Biology 423/423L (Fall 2018)
Genomics Lecture/Lab

Lectures:	MF 9:30 - 10:45 am, RITA 273
Labs:	F 12:30-3:30pm, RITA 145 (wetlab), RITA 273 (computer labs)
Instructor:	Dr. Christine Byrum
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Office Hours:	By appointment

Course Overview: This upper level undergraduate course is designed to familiarize students with the field of genomics and current topics of interest in this quickly expanding discipline. We will explore several subdisciplines in the field and learn about a variety of techniques applicable to genomic analysis. Particular attention will be devoted to new advances in the area of marine genomics as well as biomedically relevant areas of genomics. Materials will be presented as lectures, classroom discussions of journal articles, and labs/workshops.

Course Objectives/Student Learning Outcomes:

Course objectives/student learning outcomes include the following. Students will:

1) Recognize terminology used by genomicists and be able to explain key principles and theories associated with this field.
2) Be able to describe genomic concepts and apply these concepts to new situations or to interpret data based on what they have learned in class.
3) Learn how to operate bioinformatics programs to detect/identify genes in a genome and better characterize gene products.
4) Discuss recent genomic research described in selected readings from the scientific literature.
5) Complete phylogenetic analyses applicable to genomic studies.
6) Become familiar with all aspects of QPCR analysis including sample preparation, primer design, primer testing, controls necessary for QPCR analysis, running QPCR reactions, and analysis of QPCR results.
7) Compare sequencing technologies, methods used to analyze gene expression, and proteomic technologies.
8) Discuss ethical issues relevant to genomics.
9) Identify local/regional facilities that provide genomic resources.
10) Describe findings in the field of genomics in a talk and/or a paper.

Recommended Text:

Concepts in Bioinformatics and Genomics, 1st edition. J. Momand, A. McCurdy, S. Heubach, N. Warter-Perez, 2016 (Oxford University Press).

Optional:

Bioinformatics and Functional Genomics, 3rd edition. J. Pevsner, 2015 (Wiley Blackwell).
A Primer of Genome Science, 3rd edition, G. Gibson and S. Muse, 2009 (Sinauer Associates).
Phylogenetic Trees Made Easy, 4th edition. B.G. Hall, 2011 (Sinauer Associates).

Prerequisites: Genetics (BIOL 305), Introduction to Statistics 1 (MATH 250), Molecular Biology (BIOL 312) / Cell Biology (BIOL 313) or permission of the instructor.

Course Policies

Attendance: Regular classroom participation is critical in this course. If the student is unable to attend a class, he/she should be sure to get the information from a classmate or from the instructor so that he/she doesn't fall behind. If an absence is anticipated, the instructor should be informed ahead of time. Make-up assignments will only be approved with an official excuse from the Dean of Students, Undergraduate Affairs Office at the discretion of the instructor. Students with multiple unexcused absences will likely fail the course.

Class Assignments:

Tests: There will be four quizzes and two tests during the course of the semester in which the students will be assessed to determine their knowledge concerning recent and/or previous materials. Quizzes will typically consist of five to ten short answer/essay questions and tests will be comprehensive with essay/short answer and multiple choice/matching sections. This is a significant portion of your grade. Be sure to prepare thoroughly for each evaluation.

Discussions: Students will also lead class discussions about topics in genomics. This will be done in teams of two. Students should introduce the class to the topic and lead a discussion reviewing two papers (30 minutes/person). Students should prepare typed notes for these discussions (notes highlighting key points in the introduction and listing discussion questions with written answers.). These notes will be handed in following the discussion session.
Those not presenting are expected to read the assigned papers before class and to participate in class discussions. Participation involves the following: A) Did the student

take time to carefully read this paper? Is he/she able to answer questions raised during discussions? Can he/she describe what was done in the paper? Has he/she thought about implications of this work? B) Is the student willing to contribute to classroom discussions? Even if one is shy, it is important to actively participate. C) Has the student taken extra steps to build on what they've learned after reading the paper? Does he/she contribute extra information in discussions? How participation is to be evaluated will be decided by students at the beginning of the semester.

Out of Class Exercises: These are short "homework" assignments. Often these are worksheets to fill out or exercises to do that will improve understanding of a technique previously discussed in class or lab. Students are encouraged to talk to each other about these assignments but should not copy work. Make sure that all work is shown and turn in assignments at the beginning of the next class period. Assignments will not be accepted after all papers have been corrected and turning in an assignment late may result in a penalty.

Class Project: Over the semester, students will work together to complete a course project in the lab during which they analyze expression of a set of genes in the sea urchin. Students will find members of a gene family, identify domains present in the members of that gene family, identify human genes that are likely homologues based on gene alignments and perform phylogenetic analysis to characterize the evolutionary relationships of these genes to those in other phyla. They will also design primers and perform QPCR analysis to determine levels of gene expression at different developmental stages. Each individual will submit his/her project as a paper.

Grading of Assignments: A single grade based on performance in both the lecture and lab will be assigned for the 4-credit Genomics course. The following criteria will be used to calculate the grade.

Tests (20%)/Quizzes (10%)	30%
Discussions – 2 Presentations (20%)/Participation (10%)	30%
Lab - Exercises (20%)/Project (20%)	40%

Grading Scale:

93 and above: A	73-76.9: C
90-92.9: A-	70-72.9: C-
87-89.9: B+	67-69.9: D+
83-86.9: B	63-66.9: D
80-82.9: B-	60-62.9: D-
77-79.9: C+	below 60: F

Classroom courtesy: Students are expected to turn off cell phones and any other disruptive devices during lectures and discussions. Exceptions will be made in extreme

situations such as spouses anticipating the birth of a child or a serious emergency. Permission to leave an electronic device on should be obtained prior to class.

Academic Integrity: Students are expected to behave in an honest and responsible manner. Violations of the honor code are offensive and will generally be dealt with severely. We will adhere to the following policy as quoted from the Honor Council's recommended guidelines:

"Lying, cheating, attempted cheating, and plagiarism are violations of our Honor Code that, when identified, are investigated. Each incident will be examined to determine the degree of deception involved.

Incidents where the instructor determines that the student's actions are related more to a misunderstanding will be handled by the instructor. A written intervention designed to help prevent the student from repeating the error will be given to the student. The intervention, submitted by form and signed both by the instructor and the student, will be forwarded to the Dean of Students and placed in the student's file.

Cases of suspected academic dishonesty will be reported directly by the instructor and/or others having knowledge of the incident to the Dean of Students. A student found responsible by the Honor Board for academic dishonesty will receive a XXF in the course, indicating failure of the course due to academic dishonesty. This status indicator will appear on the student's transcript for two years after which the student may petition for the XX to be expunged. The F is permanent. The student may also be placed on disciplinary probation, suspended (temporary removal) or expelled (permanent removal) from the College by the Honor Board.

Students should be aware that unauthorized collaboration--working together without permission--is a form of cheating. Unless the instructor specifies that students can work together on an assignment, quiz and/or test, no collaboration during the completion of the assignment is permitted. Other forms of cheating include possessing or using an unauthorized study aid (which could include accessing information via a cell phone, tablet, or computer), copying from others' exams, fabricating data, and giving unauthorized assistance.

Research conducted and/or papers written for other classes cannot be used in whole or in part for any assignment in this class without obtaining prior permission from the instructor.

Students can find the complete Honor Code and all related processes in the *Student Handbook* (http://studentaffairs.cofc.edu/honor-system/studenthandbook/index.php)."

Center for Student Learning: Students are encouraged "to utilize the Center for Student Learning's (CSL) academic support services for assistance in study strategies, speaking & writing strategies, and course content. They offer tutoring, Supplemental Instruction, study strategy appointments, and workshops. Students of all abilities have become more successful using these programs throughout their academic career and the services are available to you at no additional cost. For more information regarding these services please visit the CSL website at http://csl.cofc.edu or call (843) 953-5635."

Accommodations for Students with Disabilities: Any student who needs accommodations because of a disability should talk to the professor about this during the first week of classes or as soon as they have been approved for these services so that this can be addressed. For more information on Disability Services, call the campus office at (843)953-1431 or refer to their website: http://disabilityservices.cofc.edu

Lecture Schedule

Date	Topic
Aug. 24 - F	Gene and Genome Structure
Aug. 27 - M	Genome Size (Last Day to Add/Drop)
Aug. 31 - F	*Discussion* - Origins of Genomics
Sept. 3 - M	Sequencing Genomes
Sept. 7 - F	*Discussion* – Genome Sequencing Approaches – Quiz 1
Sept. 10 - M	Finding Genes/Annotation
Sept. 14 - F	*Discussion* – Alternative Splicing
Sept. 17 - M	Measuring Gene Expression (Sept. 20, last day to withdraw with W)
Sept. 21 - F	*Discussion* – Gene Expression – Quiz 2
Sept. 24- M	Proteomics
Sept. 28 - F	*Discussion* – Proteomics
Oct. 1 - M	**Test 1**
Oct. 5 - F	QPCR
Oct. 8 - M	Microbial Genomics
Oct. 12 - F	*Discussion* – Microbial Genomics
Oct. 15 - M	Comparative Genomics
Oct. 19 - F	*Movie* – Personalized Medicine
Oct. 22 - M	*Discussion* – Comparative Genomics – Quiz 3
Oct. 26 - F	Sequence Alignment
Oct. 29 - M	Phylogenetic Analysis
Nov. 2 - F	*Discussion* – Genome Defense/CRISPR-Cas8
Nov. 5 - M	**Fall Break**
Nov. 9 - F	*Discussion* – Phylogenomics – Quiz 4
Nov. 12 - M	Studying Genome Variation
Nov. 16 - F	*Discussion* – Ethical Issues

Nov. 19 - M **Test 2**
Nov. 23 - F **Thanksgiving Break**
Nov. 26 – M Functional Genomics
Nov. 30 - F *Discussion* – Functional Genomics
Dec. 3 – M TBA

** Schedule may vary subject to scheduling changes and other modifications as needed.*

Objectives/Student Learning Outcomes for the *Genomics* Lab: In the *Genomics* Lab, a mixture of computer-based labs and "wet lab" exercises are used to familiarize students with key procedures regularly used to study genomics. We will work together in teams to ask real scientific questions. Students will learn how to:

1) Retrieve nucleotide (transcriptomic and genomic DNA) and protein sequences from scientific databases.
2) Perform simple and advanced BLAST searches.
3) Construct standard and QPCR primer sets for reverse transcriptase PCR and QPCR.
4) Extract RNA from an organism and produce cDNA.
5) Operate equipment for and analyze the results of reverse transcriptase PCR and QPCR.
6) Extract DNA from a gel after electrophoresis and prepare samples for sequencing.
7) Interpret sequence data.
8) Identify homologous genes for phylogenetic analysis.
9) Complete phylogenetic analyses using MEGA.

Lab Safety and Attire: Before attending the first lab, each student should review the official SSM safety manual posted on OAKS. Many of the labs are computer-based, but others involve the use of hazardous chemicals. During "wet labs", students should dress appropriately, wearing closed-toed shoes and pants rather than shorts. These protect more in the case of a chemical mishap.

Genomics Lab Schedule

Date	Topic
Aug. 24	Technical Foundations of Genomics (lecture) *Goal:* Review key molecular techniques that preceded development of high throughput approaches used in Genomics.
Aug. 31	Finding Genes in a Genome/Domain Analysis *Goal:* Outline lab organization, goals for semester. Learn to search for annotated and unannotated genes. Discuss how to deal with "problematic" sequences. Learn to do domain searches (Pfam, NCBI, SMART, TMHMM) and how to make drawings showing key domains.

Assignment: Practice finding genes and characterizing domain structure in these products.

Sept. 7 Performing BLAST Searches

Goal: Become proficient at performing different types of BLAST searches on NCBI's BLAST site. Learn how to select the correct BLAST program for your question, which databases are available on BLAST, parameters available, and how to perform specialized BLAST searches.

Assignment: Complete BLAST worksheet before next lab.

Sept. 14 Standard and QPCR Primer Design/Review of PCR

Goal: Learn to make primers for standard PCR and QPCR analysis.

Assignment: Design standard PCR and QPCR primer sets.

Sept. 21 Collecting Specimens for QPCR Analysis

Goal: Learn how to prepare specimens for QPCR analysis. Induce spawning in sea urchins, culture and collect embryos at specific developmental stages, and prepare for RNA extraction.

Assignment: Obtain specimens for QPCR labs.

Sept. 28 Extracting RNA/Producing cDNA

Goal: Collect/extract RNA and use reverse transcriptase to produce cDNA for RT-PCR or QPCR.

Assignment: Isolate mRNA and produce cDNA.

Oct. 5 Performing the Standard PCR Reaction

Goal: Test standard primers you made using standard PCR .

Assignment: Obtain PCR products (if possible) using your primer sets before the next lab.

Oct. 12 Electrophoresis of PCR products/Gel Extractions for Sequencing

Goal: Evaluate PCR products obtained in last lab using gel electrophoresis and prepare samples for sequencing.

Assignment: Determine whether primers amplified genes of interest and verify by sequencing the product.

Oct. 19 Optimizing for QPCR/Running Reactions

Goal: Run a QPCR reaction after performing necessary tests.

Assignment: Acquire QPCR data.

Oct. 26 Optimizing for QPCR/Running Reactions

Goal: Continue collecting data for class project.

Assignment: Acquire QPCR data.

Nov. 2 Finding Potential Homologues /Sequence Alignment

Goal: Introduce websites useful for finding homologous genes (Ensembl, Homologene, HUGO, Mouse Genome Informatics, etc.). Learn to how to do pairwise and multiple sequence alignments. Discuss editing multiple sequence alignments.

Assignment: Perform pairwise and multiple sequence alignments on your project genes to prepare for phylogenetic analysis. Edit the multiple sequence alignment.

Nov. 9 Generating Phylogenies to Identify Homologues

Goal: Learn to generate neighbor-joining & maximal parsimony trees.
Assignment: Produce a neighbor-joining tree and a maximal parsimony tree for a family of genes you are working on. Compare your genes to potential homologues in humans. Then perform a second analysis in which the genes are compared to a range of organisms to assess evolution of the gene.

Nov. 16 Analyzing QPCR data
Goal: Complete QPCR analysis for class project and related analysis.
Assignment: Analyze QPCR data.

Nov. 30 Summary Lab
Goal: Discuss final outcomes of class project.

** Schedule may vary subject to scheduling changes and other modifications as needed.*
Bold dates: Lab will be held in RITA 273.