Version 08/18/2020...may need minor revisions the first day of class

Biology 523/523L (Fall 2020)
Genomics Lecture/Lab

Lectures:	TTh 10:50 - 12:05 am, Online
Labs:	T 1:30-4:30pm, Online or RITA 147
Instructor:	Dr. Christine Byrum
Email:	byrumc@cofc.edu
Phone:	(843) 953-7176
Office Hours:	Zoom sessions by appointment (email to make appointment)

Course Overview: This graduate course is designed to familiarize you 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. Due to COVID-19, this class will be taught as a hybrid course. Lectures and discussions of journal articles will be presented online (synchronously) using Zoom or similar alternate technologies and most of the labs/workshops will also be taught online. A few wet labs will be taught face-to-face if conditions permit it.

Course Objectives/Student Learning Outcomes:

Course objectives/student learning outcomes include the following. You 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) Learn how to write a publication quality paper that describes findings relevant to the field of genomics.

10) 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.
11) 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.

Required Supplies:

- Computer/laptop with a camera and microphone. Internet access.
- SEA-PHAGES Bioinformatics Guide and Phage Discovery Guide – These are available online free of charge at:
  https://seaphagesbioinformatics.helpdocsonline.com/home
  https://seaphagesphagediscoveryguide.helpdocsonline.com/home

Optional Texts (for reference):

Concepts in Bioinformatics and Genomics, 1st edition. J. Momand et al., 2016 (Oxford University Press).
Bioinformatics and Functional Genomics, 3rd edition. J. Pevsner, 2015 (Wiley Blackwell).

Prerequisites: Genetics (BIOL 305), Molecular Biology (BIOL 312) / Cell Biology (BIOL 313) or permission of the instructor.

Course Policies

Attendance: Regular class participation is critical in this course. If you are unable to attend a class, be sure to get the information from me or from one of your classmates so that you don't fall behind. If an absence is anticipated, be sure to inform me ahead of time. Also, check with me about the materials you've missed so that you don't fall behind and can make up any missing assignments. If you have a religious conflict, please let me know Accommodations can be made.

COVID-19 Precautions/Continuity of Learning: Due to social distancing requirements, this class will include a variety of online and technology enhanced components to reinforce continuity of learning for all enrolled students. Before the drop/add deadline, decide whether the course plan outlined in this syllabus matches your own circumstances. Genomics will be taught as a hybrid course. Lectures and discussions will be presented online (synchronously) using Zoom or similar alternate technologies and most labs will also be taught online. If circumstances permit, I hope to meet face-to-face to teach a few wet labs later in the semester. When we meet face-to-face, be sure to wear a face mask that completely covers your nose and mouth at all times. Also respect social distancing guidelines and maintain at least 6 feet between

yourself and others. Before and after lab, we will carefully clean the workspace to reduce possible spread of the virus. Students disregarding these guidelines will be asked to leave the classroom and may lose credit if work is not completed. Please be considerate. These precautions have been put in place to protect everyone.

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. The team should introduce the class to the topic and lead a discussion reviewing two papers (30 minutes/person). They should also prepare detailed 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 to the instructor following the discussion session.

Those not presenting are expected to read the assigned papers before class and to actively participate in class discussions. On the day of the discussion, each participant should email (in a 1-page Word document) a brief summary outlining 4-5 points they want others to consider in that day's discussion. Evaluation of class participation will also be based on 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 or VoiceThread 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. They will also submit a copy of their slides.

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 be sure to turn in assignments at the beginning of the next class period. Turning in an assignment late may result in a penalty.

Class Project(s): Over the semester, students will work together to complete 1-2 course projects in the lab. In the first project, the class will work together to characterize the viral genome of Luna22, a bacteriophage isolated at the College of Charleston by students in 2018. After the genome has been annotated, each student will write a genome annotation paper formatted to comply with standards of the journal *Microbiology Resource Announcements.*

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)	20%
Class Project Paper(s) (lab)	10%

Grading Scale:

90 and above: A	77-79.9: C+
87-89.9: B+	70-76.9: C
80-86.9: B	<70: F

OAKS and Other Websites: In this course, I will regularly post information, including grades, on OAKS throughout the semester. The syllabus and class materials will also be available at this site. In addition, we will utilize the HHMI SEA-PHAGES website, https://phagesdb.org . If you need help obtaining a laptop or internet access, you may find information at this site helpful (https://it.cofc.edu/laptops/).

Zoom Office Hours: Office hours will be held by appointment. To schedule a Zoom appointment, contact me by email, telephone, or during/after class. Questions are highly encouraged. Feel free to schedule a session and discuss them with me!

Recording of the Class: During the semester, I may record some of the class sessions via either voice and/or video. By attending and remaining in the course, you consent to being recorded. Recorded class sessions are for instructional use only and may not be shared with anyone not enrolled in the class.

Classroom Courtesy: Switch off cell phones or other disruptive devices during class. Do not text, check emails, watch videos, shop, or engage in any other disruptive behaviors. Focus on class activities. Exceptions to this policy will be made in situations such as spouses anticipating the birth of a child or serious emergencies. Permission to leave an electronic device on should be obtained before class.

Academic Integrity

You 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 suspected, are investigated. Each incident will be examined to determine the degree of deception involved.

Incidents where the instructor determines the student's actions are related more to misunderstanding and confusion will be handled by the instructor. The instructor designs an intervention or assigns a grade reduction to help prevent the student from repeating the error. The response is recorded on a form and signed both by the instructor and the student. It is forwarded to the Office of 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.

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 ."

Other Considerations

Inclement Weather, Pandemic, or Substantial Interruption of Instruction: If we need to evacuate or experience disruptions due any of the listed situations, I will announce a detailed plan for any changes in modality. Be sure to take your computer and any other course materials with you. All students must have access to a computer equipped with a web camera, microphone, and internet access. If this is a problem, resources are available to provide you with these essential tools.

Center for Student Learning: You 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. This office offers tutoring, study strategy appointments, supplemental instruction, and workshops. Services are available at no additional cost. For more information regarding the CSL, see their website at http://csl.cofc.edu or call (843) 953-5635."

Accomodations 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 the website: 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.

Inclusion: I will gladly honor your request to address you by the name and gender pronouns of your choice. Please advise me of this at your earliest convenience via your college-issued email account or in person. For more resources, see http://gender-sexuality-equity.cofc.edu.

Food/Housing Insecurity: If you are not economically secure in food and housing, the College has assistance programs. Contact the Dean of Students or refer to this website (http://deanofstudents.cofc.edu/student-food-temp-housing-asst/index.php). I would also be happy to help you find confidential assistance.

Lecture Schedule

Date	Topic
Aug. 25 - T	Gene and Genome Structure
Aug. 27 - Th	Sequencing Genomes
Sept. 1 – T	Finding Genes/Annotation
Sept. 3 – Th	*Discussion* - Origins of Genomics – Quiz 1
Sept. 8 - T	*Discussion* – Genome Sequencing Approaches
Sept. 10 - Th	Genome Size
Sept. 15 - T	*Discussion* – Alternative Splicing
Sept. 17 - Th	Measuring Gene Expression
Sept. 22 - T	*Discussion* – Gene Expression – Quiz 2
Sept. 24 - Th	Genome Annotation papers/Primer Design
Sept. 29- T	Proteomics
Oct. 1 - Th	*Discussion* – Proteomics
Oct. 6 - T	Microbial Genomics
Oct. 8 - Th	**Test 1**
Oct. 13 - T	*Discussion* – Microbial Genomics
Oct. 15 - Th	Comparative Genomics
Oct. 20 - T	*Discussion* – Comparative Genomics – Quiz 3
Oct. 22 - Th	QPCR
Oct. 27 - T	Studying Genome Variation (read paper for lab)
Oct. 29 - Th	*Discussion* – Genome Defense/CRISPR-Cas8
Nov. 3 - T	**Election Day**
Nov. 5 - Th	Sequence Alignment – Quiz 4
Nov. 10 - T	Phylogenetic Analysis
Nov. 12 - Th	*Discussion* – Environmental Genomics
Nov. 17 – T	**Test 2**
Nov. 19 - Th	*Movie* – Personalized Medicine
Nov. 24 - T	*Discussion* – Ethical Issues
Nov. 26 – Th	**Thanksgiving Break**
Dec. 1 - T	Functional Genomics
Dec. 3 – Th	*Discussion* – Functional Genomics

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

Objectives/Student Learning Outcomes for Genomics Lab

In the *Genomics* Lab, a mixture of computer-based and "wet lab" approaches 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:

1) Retrieve nucleotide (transcriptomic and genomic DNA) and protein sequences from scientific databases.
2) Perform simple and advanced BLAST searches.
3) Annotate a viral genome. This includes detecting gene start/stop sites, tRNA/tmRNA sequences, sequences coding for transmembrane proteins, and frameshifts as well as making functional assignments and performing comparative analyses.
4) Examine approaches used in genome assembly.
5) Design standard and QPCR primer sets for reverse transcriptase PCR and QPCR.
6) Learn how to extract RNA from an organism and produce cDNA.
7) Learn how to perform and analyze results of reverse transcriptase PCR and QPCR.
8) Learn how to extract DNA from a gel after electrophoresis and prepare samples for sequencing.
9) Analyze and interpret sequence data.
10) Perform pairwise and multiple sequence alignments.
11) Perform phylogenetic analyses using MEGA and become familiar with advanced functions offered in this web-based program.

Lab Safety and Attire: Before attending face-to-face labs, each student should review the official SSM safety manual posted on OAKS. "Wet labs" may involve the use of hazardous chemicals. During these labs, students should dress appropriately, wearing closed-toed shoes and pants rather than shorts. This attire will offer better protection in the case of a chemical mishap.

Lab Schedule

Date	Topic
Aug. 25	Introduction to Virus Annotation Project *Goal:* Discuss plans for virus annotation project and set up bioinformatic programs on student computers including Phamerator, PECAAN, PhagesDB, and the Bioinformatics Guide.
Sept. 1	Finding Genes in a Genome and Identifying Start Sites *Goal:* Learn to find unannotated genes using BLAST and Phamerator. Identify start sites using GeneMark, Glimmer, and Starterator. *Assignment:* Identify start sites for your assigned viral genes.

Sept. 8 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. 15 Functional Annotation and tRNA Identification

Goal: 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.

Assignment: Analyze your assigned viral genes for functional domains and structural features. Also search for tRNA and tmRNA sequences.

Sept. 22 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. 29 PECAAN

Goal: Learn how to organize your final datasets in the annotation management tool, PECAAN, for submission to SEA-PHAGES.

Assignment: Enter all of the data that you've previously accumulated so that the viral genome can be submitted for review.

Oct. 6 Extracting RNA/Producing cDNA

Goal: Extract RNA. Use reverse transcriptase to make cDNA for QPCR.

Oct. 13 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. 20 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. 27 Finishing Genomes (can be moved to Oct. 6th if needed)

Goal: Discuss procedures used to transform raw sequence data into a fully assembled genome & examine how to do this using RAST.

Assignment: TBA.

Nov. 10 Optimizing for QPCR/Running Reactions

Goal: Continue collecting data for class project.

Assignment: Acquire QPCR data.

Nov. 17 Optimizing for QPCR/Running Reactions

Goal: Run a QPCR reaction after performing necessary tests.

Assignment: Acquire QPCR data.

Nov. 24 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.

Dec. 1 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.

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

Bold dates: Lab will be held in RITA 153.