Sample Syllabus - **Molecular Ecophysiology**

Course Summary: A critical aspect of the integrative discipline of physiological ecology is the genetic architecture of physiological traits and how selection on physiological mechanisms maintains genetic variation in natural populations. This course will examine physiological responses to ecological selection from a genomic perspective. Analysis of proximate mechanisms will include genes underlying physiological traits and the genetic regulation of relevant molecular pathways. The course will investigate the ultimate evolutionary consequences by examining how the interaction between ecology and physiology shapes genetic variation in natural populations. We will also emphasize emerging molecular techniques for detecting adaptive ecological and physiological change in natural populations. **Intended for:** Graduate students with some prior coursework in related sub-disciplines (or consent of the instructor).

Textbook & Readings: The course will rely on readings from the primary literature. There is no textbook, though occasional supplemental readings from textbooks may be provided by the instructor.

Coursework, Exams, and Projects: *Reading summaries***:** Students will turn in a one page summary of the papers in bold below on the day that the reading is scheduled.
Exams: There will be three exams throughout the semester summarizing lecture and reading material
Grant proposal: Choose one lecture subject and write a grant proposal to investigate a question related to that subject. The proposal should include (1) Background on why the question being addressed is important in ecophysiology, (2) Methods of how the question will be tested, (3) Hypotheses and predicted outcomes of the project, and (4) Budget. A hand-out will be given with more detail early in the semester and students should take example from the literature readings on how to structure and write their proposal. Students will be graded on their grant proposal and their peer reviews of two, anonymous proposals of fellow students assigned by the instructor.

Lecture Topics - Each lecture will begin with a brief discussion of the assigned readings for that day

1. Review: Ecological Genetics
    Adaptive Genetic Variation; Forms of Selection: Directional, stabilizing, balancing; Quantitative Genetics and G x E interactions
        Hughes et al. 2008 - Ecological consequences of genetic variation
        Whitehead 2012 - Comparative genomics in ecological physiology
2. Review Cont'd from Lecture 1
    Structure and Function:
        Colosimo et al. 2005 - Genetic basis of structural evolution
        Abzhanov et al. 2006 - The calmodulin pathway and beak morphology
3&4. Introduction to "-omics"
    Genomics - Davey et al. 2011 - Genome-wide genetic marker discovery
    Transcriptomics - Singhal 2013 - *De novo* transcriptome analysis in non-model organisms
    Metabolomics - Bundy et al. 2009 - Environmental metabolomics: review and perspectives
        Macel et al. 2010 - Metabolomics: ecology meets genetics (not required reading)
5&6. Tools of the Trade
    Candidate Gene Discovery: Hohenlohe et al. 2013 - RAD
        Jones et al. 2012 - Genome-wide SNP genotyping
        Hemmer-Hansen et al. 2011 - Using existing genomic resources
    Adaptive Gene Expression: Wolf 2013 - Principles of transcriptome analysis
        Wang et al. 2009 - RNA-Seq for transcriptomics
        DeWoody et al. 2013 - Transcriptomics pitfalls
7&8. Osmoregulation
    Water Stress and Urea Tolerance:
        Pierce et al. 1999 - Selection for increased urea tolerance
        Marra et al. 2012 - Functional transcriptomics of a desert rodent

Salinity Tolerance:
Kavembe et al. 2015 - Genomics of adaptation to multiple concurrent stressors
Lee et al. 2011 - Ionic regulation following habitat invasions
OMICS: Janz et al. 2010 - Transcriptomics and metabolomics of salt tolerance

9&10. Thermoregulation and Thermal Tolerance
Thermal Tolerance:
Culumber et al. 2012 - Local physiological adaptation and gene expression
Dilly et al. 2012 - Comparative proteomics of metazoan thermal tolerance
Cheviron et al. 2012 - Regulatory changes to thermogenic capacity
Temperature Sensation and Thermoregulatory Behavior:
Saito et al. 2011 - Evolution of opposite temperature sensitivity
Hamada et al. 2008 - Temperature preference in *Drosophila*
Video: Thermoregulatory behaviors
Oxygen-limitation of Thermal Tolerance:
Portner 2001 - Oxygen limitation of thermal tolerance
Nikinmaa et al. 2013 - Transcription and enzymes in thermal tolerance
OMICS: Verberk et al. 2013 - Metabolomics of oxygen-limitation of thermal limits

11. Respiration and Circulation
Hypoxia:
Storz et al. 2007 - Molecular basis of high-altitude adaptation
Tufts et al. 2013 - Phenotypic plasticity of blood-oxygen transport

12. Metabolism
Wagner et al. 2005 - Energy constraints on the evolution of gene expression
Niitepold et al. 2009 - Genetics of flight metabolic rate and dispersal ability

13.&14. Locomotion and Energetics
Locomotion and Performance:
Dalziel et al. 2015 - Adaptation and acclimation of exercise physiology in Lake Whitefish
Odell et al. 2003 - Microevolution in physiology of burst performance
OMICS: Jordan et al. 2007 - Quantitative genomics of locomotion in *Drosophila*
Video: Grasshopper escape
Energetics:
Nespolo et al. 2003 - Heritability of energetics
Wagner 2005 - Energetic constraints on gene expression

*** Grant proposals due**

15&16. Temperature-dependence of Physiology
Locomotion and Energetics:
Fangue et al. 2008 - Temperature-dependent performance and energetics
McClelland et al. 2006 - Gene expression and metabolic enzymes
Pigmentation:
Gibert et al. 2007 - Temperature, pigmentation and the calmodulin pathway
Horth 2006 - Temperature-dependent melanism in mosquitofish

*** Grant proposal reviews due**