

## Syllabus for Introduction to Bioinformatics

BIOL 4395 Lectures: Mondays: Asynchronous on Blackboard

Wednesdays: Quinn Hall 206: In-person/Synchronous 4:30 pm - 5:50 pm

Lab/Homework Assignments: Online

### Course Description:

The objective of this course is to teach how computational techniques can help with solving biological problems. Students will learn to efficiently use multiple genomics and bioinformatics tools, that are freely available, for the analysis of DNA, RNA and protein sequences and structure. No programming skills are necessary for this course. This interdisciplinary course would be helpful for students in the department of Biology, Computer Science, Mathematics and Chemistry who aspire to go to either graduate school or medical school, or plan to work in the Bioinformatics industry that has experienced exponential growth within the last decade.

### Course Goals:

With successful completion of this course, students will:

1. Gain knowledge about the current genome sequencing techniques.
2. Understand how bioinformatics is related to biology and medicine.
3. Gain knowledge about DNA, RNA and protein sequences and structures.
4. Learn to gather and use information UCSC and ENSEMBL genome browser.
5. Be able to perform pairwise and multiple sequence alignments.
6. Gain knowledge on searching multiple sequence databases.
7. Be able to perform phylogenetic analysis.
8. Be able to predict genes.
9. Be able to analyze RNA and protein structures.
10. Learn how to design and analyze primers.

### Instructor:

**Dr. Sourav Roy**

BRB 2.172(Office)

[sroy1@utep.edu](mailto:sroy1@utep.edu)

Office hours: By appointment

Teaching Assistant

TBA

### Course Resources:

The Recommended **textbook** for this course is **Essentials of Bioinformatics by Jin Xiong**. The course will be coordinated through a Blackboard course connection (access via [my.utep.edu](https://my.utep.edu)). Blackboard will provide an online syllabus, course calendar, course bulletin board, and some supplemental web sites and notes for lectures. Grades will also be presented through Blackboard.

## Grades

This course will employ a variety of teaching methods according to the type and content of material presented. The class is composed of quizzes, assignments and exams for this course. Applicable core concepts taught previously will be assessed throughout the length of this course. Note that the points for a given graded event (assignment, quizzes, exams, etc.) will be weighted and adjusted per the percentage allocations as noted in the table below.

**Quizzes:** Most lectures will have an open-book, open-notes quiz at the end of the lecture.

**Online Exams:** Two online exams (45 mins each) will be composed of a combination of multiple-choice, true or false, matching, and/or short answer questions. Mid-term will have questions from materials covered in lecture and lab until the mid-term. Final exam would consist of questions from material covered after the mid-term.

**Lab/Homework Assignments:** Students will be given assignments for each lab section; they will use the bioinformatics tools (they will learn how to use these in the lectures) to complete the assignments. Their participation in these sections, as well as their demonstrated understanding of the readings' content and significance, will be assessed through their performance in the lab sections.

Assessments	Points	Percentage of Grade
Quizzes	50	25
Homework Assignments	50	25
Midterm Exam	25	25
Final Exam	25	25
Total	200	100

## COURSE POLICIES

### **Class participation:**

You are expected to attend the in-person or synchronous sessions, be prepared to answer questions about the assigned readings or other materials.

### **E-mail and Blackboard:**

You are required to provide the teaching team with a UTEP e-mail address and check your UTEP e-mail and Blackboard daily. We will use your UTEP e-mail to contact you and you will use your UTEP e-mail to contact us as well. Do not use Blackboard for e-mail.

### **Dropping the course:**

Students may drop the class and receive a W (withdrawal) on their transcript prior to April 1st, 2022. You must consult the instructor prior to dropping. Due to the University's six-drop rule, dropping the course may not be in your best interest. After April 1st, a drop will result in an F on your transcript. Receiving either a W or an F in any course may prevent you from meeting the satisfactory Academic Progress requirements necessary to receive financial aid.

### **Student Conduct:**

Each student is responsible for notice of and compliance with the provisions of the Regents' [Rules and Regulations](http://www.utsystem.edu/bor/rules/homepage.htm), available at <http://www.utsystem.edu/bor/rules/homepage.htm>. All students are expected to behave as courteous, responsible adults. We will have frequent

discussions and students are expected to tolerate and respect the opinions of others.

**Cellular and electronic devices:**

Cell phones and other electronic and recording devices must be turned off during class time to minimize classroom disruptions and protect the integrity of test-taking situations. This means you cannot make calls, send text messages, or use social media during class. You may use your laptop or tablet to take notes in class, but this privilege will be revoked if the devices are used inappropriately.

Students who fail to follow this rule may incur disciplinary action up to and including dismissal from the class and upon repeated offenses, the course.

**Final Exam:**

[From the online Schedule of Classes] “Exemption from final examination may not be given.” Final examinations will take place during the final examination period. It is the policy of the university not to administer a second final examination in the course. It is also university policy that students shall not have more than two final examinations in a single day. In the unlikely event that the examination schedule results in a student having three final examinations on a single day, the faculty member upon the request of the student shall reschedule the second of that student’s three examinations.”

**Academic Integrity:**

All graded assignments must be entirely the work of the individual student. "Plagiarism" means the appropriation, buying, receiving as a gift, or obtaining by any means another's work and the unacknowledged submission or incorporation of it in one's own academic work offered for credit, or using work in a paper or assignment for which the student had received credit in another course without direct permission of all involved instructors. (from the Regents' [Rules and Regulations](#)) Plagiarism is a serious violation of university policy and will not be tolerated. All cases of suspected plagiarism will be reported to the Dean of Students for further review.

**Disability accommodations:**

If you have or suspect you might have a disability and need an accommodation you should contact the Center for Accommodations and Support Services (CASS) at 747-5148 or at [cass@utep.edu](mailto:cass@utep.edu) or go to Room 106 Union East Building. Students are responsible for providing any CASS accommodation letters and instructions.

**Campus Carry:**

Persons holding a Concealed Handgun License can lawfully carry their handgun into a UTEP classroom as long as the gun remains concealed. Open carry remains prohibited on campus. In other words, none of us should see (or be able to tell that there is) a gun at UTEP. Call the University Police at 747-5611 or dial 911 if you see any individual on campus with a handgun or other type of weapon. For more information on campus carry, see [<http://sa.utep.edu/campuscarry/>]; for more information on overall campus safety, see [<http://admin.utep.edu/emergency>].

**Military Statement:**

If you are a military student with the potential of being called to military service and /or training during the course of the semester, you are encouraged to contact us no later than January 27.

\*\*\* Disclaimer: This syllabus may be changed as necessary at the discretion of the instructor.

## Course Outline

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### **Jan 19. Basics of genomics and bioinformatics:**

#### **Session 1 : Synchronous**

Central Dogma (DNA → Transcription → RNA → Translation → Protein)

Describe gene and genome.

What is genomics?

What is Functional genomics and Comparative genomics?

Describe proteome.

What is proteomics?

Describe homologs, orthologs and paralogs

What is bioinformatics?

### **Week of Jan 24: Introduction to biological databases:**

#### **Session 2: Asynchronous**

What is a database?

Types of databases

Biological databases

Pitfalls of biological databases

Information retrieval from biological databases

#### **Session 3: Synchronous**

What are sequence databases?

Different types of sequence formats – FASTA, GENBANK, EMBL etc.

Major sequence databases

How to retrieve sequences from different databases

Sequence matrices

How to search for unknown gene using BLAST

How to search for unknown protein sequences using InterProScan

### **Week of Jan 31. Human genome and browsers:**

#### **Session 4 Asynchronous**

Genome sequencing methods

Sequencing of the Human genome

Genome browsers

#### **Session 5 Synchronous**

How to navigate and use the UCSC genome browser

ENSEMBL browser

### **Week of Feb 7. Pairwise Sequence alignment:**

#### **Session 6 Asynchronous**

What is sequence Alignment?

Global alignment and local alignment

What information can be gathered from sequence alignment

Methods of pairwise sequence alignment

#### **Session 7 Synchronous**

Scoring matrices and gap penalties in sequence alignment

Pairwise alignment with Blast2seq

### **Week of Feb 14. Multiple Sequence alignment:**

#### **Session 8 Asynchronous**

Methods of multiple sequence alignment

Structural or evolutionary alignment?

How to align multiple sequences

#### **Session 9 Synchronous**

Global multiple sequence alignment with CLUSTAL Omega, T-COFFEE  
Local multiple sequence alignment

**Week of Feb 21. Sequence polymorphism:**

**Session 10 Asynchronous**

Overview of molecular evolution

Origins of polymorphisms

Types of polymorphisms

**Session 11 Synchronous**

SNP discovery methods

Genotyping

The international haplotype map project

**Week of Feb 28. Review and Midterm**

**Session 12 Asynchronous**

Review

**Session 13 Online**

Midterm

**Week of March 7. Phylogenetic analysis:**

**Session 15 Asynchronous**

Relation between phylogenetic analysis and multiple sequence alignment

Methods for phylogenetic prediction

Genome complexity and phylogenetic analysis

Methods of phylogenetic prediction

**Session 16 Synchronous**

Phylogenetic trees: reliability and uses

Forms of tree representation

Phylogenetic programs

Building phylogenetic trees – Phylogeny.fr

**Week of March 14: Spring Break**

**Week of March 21. Gene finding/prediction:**

**Session 17 Asynchronous**

Introduction

Prokaryotic and Eukaryotic gene prediction

Open reading frame and its reliability

Gene prediction methods

Gene prediction Programs

**Session 18 Synchronous**

Exon, intron, UTRs, promoters

Gene prediction with GeneMark, GENSCAN

**Week of March 28: Promoter and regulatory element prediction:**

**Session 19**

In-class/Take-home assignment

**Session 20 Synchronous**

Promoter and regulatory elements in Prokaryotes

Promoter and regulatory elements in Eukaryotes

Prediction Algorithms

**Week of April 4. RNA sequences: prediction and analysis of structures:**

**Session 21 Asynchronous**

Basics of RNA secondary structure

Features of secondary and tertiary structure  
RNA folding: Sequence and base pairing patterns  
Free energy determination  
Levels of prediction (pseudoknot free; nested pseudoknots; pseudoknotted with nested pseudoknots)

**Session 22 Synchronous**

Methods for predicting RNA secondary structure  
RNA secondary structure prediction and analysis with MFold and IPKnot

**Week of April 11. Principles of protein structure:**

**Session 23 Asynchronous**

Description of protein structure  
Amino Acids  
Peptide Formation  
Dihedral Angles  
Structure and sequence similarity  
Analyzing an active site

**Session 24 Synchronous**

Protein structural visualization  
Molecular viewers: POLYVIEW-2D and Swiss PDB Viewer  
Protein structure comparison  
Protein structure classification  
Prediction of protein secondary structure from amino acid sequences

**Week of April 18. Primer designing:**

**Session 25 Asynchronous**

Primers and their uses  
Basics of primer and oligo designing  
Optimal size  
Melting Temperature  
GC content

**Session 26 Synchronous**

Self-complementarity  
Hairpin Structures  
Mis-priming  
Primer designing using Primer3 and OligoAnalyzer 3.1

**Week of April 25. Genomics and Proteomics:**

**Session 27 Asynchronous**

Challenges for genome analysis  
Comparative genomics  
Functional classification of genes Genomes  
Functional genomics approaches  
Posttranslational modification  
Protein-Protein interactions

**Session 28 Synchronous**

Importance of rigor and reproducibility in scientific research. [Dr. Aguilera \(guest lecture\)](#)

**Week of May 2. Review and Final Exams:**

**Session 29. Asynchronous**

Review for final exam.

**Session 30. Online**

**Final Exam: May 5**