

MCB 291: Genetics, Genomics, and Evolutionary Biology

Instructors: Cassandra Extavour (CE), Andrew Murray (AM), Andrew Berry (AB)
Teaching Assistants: Guo-Liang "Chewie" Chew (GC), Nichole Collins (NC)
Office Hours:

Lectures: M, W, 10:30 – Noon

Discussion: F, 10 – Noon

This is a graduate student class that will provide an integrated introduction to the interface between genetics, genomics, and evolutionary biology. Our aim is to assume a minimum of background information and progress rapidly to a sophisticated level of understanding by focusing on a few examples rather than trying to provide a comprehensive view of a very large subject. The course will begin with three lectures on applying quantitative approaches to understanding biological problems (Murray), touch on Darwin/Wallace and Mendel in their historical contexts (Berry/Murray), discuss how to find and analyze genetic elements that control traits of interest (Extavour/Murray), introduce some key concepts in population genetics (Murray), cover the evolution of developmental processes, biological regulatory networks, and proteins (Extavour), and close by discussing some unsolved problems in evolution.

The format of the course will be informal, with the expectation that lectures will be frequently interrupted by questions and discussion, and that all students will participate in each of the weekly discussion sections.

The course will be graded on three problem sets (30%), a final exam (50%), and participation in discussion sections (20%).

Books

There is no textbook that we recommend for the entire class. For population genetics, two short books may be useful, although both go well beyond the material we will present.

Maynard-Smith, J. 1997 Evolutionary Genetics. Oxford University Press.

Hartl, D. 2000. A primer of population genetics. Sinauer.

For genetics, all the standard textbooks have expanded to a point where they are more useful as doorstops than a distillation of the minimum material that a graduate student should master. There is little to choose between the contenders, although

Suzuki et al. 2004. An introduction to genetic analysis. Freeman.

may be the least excessive, and has a website at <http://www.whfreeman.com/iga/>.

For comparative and evolutionary developmental issues, see the following:

Minelli, A. and Fusco, G., eds. 2008 Evolving Pathways: Key Themes in Evolutionary Developmental Biology. Cambridge University Press.

Reviews

Some things to warm up with, only if the beach has begun to seem stale, flat, and unprofitable.

Hartwell, L. H., Hopfield, J. J., Leibler, S., and Murray, A. W. (1999). From molecular to modular cell biology. *Nature* 402, C47-52. *A review about modularity and levels of explanation*

Abzhanov, A., Extavour, C., Groover, A., Hodges, S. A., Hoekstra, H. E., Kramer, E. M. and Monteiro, A. (2008). Are we there yet? Tracking the development of new model systems. *Trends in Genetics* 652, 353-360.

Rules and regulations

Discussion sections

You should read the paper or papers in depth and come prepared to discuss them. We don't pre-assign individual students to lead the discussion or research specific questions. We do direct questions to individual students, so each of you will need to be ready to answer questions about the fundamental question the paper sets out to tackle, the design of the experiments or calculations, the results obtained, and the extent to which you buy the authors conclusions, inferences, and speculations. Doing things this way is not a hazing ritual, but an attempt to make sure that you each get as much as you can out of each discussion and that you participate equally, rather than allowing the extroverts to dominate the introverts.

Problem sets

There will be three problem sets. Each will focus on a specific area and ask you to read and think about a topic that is related to something that we covered in class, but will require you to approach the topic in a depth that we cannot reach in a course that covers such a wide array of material. You are encouraged to collaborate with each other in thinking about and discussing the topic and the questions you ask, but each of you must write your own answers to the questions. Beware of the herd effect. The point of view that the majority of your colleagues has decided a particular is correct may be wrong, or even dead wrong! We expect that the reading, thinking, and writing associated with each problem set will occupy around 12 hours of your time.

Final

There will be a 3 hour, in-class, final, which will be designed to test your ability to use the concepts we expose you to. You may bring with you all the facts that you can fit on one side of a single piece of 8.5 x 11 inch paper.

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Day	Date	Notes	Lecture/Discussion	Title/Topic	Lecturer	Content Guide
W	8/31/11	Class Start	Lecture 1	Numbers matter	GC + NC	Probabilities
F	9/2/11		Discussion 1	Probabilities		Problem-solving using statistics
M	9/5/11	Labor Day	no class			
W	9/7/11		Lecture 2	Why questions matter	AM + CE	Course overview, diagnostic quiz (20 min)
F	9/9/11		Discussion 2	Luria and Delbruck		Using statistics to make discoveries
M	9/12/11		Lecture 3	The Lac operon	AM	Reaching a sophisticated understanding of a classic problem
W	9/14/11	PS 1 Out	Lecture 4	Darwin in context	AB	Thought pre-Darwin, Darwin on Evolution, what's missing
F	9/16/11		Discussion 3	Novick and Weiner, Van O		Sophisticated analysis of Lac in 1957 and again in 2004
M	9/19/11		Lecture 5	Mendel in context	AM	Thought pre-Mendel, rediscovery, macro vs micro mutation
W	9/21/11		Lecture 6	Tree of Life	CE	Model system relationships, evolution of major morphologies
F	9/23/11		Discussion 4	Mendel		The pea experiments as an example of reductionism
M	9/26/11	PS 1 Due	Lecture 7	Homology	CE	Definitions, history, criteria, hierarchical levels of selection
W	9/28/11		Lecture 8	Homoplasmy	CE	Convergence, parallelism, morphological & molecular levels
F	9/30/11		Discussion 5	Lahn, Domazet		chromosomal evolution (or genomic hourglass)??
M	10/3/11		Lecture 9	Genetics I	AM	How to do and exploit genetic screens & selections
W	10/5/11		Lecture 10	Genetics II	AM	Chromosome behavior: centromeres, origins, mitosis/meiosis
F	10/7/11		Discussion 6	Ellis and Horvitz		How to do a genetic screen
M	10/10/11	Columbus Day	no class			
W	10/12/11	PS 2 Out	Lecture 11	Genetics III	CE	Genetics in diploid organisms?
F	10/14/11		Discussion 7	Andersen		Genome based genetic screens
M	10/17/11		Lecture 12	Genomics	AM	Genome structure, high throughput analysis
W	10/19/11		Lecture 13	Pop Gen I	AM	Asexual issues: drift, selection, speed; Sex
F	10/21/11		Discussion 8	Cairns and Foster		Is Lamarck alive or dead? Adaptive mutation
M	10/24/11	PS 2 Due	Lecture 14	Pop Gen II	AM	Speed of evolution, mutators, regulatory networks
W	10/26/11		Lecture 15	Pop Gen III	AM	Detecting selection: linkage disequilibrium, drift, QTLs
F	10/28/11		Discussion 9	Sabeti, Kingsley		Detecting selection in the human genome
M	10/31/11		Lecture 16	Phylogenetics	AM	An introduction to trees, construction & interpretation
W	11/2/11		Lecture 17	Modularity/Co-option	CE	Definitions, implications, modification mechanisms

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F	11/4/11		Discussion 10	Seo, HIV		<i>Hox cluster disintegration, HIV tree analysis</i>
M	11/7/11		Lecture 18	Protein Evolution	CE	<i>Logic, support, implications, functional mechanisms</i>
W	11/9/11	PS 3 Out	Lecture 19	Bioinformatics	AM	<i>How to infer biological function from sequence data</i>
F	11/11/11		Discussion 11	Halabi, Milo		<i>protein sectors, constraints on the evolution of hemoglobin</i>
M	11/14/11		Lecture 20	Constraint	CE	<i>Definitions, concept evolution; evolvability</i>
W	11/16/11		Lecture 21	Cis-Reg Evolution	CE	<i>Interpretation of heterologous expression, gene duplication</i>
F	11/18/11		Discussion 12	Chan, McGinnis		<i>sticklebacks, Hox genes, Hoekstra & Coyne review</i>
M	11/21/11	PS 3 Due	Lecture 22	Species, Speciation	AM	<i>Formation, definition, immutability</i>
W	11/23/11	pre-Thanksgiving	<i>no class</i>			
F	11/25/11	Thanksgiving	<i>no class</i>			
M	11/28/11		Lecture 23	Prediction/Evolution	AM	<i>Bet-hedging: specialized kin-selection, role in disease</i>
W	11/30/11		Review			
F	12/2/11	Class End	FINAL EXAM			