**MCB 6937 Computational Genomics and Epigenomics**

**Spring 2023 – 3 credits**

**Class Location:** This course and all class materials (e.g. lecture podcasts, discussion papers, quizzes, assignments, exams, and final project) are available online through the Canvas course website (see below).

**Instructor Information**

Dr. Meixia Zhao

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**Office Hours:** Mondays & Wednesdays 4:00 pm - 5:00 pm or by appointment.

**Teaching Assistant**

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**Office Hours:** Tuesdays & Thursdays 4:00 pm - 5:00 pm or by appointment.

**Course Description**

Genomics and epigenomics are emerging areas that utilize high-throughput sequencing technologies to allow rapid advances in our understanding of complicated biology questions. The primary goal of this course is to introduce students to the history, theory, latest advances, and computational approaches of genomics and epigenomics to prepare them for conducting large scale genomic analyses in their independent research. Course topics include but are not limited to sequence mapping and alignments, genome assembly, annotation and comparative genomics, variant identification and analysis (e.g. SNP calling and GWAS), transcriptomics (e.g. single-cell RNA-seq), small RNAs and long noncoding RNAs, DNA methylation, histone modification, open chromatin region (e.g. ATAC-seq), 3D chromatin interaction, cancer genomics, proteomics and phenomics.

**Course Objectives**

*After successful completion of this course, students should be able to gain:*

* In-depth knowledge and understanding and mastery of the fundamental concepts and methodology of genomics and epigenomics.
* Familiarity with computational approaches and methods in analyzing different types of high-throughput genomic data.
* Understanding of the advantages and disadvantages of different computational approaches and methods.
* Demonstrated ability to interpret the data generated by the computational approaches and methods.

**Course Website**

Login available through Canvas https://elearning.ufl.edu/

**Course Prerequisite**

None. Although familiarity with the UNIX operating system is not required prior to taking this course, if you do not have prior experience using UNIX, it is highly recommended that you complete the “UNIX Basics” module during the first week of class and before attempting the other course modules. All students will be provided with user accounts on our course UNIX server. Access to the course UNIX server is required to complete the weekly laboratory exercises and assignments. Please consult the “How to Access the Course UNIX Server” documentation during the first week of class to verify that you can connect to and complete laboratory exercises on our server.

**Textbook Information**

Textbook is not required. Before each class, PDF and other documents will be prepared and made available for you online. In addition, handouts will be provided for you to study. Students are also required to read the research articles that are related to the topics, which will be posted on the course website. For instance,

* Law, J., Jacobsen, S. 2010. Establishing, maintaining and modifying DNA methylation patterns in plants and animals. Nat Rev Genet 11, 204–220.
* Krueger F, Andrews SR. 2011. Bismark: a flexible aligner and methylation caller for Bisulfite-Seq applications. Bioinformatics. 27, 1571-1572.
* Kim, D., Paggi, J.M., Park, C. et al. 2019. Graph-based genome alignment and genotyping with HISAT2 and HISAT-genotype. *Nat Biotechnol* 37, 907–915.

The following are recommended textbooks that might be helpful or interesting:

* Concepts in Bioinformatics and Genomics. 2017. Jamil Momand, Alison McCurdy, Notes by Silvia Heubach, and Nancy Warter-Perez. ISBN: 9780190610548.
* Computational Epigenetics and Diseases. 2019. ISBN: 978-0-12-814513-5.

**Grade Points**

The overall course is based on 1000 points.

* **Weekly quizzes (100 points, 10% of final grade):** There will be a weekly or biweekly quiz that needs to be completed on the Canvas course website. The quizzes are designed to help you understand the lectures and materials.
* **Literature reading and discussion (50 points, 5% of final grade):** Research articles will be given to students to read. Students will be required to submit a report <300 words for each assigned paper. We will roughly discuss the papers before the beginning of each class.
* **Assignments after class (400 points, 40% of final grade):** There will be assignments after class. Any late assignment will incur a 5% penalty per day. The assignments are designed to help you practice the computational approaches that will be talked in the lectures.
* **Final project (150 points, 15% of final grade):** There will be a final project at the last quarter of the semester. Students are required to design, develop, and conduct the project using the computational approaches learned in this course. Students will be required to submit the draft of the project in the middle of the semester. The final project can be related to the independent research that are conducted in the students’ graduate study.
* **Midterm (150 points, 15%) and final exam (150 points, 15% of final grade):** Both the midterm and final exams will be based exclusively on materials presented during class. It will test your understanding of basic concepts and techniques in computational genomics and epigenomics.

**Submission Methods:** You need to submit your assignment through our class Canvas website.

**Grading:**

For more details of the University of Florida grading policy please visit:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

930 – 1000 points 93% - 100% A

900 – 929 points 90% - 92.9% A-

870 – 899 points 87% - 89.9% B+

830 – 869 points 83% - 86.9% B

800 – 829 points 80% - 82.9% B-

770 – 799 points 77% - 79.9% C+

730 – 769 points 73% - 76.9% C

700 – 729 points 70% - 72.9% C-

670 – 699 points 67% - 69.9% D+

630 – 669 points 63% - 66.9% D

600 – 629 points 60% - 62.9% D-

Less than 600 points <60% E

**Attendance and Make-Up Work**

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>.

**Tentative Course Schedule**

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| --- | --- | --- | --- | --- |
| **Module** | **Week** | **Date** | **Topic** | **Quizzes and Assignments** |
| Module 0 | Week 1 | Jan 9-13 | **UNIX Basics (optional):**1. Introduction of supercomputer2. Overview of the UNIX operating system3. Introduction and hands-on UNIX for shell and command lines4. Hands-on UNIX for module and running batch jobs | Complete this module by the end of week 1 if you are not comfortable working in the UNIX operating system |
| Module 1 | Week 1 | Jan 9-13 | **Introduction and sequencing:**1. Course information2. Brief history of genomics and epigenomics3. High throughput sequencing (sequencing technologies, FASTA and FASTQ sequences, and tools)4. Sequence mapping and alignments (SAM/BAM, Samtools, etc.) | Quiz 1 |
| Module 2 | Week 2 | Jan 16-20 | **Sequence comparison and phylogenetics analysis:**1. Web and local BLAST, pairwise and multiple sequence alignments2. Phylogenetics analysis of homologous genes among different species | Quiz 2Assignment 1, due at 11:59 PM Jan 27 |
| Module 3 | Weeks 3 & 4 | Jan 23 - Feb 3 | **Genome assembly and annotation:**1. Genome assembly (Introduction & approaches)2. Genome annotation (gene finding)3. Genome annotation (transposable elements finding)4. Comparative genomics (compare whole genome sequences between different species) | Quizzes 3 & 4Assignment 2, due at 11:59 PM Feb 10 |
| Module 4 | Week 5 | Feb 6-10 | **Variant identification and analysis:**1. Single nucleotide polymorphism calling (SNPs)2. Structural variant analysis (InDel)3. VCF annotation and interpretation (bcftools, vcftools and bedtools toolkits)4. Genotyping by sequencing and genome-wide association studies (plink) | Quiz 5Assignment 3, due at 11:59 PM Feb 17 |
|  | Week 6 | Feb 13-17 | **Content review, trouble shooting and mid-term exam** |  |
| Module 5 | Weeks 7 & 8 | Feb 20- Mar 3 | **Transcriptomics analysis:**1. RNA-seq reads quality control and mapping 2. Identification of differentially expressed genes (DEGs)3. Gene ontology of DEGs4. Clustering (Heatmap, K means, and others)5. Single-cell RNA-seq (Introduction, techniques, and data analysis) | Quiz 6Assignment 4, due at 11:59 PM Mar 10 |
| Module 6 | Week 9  | Mar 6- 10 | **Small RNAs and long-noncoding RNAs (lncRNAs):**1. Introduction of small RNAs (microRNAs, small interfering RNAs, and piwi-interacting RNA) and lncRNAs2. Small RNA and lncRNA analyses3. Target site prediction of small RNAs and lncRNAs | Quiz 7Assignment 5, due at 11:59 PM Mar 24 |
|  | Week 10 | Mar 13-17 | No classes, spring break. |  |
| Module 7 | Week 11  | Mar 20-24 | **DNA methylation in plants and animals:**1. DNA methylation (Initiation and maintenance of DNA methylation)2. Identification of differentially methylated regions (DMRs)3. Integrative analysis of DEGs, small RNAs and DMRs4. Epigenome-wide association study (EWAS) | Quiz 8Assignment 6, due at 11:59 PM Mar 31  |
| Module 8 | Weeks 12 & 13 | Mar 27 - Apr 7 | **Histone modification and chromatin interaction:**1. Histone marks (ChIP-seq)2. Chromatin accessibility (ATAC-seq including single-cell ATAC-seq)3. 3D chromatin interaction (HiC) | Quiz 9Assignment 7, due at 11:59 PM Apr 14 |
| Module 9 | Week 14 | Apr 10-14 | **Cancer genomics and CRIPSPR genome editing** | Quiz 10Assignment 8, due at 11:59 PM Apr 21 |
| Module 10 | Week 15 | Apr 17-21 | **Proteomics and phenomics** |  |
|  | Week 16 | Apr 24-28 | **Final project** |  |
|  |  | May 1–5  | **Final exam** |  |

**Note: Exact schedule may be changed based on the progress of the class.**

**Online Course Evaluation Process**

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. These evaluations are conducted online at <https://evaluations.ufl.edu>. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results>.

**Academic Honesty**

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: “*We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.”*  You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment*."

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor Code.  Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: <http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>.

**Software Use**

All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

**Services for Students with Disabilities**

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the instructor when requesting accommodation

0001 Reid Hall, 352-392-8565, [www.dso.ufl.edu/drc/](http://www.dso.ufl.edu/drc/)

**Campus Helping Resources**

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university’s counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

* *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575,* [www.counseling.ufl.edu](http://www.counseling.ufl.edu)

Counseling Services

Groups and Workshops

Outreach and Consultation

Self-Help Library

 Wellness Coaching

* U Matter We Care, [www.umatter.ufl.edu/](http://www.umatter.ufl.edu/)
* *Career Connections Center,* First Floor JWRU, 392-1601, <https://career.ufl.edu/>.
* *Emergencies*, University Police Department: 392-1111 or 9-1-1

**Student Complaints**

* Residential Course: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>.
* Online Course: <http://www.distance.ufl.edu/student-complaint-process>