Biology 523/523L (Fall 2019)
Genomics Lecture/Lab

Lectures: TTh 10:50 - 12:05 am, RITA 147
Labs: Th 1:30-4:30pm, RITA 145 (wetlab), RITA 147 (computer labs)
Instructor: Dr. Christine Byrum
Email: byrumc@cofc.edu
Phone: (843) 953-7176 office
Office: RITA 233, College of Charleston
Office Hours: By appointment

Course Overview: This graduate 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) Become familiar with terminology used by genomicists as well as key principles and theories associated with this field.
2) Coherently explain genomic concepts and apply these concepts to new situations to predict outcomes based on what was learned in class.
3) Discover/identify genes in a genome using bioinformatics tools and determine the distribution of protein domains in the predicted proteins.
4) Assess recent genomic research through discussion of the scientific literature.
5) Learn techniques in phylogenetic analysis that are 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 classical and recent sequencing technologies, methods of gene expression analysis, and proteomic approaches.
8) Debate pros and cons of legal, ethical and sociological issues relevant to genomics.
9) Evaluate local/regional facilities that provide genomic resources.
10) Learn how to write a publication quality paper that describes findings relevant to the field of genomics.
11) Prepare and lead class discussions in a team and independently. Interpret and organize information from recent publications in a selected area and also submit a term paper to accompany a discussion lead independently.

12) Answer graduate level test questions that require creative synthesis of the information presented in class or may that require the student to formulate new experiments.

Optional Texts (for reference):

Prerequisites: Genetics (BIOL 305), 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 you are unable to attend a class, be sure to get the information from a classmate or the instructor so that you don’t fall behind. If an absence is anticipated, inform the instructor 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 missing 3 or more labs without permission will fail the course.

Class Assignments:
Tests: There will be four quizzes and two tests during the course of the semester to assess your 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. Graduate students are expected to answer an additional question on each test that will require a more detailed, critical answer than to questions given to students taking the course for undergraduate credit.

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?

Solo Discussion/Paper: In addition to the team-led discussion, each graduate student will be expected to lead a second discussion session independently. He/she will select 1-2 papers to discuss and will prepare a Powerpoint presentation (20-25 minutes) to present before the discussion that will give the other students some background on the topic. Following this introduction, the student will lead a classroom discussion about the chosen paper(s) and they will submit a paper on this topic to the instructor following the presentation.

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 Projects: Over the semester, students will work together to complete 2 course projects in the lab. In the first project, the class will work together to annotate a viral genome. In the second project, each student will analyze expression of a set of genes in the sea urchin using QPCR. Students will also perform phylogenetic analysis relevant to the two projects. Each individual will submit summaries of these projects.

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%
Participation in Class Discussions (lecture) 10%
Leading Class Discussions in Team of Two (1) (lecture) 10%
Solo Class Discussion/Paper (1) (lecture) 20%
Out of Class Exercises (lab/lecture) 10%
Class Project Papers (lab) 20%
Grading Scale:

- 90 and above: A
- 77-79.9: C+
- 70-76.9: C
- 80-86.9: B
- <70: 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.

Policy in event of campus evacuation: If the College of Charleston closes and members of the community are evacuated due to inclement weather, students are responsible for taking course materials with them in order to continue with course assignments consistent with instructions provided by faculty. In cases of extended periods of institution-wide closure where students have relocated, instructors may articulate a plan that allows for supplemental academic engagement despite these circumstances.

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 at: 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](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](http://disabilityservices.cofc.edu)

**Veterans and Active Duty Personnel:** Veterans and active duty personnel with special circumstances (e.g. upcoming deployments, drill requirements, disabilities) are welcomed and encouraged to communicate these, in advance if possible, to the instructor.
## Lecture Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Aug. 20 - T</td>
<td>Gene and Genome Structure</td>
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<tr>
<td>Aug. 22 - Th</td>
<td>Sequencing Genomes</td>
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<tr>
<td>Aug. 27 – T</td>
<td>Finding Genes/Annotation</td>
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<tr>
<td>Aug. 29 – Th</td>
<td><em>Discussion</em> - Origins of Genomics – Quiz 1</td>
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<tr>
<td>Sept. 3 - T</td>
<td><em>Discussion</em> – Genome Sequencing Approaches</td>
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<tr>
<td>Sept. 5 - Th</td>
<td>Genome Size</td>
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<td>Sept. 10 - T</td>
<td><em>Discussion</em> – Alternative Splicing</td>
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<tr>
<td>Sept. 12 - Th</td>
<td>Measuring Gene Expression</td>
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<tr>
<td>Sept. 17 - T</td>
<td><em>Discussion</em> – Gene Expression – Quiz 2</td>
</tr>
<tr>
<td>Sept. 19 - Th</td>
<td>Genome Annotation papers/Primer Design</td>
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<tr>
<td>Sept. 24 - T</td>
<td>Proteomics</td>
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<tr>
<td>Sept. 26 - Th</td>
<td><em>Discussion</em> – Proteomics</td>
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<tr>
<td>Oct. 1 - T</td>
<td>Microbial Genomics</td>
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<tr>
<td>Oct. 3 - Th</td>
<td><strong>Test 1</strong></td>
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<tr>
<td>Oct. 8 - T</td>
<td><em>Discussion</em> – Microbial Genomics</td>
</tr>
<tr>
<td>Oct. 10 - Th</td>
<td>Comparative Genomics</td>
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<tr>
<td>Oct. 15 - T</td>
<td><strong>Fall Break</strong></td>
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<tr>
<td>Oct. 17 - Th</td>
<td><em>Discussion</em> – Comparative Genomics – Quiz 3</td>
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<tr>
<td>Oct. 22 - T</td>
<td>QPCR</td>
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<tr>
<td>Oct. 24 - Th</td>
<td>Sequence Alignment</td>
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<tr>
<td>Oct. 29 - T</td>
<td><em>Discussion</em> – Genome Defense/CRISPR-Cas8</td>
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<tr>
<td>Oct. 31 - Th</td>
<td>Phylogenetic Analysis</td>
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<tr>
<td>Nov. 5 - T</td>
<td><em>Discussion</em> – Environmental Genomics – Quiz 4</td>
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<tr>
<td>Nov. 7 - Th</td>
<td>Movie – Personalized Medicine</td>
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<tr>
<td>Nov. 12 - T</td>
<td>Studying Genome Variation</td>
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<tr>
<td>Nov. 14 - Th</td>
<td><strong>Test 2</strong></td>
</tr>
<tr>
<td>Nov. 19 - T</td>
<td><em>Discussion</em> – Ethical Issues</td>
</tr>
<tr>
<td>Nov. 21 - Th</td>
<td>Functional Genomics</td>
</tr>
<tr>
<td>Nov. 26 – T</td>
<td><em>Discussion</em> – Functional Genomics</td>
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<tr>
<td>Nov. 28 - Th</td>
<td>Thanksgiving Break</td>
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* 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) Design standard and QPCR primer sets for reverse transcriptase PCR and QPCR.
4) Extract RNA from an organism and produce cDNA.
5) Perform and analyze the results of reverse transcriptase PCR and QPCR.
6) Extract DNA from a gel after electrophoresis and prepare samples for sequencing.
7) Analyze and interpret sequence data.
8) Annotate a viral genome.
9) Perform pairwise and multiple sequence alignments.
10) Perform phylogenetic analyses using MEGA and become familiar with advanced functions offered in this web-based program.

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 pants rather than shorts and closed-toed shoes. These protect more in the case of a chemical mishap.

Genomics Lab Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Aug. 20</td>
<td>Introduction to Virus Annotation Project&lt;br&gt;&lt;br&gt;&lt;em&gt;Goal:&lt;/em&gt; Discuss plans for virus annotation project and set up bioinformatic programs on student computers including Phamerator, PECAAN, PhagesDB, and the Bioinformatics Guide.</td>
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<tr>
<td>Aug. 27</td>
<td>Finding Genes in a Genome and Identifying Start Sites&lt;br&gt;&lt;br&gt;&lt;em&gt;Goal:&lt;/em&gt; Learn to find unannotated genes using BLAST and Phamerator. Identify start sites using GeneMark, Glimmer, and Starterator. &lt;br&gt;&lt;br&gt;&lt;em&gt;Assignment:&lt;/em&gt; Identify start sites for your assigned viral genes.</td>
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<tr>
<td>Sept. 3</td>
<td>Performing BLAST Searches&lt;br&gt;&lt;br&gt;&lt;em&gt;Goal:&lt;/em&gt; 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. &lt;br&gt;&lt;br&gt;&lt;em&gt;Assignment:&lt;/em&gt; Complete BLAST worksheet before next lab.</td>
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<tr>
<td>Sept. 10</td>
<td>Functional Annotation and tRNA Identification&lt;br&gt;&lt;br&gt;&lt;em&gt;Goal:&lt;/em&gt; Learn to detect functional domains in gene sequences using HHpred, NCBI’s Conserved Domain Database (CDD), or Interpro. Detect membrane proteins with TMHMM and find tRNA sequences using Aragorn and tRNA-Scan. Make drawings showing key domains. &lt;br&gt;&lt;br&gt;&lt;em&gt;Assignment:&lt;/em&gt; Analyze your assigned viral genes for functional domains and structural features. Also search for tRNA and tmRNA sequences.</td>
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</tbody>
</table>
Sept. 17  Comparative Analysis of Viral Genomes
   Goal: Learn how to use Phamerator and Excel to compare genomes
closely related to your viral genome.
   Assignment: Complete comparative analysis and annotation of your
viral genome. Write announcement describing viral genome features.

Sept. 24, Oct. 1  Extracting RNA/Producing cDNA
   Goal: Extract RNA. Use reverse transcriptase to make cDNA
for QPCR.

Oct. 8  Performing a 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. 15  Fall Break

Oct. 22  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 amplify genes of interest and
verify by sequencing the product.

Oct. 29  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. 5  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 the virus we annotated. Also compare assigned
eukaryotic genes to genes in humans to confirm homology.

Nov. 12  Optimizing for QPCR/Running Reactions
   Goal: Run a QPCR reaction after performing necessary tests.
   Assignment: Acquire QPCR data.

Nov. 19  Optimizing for QPCR/Running Reactions
   Goal: Continue collecting data for class project.
   Assignment: Acquire QPCR data.

Nov. 26  Analyzing QPCR data/Summary lab
   Goal: Complete QPCR analysis for class project 2.
   Assignment: Analyze QPCR data.

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

Bold dates: Lab will be held in RITA 273.