ECOLOGICAL GENOMICS (BIOL 7800)

Level: Graduate
Instructor: Andrew Whitehead, office LSA 112 (8-8210), lab LSA 124 (8-2688), andreww@lslu.edu
Semester: Fall 2007, Tues/Thurs, 9:00-10:30 AM, LSB 28

Course Materials:

- Book: Nico Van Straalen & Dick Roelofs (2006). "An Introduction to Ecological Genomics". Oxford University Press.
- Various foundation papers from the primary literature (listed below).

Course Background:

The purpose of this course is to provide both a conceptual and methodological foundation for the new and rapidly emerging field of environmental/ecological genomics. Ecological genomics may be defined as "a scientific discipline that studies the structure and functioning of a genome with the aim of understanding the relationship between the organism and its biotic and abiotic environments". In addition to providing more research tools, the advent of genomics has allowed new scientific questions to emerge and existing questions to be answered in ways not previously considered. We will examine how genomic technologies and approaches, that have recently emerged and are currently revolutionizing the biological sciences, may be applied to reformulate or solve ecological questions. The course will take advantage of a recently published text as background, and will also summarize developments in the last 5 years from the primary literature. The course will start with an introduction to genomics tools and analyses, and the remaining bulk of the course will examine how ecological questions may be evaluated using these approaches. Class meetings will involve a mix of lecture and discussion of readings from primary literature.

LECUTRE TOPICS:

1. Properties of genomes

- genome structure
- genome function
- evolution of genomes
- comparative genomics

2. Genome analysis

- DNA cloning
- genetic and physical mapping
- genome sequencing
- genome annotation
- transcriptional profiling
- genome comparison

- computation and bioinformatics

Assigned Readings:

- Colosimo, et al., 2005. Widespread parallel evolution in sticklebacks by repeated fixation of ectodysplasin alleles. *Science* **307**; 1928-1933
  Storz, 2005. Using genome scans of DNA polymorphism to infer adaptive population divergence. *Molecular Ecology* **14**; 671-688.
- Bar-Or, et al., 2007. Cross-species microarray hybridizations: a developing tool for studying species diversity. *Trends in Genetics* **23**; 200-207
  Bouck and Vision, 2007. The molecular ecologist's guide to expressed sequence tags. *Molecular Ecology* **16**; 907-924.
- Church, 2006. Genomes for all. *Scientific American* **294**; 46-54
  Reed, et al., 2006. Towards multidimensional genome annotation. *Nature Reviews Genetics* **7**; 130-141.

3. Ecological community structure and function

- microbial community genomics
- viral community genomics
- genomics of biogeochemical cycles
- genomes in extreme environments

Assigned Readings:

- Rusch, et al., 2007. The Sorcerer II Global Ocean Sampling expedition: Northwest Atlantic through Eastern Tropical Pacific. *Plos Biology* **5**; 398-431
  Yooseph, et al., 2007. The Sorcerer II Global Ocean Sampling expedition: Expanding the universe of protein families. *Plos Biology* **5**; 432-466.
- Angly, et al., 2006. The marine viromes of four oceanic regions. *Plos Biology* **4**; 2121-2131
  Edwards and Rohwer, 2005. Viral metagenomics. *Nature Reviews Microbiology* **3**; 504-510.
- Ram, et al., 2005. Community proteomics of a natural microbial biofilm. *Science* **308**; 1915-1920
  Tyson, et al., 2004. Community structure and metabolism through reconstruction of microbial genomes from the environment. *Nature* **428**; 37-43.
- DeLong, et al., 2006. Community genomics among stratified microbial assemblages in the ocean's interior. *Science* **311**; 496-503
  Tringe, et al., 2005. Comparative metagenomics of microbial communities. *Science* **308**; 554-557.

4. Ecological genomics of life-history patterns

- longevity and aging
- genomics of the life cycle and development
  - developmental stage
  - diapause
  - flowering time
- phenotypic plasticity

- polyphenetic development
- body size

Assigned Readings:

- Mathavan, et al., 2005. Transcriptome analysis of zebrafish embryogenesis using microarrays. *Plos Genetics* **1**; 260-276
  McCarroll, et al., 2004. Comparing genomic expression patterns across species identifies shared transcriptional profile in aging. *Nature Genetics* **36**; 197-204.
- Balasubramanian, et al., 2006. Potent induction of Arabidopsis thaliana flowering by elevated growth temperature. *Plos Genetics* **2**; 980-989
  Putterill, et al., 2004. It's time to flower: the genetic control of flowering time. *Bioessays* **26**; 363-373.
- Bochdanovits and de Jong, 2004. Antagonistic pleiotropy for life-history traits at the gene expression level. *Proceedings of the Royal Society of London Series B-Biological Sciences* **271**; S75-S78
  Whitfield, et al., 2003. Gene expression profiles in the brain predict behavior in individual honey bees. *Science* **302**; 296-299.

5. Physiological Ecology

- stress and ecological niche
- cellular defense mechanisms
- heat, cold, drought, salinity, and hypoxia
- herbivory and infection
- ecotoxicogenomics

Assigned Readings:

- Gasch, et al., 2000. Genomic expression programs in the response of yeast cells to environmental changes. *Molecular Biology of the Cell* **11**; 4241-4257
  Promislow, 2005. A regulatory network analysis of phenotypic plasticity in yeast. *American Naturalist* **165**; 515-523.
- Gracey, et al., 2004. Coping with cold: An integrative, multitissue analysis of the transcriptome of a poikilothermic vertebrate. *Proceedings of the National Academy of Sciences of the United States of America* **101**; 16970-16975
  Gracey, et al., 2001. Hypoxia-induced gene expression profiling in the euryoxic fish Gillichthys mirabilis. *Proceedings of the National Academy of Sciences of the United States of America* **98**; 1993-1998.
- Reymond, et al., 2004. A conserved transcript pattern in response to a specialist and a generalist herbivore. *Plant Cell* **16**; 3132-3147
  Woyke, et al., 2006. Symbiosis insights through metagenomic analysis of a microbial consortium. *Nature* **443**; 950-955.

6. Integrative Ecological Genomics

- systems biology
- network theory
- linking genomics with hypothesis-driven research
- emerging issues

- comparative genomics
- natural variation
- genetical genomics
- epigenetics
- new methods of data analysis

Assigned Readings:

- Jirtle and Skinner, 2007. Environmental epigenomics and disease susceptibility. *Nature Reviews Genetics* **8**; 253-262
  Kitano, 2002. Systems biology: A brief overview. *Science* **295**; 1662-1664.

STUDENT EVALUATION:

1. **Class participation (25% of grade)**
   If students actively contribute to class discussions of primary literature and assigned research proposal evaluations (see item 3 below) in thoughtful and intelligent ways, they will earn this proportion of their grade.

2. **Literature review (25% of grade)**
   This will involve a review of recent literature on an approved environmental genomics topic of choice. Review should include at least 5 research articles and be 4-5 pages long.

3. **Research proposal (25% of grade)**
   This will involve writing an NSF-style research proposal to address an approved environmental genomics question of choice. It is encouraged that this topic be complementary to the topic chosen for the literature review. The proposal will be written, but will be orally presented and evaluated in class in a review-panel format.

4. **Final examination (25% of grade)**
   This will examine synthetic understanding of lecture material and assigned readings from primary literature.