Population Genetics & Genomics
BIL 551 | BIL 651 | MBE 529 | MBE 629
Spring 2023

3 credits

Class Time
Tue & Thu 1:30-2:45PM
Marine Science Center 125
RSMAS Campus

Instructor:
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Department of Marine Biology & Ecology (RSMAS)
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Office & Lab:
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Office hours:
Tue & Thu 3:00-4:00 PM (after class at RSMAS), or any other time by appointment on the Coral Gables Campus

Lab Website:
http://www.duckdna.org/

Website for the Summer Course:
https://www.genomica-de-poblaciones.org/

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Textbooks:
Nielsen, R. and M. Slatkin. 2013. An Introduction to Population Genetics: Theory and Applications. Sinauer Associates, Sunderland, Massachusetts, USA.

ISBN-13: 978-1605351537
ISBN-10: 1605351539

Course Description:
This course provides an introduction to population genetics & genomics, which examines the evolutionary processes that affect the allele frequencies of natural populations: mutation, genetic drift, natural selection, and gene flow. Population genetics has had a long mathematical tradition and is rich in theory and empirical data. In this course, we will examine all aspects through mathematical models, methods of measuring genetic variation, and readings of published empirical studies. Taxonomic focus will be broad and will include both model and non-model organisms. With the advent of genome sequencing, population genetics theory has renewed relevance for understanding genomic-scale patterns of genetic diversity, as a means to identify genes of importance for human disease, agricultural diseases and breeding, and for developing conservation and management strategies. The practicum and software components of the course focuses on pertinent readings, examples of data analysis pipelines, and commonly used software packages. This course is usually offered every other spring in odd-numbered years. A compressed version of this course is offered in the summer.

Student Learning Objectives:
By the end of this course students will have a solid foundation in the mechanisms of evolution, population genetic theory, mathematical applications, and genomics, including exposure to some routine data analysis pipelines, and software packages. For undergraduate students, this course will prepare you for an entre into fields of bioinformatics, population genomics, including applications in agriculture, biotechnology, and medical fields. For graduate students, this course is meant to be a beginning. It will offer an opportunity to integrate an aspect of population genetic and evolutionary thinking into your current research and will give you perspective for future forays in the field.

Schedule of Lecture Topics

Lecture Topic
History of Population Genetics
Allele Frequencies, Genotype Frequencies, & Hardy-Weinberg Equilibrium
Mutation & Genetic Drift
Coalescent Theory
Maximum Likelihood, Bayesian Statistics, Markov Chain Monte Carlo
Effective Population Size
Inbreeding & Inbreeding Depression
Tajima's D & the Site Frequency Spectrum
Population Subdivision
Migration & Gene Flow
Adaptive introgression
Trees & Networks
Linkage Disequilibrium & Recombination
Selection 1
Selection 2
Neutral Theory
Selection 3
Quantitative Genetics

*There are a total of 28 class meetings this semester. Approximately 18 will entail lectures, the other 10 will be divided by paper discussions with articles to be assigned and software demonstrations.

Course Format:

The course will be interactive, a hybrid between traditional lecture and flipped format, substantial class time devoted to assigned readings as well as presentations on the use of data analysis pipelines and/or common software packages frequently used by population geneticists. This will entail formal lectures presented by the professor, followed generally by student-led discussion of assigned readings and/or computers exercises. Students will be expected to prepare for each class section by completing the assigned readings, thinking about previous lecture topics, and preparing questions for the instructor and their classmates. During the semester, each student will select a particular published journal article or an analytical software package to interpret/learn on their own, and exhibit to the class at the end of the semester with a 20-min presentation during the scheduled final exam period. There will be one mid-term exam following spring break and a final exam based on the readings and lectures. Both of these exams will be a take-home format.

Grading:

Participation	20%	
Exam 1	30%	TBA due around spring break
Exam 2	30%	TBA finals due week
Software/paper presentation	20%	

Participation: You are signing up for a course called "Population Genetics & Genomics" so I assume you are self motivated to learn the material. I expect everyone to show up for every class unless you are sick or have an acceptable excuse. "Participation" doesn't mean just showing up, though. This is a small class, so participation means engaging in the material, asking relevant questions, and providing insights that others do not see---educating your peers through insightful thinking and speaking. Most Thursday class sessions will follow a discussion format and/or work through software analyses together. You should also take notes as you read or encounter difficulties for with software/data assignments so that you are prepared for a discussion part or software practical. We will review the answers to the questions you prepare during our discussion. So…. participation means being fully engaged and prepared for class by questioning and thinking critically and sharing both your questions and insights.

Softwares: To help you synthesize and learn to apply the issues covered in lecture and discussion sections, analysis of data sets will be undertaken together using some commonly used software packages. Examples may include some but not all:

PCA (adegenet)
Admixture
Coancestry
PopGenome
Abbababa & Dsuite
VCFtools
Plink

To execute these softwares generally you will require the UNIX operating environment built into your Mac or something such as Ubuntu running on Virtual Box in your Windows machine. Instructions for how to set these up will be discussed further.

Exams: Two exams will be assigned, a mid term and a final. These will differ somewhat for graduate and undergraduate students.

Software Presentation: Many software programs have been developed in the fields of population genetics and molecular evolution. We will only have time to work through a few each semester. So each student will be asked to review and present the utility and functionality of a software not covered in class at the end of the term. Which program you will present will be determined in consultation with me. An annotated list of some of the many softwares you might choose from is provided here: http://www.duckdna.org/softwares/. Alternatively, you may present a journal article you read.

Exam Make-up and Incomplete Policy:
Make-up exams are discouraged. If circumstances are such that you are unable to take the exam, please contact me by gmail (kevin.g.mccracken@gmail.com) in advance of the exam. Incomplete grades will only be authorized under special circumstances. Your participation in the course will factor into this decision.

Student Code of Conduct:
Students are subject to the UM Student Honor Code. The *existence or even the appearance* of plagiarism, cheating, or any other forms of academic dishonesty will not be tolerated, and will result in immediate failure of the course (not just the assignment). Students that *participate or appear to participate* in these types of activities will receive a F as the final recorded grade, be withdrawn from the course, and may be referred to the Dean of Students. Participation in this course implies that these terms are mutually agreed upon.

Other Policies:
Needs of students with disabilities will be accommodated following university policies and all applicable federal laws. Please talk to the instructor if you require assistance. The Office of Disability Services in the Academic Resource Center, N201, Whitten University Center provides disability services. Student athletes and members of the U.S. military should coordinate their absences with the instructor in advance.

Additional Texts:

There are several other good books in the field of population genetics. You might find some of these helpful.

Avise J.C. 2004. Molecular Markers, Natural History, and Evolution. 2nd edition. Sinauer Associates.
**Avise's book is a classic in molecular ecology.*

Gillespie J.H. 2004. Population Genetics; A Concise Guide, 2nd edition. Johns Hopkins University Press.
**A classic guide to fundamental population genetics concepts*

Hahn M. W. (2018). Molecular population genetics. Sunderland: Sinauer Associates.
**This is an equally good and among the newest pop gen text books.*

Hartl, D. L. (2020) A primer of population genetics and genomics, 4th edition. Oxford University Press.
**The more recent incarnation of the classic text below.*

Hartl D.L., Clark A.G. (2007) Principles of Population Genetics, 4th edition. Sinauer Associates.
**A great classic textbook covering population genetics. Descriptions of population genetic principles are lucid.*

Halliburton R. 2004. Introduction to Population Genetics. Pearson Prentice Hall.
**Another excellent population genetics textbook.*

Wakeley J. 2008. Coalescent Theory: An Introduction, 1st edition. W.H. Freeman.
**A advanced population genetics text dealing with coalescent theory.*

Li W.-H.1997. Molecular Evolution. Sinaur, Sunderland, MA.
**This is probably the best reference text for molecular evolution, but it can be very mathematical and difficult at times. It is now out of print. The text covers phylogenetics, coalescent theory, and higher level mechanisms for molecular evolution such as gene duplication and transposition.*