Welcome to Bio Core I: Molecular Systems! This intensive team-taught core course, which is strongly recommended for incoming biology M.S. and PhD students, surveys the major areas of up-to-date molecular biology, molecular genetics and systems biology. Topics include the molecular structure and function of polynucleic acids and proteins, and their fundamental roles in cell biology and disease. The course will also introduce basic concepts in genetics, genomics, and systems biology. A strong emphasis will be placed on novel experimental approaches that form the basis of the current wave of discovery in biomedicine.

This document presents the course policies and schedule. Any updates will be posted to NYU Classes.
COURSEWORK AND POLICIES

Exams
There will be three exams. Exam 1 covers material of Module 1, Exam 2 covers material of Module 2, Exam 3 covers material of Module 3. Please note, however, that fundamentals learned in the earlier modules are expected knowledge for the later modules. The format of the exam is at the discretion of the instructors and will be announced in the course of the modules. In the recent past, most exams were a mix of multiple-choice and short-answer questions. All exams are open-book.

All exams are mandatory. If you have a schedule conflict involving other courses, religious observance, or personal matters, you must see Dr. Hochwagen at least one week prior to the exam. Any missed exam will result in a grade of 0 for that exam, unless there are serious extenuating personal circumstances that are immediately brought to the attention of Dr. Hochwagen. Illness will be accepted as a justification for absence from a scheduled test if a doctor’s excuse is presented. The excuse must be dated on or immediately prior to the exam date, and you must contact Dr. Hochwagen prior to the exam in order to be excused. If either of these conditions is not met, you will be given a grade of 0. If you miss a midterm exam and present a legitimate excuse, then, at the discretion of the instructors, either a make-up test will be made available to you or the final exam will count more toward your grade. A grade of “Incomplete” (I) will not be given unless it is warranted by circumstances like those described above. If you miss the final exam and present a legitimate excuse then a grade of “I” will be given and a make-up exam will be scheduled for the Spring 2021 semester. No alternative dates for the final exam will be offered.

Grading and Calculation of Final Grades
A correctly answered exam earns 35 points for Exam 1, 30 points for Exam 2, and 35 points for Exam 3. Exams 2 and 3 will contain a set of “resurrection questions”. These questions are optional. If answered correctly, they will add up to 3 points to the score of the previous exam (resurrection points that would lead to a point total exceeding maximum of 35 points for Exam 1 and 30 points for Exam 2 will not be considered). The resurrection questions will typically cover material that caused difficulties during the previous exam and are meant to provide a second chance to demonstrate understanding of that material.

The final course grades will be calculated as follows:

<table>
<thead>
<tr>
<th>Exam</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam 1 (70 min)</td>
<td>35%</td>
</tr>
<tr>
<td>Exam 2 (70 min)</td>
<td>30%</td>
</tr>
<tr>
<td>Exam 3 (70 min)</td>
<td>35%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Letter Grades
After each midterm exam, the full distribution of scores for the entire class will be posted on NYU Classes. An indication will also be given of what score ranges would correspond to what letter grades, if that exam were representative of the student’s performance in the whole course. When the final course grade is calculated, it is the numerical scores (not the letter grades) that get combined and ultimately converted into a single letter grade for the entire course. It is expected that approximately 2/3 of the students will receive a course grade of B– or higher.

Academic Integrity
The professors instructing this course will not tolerate cheating or plagiarism. When academic dishonesty is suspected, it will be dealt with seriously in adherence to the official guidelines of New York University. Instructors are required to report all instances of suspected cheating or plagiarism.

The Graduate School of Arts & Science guidelines, which all students should read, are available online at [http://gsas.nyu.edu/object/nyu.policies](http://gsas.nyu.edu/object/nyu.policies)
Recitations
The aim of the recitation sessions is to review material presented in class, to ask questions, and to discuss specific topics in more detail. Attendance is optional but highly recommended. Although the recitations do not directly contribute to the final grade, their function is to solidify understanding and help prepare you for the exams.

There will be no recitations prior to the first class.

If you need additional help, you are strongly encouraged to participate in student-run study groups. In addition, there will be opportunities to ask questions and discuss problems in forums on the NYU Classes website.

Office Hours
Prof. Broyde: Mondays and Wednesdays 5:30-6:30 pm (or by appointment)
Prof. Hochwagen: Fridays 1-3 pm (or by appointment)

Office hours are to be used to ask questions about course material. You should prepare for the meeting by making a list of specific questions. Those questions should be about the scientific content of the course and not about what material will appear on an exam.

Reading Assignments
The schedule of class meetings and associated readings are on the following pages. Reading assignments should be completed prior to each meeting. Any changes to the readings or lecture schedule will be on NYU Classes as well. All lectures are expected to be recorded and recordings will be made available via NYU Classes. These recordings represent an additional service to aid studying. Recordings are not guaranteed, as unexpected technical failures may prevent individual lectures from being recorded/posted. It is important to understand that lectures often present subject matter that is not introduced in the text. It therefore behooves you to attend class.
SCHEDULE OF LECTURES AND READING ASSIGNMENTS

MODULE 1 | Biomolecules

Meeting 1 Hochwagen
September 3, 2020

Introduction

Topics: Biomolecules, molecular forces, ATP, model organisms, prokaryotes and eukaryotes, phages, recombinant DNA

Techniques: restriction enzymes, cloning, PCR, reporter constructs

Chapter 1.1 The molecules of life (p. 1-9)
Chapter 1.2 Prokaryotic cell structure and function (p. 10-12)
Chapter 1.3 Eukaryotic cell structure and function (p. 12-19)
Chapter 1.4 Unicellular eukaryotic model organisms (p. 19-22)
Chapter 2.1 Covalent bonds and noncovalent interactions (p. 31-41)
Chapter 2.2 Chemical building blocks of cells (p. 41-46)
Chapter 6.2 DNA cloning and characterization (p.234-242)
Chapter 6.3 Using cloned DNA fragments to study gene expression (p. 252-253)

Meeting 2 Broyde
September 10, 2020

Nucleic Acids

Topics: Structures of DNA bases, sugars, polynucleotides, nucleosides and nucleotides, duplex B-DNA, A, B and Z-DNA, glycosidic bond and sugar conformations, RNA structure, real and ideal B-DNA, grooves, Watson-Crick and mismatched base pairing, triple helices, hairpin loops, supercoils, nucleosome structure.

Chapter 2.3 Chemical reactions and chemical equilibrium (p. 51-57)
Chapter 2.3 Biochemical energetics (p. 57-64)
Chapter 5.1 Structure of nucleic acids (p. 167-176)

Meeting 3 Broyde
September 17, 2020

DNA Replication

Topics: Semi-conservative replication, the prokaryotic model system: the replisome, initiation of replication, elongation, DNA polymerase structure and function, replication fidelity, priming DNA synthesis, leading and lagging strand DNA synthesis, the replication fork assembly, topoisomerases, eukaryotic replication.

Chapter 5.5 DNA replication (p. 197-203)

Meeting 4 Broyde
September 24, 2020

DNA Repair

Topics: DNA damage, base excision repair, mismatch repair, nucleotide excision repair, double
strand break repair, DNA lesion-bypass polymerases.

Chapter 5.6 DNA repair and recombination (p. 203-212)

Meeting 5 Broyde
October 1, 2020

**Protein Structure and Interactions**

Topics: Overview of protein three dimensional structures and function, primary, secondary, tertiary, quaternary structures, protein folding, chaperones, protein domains, interactions governing protein structure and function, amino acid stereochemistry and structures, protein primary structure, the peptide bond, protein secondary structures: alpha helices, beta sheets, turns; protein structural motifs and examples of their functions: coiled-coil, helix-turn-helix, helix-loop-helix, four helix bundle, beta barrel, zinc finger, alpha/beta barrel.

Chapter 3.1 Hierarchical structure of proteins (p. 67-80)
Chapter 3.2 Protein folding (p. 81-88)
Chapter 3.3 Hierarchical structure of proteins (p. 67-80)

**MIDTERM EXAM I (70 min, 35%)**
October 8, 2020

**MODULE 2 | Transcription and Translation**

Meeting 6 Hochwagen
October 8, 2020

**Gene Expression I: Gene Structure and Transcription**

Topics: gene structure in prokaryotes and eukaryotes, promoters, enhancers, RNA polymerases, Pol II C-terminal domain, general transcription factors, transcription initiation, activators and repressors

Techniques: transmission and cryo electron microscopy

Chapter 4.3 Electron microscopy: high-resolution imaging (p. 156-161)
Chapter 5.2 Transcription of protein coding genes and formation of functional mRNA (p. 176-183)
Chapter 8.1 Eukaryotic gene structure (p. 301-308)
Chapter 9.1 Control of gene expression in bacteria (353-360)
Chapter 9.2 Overview of eukaryotic gene control (p. 363-370)
Chapter 9.3 RNA polymerase II promoter and general transcription factors (p. 371-377)
Chapter 9.4 Regulatory sequences in protein-coding genes and the proteins through which they function (p. 378-390)
Chapter 9.8 Other eukaryotic transcription systems (p. 412-414)

Meeting 7 Hochwagen
October 15, 2020

**Eukaryotic Gene Expression II: Chromatin and Epigenetics**

Topics: DNA binding proteins, chromatin, chromatin remodeling, histone code, heterochromatin, higher-order chromosome structure, pioneer factors, epigenetic mechanisms, imprinting
Techniques: Dnase I footprinting, electrophoretic mobility shift assay (EMSA), yeast one hybrid system, SELEX, Southern blotting, chromatin immunoprecipitation, fluorescence in situ hybridization (FISH), chromosome conformation capture, methylation mapping

Chapter 6.3 Using cloned DNA fragments to study gene expression (p. 246-247)
Chapter 8.5 Structural organization of eukaryotic chromosomes (p. 327-340)
Chapter 9.5 Molecular mechanism of transcription repression and activation (p. 390-397)
Chapter 9.7 Epigenetic regulation of transcription (p. 404-411)

Meeting 8 Hochwagen
October 22, 2020

Post-Transcriptional Regulation

Topics: 5’ capping, transcriptional elongation and termination in eukaryotes, 3’ polyadenylation, splicing, RNA editing, nuclear export, RNA degradation, rRNA and tRNA processing, nuclear bodies

Techniques: Northern blotting, in vitro phosphorylation assay, pharmacological inhibition, cDNA libraries, poly (A) tail assay

Chapter 10.1 Processing of eukaryotic pre-mRNA (p. 417-434)
Chapter 10.2 Regulation of pre-mRNA processing (p. 435-440)
Chapter 10.3 Transport of mRNA across the nuclear envelope (p. 440-445)
Chapter 10.4 Cytoplasmic mechanism of post-transcriptional control (p. 445-447)
Chapter 10.5 Processing of rRNA and tRNA

Meeting 9 Hochwagen
October 29, 2020

Translation

Topics: genetic code, tRNAs, ribosome, translation initiation, elongation and termination, regulation of translation, upstream ORFs, RNAi, miRNA, protein degradation, genetic engineering

Techniques: ribosome profiling, RNAi, protein production, synthetic biology

Chapter 3.4 Regulating protein function (p. 97-105)
Chapter 5.3 The decoding of mRNA by tRNAs (p.183-188)
Chapter 5.4 Stepwise synthesis of proteins on ribosome (p. 188-197)
Chapter 10.4 Cytoplasmic mechanism of post-transcriptional control (p. 447-461)

MIDTERM EXAM II (70 min, 30%)
November 5, 2020

MODULE 3 | Genetics, Genomics, and Systems Biology

Meeting 10 Hochwagen
November 5, 2020

Functional DNA Elements

Topics: centromeres, telomeres, repetitive DNA, DNA transposons and retrotansposons
Techniques: Immunofluorescence

Chapter 8.2: Chromosomal Organization of Genes and Noncoding DNA (p. 309-312)
Chapter 8.3: Transposable (Mobile) DNA Elements (p. 312-323)
Chapter 8.6: Morphology and Functional Elements of Eukaryotic Chromosomes (p. 341-349)

Meeting 11 Hochwagen
November 12, 2020

Genetic Analysis I: Forward Genetics

Topics: genetic and physical nature of mutations, modes of inheritance, gene interactions

Techniques: mapping, mitotic recombination, genetic screens, epistasis analysis

Chapter 6.1: Genetic Analysis of Mutations to Identify and Study Genes (p. 224-234)
Chapter 6.4: Locating and Identifying Human Disease Genes (p. 254-259)

Meeting 12 Hochwagen
November 19, 2020

Genetic Analysis II: Reverse Genetics

Topics: transgenes, gene inactivation, genome editing

Techniques: gene cloning, transfection, RNAi, knock-outs, CRISPR

Chapter 6.2: DNA Cloning and Characterization (p. 234-243)
Chapter 6.3: Using Cloned DNA Fragments to Study Gene Expression (p. 249-253)
Chapter 6.5: Inactivating the Function of Specific Genes in Eukaryotes (p. 259-268)

NO MEETING November 26 Thanksgiving

Meeting 13 Hochwagen
December 3, 2020

Genomics

Topics: Human Genome Project, genome annotation

Techniques: ChIP-seq, metagene analysis, MNase-seq, DNase-seq, Hi-C

Chapter 6.2: DNA Cloning and Characterization (p. 243-246)
Chapter 8.4: Genomics: Genome-Wide Analysis of Gene Structure and Function (p. 323-327)
Chapter 8.5: Structural Organization of Eukaryotic Chromosomes (p. 335-341)

Meeting 14 Hochwagen
December 10, 2020

Proteomics and Systems Biology

Topics: transcriptomics, tissue-specific expression, OMICs, scale-free networks
Techniques: northern blotting, microarrays, hierarchical clustering, RNA-seq, in situ hybridization, mass spectrometry, genome-wide association studies (GWAS)

Chapter 3.5: Purifying, Detecting, and Characterizing Proteins (p. 116-118)
Chapter 3.6: Proteomics (p. 122-125)
Chapter 6.3: Using Cloned DNA Fragments to Study Gene Expression (p. 247-249)

FINAL EXAM (70 min, 35%)
December 17, 2020

Time of exam remains to be determined.