Biology ###: Genetics
Syllabus

"An exact determination of the laws of heredity will probably work more change [on our] outlook on the world, and in [our] power over nature, than any other advance in natural knowledge that can be clearly foreseen."

William Bateson, 1900
Journal of the Royal Horticultural Society

Description:
Genetics is the study of heredity and the variation of inherited characteristics. In this course, you will learn the basic principles of classical and modern molecular genetics in prokaryotes and eukaryotes. You will also consider and debate the impact of genetics on modern society.

Meetings:
Classroom: Meets twice a week for a semester for a total of about 29 meetings
Laboratory: Meets once per week

Reading/viewing material:
Any genetics textbook published after 2012 will cover the required material for this course. You may use any textbook but will be responsible for identifying the analogous sections in your own text.

The reading will be assigned from:

1) Principles of Genetics 6th Edition, D. Peter Snustad, Michael J. Simmons (or other current textbook)
2) Primary literature
3) Lectures on iBiology website (http://www.ibiology.org/)

Other Required:

Personal Response Device (Clickers)
Lab Notebook (any kind, bound)

Course Goals and Learning Objectives[1,2]:
These goals and objectives will be assessed by: In-class quizzes and activities, reading questions, homework problems and in-class exams

Upon completion of this course, students will…

Know/Understand:	**Be able to:**	**Deep connections**
How to think critically	Solve problems or analyze data at any level of genetic analysis. Make hypotheses and design experiments using appropriate technology.	*If you identified a wild-caught Drosophila phenotype mutant, how could you identify the mutation?*
The vocabulary and processes in genetics topics	Communicate with colleagues and lay people about topics in genetics.	*What are the important questions facing the field of genetics today? How does genetics influence our every day lives?*
The connections between	Articulate how molecular	*What are some of the*

multiple levels of genetic organization	mechanisms, DNA expression at the individual level, and the transmission of that DNA across generations at the population level are related.	*mutations that cause common human diseases? Why do they sometimes exist in high frequencies?*
How to read the primary literature	Analyze the experiments, hypotheses and data that led to insights into our current understanding of genetics.	*How would you design an experiment to show that two genes are near each other in the genome?*
The Mendelian and non-Mendelian modes of inheritance that govern passage of genetic traits across generations	Use this knowledge of inheritance to track alleles through generations and categorize and predict genotypes and phenotypes	*How do the rules of probability allow us to predict the results of crosses? Can we predict phenotype when hundreds of genes are involved (height, diabetes)?*
The basic structure and function of DNA and chromosomes. How chromosomes move through mitosis and meiosis	Draw the stages of mitosis and meiosis and explain how the process of mutation occurs and generates phenotypic diversity.	*How did Mendel's crosses give evidence for the process of meiosis? How was it shown that DNA is the hereditary material?*
The Hardy-Weinberg equilibrium equation and the requirements for maintaining Hardy-Weinberg equilibrium in a population	Calculate p, q, p^2, q^2 and 2pg for populations	*If a population is not in HW, how can we determine the cause?*
The basics of molecular processes of DNA replication, transcription and translation and important characteristics of the genetic code	Draw and name relevant machinery for DNA replication, transcription and translation Identify the parts of a gene, transcribe it, and translate it into protein	*How does gene organization and regulation differ in prokaryotes and eukaryotes? What are the explanations for these differences?*
How humans use natural processes and aspects of molecular structure of DNA to develop new technologies	Understand how technologies are derived from first principles of genetics and molecular biology.	*What were the key insights that led to CRISPR and genome sequencing technologies?*
Be informed on topics including; personal genomics, personalized medicine, eugenics, genetically modified organisms…	Make a critical analysis of the controversial topics that relate to genetics.	*What is the basis for the technology? What are the possible upsides? Are there downsides?*
Larger scale analysis: functional genomics and proteomics		

In-class projects:

Week 1a	Introduction/In-class activity
Week 1b	Structure and function of the genome
Week 2a	Mitosis, meiosis, ploidy and gametes
Week 2b	Rearrangements and Intro to Mendel
Week 3a	Mendel, Punnetts, and Probabilities
Week 3b	Non-Mendelian Genetics and Probabilities II
Week 4a	Human pedigrees
Week 4b	Review
Week 5a	**Exam 1**
Week 5b	Linkage, Crossing over, and mapping I
Week 6a	Linkage, Crossing over, and mapping II
Week 6b	Structure, function and mutation of the DNA molecule
Week 7a	Mutations: molecular and phenotypic
Week 7b	Population genetics: Hardy Weinberg
Week 8a	Review
Week 8b	**Exam 2**
Week 9a	*Mid-semester break*
Week 9b	*Mid-semester break*
Week 10a	Cell cycle and DNA repair
Week 10b	Replication of the DNA molecule
Week 11a	Eukaryotic replication and recombination
Week 11b	Transcription
Week 12a	Translation
Week 12b	Review
Week 13a	**Exam 3**
Week 13b	Proteins
Week 14a	Genetic code and genetic sequencing
Week 14b	Evolution
Week 15a	Controversial topics in genetics
Week 15b	Controversial topics in genetics
Week 16a	Review
Week 16b	**Cumulative final exam**

Controversial Topics in Genetics

Student groups will choose any controversial topic in the field of genetics. Examples may include personal genomics, personalized medicine, eugenics, genetically modified organisms, or others. Groups will choose the method in which they will present their research.

Week 5	Groups meet and discuss topics
Week 6	Groups turn in topic choice and method of presentation
Week 10	First draft due
Week 12	Second draft due

The method of presentation can be anything; a standard paper, a series of blog posts, a YouTube channel, an annotated syllabus for a course on your topic, an oral presentation with slides (Ted talk style), a debate, an outreach activity for elementary aged students, or anything I have approved. You may choose your target audience (as long as the topic is appropriate). Be as creative as you like. Likewise, the drafts can take any form but must include an annotated bibliography. If you chose a standard paper, you may turn in a detailed outline of your paper for draft 1. If you chose a YouTube channel, you may turn in a detailed script. The drafts are worth 5% of your total grade, so take them seriously.

Rubric – applied to the final product and the drafts. I will supply you with example rubric and we will decide on a fair grading scale.

Criteria/Scale	Exceeds Expectations	Meets Expectations	Needs Improvement	Inadequate
Structure *Is presentation or paper well constructed?*				
Genetics Vocabulary *Do you show a command of the vocabulary and connect your topic to the principles from class?* *Is your tone respectful and match your audience?*				
Content/Information *Is the overall argument well constructed?*				
Platform specific creativity *Depending on the method you chose to present your topic, how much creativity did you show in delivering the content?*				
Other *What other criteria should we use to judge these papers?*				

Grades:

Lecture 65%

Pre-lecture quizzes	100
Post-lecture assignments	50
Clicker questions	100
Controversial presentation drafts	50
Exam 1	100
Exam 2	100
Exam 3	100
Final	100

Laboratory 35%

Lab notebook	50
Lab assignments	50
Lab report	100
Controversial genetics presentation	100

Total	1000 points

Genetics Laboratory

Lab 1	*Brassica rapa:* Mendelian and quantitative genetics (selection and phenotyping)
	Mitosis and meiosis beads
Lab 2	Genotyping and phenotyping of tDNA knockout plants
Lab 3	Analyze data from knockout segregation
	Brassica rapa: crosses
Lab 4	Mendelian, Punnett and Pedigree problems
Lab 5	Mapping traits in *Brassica rapa*
	Brassica rapa: collect and plant seeds
Lab 6	Gene expression, RNA extraction from Arabidopsis, Miroarray and/or RNA-seq
Lab 7	*Brassica rapa*: phenotyping, probability calculations
Lab 8	Bioinformatics
Lab 9	*Mid-semester break*
Lab 10	Bioinformatics
Lab 11	Design cloning project
Lab 12	Cloning project
Lab 13	Cloning project
Lab 14	Prep for controversial topics presentation
Lab 15	Controversial topics in genetics presentations

Materials I used to create this syllabus:
1) Dr. Heather Doherty's Genetics Syllabus (10/2015)
https://curriculumfellows.hms.harvard.edu/sites/curriculumfellows.hms.harvard.edu/files/Sample%20syllabus%20using%20template_Genetics%20274%20Sufflok.pdf

2) Dr. Amanda Little Genetics Syllabus (10/2015)
http://www.d.umn.edu/~alittle/genetics/

3)Dr. Karen Hales Genetics Syllabus
http://bio.davidson.edu/people/kahales/BIO201syllabus.html (10/2015)

(Smith & Knight, 2012)

(Burnette & Wessler, 2013)

http://udel.edu/~mcdonald/geneticssyllabus.html

http://www.usca.edu/biogeo/faculty/jackson/genetics/laboratory/labsyllabus.html

http://www.uwplatt.edu/system/files/UCDenver%20writing%20rubric.pdf

Instructor-only material

Annotations and materials for improving the genetics course.

Common misconceptions in Genetics (Smith & Knight, 2012):
Different cells in individuals contain different genes.
Inherited diseases that affect only women are caused by mutations on the X chromosome
A change is a mutation only if it will produce a change in the amino acid sequence
When two heterozygotes mate, probability calculations do not need to be adjusted even if an offspring is known to be unaffected.
A stop codon stops transcription
A frame shift mutation cannot lead to an early stop in translation.
DNA and amino acid sequences are equally variable.
Chromosome separation errors happen only in meiosis I.
If proteins have the same function, they must have the same amino acid sequence.

What did Mendel discover?
http://www.mendelweb.org/MWhartl.html#s1

Burnette, J. M., & Wessler, S. R. (2013). Transposing from the laboratory to the classroom to generate authentic research experiences for undergraduates. *Genetics*, *193*(2), 367–375. http://doi.org/10.1534/genetics.112.147355

Smith, M. K., & Knight, J. K. (2012). Using the Genetics Concept Assessment to document persistent conceptual difficulties in undergraduate genetics courses. *Genetics*, *191*(1), 21–32. http://doi.org/10.1534/genetics.111.137810