CHEM 2810: Biological Chemistry 1
Fall 2018, TuTh: 5.30-6.45 PM
Lecture room: Eberly 228

Instructor: Kabirul Islam
Office: 1307 Chevron Science Center
Office Hours: By appointment
E-mail: kai27@pitt.edu

Learning Objectives:

Students will learn (1) the fundamentals of the structure and function of nucleic acids and proteins, their interactions, and their involvement in biological processes; (2) basic and advanced methodologies for the characterization, measurement, and control of the structure and function of nucleic acids and proteins *in vitro* and *in vivo*. After successful completion of this course, students will have the tools to succeed in their biologically driven projects and to understand and discuss the chemical biology literature.

Course Description:

The field of chemical biology connects chemistry, biology, physics and medicine. It gained an ever-increasing interest during the turn of 21st century to provide molecular, quantitative and system level understanding of biological processes relating to human health and disease. It involves the application of chemical methods and principles to the study and manipulation of biological systems. Chemical biology has scientific, historical and philosophical roots in medicinal chemistry, bioorganic chemistry, pharmacology, genetics and biochemistry. To harness the full potential of this interdisciplinary science, students must be acquainted with biology to ask unsolved biological questions, and trained in chemistry to provide answers with molecular precision. This multidimensional training is essential to examine and understand the complexity of eukaryotic biology and human disease.

Organization and Goals of the Course:

The course has been organized in three major parts: **1**. Introduction to Biomolecules: Structures and Functions, **2**. Synthesis of Biomolecules: Methods and Applications, and **3**. Small Molecules in Biology: Cofactors, Inhibitors and Chemical probes. We will begin by discussing the structures and components of major classes of biomolecules (proteins, nucleic acids, and to some extent carbohydrates and lipids) and the non-covalent interactions that influence their topology and functions. *The goal of this section is to understand the chemical origin of life.* In the second part, we will discuss how Nature synthesizes these biomolecules. We will also examine the approaches that chemists have undertaken to synthesize biomolecules in laboratory. *The goal here will be to get acquainted with biochemical machineries that produce these biomolecules along with chemists' efforts towards alternative route for analogue synthesis.* Furthermore, we will discuss various biochemical and biophysical methods to measure the dynamics and activities of biomacromolecules. In the third part of the course, we will be engaged in understanding the

important roles that various small molecules, such as cofactors and vitamins, play in living processes. *This will set the stage for design of small-molecule based protein inhibitors, a major focus in the field of chemical biology.* Various approaches to inhibitor development will be reviewed.

In addition to above-mentioned topics, students will present articles from recent literature on the topics at the interface of chemistry and biology (and/or medicine).

Recommended (not required) Textbooks:

- *Introduction to Bioorganic Chemistry and Chemical Biology,* Vranken and Weiss
- *Essentials of Chemical Biology: Structure and Dynamics of Biological Macromolecules*, Miller and Tanner
- *The Organic Chemistry of Biological Pathways*, McMurry and Begley
- *Molecular Biology Made Simple and Fun,* Clark and Russell

A large part of the course will be taught from published articles that will be cited in the relevant lectures. Students are expected to read these papers.

Exam Schedule:

- Midterm Exam 1 (11th October)
- Midterm Exam 2 (13th November)
- Literature Presentation (11th December)
- Final Exam (13th December)

(Exam dates and syllabi are tentative. Actual dates and syllabi will be announced in the class.)

Student Presentation:

Students will be divided into groups of two or three depending on the strength of the class to give an in-class presentation on chemical biology research. Each group will consult with the instructor to select an article from recent literature. Research related to chemical biology is routinely published in the following journals: *Nature Chemical Biology, ACS Chemical Biology, Chemistry and Biology, Journal of the American Chemical Society, Nature, Science, Cell, Angewandte Chemie International Edition* and *ChemBioChem*.

In each presentation students will introduce the lead author (Principal Investigator) by giving his/her educational and research information. Students should be aware that a good presentation begins by providing relevant background information that helps audience know the 'knowledge-gap' in the filed. Students are expected to present the central question asked in the article and how that has been addressed through carefully designed experiments. It is highly appropriate to

discuss any limitations in the methods used in the study and how it can be improved. Details about the group formation, paper selection and presentation format will take place in November.

Homework:

In general, students will be asked a range of basic questions during the discussion in class. Some of these questions will be considered as homework and asked later in arbitrary fashion.

Grading:

- 2 Midterm Exams: 200 points (Each 100 points)
- Final Exam: 140 points
- Literature Presentation: 60 points
- 2 Surprise Tests: 40 points
- Attendance: 60 points (Minimum 70% attendance is required)
- **Total:** **500 points**

Academic Integrity:

Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity (http://www.as.pitt.edu/fac/policies/academic-integrity). Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

Disability Services:

If you have a disability that requires special testing accommodations or other classroom modifications, you need to notify both the instructor and Disability Resources and Services (http://www.studentaffairs.pitt.edu/drswelcome) no later than the second week of the term. You may be asked to provide documentation of your disability to determine the appropriateness of accommodations. To notify Disability Resources and Services, call (412) 648-7890 (Voice or TTD) to schedule an appointment. The Disability Resources and Services office is located in 140 William Pitt Union on the Oakland campus.

Course Outline and Tentative Schedule:

I. Introduction to Biomolecules: Structures and Functions

Special Lecture	Chemical Biology: It's Past, Present, Future and Promises
Lecture 1	Biomolecules, the Central Dogma and Non-Covalent Interactions
Lecture 2	Nucleic Acids: Structures, Functions and the Genetic Code
Lecture 3	Proteins: Structures and Functions
Lecture 4	Enzymes and Biochemical (Bioorganic) Reactions
Lecture 5	Molecular Recognition, Binding and Catalysis

II. Synthesis of Biomolecules: Methods and Applications

Lecture 6	Biological Synthesis of DNA: Replication
Lecture 7	Biological Synthesis of RNA: Transcription
Lecture 8	Biological Synthesis of Proteins: Translation
Lecture 9	Chemical Synthesis of DNA and RNA: Methods and Applications
Lecture 10	Solid Phase Peptide Synthesis: Methods and Applications
Lecture 11	Chemical Ligation Technologies: Methods and Applications
Lecture 12	Molecular Biology Techniques: Plasmids, Cloning, Protein Expression, PCR
Lecture 13	In-vitro Incorporation of Non-Canonical Amino Acid into Proteins
Lecture 14	Incoporation of Non-Canonical Amino Acid into Proteins in Bacterial Cells

III. Small Molecules in Biology: Cofactors, Inhibitors and Chemical Probes

Lecture 15	Cofactors, Ligands and Concenpt of Pharmacological Perturbations
Lecture 16	Chemical Genetics: Concept, Historical Perspective and Selected Examples
Lecture 17	Accessing Small Molecules: Diversity- and Biology-Oriented Synthesis
Lecture 18	Approaches towards Design and Development of Small-Molecule Inhibitors
Lecture 19	Target Identification of Small-Moelcule Inhibitors: Biochemical Appraoches

11-Oct	**EXAM 1**
13-Nov	**EXAM 2**
11-Dec	**LITERATURE PRESENTATION BY STUDENTS**
13-Dec	**FINAL EXAM**

10/16/18	**FALL BREAK**
11/22/18	**THANKSGIVING**