Genomics, Proteomics & Bioinformatics

Course Description: An introduction to integrative biological study using genome-wide approaches and bioinformatics. The “-omics” technologies (genomics, transcriptomics, proteomics, metabolomics, etc) will be reviewed. Applications to understanding biological function in various biological disciplines will be emphasized. Hands-on bioinformatics activities will be practiced. Prerequisites: Genetics (BIOL 2416) AND either Cell Biology (BIOL 3410), Molecular Biology (BIOL/BIMS 3403) or Biochemistry I (CHEM 4401).

LEARNING OBJECTIVES

By the end of the course, students should be able to:

1. Conceptualize the function of organisms at the levels of the genome, the transcriptome, the proteome and the metabolome.
2. Describe basic methodology associated with genomics, comparative gene expression studies, proteomics and metabolomics.
3. Describe the utility of genome database projects in model and commercial organisms.
4. Describe basic methodology associated with sequence processing, comparative gene expression analysis, and data mining.
5. Describe the contribution and importance of bioinformatics in the application of the “-omics” technologies.
6. Describe applications of genomics technologies in medicine, agriculture and environmental science.
7. Describe the concept of “Systems Biology” as distinct from traditional biological disciplines.
8. Describe the theoretical bases for sequence comparisons, including alignment and scoring.
9. Obtain hands-on experience in bioinformatics analysis of large datasets using GUI and command-line applications.
10. Critically evaluate the quality and utility of genomic data.
11. Describe “2nd and 3rd Generation” DNA sequencing technologies and their application to genomic studies.

Major Course Requirements

Tentative Evaluation: Your final grade will be based on the percentage you earn out of the total possible points. Individual extra credit is not possible, but bonus points may be built into exams or other assignments. Statistical manipulations, if used (at the Instructor’s discretion), will be performed only once, at the end of the semester. A 10-point grading scale will be used:

A = 90 - 100 %
B = 80 - 89.9 %
C = 70 - 79.9 %
D = 60 - 69.9 %
F = 0 - 59.9 %
Components of Course Grade (Tentative)

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>MidTerm Exam (In-class + Take Home)</td>
<td>125</td>
</tr>
<tr>
<td>Final Exam</td>
<td>125</td>
</tr>
<tr>
<td>Quizzes (exams &amp; quizzes 40%)</td>
<td>100</td>
</tr>
<tr>
<td>Paper Presentation (10%)</td>
<td>90</td>
</tr>
<tr>
<td>Homeworks or Other Assignments (40%)</td>
<td>345</td>
</tr>
<tr>
<td>Attendance/Participation (10%)</td>
<td>90</td>
</tr>
<tr>
<td><strong>TENTATIVE TOTAL</strong></td>
<td><strong>875</strong></td>
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The time schedule may require adjustment. Should this be the case, the assignments and weighting may change. Additional assignments may or may not be provided at the Instructor’s discretion and depending upon opportunities. Such assignments might include seminar attendance, homeworks, group projects, reading assignments, quizzes, etc.

*An assignment will likely be due during the last week of class.*

Every attempt will be made to follow the time and evaluation schedules shown here. It is the student’s duty to attend each class session and be aware of all assignments, deadlines, changes, etc.

Exams will be a mixture of multiple choice, matching, fill-in the blank, short answer, labeling, calculations and essay questions. Some will require analysis and interpretation of data or experimental design to assess critical thinking skills. For Graduate Students, there will be additional take-home sections of major exams. The Final Exam (Tuesday, Dec. 9 from 11:00 AM - 1:30 PM) will contain new material from the end of the semester.

Quizzes may be given at any time in class. There will be no makeups. Homworks and other assignments may be given in class. The other assignments may include seminar attendance, data interpretation, experimental design, calculations, opinion papers, research article summaries, etc. They will generally be due at the start of lecture class the following week. You are encouraged to get together and work on them as a group. However, unless specified otherwise, the assignments must be turned in individually and be written in your own words, NOT COPIED. An assignment grade of ZERO will be given if the work is not in your own words.

Attendance at class is required. Each student will be given a 2-absence grace allowance before losing attendance points.

Assignments will include paper reading and discussion, presentation of a paper to class, and hands-on activities like DNA sequence analysis projects, particularly for large datasets, using both GUI and command-line tools. Do Not wait to the last minute to do these assignments, there are often technical difficulties with computer-based assignments and it may take some time to resolve these issues. Please maintain a good attitude and flexibility, and we’ll get through these issues together! We will work on a special assignment this semester, in which we will use command-line tools to analyze a 16S rRNA itag dataset as a collaboration with the Microbial Ecology class. We will hold several joint meetings to discuss the experiments and data analysis between the two classes. The goal of this project is to characterize and compare environmental microbiomes. Graduate Students will be expected to take a leadership role in team projects, perform additional analyses, and to analyze results in greater depth, relative to the undergraduate students.

Required Readings

*Textbook:* No textbook is required. However, numerous readings will be assigned from materials placed on library reserve, posted to BlackBoard, or via links made available on BlackBoard.
Other Required, Recommended or Supplemental Readings: (See above) It is highly recommended that you obtain a genetics book to use as a reference. You may be able to borrow one if you do not own one. Cell Biology, Molecular Biology and/or Biochemistry texts may also be useful.

BlackBoard: Course-associated site for posting notes, readings, labs, data, announcements, etc. Assignment handouts will be made available on BlackBoard. A class announcement will generally be made when these are posted.

Course Listserv: All students must subscribe to the class listserv, using your official University-mandated email account (firstinitiallastname@islander.tamucc.edu). You may ask questions of interest to the instructor or other students on the class listserv, eg. clarification of an assignment, as well as receive important class announcements. You are encouraged to subscribe to the Opportunities Listserv as well.

To subscribe, send an e-mail to “Genomics-list-request@Listserv.tamucc.edu”. Make sure that your e-mail address appears in the “From:” heading, and that the word “subscribe” is typed in the subject line. You will receive a subscription acknowledgement confirming that you have done everything correctly. To post messages to the listserv, send to “Genomics-list@Listserv.tamucc.edu”. Because of security concerns, you should post messages from the official TAMUCC computer account (Islander) that is used to subscribe to the listserv. At the end of class, please send an e-mail to “Genomics-list-request@Listserv.tamucc.edu” with “unsubscribe” in the subject heading. Please use this service to ask questions about class materials, dates, assignments, etc.

You should also subscribe to the Opportunities Listserv using the same procedure: “opportunities-list-request@Listserv.tamucc.edu” This service provides notification of scholarships, research and volunteer opportunities and science-related job opportunities.

List of Supplies
You must have access to a computer and internet.

Course Policies
ALL E-MAIL COMMUNICATIONS WITH THE INSTRUCTOR OR LAB TA MUST BE MADE THROUGH YOUR OFFICIAL UNIVERSITY E-MAIL (@ISLANDER), BY UNIVERSITY RULE.

Attendance/tardiness, Late work and Make-up Exams: You are expected to attend all classes and labs in a timely manner. Important new material, as well as schedule changes and quizzes may occur at any time. It is expected that you will take notes, ask/answer questions, and participate in group activities.

LATE WORK will not be accepted, except as below, or unless otherwise specified.

Attendance is the student’s responsibility. You are responsible for the material covered, including last minute course change announcements, in every lecture, even if it is not in the book, regardless of your attendance. Nothing missed during an unexcused absence can be made up. An excused absence allows us to make alternative arrangements to complete an assignment. Only unavoidable absences are excused. Routine events (holiday travel, non-emergency medical visits, parent-teacher conferences, household or auto repairs) should be scheduled to avoid conflicts with class. An acceptable excuse must be:

•from an appropriate source (doctor, dentist, funeral director) stating the nature of the event
•In writing, on official letterhead, and signed (it will not be returned)
•presented prior to, or within 1 week of, the absence
•It must state the dates for which the excuse applies

There are No make-up examinations: For some scheduled events, you may arrange to take a lecture exam before, but not after, its scheduled time. Quizzes cannot be made-up.
Expectations:

**You are responsible for your own education.** Take notes in class as some new information may be presented. Lecture notes from the instructor, when made available, do not represent everything you need to know. Read the book and handouts for further detail not covered in class, and to be prepared for laboratory. If you don’t understand, then please ask, or see the instructor after class. Don’t allow yourself to fall behind. Be diligent and thorough on written assignments and examination answers. If you are not sure of an answer, at least try. For many people, putting anything down on paper clarifies their thinking and helps with recall. Also:

- Be aware of university-imposed deadlines (i.e., drop dates)
- Be aware of test times and dates, including changes which may be announced in class
- Check your exams for clerical errors. The test score is not the end of the learning process. Review tests to determine why you missed an answer. Correcting your mistakes is an effective way to learn material (reflective learning).
- Work on all assigned homework problems in a timely manner. Seek tutorial help from classmates or the course/laboratory instructors.
- Keep track of your progress in class.

The following procedures will be enforced:

- All major exams are the property of the instructor and may not be removed from class, copied, reproduced or photographed in any way. Violation will result in a grade of “F”
- You must be prepared to present a photo ID at all examinations
- If you leave an examination room—for any reason—you must hand in your test and you will not be allowed to resume the examination. Attend to personal matters (e.g., rest room visits) before the examination.

Cell Phone/Electronic Device Usage Policy on Disruptive Behavior:

As adult university students, you are expected to act with courtesy and common sense. Disruptive, disrespectful, or abusive language/behavior towards anyone in class (student, staff, faculty) will not be tolerated and could result in permanent removal from class. This includes tardiness to class, talking in class, insubordination, and electronic disturbances (cell phones, ipods, etc). Turn it off unless specifically being used for class. Hazardous materials are used in the laboratory so “play” or reckless behavior will not be allowed. Children are not allowed in class or lab.

Academic Integrity/Plagiarism*

University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one’s own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in appropriate action at the discretion of the instructor, including failure of the course. Everything should be in your own words.

Dropping a Class*

Be aware of the last day to drop a class with an automatic grade of “W” this term. I hope that you never find it necessary to drop this or any other class. However, events can sometimes occur that make dropping a course necessary or wise. Please consult with me before you decide to drop to be sure it is the best thing to do. Should dropping the course be the best course of action, you must initiate the process to drop the course by going to the Student Services Center and filling out a course drop form. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. **Friday November 7** is the last day to drop a class with an automatic grade of “W” this term.
Preferred methods of scholarly citations  (Format from J. Experimental Marine Biology and Ecology)

Statement of Civility and Classroom/professional behavior**
Texas A&M University-Corpus Christi has a diverse student population that represents the population of the state. Our goal is to provide you with a high quality educational experience that is free from repression. You are responsible for following the rules of the University, city, state and federal government. We expect that you will behave in a manner that is dignified, respectful and courteous to all people, regardless of sex, ethnic/racial origin, religious background, sexual orientation or disability. Behaviors that infringe on the rights of another individual will not be tolerated.

Texas A&M University-Corpus Christi, as an academic community, requires that each individual respect the needs of others to study and learn in a peaceful atmosphere. Under Article III of the Student Code of Conduct, classroom behavior that interferes with either (a) the instructor’s ability to conduct the class or (b) the ability of other students to profit from the instructional program may be considered a breach of the peace and is subject to disciplinary sanction outlined in article VII of the Student Code of Conduct. Students engaging in unacceptable behavior may be instructed to leave the classroom. This prohibition applies to all instructional forums, including classrooms, electronic classrooms, labs, discussion groups, field trips, etc.

Grade Appeals (College of Science and Engineering Version)***
As stated in University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures, a student who believes that he or she has not been held to appropriate academic standards as outlined in the class syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is upon the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade is encouraged to first discuss the matter with the instructor. For complete details, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, see University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures. These documents are accessible through the University Rules website at http://www.tamucc.edu/provost/university_rules/index.html, and the College of Science and Engineering Grade Appeals webpage (http://sci.tamucc.edu/students/GradeAppeal.html). For assistance and/or guidance in the grade appeal process, students may contact the chair or director of the appropriate department or school, the Office of the College of Science and Engineering Dean, or the Office of the Provost.

Disabilities Accommodations***
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please call or visit Disability Services at (361) 825-5816 in Corpus Christi Hall 116. If you are a returning veteran and are experiencing cognitive and/or physical access issues in the classroom or on campus, please contact the Disability Services office for assistance at (361) 825-5816.

Statement of Academic Continuity*
In the event of an unforeseen adverse event, such as a major hurricane and classes could not be held on the campus of Texas A&M University–Corpus Christi; this course would continue through the use of Blackboard and/or email. In addition, the syllabus and class activities may be modified to allow continuation of the course. Ideally, University facilities (i.e., emails, web sites, and Blackboard)
will be operational within two days of the closing of the physical campus. However, students need
to make certain that the course instructor has a primary and a secondary means of contacting each
student

**Tentative Assessment Dates:**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Quiz 1</td>
<td>Wk of Sept 15</td>
</tr>
<tr>
<td>Quiz 2</td>
<td>Wk of Sept 29</td>
</tr>
<tr>
<td>MidTerm Exam</td>
<td>Wk of Oct 13</td>
</tr>
<tr>
<td>Quiz 3</td>
<td>Wk of Nov 3</td>
</tr>
<tr>
<td>Quiz 4</td>
<td>Wk of Nov 17</td>
</tr>
<tr>
<td>Final Exam</td>
<td>Tues Dec 9; 11:00 AM – 1:30 PM</td>
</tr>
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**Tentative Topic List**  
*(course schedule)*

[See PPT Notes for Specific Reading Assignments]

### Introduction to Genomics, Proteomics and Bioinformatics; The “Omens” Technologies

- What is genomics? What do we need to study, understand and interpret genomes?
  - Extended Central Dogma
  - Overview of different –omics technologies
  - Genomes and genome structure
  - Transcriptomes, gene structure and transcription mechanisms
  - Proteomes and their regulation
  - Metabolomics
  - Other “-Omes”
  - Regulation is key
  - Evolution of genomes
  - Systems Biology and Synthetic Biology

### Historical Perspectives of Methods, Scale and Biological Insight: The Human Genome Project (HGP) and the Human Genome

- The Human Genome Project
  - Cloning, Mapping & Sequencing
    - Effects of Technological Advances
    - Biological Insights into the Human Genome: Structure, Expression and Selection

### Second (“Next”) Generation DNA Sequencing Technologies (and their error modes)

- Roche 454, Illumina and ABI Solid
- The $1,000 Human Genome

### How Do We Analyze All of This Data?

- Handling and manipulating Large Datasets
  - Evaluating Quality and Filtering
  - Comparisons, Interpretation & Visualization
  - Standards

- Bioinformatics
  - GUI vs Command Line
  - Finding/Predicting Genes and Annotating Genomes: “Signposts”
  - Foundations of Sequence Comparisons
Pairwise: Dot-Plots
Aligning and Scoring Alignments for Comparisons: How Matrices are Used
Shortcuts and Heuristics: Smith-Waterman, BLAST, Pearson FastA
Assembling Short Reads
  Challenges
  DeBruijn Graphs and Burrows-Wheeler Algorithm (BWA)

Applications of DNA Sequencing Technologies
  Signature Genes & itag sequencing for Microbiomes
  Whole-Genome Metagenomics
  Transcriptomics: RNAseq vs DNA Microarray
Other Applications:
  Genomic Polymorphisms
  Genome-Wide Association Studies
  ChIPseq
  Etc.
Applications: Medicine, agriculture, biofuels, environment

3rd Generation Single Molecule Real Time (SMRT) DNA Sequencing Technologies
  Ion Torrent
  PacBio
  The (Elusive) Nanopore
  Others
  Illumina’s Adaptive Strategy

Proteomics Technologies and Applications
  Protein Profiling Methods
  Protein Interactions

Ethical, Legal and Social Implications (ELSI) of Genomics Technologies
Possible Hands-On Projects
Applications of New DNA Sequencing Technologies
  Read/Present Application Papers

Bioinformatics Sequence Analysis Projects
  Genome Annotation: BLAST, ORFs, Domains/Motifs, Transposable Elements (DNA Subway)
  Multiple Sequence Alignment: Galaxy
  BLAST: Compare Effects of Modifying Parameters
  LINUX/UNIX: Command Line Tutorial
  Signature Genes Metagenomics: DNA Subway, BLAST, RDP II, Galaxy, Command Line on HHMI Cluster
  Transcriptomics: RNAseq on Galaxy; BLAST2GO Pathway Analysis

ELSI Assignment
  Read/Discuss ELSI Papers