treat a cold? Should physicians and nurses treat fever in the emergency room or clinic? When should diarrhea be treated?

3) We give IV fluids to trauma victims in the ER. Is low blood pressure adaptive in trauma? How about infection?

Week 5 - 9/22/09 – All Stings Considered.

Evolutionary Considerations of Venoms (JA)

What is the difference between a toxin and a venom?

Endotoxin and Jarisch Herxheimer reaction – toxin or host defense?

Can evolutionary medicine predict when antitoxins, immunotherapy, and vaccines to toxins will be effective?

Readings:

1. An evolutionary perspective of endotoxin: a signal for a well adapted defense system. Legrand EK. *Med Hypotheses* 1990. Sep; 33(1) 49-56.

3. Lipopolysaccharide: An Endotoxin or an Exogenous Hormone? Marshall JC. *Clin Infect. Dis.* 2005;41 (Suppl 7). S470-80.

9/24/09

Journal Club (MF)

Student Journal Article Presentations and Discussion

Week 6 -

9/29/09 Vector-borne diseases and virulence

Evolution of Virulence

Hospital Acquired Infections – are medical workers vectors of disease?

Do pathogens evolve toward commensalism?

Readings:

1. Evolution of virulence. Ewald PW. 2004. Infect Dis Clin N Am (18) 1-15.
2. Epidemiology of Virulence. Galvani AP. 2003. TRENDS in Ecology and Evolution 18(3) 132-139.
3. How Virulent should a Parasite be to its Vector. Elliot SL, et al. 2003. Ecology 84(10) 2568-2574.
4. Crossing the Line: Selection and Evolution of Virulence Traits. Brown NF et al. 2006. PLoS Pathogens. 2(5) e42. Pages 0346-0353
5. Global Spread and Persistence of Dengue. Kyle JL and Harris E. Annu Rev Microbiol. 2008. 62: pp 71-81.

Writing project (due next week)

Choose one:

- a) Dengue fever immobilizes its adult victims. Does immobilization help or hurt the transmission of the virus? How is dengue different from the common cold?
- b) Why do "hospital-acquired" infections get different antibiotics than "community acquired" infections. Which are generally worse and why?

10/1/09

Discussion (MF):

Some illnesses make you feel bad, but you can still go about your business: e.g upper respiratory infections caused by rhinoviruses. Other infections wipe you out and you can't get out of bed. Is it in the rhinovirus's best interest to keep infected hosts in bed? What symptoms associated with common cold facilitate transmission of the virus? What is the best public health directive for colds: 1) go to work as usual. 2) go to the urgent care center for a work note. 3) stay at home.

Week 7 - 10/6/08 – Antimicrobial Resistance

Special Guest Lecturer: Roland Cooper PhD. Topic: Evolution of resistance to chloroquine in falciparum malaria.

Readings:

1. Bergstrom CT & Feldgarden M. The ecology and evolution of antibiotic-resistant

bacteria. Chapter 10 in: Evolution in Health and Disease. Second edition. Eds. Stearns SC and Koella JC. 2008. pages 125-137.

2. pfcrt is more than the Plasmodium falciparum chloroquine resistance gene: a functional and evolutionary perspective. Cooper RA, et al. 2005. Acta Tropica 94. pp 170-180.

3. Requiem for Chloroquine. Hastings IM, et al. 2002. Science 298. pages 74-75.

Writing project:

Plasmodium falciparum is an extremely difficult organism to eradicate and has developed resistance to most antimalarials. Explain why the way antimalarials are used might lead to resistance. Vaccine efforts have also failed. Come up with a hypothesis why it is harder to make a vaccine for a protozoan like plasmodium than for a bacterium like diphtheria.

10/08/09

Discussion (MF)

Discussion topics:

What are the downsides of putting antibiotics into animal feed?

Is it smart science or smart business of pharmaceutical companies to try to market brand new antibiotics to physicians?

Week 8 - 10/13/08 - Reproduction: Morning Sickness & Menopause

Morning Sickness – why does it occur; does it have a benefit to the fetus or mother?

Menopause – why do women cease to reproduce in middle age?

Readings:

1. Evolution of the human menopause. Shanley DP and Kirkwood TB. 2001 Bioessays 23. 282-287.

2. Nausea and vomiting of pregnancy in an evolutionary perspective. Sherman PW, Flaxman SM. 2002. Am J Obstet Gynecol 186:S190-7.

3. Evolutionary Obstetrics. Trevathan WR. Chapter 8 in Evolutionary Medicine (1st edition) 1999. Eds Trevathan WR, Smith EO, McKenna JJ. Oxford University Press. pages 183-207.

Writing project:

Some suggest that menopause evolved because grandmothers are more successful at passing on their genes by investing in grandchildren than in more babies of their own. Others argue that menopause is a consequence of modern medicine

prolonging the lifespan of women past 60 when most pre-historic women would be dead. So in the past reproductive aging would have been in sync with aging of the rest of the body. In this view menopause reflects the early mortality in pre-history and is a gene-environment mismatch. There is evidence for and against both the "grandmother hypothesis" and the "artificial lifespan prolongation" hypothesis. Argue for or against either in your paper.

Extra credit: Hormone replacement therapy. Is menopause a treatable deficiency disease? Write about the pros and cons of hormone replacement therapy from an evolutionary point of view. Under which hypothesis, "grandmother" or "artificial lifespan prolongation" would you predict that HRT would be more helpful in promoting health and preventing disease. What does the data say? (This will take some research.)

No discussion this week (Fall break)

Week 9 -10/20/09 – Genomic imprinting and reproductive conflicts (JA)

Do genes derived from maternal or parental sources have different effects on offspring?

Gestational diabetes – a paternal gene effect?

Pre-eclampsia – what effect does blood pressure have on the placenta and vice-versa?

Readings:

1. Ness RB and Grainger DA, et al. Male reproductive proteins and reproductive outcomes. *Am J Obstet Gynecol* 2008;198:620.e1-620.e4.
2. Haig D. Genetic Conflicts in Pregnancy. *Quarterly Review of biology*. Volume 68(4). Dec 1993, 495-532.

Writing project:

Some have suggested that the age of weaning of infants from the breast is subject to parent offspring conflict. Eg. infants might want to breastfeed longer than the mother would like. Breastfeeding tends to suppress ovulation and delay pregnancy. Give an evolutionary hypothesis for why infants might exhibit behavior that promotes longer breastfeeding. What behaviors might these be? The infant has 1/2 maternal derived genes and 1/2 paternal derived genes; which of these would these be expected to prolong breastfeeding?

10/22/09

Discussion (MF)

Topics for Discussion:
their own. Others argue that menopause is a consequence of modern medicine

Why would exposure to sperm decrease the incidence of preeclampsia?

Why should spontaneous abortions and preeclampsia have the same risk factors?

Should donor-egg IVF recipients be warned about the risk of preeclampsia?

Should sperm donors be held responsible for preeclampsia induced by their sperm?

Week 10 - 10/27/09

High Altitude Peoples and Altitude Illness

Guest Lecturer - Otto Appenzeller MD

High altitude adaptation among the Ethiopian Highlanders. Genetic change in high altitude populations - Ethiopians vs. Sherpas and Andeans.

The role of nitric oxide physiology in mitigating disease in a high altitude culture.

Readings: Appenzeller, O, et. al. Cerebral vasodilation to endogenous NO is a measure for fitness for life at altitude. Stroke 2008. <http://stroke.ahajournals.org/cgi/content/full/37/7/1754>

Additional readings will be posted on the blog

10/29/09

Discussion (MF) TBA

Week 11 - 11/3/09 - Aging

Senescence - why we get old (JA)

Declining power of selection – does natural selection keep post-reproductive people alive?

Antagonistic pleiotropy – do genes that promote youthful health also cause disease in the elderly?

Disposable soma hypothesis.

The role of infection in diseases of senescence.

Topics for discussion:

What explains the frequency of lipoprotein ApoE in humans; could balancing selection explain the persistence of an allele that is associated with cardiovascular disease and Alzheimer disease.

Readings:

1. Still Pondering an Age-Old Question. Flatt T and Promislow EL. 2007. Science (318) 1255-1256.
2. Systemic inflammation, infection, ApoE alleles, and Alzheimer disease: a position paper. Finch CE, Morgan TE. Curr Alzheimer Res. 2007 Apr;4(2):185-9.

11/5/09

Discussion (MF)

Week 12 - 11/10/09 – Diabetes and Insulin Resistance (JA)

Diabetes and Insulin Resistance are among the best studied but still poorly understood conditions in medicine. An evolutionary hypothesis is presented.

Readings:

1. The Developmental Origins of Adult Health. Kuzawa C. Chapter 18 in Evolutionary Medicine and Health. 2008. Trevathan WR, Smith EO, McKenna JJ. pages 325-349.

Writing project:

There appears to be switch activated in underweight babies that leads to diabetes later in life. Early on, these individuals might be insulin resistant - so less glucose gets metabolized by muscle tissue. As a result, less energy is devoted to growth and building muscles and bones. On the flip side, more glucose is available for other tissues - like the brain and also infection fighting cells. Come up with a hypothesis for how insulin resistance might be helpful for underweight neonates?

11/12/09

Discussion (MF)

Week 13 - 11/17/09 – Fat & Inflammation (JA)

Why is obesity so dangerous? Why does dietary fat cause inflammation?

Why are certain fats "bad", e.g. trans fats, saturated fats, and other fats "good", e.g. omega 3 polyunsaturated fats.

11/19/09

Discussion (MF)

disease and Alzheimer disease.
Topics for discussion.

Why does obesity cause disease?

Week 14 - 11/24/09 – Evolutionary Consideration of a Thanksgiving Meal - Industrialized Food, Lactose Intolerance, and the use of Spice in Food.

Are we healthiest when eating what our ancestors ate?

Why do some populations have trouble digesting milk?

No writing project this time. Work on your presentations!

No Discussion this week (Thanksgiving Break)

Week 15 -12/1/09.- Presentations (15 minutes each)

12/3/09 - Presentations

Week 16, 12/8/09 - Presentations

12/10/09 - Presentations

Discussion (MF)

Topics for discussion: