Rutgers University – New Brunswick, Spring 2022

Chemical Biology (Chem 482)
Special Topics in Biological Chemistry (Chem 544)

Instructor: Prof. Enver Cagri Izgu. Office: CCB-2302
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Course Location: CCB 1203 (Busch Campus)
Time: Monday 10:20 – 11:40 am / Thursday 10:20 – 11:40 am

General Description

This is a single course with two codes, offered to both advanced undergraduate students (Chem 482) and graduate students (Chem 544). Although chemical biology and biological chemistry are not identical, they are two intermingled fields, and this course will focus on using "chemical biology" for the most part.

Chemical biology is an emerging and exciting field at the interface of chemistry and biology. Research in chemical biology aims to investigate, manipulate, or mimic biological systems by means of (typically synthetic) molecular tools. Design principles of such research are geared towards understanding a complex biological phenomenon or developing platforms that can display functions useful for biotechnology or medicine. Experimental results are typically obtained by advanced analytical techniques, including, but not limited to, electrophoretic separations, spectrophotometry and spectroscopy measurements, and bioimaging. This course will teach the fundamentals (both theory and technique) of chemical biology and the research strategies from a chemist's perspective.

Prerequisites

01:160:308 or 01:160:316; 11:115:403 or 01:694:407, or permission from instructor.

Course Material

A specific textbook is not required, as it is challenging to adequately cover the quickly progressing advancements in chemical biology. The course will therefore follow the lecture notes that are periodically updated based on the most recent scientific literature. These lecture notes will be available free of charge at the beginning of the course. Participants are advised to attend all the classes and study the lecture notes. To get more insight on a specific topic, the students are encouraged to refer to the recommended supportive textbooks and online sources.

Recommended Supportive Textbooks

- Van Vranken, D. and Weiss, G., *Introduction to Bioorganic Chemistry and Chemical Biology*, 1st edition, Garland Science.
  ISBN-13: 978-0815342144; ISBN-10: 0815342144
- Watson, J. D. et al., *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press.
  ISBN-13: 978-0-321-76243-6; ISBN-10: 0-321-76243-6
- Hermanson, G. T., *Bioconjugate Techniques*, 3rd edition, Academic Press
  ISBN: 978-0-12-382239-0
- Blackburn, G. M. and Gait, M., *Nucleic Acids in Chemistry and Biology*, 3rd edition, RCS Publishing.
  ISBN: 0-85404-654-2

Recommended Online Sources

Protein Data Bank (PDB), Rutgers and UCSD: https://www.rcsb.org/pdb/home/home.do
E-book by Tom Brown / ATDBio Ltd: http://www.atdbio.com/nucleic-acids-book

Office Hours

Instructor will provide office hours for 2 hours per week. Further details will be given in the beginning of the course.

Course Grading

The overall grade will be determined based on the followings:

- Two mid-term exams (100 pts each, 200 pts total)
- Research Article Presentation (100 pts)
  Students will carry out a 15-min presentation of a recent and comprehensive research article using PowerPoint slides. At the end of the presentation, there will be a 5- to 10-min of Q/A session. Students are strongly encouraged to engage with the presentations and ask questions.
- Final exam (200 pts)
  This exam will be comprehensive. In addition to the fundamental concepts, some of the key knowledge covered throughout the article presentations will also be included.

Grade	**A**	**B+**	**B**	**C+**	**C**	**D**	**F**
Points	500–425	424–375	374–325	324–300	299–275	274–250	≤ 249

Lecture Attendance

Students are strongly advised and expected to attend all classes; if you anticipate to miss a class due to legitimate reasons, students must use the University absence reporting website https://sims.rutgers.edu/ssra/ to indicate the date and reason for the absence. An email is automatically sent to the instructor.

Academic Integrity

All assignments (presentation slides, midterm and final exams) submitted for credit in Chem 482 / 582 should reflect individual scholarship. While teamwork is encouraged, students can **never copy others' answers**. Academic dishonesty and violation of academic integrity will have consequences in strict accordance with the Rutgers University Academic Integrity Policy. A copy of the Academic Integrity Policy, which went into effect on September 1, 2013, can be found at:
http://studentconduct.rutgers.edu/student-conduct-processes/academic-integrity/

Student-Wellness Services

Counseling, ADAP & Psychiatric Services (CAPS): (848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901/ http://health.rutgers.edu/medical-counseling-services/counseling/**.** CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professionals within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include: individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community, and consultation and collaboration with campus partners.

Crisis Intervention:
http://health.rutgers.edu/medical-counseling-services/counseling/crisis-intervention/
Report a Concern: http://health.rutgers.edu/do-something-to-help/

Violence Prevention & Victim Assistance (VPVA): (848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901 / www.vpva.rutgers.edu/**.** The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling and advocacy for victims of sexual and relationship violence and stalking to students, staff and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

Exam Regrade Requests

All student complaints about grades will be managed in close agreement with University Policies and Procedures. Students wishing to file a complaint about an exam grade or the course grade should initiate all attempts to resolve the matter through discussion with the Instructor. Such a discussion shall be NO LATER than one week after the exam in

question is posted. If the issue cannot be satisfactorily resolved this way, the instructor will direct the student to the Vice-Chair of the Undergraduate Program (for Chem 482) or the Vice-Chair of the Graduate Program (for Chem 582). Student may specify in writing the basis for the complaint and request a review by the Vice-Chair and the Department Chair. A written complaint must be submitted to the department chair no later than (a) two weeks after notification of a disputed exam grade for disputed exam grades or (b) four weeks after the end of the exam period for that semester. For all appeals, and for additional information, please be sure follow these policies on grading as specified: https://sasoue.rutgers.edu/policies-resources/grading/53-policies-resources/125-grade-appeals

Exam Conflict

Certain scheduled Rutgers activities may take precedence over class activities for students who are formally registered to participate in those activities (see also RU Common Hour Exam Policies). If a student has an exam conflict between an examination and a scheduled activity, that students **MUST notify the instructor, by email 2 weeks before such conflict(s)**, so that alternative arrangements can be made. These arrangements may include, for example, an earlier or a later assessment. An exam conflict will be treated as if the student has missed the exam due to a legitimate reason (see below). A student with final exam conflict will be allowed to take a make-up exam. The exact date and location will be announced later.

Missed Exam

Exams must be taken at the scheduled times. Only excusable reasons will be considered (e.g. illness or family emergency). **To be excused from an exam, students must fill out a self-reported absence form,** available at https://sims.rutgers.edu/ssra, and **MUST notify the instructor, by email at least 48 hours before the exam**, so that alternative arrangements can be made. These arrangements may include, for example, an earlier or a later assessment. Unexcused missed exams will result in a score of zero (0) for that exam.

Special Needs

Any student requiring extra time and/or other unusual testing accommodations must provide documentation supporting their circumstances and **MUST notify the instructor.** ALL requests for extending time and/or other special accommodations for exams must be handled through the Office of Disability Services (https://ods.rutgers.edu) The office of Disability Services will be responsible for all necessary proctoring arrangements.

Course Outline

Class #	Modules
1 – 3	**M1:** The Central Dogma and Chemical Origins of Biology
4 – 6	**M2:** Nucleic Acids
7 – 9	**M3:** Proteins
10	*Mid-term Exam 1, covering* **M1** – **M3**
11	*Discussion on Exam 1 (solutions and strategies)*
12 – 14	**M4:** Small-Organic-Molecule Regulators and Inhibitors
15 – 16	**M5:** Bioconjugate Chemistry
17	*Mid-term Exam 2, covering* **M4** – **M5**
18	*Discussion on Exam 2 (solutions and strategies)*
19 – 20	**M6:** Photochemistry
20 – 21	**M7:** Chemical Tools for Biomolecular Imaging and Biotechnology
22 – 23	Research Article Presentations
24	*Final Exam, covering* **M1** – **M7**
25	*Discussion on Final Exam (solutions and strategies)*

Learning Goals

Students will learn to describe, analyze, rationalize, and apply technical and core concepts related to the *Central Dogma*, nucleic acids, proteins, small-organic-molecule regulators and inhibitors, bioconjugate chemistry and their applications in chemical biology, photochemistry and its application in chemical biology, chemical tools for biomolecular imaging. These concepts will be taught in individual modules, and the details of the specific learning goals for each specific module are described below.

M1. The Central Dogma and Chemical Origins of Biology

- Replication, transcription and translation of the genetic information
- Role of organic chemistry in understanding the central dogma
- Functionality and catalysis induced by biomacromolecules
- Organic molecules that might have led to the emergence of information transfer.
- Chirality in biologically relevant building blocks

M2. Nucleic Acids

- Structural features of DNA, RNA, and non-biological nucleic acids (e.g., TNA, PNA, NP-DNA)
- Nomenclature and synthesis of nucleobases, nucleosides and nucleotides
- H-bonding properties and tautomerization of nucleobases
- Solid-phase organic synthesis of nucleic acids
- Chemical modifications and metabolic labeling of nucleic acids.
- Functional nucleic acids (e.g., ribozymes)
  Natural nucleic acid enzymes
  Laboratory-evolved nucleic acid enzymes

M3. Proteins

- Structural features of polypeptides and proteins
- Nomenclature and chemical properties of amino acids
- Classical / bioorthogonal peptide bond formation
- In-solution synthesis of peptides
- Solid-phase synthesis of peptides
- Incorporation of unnatural amino acids into proteins

M4. Small-Organic-Molecule Regulators and Inhibitors

- Interactions between organic molecules and nucleic acids.
- Synthetic drug molecules that work by stalling DNA replication or translation (e.g., organic / organometallic intercalators)
- Interactions between organic molecules and proteins. Small-molecule inhibitors of protein enzymes

M5. Bioconjugate Chemistry

- Chemoselectivity and cytocompatibility in reaction design
- Ligations, cycloadditions (e.g., Diels-Alder reaction, copper-mediated and copper-free click chemistry, tetrazine ligation), and other bioorthogonal conjugation reactions

M6. Photochemistry

- Jabłoński diagram (excitation, emission, Stokes shift)
- The concept of brightness
- The concept of luminescence
- Photoisomerism and design principles of photoswitchable probes

- Photopharmacology

M7. Chemical Tools for Biomolecular Imaging and Biotechnology

- Organic fluorophores for imaging (bio)molecules *in vitro* and *in vivo* (their classification, synthesis, and implementation in chemical biology)
- Green Fluorescent Protein (GFP)
- Nucleic acid-derived imaging technologies (trafficking RNA or metabolites in cells and applications in nanotechnology)
- CRISPR-based imaging tools and diagnostics