

Cornell courses relevant to Population, Comparative & Evolutionary Genomics

Assembled by the Cornell Center for Comparative and Population Genomics (<http://3cpq.cornell.edu>)

Available as a pdf downloadable from the 3CPG web site under "For Current Grads & Postdocs"; "For Undergrads", and "For Prospective Grad Students & postdocs")

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SPRING 2012 COURSES

BIOMG 1290 Personal Genomics and Medicine: Why should you care about what's in your genes? --Chip Aquadro & Spencer Wells (Nat'l Geog & F.H.T. Rhodes Class of '56 Professor at Cornell)

3 credit. Preference given to freshman & sophomores, no prerequisites. A new "University Course" to be first offered Spring 2012. Capped at 100.

MWF 11:15 am – 12:05 pm (lectures M & W, discussions F)

Charles (Chip) Aquadro (MBG) together with Spencer Wells (National Geographic and Frank H.T. Rhodes Class of '56 Professor at Cornell)

Are you curious about your family ancestry? How, and why, might your genetic ancestry have influenced the diseases to which you are susceptible? Do you have allergies to milk or wheat? Does a relative suffer from a genetic disease, and you wonder if you might also be at risk? How will medicine and insurance be impacted by DNA testing? How will your own future, your quality of life, your decisions regarding children be impacted with this information available to anyone with as little as \$99 and a saliva sample? What are the scientific, ethical, legal and social challenges obtaining and using this information? This course will introduce you to the challenges and opportunities of DNA testing that is rapidly becoming part of our future.

BIOMI 3210 The Normal Microbes of the Human Body in Health and Disease – Ruth Ley

3 credits. Letter only. Prerequisite: BIOMI 2900 or permission of instructor.

Tuesdays/Thursdays 2:55-4:10, 146 Morrison.

The human body is coated with microbes outnumbering "our own" cells 10 to 1, providing us with capacities we have not had to evolve on our own. This course will introduce the microbes of the human body, discuss their origins, adaptations to the body, molecular interactions, and associations with health and disease.

This course will introduce students to the normal commensal microbes in the human body, their evolutionary origins, ecology, interactions with the host, and involvement in increasingly common chronic inflammatory diseases such as obesity and colitis. This is a contemporary topic and an active area of research that has expanded with the recent launch of NIH's Human Microbiome Project. Thus, course materials will draw primarily on current and recent research. Students will acquire a broad-based and integrative understanding of the human-associated microbes, from their genomes and molecular interactions with the host, to their distribution across human populations.

PLBR 4093: QTL Analysis: Mapping Genotype to Phenotype in Practice- Ed Buckler & Jean-Luc Jannink

1 credits, S/U grading, meets 04/12/2011 – 05/05/2011 on TR 10:10-11:25 am

Discussion of mating designs and populations as well as statistical models to identify genetic loci that affect the phenotype and to predict breeding and genotypic value using DNA polymorphisms, with practical application to real datasets.

NS 4130: Nutritional Genomics – Evolution and Environment -- Zhenglong Gu

2 credit, Prereq: senior or graduate standing, BIOMG 2810 or permission of instructor

Examines selected topics related to nutrition and genome biology. Discussion of nutrition and human evolution, such as human brain evolution, evolution of taste, population variation related with nutrition, and evolution of human diseases. Reading materials are from literature and participation in class discussion is required.

ANSC 4300: Comparative Genomics of Health and Disease in Domesticated Animals – Samantha Brooks

2 credits, Prereq: BIOMG2800 or ANSC2210, TR 2:30-3:20

As we approach the age of the "\$1000" genome the number of mammals with at least a draft reference genome sequence is rapidly increasing. This is particularly true for large domesticated mammals like the horse, cattle, dog, pig and sheep. Genomic research in large animals, rather than traditional laboratory species, opens up new horizons in diversity of phenotype, mechanisms and technique. Through research papers we will explore recent discoveries that have both practical application and notable scientific implications. Concepts covered will include the impact of domestication on the genome, use of animals as models, genome wide mapping, chromosome evolution and structural variation. Students will be expected to present interesting findings to the class and participating in discussion.

BIOEE 4640: Macroevolution – Amy McCune

4 credits. Lecture TTh 10:10-11:25, Discussion section to be arranged. Limited to 35 students. Offered alternate springs, next offered spring 2012.

Prerequisite: BIOEE 1780 or permission of instructor.

Advanced course in evolutionary biology centered on large-scale features of evolution. Areas of emphasis include phylogeny reconstruction, using phylogenies, patterns and processes of speciation, the origin of evolutionary novelties, causes of major evolutionary transitions, and patterns of diversification & extinction in the fossil record. Discussion of these topics requires integration of genetics, morphology, systematics, paleobiology, development and ecology.

BTRY 4820/6820 - Statistical Genomics -- Coalescent Theory & Human Population Genomics – Alon Keinan

4 credits, S/U or letter. Lecture TR 10:10AM - 11:25AM, Discussion R 12:20pm-1:10pm

Prerequisites: Math 1110 or equivalent; At least one previous course in statistical methods and at least one involving programming, or permission of instructor.

Web site: http://keinanlab.cb.bscb.cornell.edu/BTRY_6820_4820_Statistical_Genomics_Spring2012.html

Statistical methods for genomic data, emphasizing coalescent theory and molecular population genetics and genomics. Topics include derivation of coalescent theory, tests of natural selection, population structure, and statistical inference, with a focus on the population genomics of human populations.

BIOMG 4840, Molecular Evolution -- Daniel Barbash

3 credits, Monday & Wednesday 2:55 – 4:10pm

Explores the various processes by which DNA and protein sequences evolve over time, and how this evolution at the molecular level relates to changes in the morphology, behavior, and physiology of organisms that have occurred over time scales ranging from thousands to billions of years. After developing basic principles the course discusses the evolution and organization of genomes from microbes to higher eukaryotes including humans, and the relationship between molecular evolution at the sequence level and the evolution of developmental pathways and systems.

Prerequisites: BIOMG 2810.

BIOPL 4400 / ENTOM 4400 Phylogenetic Systematics - Kevin Nixon

4 cr, Tu/Th 10.10-11 am and a biweekly computer lab, for a total of 5 lab hours per week (lab times TBA)

This course covers basic and advanced theory and methods of phylogenetic analysis. Introduces students to phylogenetic analysis using parsimony, maximum likelihood and bayesian analysis methods. Allows students to gain hands-on experience with computer programs which analyze both morphological and molecular data. Topics also include applications of phylogenetic methods to biogeography and evolutionary studies. Provides the fundamentals of understanding and interpreting phylogenetic analyses to any student using phylogenetic trees in their current or future research.

BIOMG 4610 Development & Evolution – Mariana Wolfner – NOT OFFERED SPR 2012

TR 2:55-4:10; 3 credits, letter grade only. Every other year (odd-number years); next offered Spring 2013.

Prerequisites: genetics, molecular biology and evolution (e.g. BioMG2810, BioMG3320 (or 3300 or 3330), BioEE1780 or their equivalents).

Have you ever wondered what makes animals develop to look so different? Amazingly, the same fundamental pathways regulate many aspects of development across the animal kingdom, but over the course of evolution they have been modified in different lineages to cause striking variation in form and function. This course addresses the ways in which these fundamental pathways have changed during evolution, and how this results in the dazzling diversity seen in the animal kingdom. Class meets twice a week to explore the fascinating, new and current field of "EvoDevo" through readings of papers in the current scientific literature, and lecture and in-class discussion. The course material requires background in Genetics, Evolution and Molecular Biology - usually acquired through the prereq courses.

ENT 4700 / BioEE 4800 Ecological Genetics – Brian Lazzaro – NOT OFFERED SPR 2012

4 credits, Offered odd-year spring semesters (Next offered Spr 2013)

Prereq: BioEE 1780 or permission of instructor. Familiarity with genetics and basic statistics is recommended. Satisfies major requirements in Entomology and Ecology and Evolutionary Biology.

This course focuses on the application of population genetic concepts in ecological or applied contexts. Emphasis is placed on measuring adaptation in natural populations, detecting the effects of population

demography, and determining the genetic basis of quantitative traits. Examples are drawn from primary research on animals and plants to illustrate experimental techniques and methods of data analysis on single-gene, multi-locus and genome-wide scales.

BIOMG 6200, Evolutionary Genomics of Bacteria – Michael Stanhope

Credits: 1; Letter or S/U, Meets: Tuesday and Thursday

An overview of comparative evolutionary genomics of bacteria, with an emphasis on pathogens. Principles and concepts will be stressed, although methodology and bioinformatics tools will also be addressed. The course involves a combination of lectures and discussion of primary scientific literature. There will be three classes devoted to bioinformatics tools for studying bacterial genomics, including a lecture, an open tutorial session, and a group presentation of the assigned bioinformatics exercises.

BTRY 6890 - Topics in Population Genetics and Genomics – Alon Keinan, Adam Siepel, Jason Mezey, & Andy Clark

1 credit S/U, Wed 1:25PM - 2:15PM, Room 121 Weill Hall

Prerequisites: BTRY 6820 or permission of instructor.

Graduate seminar on current topics in population genetics.

BIOEE 6900/ENTOM 6900 - Ecology and Evolution of Infection and Disease

1 credit S/U, Monday 02:30PM - 03:30PM, Hajek,A (aeh4), Harvell,C (cdh5), Lazzaro,B (bl89)

NTRES 7283 Molecular Genetic Approaches to Study of Ecology & Evolution -- Matt Hare

1 credit Seminar, S/U. In this seminar we will cross traditional disciplinary lines to examine discoveries in natural history, ecology and evolution made through the innovative assay and analysis of molecular genetic polymorphisms. Readings will relate to theory and methods applied in population genetics, quantitative genetics, evolutionary genetics, and conservation genetics research, with a focus in 2012 on genomic and transcriptomic studies utilizing next-generation sequencing to study non-model species. The weekly workload will usually consist of preparing for discussion by reading two articles of which one will be discussed in detail. On a rotating basis each student will organize a week's discussion by (1) working with me to choose articles, (2) prepare questions for discussion and (3) lead discussion.

BIOMG 8340 - Quantitative Biology for Molecular Biology & Genetics – Jeff Pleiss

2 credits. Limited to 1st year Ph.D students in the grad fields of BMCB and GD. We will examine topics in modern molecular biology and genetics focusing on the quantitative tools necessary for analyzing experimental data. Classes will be both lecture- and discussion-based including critical readings of current literature. Students will use computational statistical packages to individually and collaboratively re-evaluate data from the primary literature.

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FALL COURSES – (list below largely from Fall 2011 – check back in April 2012)

NS 2750 Human Biology and Evolution (also ANTHR 2750) Jere Haas & Zhenglong Gu

3 credits. Prerequisite: college biology. Lec MW 10:10-11:00, Disc selected times R or F. S–U or letter grades. Offered alt. years; next offered Fall 2011.

Examines the theories and mechanisms of modern evolutionary biology as they apply to present-day humans and their hominid ancestors. Lectures and discussions of molecular and paleontological evidence of human evolution, the causes and consequences of contemporary human biological diversity, and biological and behavioral modes of human adaptation to past and present natural and cultural environments.

NTRES 2830 DNA, Genes, and Genetic Diversity -- Matt Hare

4 credits. Prerequisites: BIOEE 1780 or permission of instructor. Preference will be given to NTRES majors. Letter grades only.

Lec MW 8:40-9:55 am, Lab Fridays 8:40 – 11am, Every fall: Next offered Fall 2011

Covers molecular, Mendelian and population genetic principles as they relate to population biology and biodiversity. A laboratory section is devoted to problem solving, computer exercises and case study discussions. We will focus on eukaryotes and cover a broad range of molecular genetic processes including DNA replication, recombination and gene expression before turning to population level processes.

Recommended as a preliminary to upper-level ecology, evolution, and natural resource management courses.

NTRES 3100 -- Applied Population Biology (every Fall). 3 credits. Tu/Th 1:25-2:40--Evan Cooch

An in-depth analysis of the ecological factors influencing the natural fluctuation and regulation of animal population numbers. The course examines models of single- and multi-species population dynamics, with emphasis on understanding the relationship between ecological processes operating at the individual level and subsequent dynamics at the population level. Significant emphasis placed on principles as applied to conservation and management. Computer and field-based exercises are used to reinforce concepts presented in lecture. An in-depth analysis of the ecological factors influencing the natural fluctuation and regulation of animal population numbers. The course examines models of single- and multi-species population dynamics, with emphasis on understanding the relationship between ecological processes operating at the individual level and subsequent dynamics at the population level. Significant emphasis placed on principles as applied to conservation and management. Computer and field-based exercises are used to reinforce concepts presented in lecture.

ENTOM 3310/3311 - Insect Phylogeny and Evolution — Bryan Danforth

Fall. 3 credits. Offered alternate years (offered Fall 2011)

Prerequisite: ENTOM 2120. Co-requisite: ENTOM 3311.

This course will provide a broad overview of insect diversity, morphology, phylogeny, evolution, and fossil history. Evolution of the insects will be discussed in light of real data sets based on morphology and/or DNA sequence data. Basic principles of phylogeny reconstruction using both morphological and DNA sequence data will be presented using published data sets. Analytical methods such as parsimony, maximum likelihood, and Bayesian methods will be discussed and compared. We will also cover how phylogenies are used to analyze evolutionary patterns, such as historical biogeography, coevolution, and host–parasite relationships.

NTRES 4100 Advanced Conservation Biology: Concepts and Techniques – Evan Cooch & Matt Hare

4 credits. Lecture: Tu/Th 10:10-11:25, Mann Library B30A, Computer Lab: Wed 10:10-12:05, Mann Library B30B Prerequisites: CALS math requirement; NTRES 3100 or equivalent or permission of instructors. Introductory genetics (NTRES 2830, ANSC 2210 or BIOMG 2810) recommended. Limited to 30 students.

Decision making in conservation biology requires measurement and analysis of variation at the genetic, population, and landscape or system levels. Emphasis in this course is on quantitative tools for the formal analysis of variation at all three levels and principles guiding maintenance and management of biological and genetic diversity.

BIOEE4530 / BIONB3530 Speciation: Genetics, Ecology, and Behavior – Richard Harrison & Kerry Shaw

Fall. 4 credits. Limited to 40 students. Prerequisites: BIOEE 1780 and BIOMG 2810 or equivalents, or permission of instructor. S-U or letter grades.

TR 10:10 – 11:25 am; Offered alternate years. R. G. Harrison and K. L. Shaw.

Advanced course in evolutionary biology focusing on the pattern and process of speciation and the nature and origin of behavioral, morphological, physiological and ecological traits that form the intrinsic barriers to gene exchange. Lecture topics include species concepts and definitions, the history of ideas about speciation, the

biological basis of intrinsic barriers to gene exchange, current models for the origin of such barriers, genetic architecture of speciation, rates of speciation. Emphasis is on developing a rigorous conceptual framework for discussing speciation and on detailed analysis of a series of case histories.

BIOPL 4470 Molecular Systematics – Jeff Doyle

Lecture, MW 8:40 – 9:55 am, 3 credits, Lec. Offered alternate odd-numbered years

Theory and practice of using molecular evidence, particularly DNA sequence data, for addressing diverse systematic and evolutionary questions. Emphasis is on phylogeny reconstruction, particularly in eukaryotic systems. The organization and evolution of nuclear and organellar genomes is described from the standpoint of their suitability for systematic and evolutionary studies.

Prerequisites: BIOEE 1780 or BIOMG 2810 or BIOMG 3300, or BIOMG 3320, or permission of instructor.

BIOMG 4810: Population Genetics -- Chip Aquadro

4 credits. Prereq: BIOMG 2810, BIOEE 1780, or equiv., Lec MWF 10:10 – 11:00am, plus disc.

Population genetics is the study of the transmission of genetic variation through time and space. This course explores how to quantify this variation, what the distribution of variation tells us about the structure of natural populations, and about the processes that lead to evolution. Topics include the diversity and measurement of genetic variation, mating and reproductive systems, selection and fitness, genetic drift, migration and population structure, mutation, multilocus models, the genetics of speciation, quantitative traits, and the maintenance of molecular variation. Emphasis is placed on DNA sequence variation and the interplay between theory and the data from experiments and natural populations. Specific case studies include the population genetic issues involved in DNA fingerprinting, the genetic structure and evolution of human populations, and the study of adaptation at the molecular level. Examples are drawn from studies of animals, plants, and microbes.

BTRY 4830 (& BTRY 6830) Quantitative Genomics and Genetics –Jason Mezey

4 credits, Lecture: MW 8:40 - 9:55 am, Lab Friday 2:30-3:20 pm

A rigorous treatment of analysis techniques used to understand complex genetic systems. This course will cover both the fundamentals and advances in statistical methodology used to identify genetic loci responsible for disease, agriculturally relevant, and evolutionarily important phenotypes. Data focus will be genome-wide data collected for association, inbred, and pedigree experimental designs. Analysis techniques will focus on the central importance of generalized linear models in quantitative genomics with an emphasis on both classical and Bayesian computational approaches to inference (EM, Variational, MCMC, etc.). Topic focus will include single and multi-marker methods, incorporation of fixed and random co-factors, and higher order genetic architectures (epistasis). Prerequisites: BTRY 4070 and introductory statistics or equivalent.

BTRY 4840/6840 Computational Genomics -- Adam Siepel - NOT OFFERED 2012

LEC TR 11:40AM - 12:55PM 4 credits. Prerequisites: BTRY 3080 and at least one previous course in statistical methods and at least one in algorithms.

Computational methods for genomic data, emphasizing comparative and evolutionary genomics. Topics include sequence alignment, gene and motif finding, phylogeny reconstruction, and gene regulatory networks. Meets concurrently with BTRY 6840.

BIOMG 4870: Human Genomics -- Andy Clark

3 credits. Prerequisite: BIOMG 2810. Lec. Tues/Thurs 8:40-9:55 am.

Applies fundamental concepts of transmission, population, and molecular genetics to the problem of determining the degree to which familial clustering of diseases in humans has a genetic basis. Emphasizes the role of full genome knowledge in expediting this process of gene discovery. Stresses the role of statistical inference in interpreting genomic information. Population genetics, and the central role of understanding variation in the human genome in mediating variation in disease risk, are explored in depth. Methods such as homozygosity mapping, linkage disequilibrium mapping, and admixture mapping are examined. The format is a series of lectures with classroom discussion. Assignments include a series of problem sets and a term paper.

BTRY 6700: Applied Bioinformatics and Systems Biology – Haiyuan Yu, Adam Siepel, Jason Mezey & Alon Keinan

4 Credits. S/U or Letter. Tuesday/Thursday – 1:25 - 2:40 pm.

DESCRIPTION: An introductory course on tools and techniques for the analysis of molecular biological data, including biosequences, microarrays, and networks. This course emphasizes practical skills, as well as basic understanding of theories and algorithms for proper application of various techniques. Two different computer languages (R and Perl) will be introduced and used throughout the lectures and homework. Possible topics

include sequence alignment, gene and motif finding, genome assembly, variant detection, demographic inference, detection of natural selection, association mapping, phylogeny reconstruction, microarray analysis, and methods for inferring and analyzing regulatory, protein-protein interaction, and metabolite networks. PREREQUISITES: Introductory courses in computer programming and statistical methods are highly recommended. For those who do not have prior programming experience, please discuss with Dr. Yu about taking the course.

BTRY 7210: Topics in Quantitative Genomics – Jason Mezey, Alon Keinan, Andy Clark & Adam Siepel

1 credit. S/U only. Prerequisites: BTRY 4830/BTRY 6830 or permission of instructor.

Weekly seminar series on recent advances in quantitative genomics. A selection of the latest papers in the field is read and discussed. Methods are stressed, but biological results and their significance are also addressed.

BIOEE 7600 - Introduction to Modeling in Ecology and Evolutionary Biology – Steve Ellner

Offered even-year fall semesters – next offered Fall 2012

3 credits, S/U grading only (no letter grades or audits), Tu-Th (75 min each), time and location TBA

Textbook (required): “A Biologist’s Guide to Mathematical Modeling In Ecology and Evolution” by S.P. Otto and T. Day (Princeton University Press, 2007)

This course will be aimed at EEB grad students with no prior exposure to modeling. The "target" audience is 2nd year or later EEB grad students; others can only enroll with permission of the instructor, if space permits.

Mathematicians and the like will be disbarred, so that I don't wind up lecturing for them. There will be no exams, no computer labs, and no homework that is turned in for grading. Course meetings will alternate between lectures (by me), and student-led presentations of homework problem solutions. Because student participation is the core of the course, auditors will not be allowed. Based on course evaluation comments from the last offering of this course, this time there will be slightly more lecture time, slightly less homework-exercise discussion, and a de-weighting of assigned homework exercises in favor of a term project in which each student will develop a model related to their personal research interests, write computer code to study the model, and present their findings. Participation in the homework discussions will be mandatory; I'll try to keep the load evenly distributed. You will learn to use R for numerical calculations, and Maxima to help with algebra and calculus. Both of these are open-source and available for PCs and Macs. Previous knowledge of R will be helpful, but I will teach enough R and Maxima to do the homework and projects.]