GENOMICS, PROTEOMICS AND BIOINFORMATICS
BIOLOGY 4340.001/5340.001 and MARB 6590.001

Department of Life Sciences
Fall 2016

A. COURSE INFORMATION

Course number/section: BIOL 4340.001/5340.001; MARB 6590.001
Class meeting time: T, R 11:00-12:15
Class location: CS 101
Course Website: See BlackBoard (https://bb9.tamucc.edu/)

B. INSTRUCTOR INFORMATION

Instructor: Kirk Cammarata
Office location: EN 319 B
Office hours: W, R 2:00-3:30; T 8:00-10:00
Telephone: 361-825-2468
e-mail: kirk.cammarata@tamucc.edu
Appointments: Email or call to check on my availability at other times or to make an appointment

C. COURSE DESCRIPTION

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 for current and potential contributions to understanding biological function at molecular, cellular, organismal and ecosystem levels. Applications to various biological disciplines will be emphasized. Hands-on bioinformatics activities will be practiced.

Learn about advanced DNA sequencing technologies, interpretation of the Human Genome, gene expression measurements, molecular identification strategies, and organismal community approaches. Develop critical skills in bioinformatics. Course is required for Cell/Molecular Track and very relevant to majors in Biomedical Sciences, Integrative Biology, Plant/Animal/Micro Biology, and Biochemistry.

D. PREREQUISITES AND COREQUISITES

Prerequisites Genetics (BIOL 2416) AND equivalent of one advanced course such as Cell Bio, Molecular Bio, Biochemistry I, Virology, Human Genetics, Medical Microbiology OR Permission of Instructor
Corequisites

None

E. REQUIRED TEXTBOOK(S), READINGS, RESOURCES AND SUPPLIES

Required Textbook(s)
No textbook is required. However, numerous readings will be assigned from scientific literature placed on library reserve, posted to BlackBoard, or via links made available on BlackBoard.

Other Resources
It is highly recommended that you access a genetics or molecular biology 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, and will be placed on library reserve.

BlackBoard: Course-associated site for posting notes, required and supplemental readings, assignments, announcements, study guides, links to websites, etc.

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. 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.

List of Supplies
You must have access to a computer and internet. You may wish to bring your own laptop to class for work on some of the bioinformatics tutorials, which will be announced ahead of time.

F. STUDENT LEARNING OUTCOMES AND ASSESSMENT

Assessment is a process used by instructors to help improve learning. Assessment is essential for effective learning because it provides feedback to both students and instructors. A critical step in this process is making clear the course’s student learning outcomes that describe what students are expected to learn to be successful in the course. The student learning outcomes for this course are listed below. By collecting data and sharing it with
By the end of this 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 the complexities of gene expression and regulation targeted by the different –omics approaches
3. Describe basic experimental approaches and methodologies associated with genome sequencing, transcriptomics, proteomics and metabolomics
4. Outline the approaches used to sequence the human genome (as a model) and contrast them with “NextGen” Sequencing-based approaches
5. Describe “2nd and 3rd Generation” DNA sequencing technologies and their advantages and disadvantages
6. Describe the contribution and importance of databases, bioinformatics and data mining in the application of the “-omics” technologies.
7. Describe the theoretical bases for sequence comparisons, including alignment and scoring
8. Describe basic approaches/theory associated with raw sequence processing, quality evaluation, and assembly
9. Describe applications of genomics technologies in medicine, agriculture and environmental science.
10. Describe the concept of “Systems Biology” as distinct from traditional biological disciplines.
11. Outline the requisite steps and perform analysis of a large dataset using accessible GUI and/or command-line applications

Students should have appropriate skills to be able to:

1. Analyze DNA sequence data using publicly available resources such as NCBI BLAST, DNA SUBWAY, and GALAXY
2. Navigate a command-line LINUX interface sufficiently to analyze a NGS metagenomics dataset

G. INSTRUCTIONAL METHODS AND ACTIVITIES

This course will utilize traditional lecture, student-led paper discussions, in-class demonstrations/animations, in-class bioinformatics tutorials and take-home assignments.
H. MAJOR COURSE REQUIREMENTS AND GRADING

Tentative Evaluation: Your final grade will be based on the percentage you earn out of the total possible points, weighted as specified below. Note that there are different expectations and grading rubrics for undergraduate vs graduate students. 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 %

The time and grading schedule may require adjustment. Should this be the case, the assignments and weighting may change slightly. Additional assignments may or may not be provided at the Instructor’s discretion. Such assignments might include homeworks, group projects, reading assignments, quizzes, seminar attendance, etc.

UNDERGRADUATE COURSE:

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>% of FINAL GRADE</th>
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</thead>
<tbody>
<tr>
<td>EXAMS &amp; QUIZZES</td>
<td>50%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>34</td>
</tr>
<tr>
<td>Final Exam</td>
<td>33</td>
</tr>
<tr>
<td>Quizzes</td>
<td>33</td>
</tr>
<tr>
<td>HOMEWORKS &amp; ASSIGNMENTS</td>
<td>30%</td>
</tr>
<tr>
<td>GROUP PRESENTATION</td>
<td>10%</td>
</tr>
<tr>
<td>ATTENDANCE/IN-CLASS PARTICIPATION</td>
<td>10%</td>
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</table>
Components of Undergraduate Course Grade (Tentative)

MidTerm Exam (exams & quizzes 50%) = 100
Final Exam = 100
Quizzes = 100
Group Presentation (10%) = 60
Homeworks or Other Assignments (30%) = 180
Attendance/Participation (10%) = 60

TENTATIVE TOTAL = 600

GRADUATE COURSE:

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>% of FINAL GRADE</th>
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<tbody>
<tr>
<td>EXAMS &amp; QUIZZES</td>
<td>40%</td>
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<tr>
<td>Midterm Exam</td>
<td>36</td>
</tr>
<tr>
<td>Final Exam</td>
<td>36</td>
</tr>
<tr>
<td>Quizzes</td>
<td>28</td>
</tr>
<tr>
<td>HOMEWORKS &amp; ASSIGNMENTS</td>
<td>40%</td>
</tr>
<tr>
<td>PRESENTATION</td>
<td>10%</td>
</tr>
<tr>
<td>ATTENDANCE/IN-CLASS PARTICIPATION</td>
<td>10%</td>
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Components of Graduate Course Grade (Tentative)

MidTerm Exam (In-class + Take Home) = 125
Final Exam = 125
Quizzes (exams & quizzes 40%) = 100
Presentation (10%) = 90
Homeworks or Other Assignments (40%) = 345
Attendance/Participation (10%) = 90

TENTATIVE TOTAL = 875
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, read messages from the Listserv and to be aware of all assignments, deadlines, changes.

Exams will be a mixture of multiple choice, matching, fill-in the blank, short answer, labeling, calculations and essay questions. Questions are often relatively long and detailed compared to what you may have seen in some introductory courses. Some will require analysis and interpretation of data or experimental design to assess critical thinking skills. For Graduate Students, there will be additional in-class and/or take-home sections of major exams. The Final Exam (Thursday, Dec. 8 from 11:00 - 1:30) will contain new material from the end of the semester.

Quizzes may be given at any time in class. There will be no makeups. Homeworks and other assignments may be given in class. The other assignments may include 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, but some assignments will be in-class only and makeups are not possible. 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.

Assignments will include paper reading and discussion, presentation of a paper to class, and hands-on activities like DNA sequence analysis projects (BLAST, DNA SUBWAY, GALAXY), 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 NGS dataset using a Linux-based command-line pipeline. 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.

All assignments and examination answers must be legible to the Instructor. Illegible answers will receive a “0”.
# I. COURSE CONTENT/SCHEDULE

**Important Dates:**

<table>
<thead>
<tr>
<th>Event</th>
<th>Dates</th>
</tr>
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<tbody>
<tr>
<td>Classes Begin</td>
<td>August 24</td>
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<tr>
<td>Last day to register</td>
<td>August 31</td>
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<tr>
<td>Labor Day</td>
<td>Sept 5</td>
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<tr>
<td>Last Day to Drop without record</td>
<td>November 11</td>
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<tr>
<td>Reading Days</td>
<td>Nov 22, 23</td>
</tr>
<tr>
<td>Last Day to withdrawal</td>
<td>December 5</td>
</tr>
<tr>
<td>Last Class Day</td>
<td>December 6</td>
</tr>
<tr>
<td>Reading Day</td>
<td>Dec 7</td>
</tr>
<tr>
<td><strong>FINAL EXAM</strong></td>
<td><strong>Thurs December 8 (11:00 – 1:30)</strong></td>
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## DATE (BY DAY OR WEEK) | TOPIC | ACTIVITIES

| Wk1: Aug 25          | Syllabus; Intro Genomics; Central Dogma; Whole-Genome -omics Approaches |  |
| Wk 2: Aug 30; Sept 1 | Genomes; Genome Structure; Transcriptomes, Mechanisms & Gene Structure |  |
| Wk 3: Sep 6, 8       | Proteomes; Metabolomes, Other –omes; Regulation is Key |  |
| Wk 4: Sep 13, 15     | Genome Evolution, Systems Biology, Synthetic Biology; Human Genome Project | Quiz 1 |
| Wk 5: Sep 20, 22     | Cloning, Mapping, Sequencing & Technology Advances; Hu Genome: Structure, Expression & Selection | Databases |
| Wk 6: Sep 27, 29     | Next (2\textsuperscript{nd}) Gen DNA Seq Technologies, $1,000 Hu Genome | Quiz 2 |
| Wk 7: Oct 4, 6       | Handling Large NGS Datasets; Data Quality & Filtering | Galaxy |
| Wk 8: Oct 11, 13     | **MidTerm Exam:** Seq Comparisons, Interpretation & Visualization | **MidTerm Exam** MSA, Genome Browsers |
| Wk 9: Oct 18, 20     | Signature Gene Metagenomics; Linux Tutorial I | Microbiome Data Project (MP) |
| Wk 10: Oct 25, 27    | Linux Tutorial II; Whole Genome Metagenomics; MP | MP |
| Wk 11: Nov 1, 3      | Bioinformatics Foundations: Annotating Genomes, Scoring Alignments, Genome Assembly | **Quiz 3;** MP; BLAST; DNA Subway |
| Wk 12: Nov 8, 10     | Transcriptomics: Microarray & | MP; Galaxy |
The time and point schedule may require adjustment. Additional assignments may or may not be provided at the Instructor’s discretion. Such assignments might include homeworks, group projects, reading assignments, quizzes, etc. 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, subscribe to the listserv, and regularly visit BlackBoard to be aware of all assignments, deadlines, and changes to such.**

**Tentative Topic List**

*(course schedule)*

[See PPT Notes for Specific Reading Assignments]

**Introduction to Genomics, Proteomics and Bioinformatics; The “Omes” 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, Command Line on HHMI Cluster
  Transcriptomics: RNAseq on Galaxy; BLAST2GO Pathway Analysis
ELSI Assignment
  Read/Discuss ELSI Papers

Other Course Requirements:
1. All Exams are the property of the Instructor as they will be saved for course records. Exams may not be removed from class, copied, reproduced or photographed in any way. Violation will result in a grade of “F”
2. All students must signup for the listserv and access BlackBoard on a regular basis to watch for class announcements, changes, and for assignments, readings, etc.
   For help with access to BlackBoard, email or internet, please contact the IT Helpdesk by phone (825-2692) or electronically (computer.helpline@tamucc.edu; http://it.tamucc.edu/selfservice/index.html)
3. Attendance at lecture, preparedness and participation in all learning activities is required and counts towards your participation points. Assignments cannot be made up later if absent without a recognized excuse (see below).

J. COURSE POLICIES
   Attendance/Tardiness
   Attendance is the student’s responsibility. You are responsible for the material covered in every lecture or online activity, regardless of your (lack of) attendance or participation. 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 (non-emergency medical visits, parent-teacher conferences, household or auto repairs) should be scheduled to avoid conflicts with class. Plane tickets booked to conflict with class do NOT constitute an excusable absence. An acceptable excuse must be:
   • from an appropriate source (doctor, dentist, funeral director) who states the nature and dates of the event
• In writing, on official letterhead, and signed (it will not be returned)
• *presented prior to*, or within 3 days of, the absence

**Late Work and Make-up Exams**

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 (non-emergency medical visits, parent-teacher conferences, household or auto repairs) should be scheduled to avoid conflicts with class. Plane tickets booked to conflict with class do NOT constitute an excusable absence. An acceptable excuse *must* be:
• from an appropriate source (doctor, dentist, funeral director) who states the nature and dates of the event
• In writing, on official letterhead, and signed (it will not be returned)
• *presented prior to*, or within 3 days of, the absence

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.

**Cell Phone Use**

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.**

**Missed Exam**

See Above.

**Participation**

All students are expected to attend the *full* class and lab periods, complete all learning assignments, complete reading assignments fully and carefully, and to participate in class discussions. A portion of your grade is earned by participation.

**Expectations:**

You are responsible for your own education. Take notes in class, during discussions, and when completing assignments. Ask questions when you have them and seek help when you need it. The instructor is here to help you. Be aware of university-imposed deadlines (ie drop dates).

**K. COLLEGE AND UNIVERSITY POLICIES**

• **Academic Integrity (University)**
  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 a failing grade.

- **Classroom/Professional Behavior**
  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.

- **Statement of Civility**
  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.

- **Deadline for Dropping a Course with a Grade of W (University)**
  The grade of W will be assigned to any student officially dropping a course. Please consult with the instructor before you decide to drop to be sure it is the best thing to do. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. Should dropping the course be the best course of action, visit the Office of the University Registrar for the Course Drop Form that must submitted. No student is eligible to receive a W without completing the official drop process by this deadline. Please consult the Academic Calendar (http://www.tamucc.edu/academics/calendar/) for the last day to drop a course.

- **Grade Appeals (College of Science and Engineering)**
  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 at 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.

- **Disability Services**  
  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 (361) 825-5816 or visit Disability Services 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.

  [http://disabilityservices.tamucc.edu/](http://disabilityservices.tamucc.edu/)

- **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.

L. **OTHER INFORMATION**

- **Academic Advising**  
  The College of Science & Engineering requires that students meet with an Academic Advisor as soon as they are ready to declare a major. The Academic Advisor will set up a degree plan, which must be signed by the student, a faculty mentor, and the
department chair. Meetings are by appointment only; advisors do not take walk-ins. Please call or stop by the Advising Center to check availability and schedule an appointment. The College’s Academic Advising Center is located in Center for Instruction 350 or can be reached at (361) 825-3928.

GENERAL DISCLAIMER

I reserve the right to modify the information, schedule, assignments, deadlines, and course policies in this syllabus if and when necessary. I will announce such changes during lecture.