# BIOE 348 / 6498
# Molecular Techniques in Bioengineering
# Spring Semester 2024

## INSTRUCTOR

Dr. Bilal Ghosn
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***Teaching Assistant***
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## COURSE TIMES

11:00 a.m. – 11:50 a.m. on Mondays, Wednesdays, and Fridays

**Catalog Course Description:**

(3 credit hours) Prerequisites: BIOS 341, concurrent enrollment in BIOE 342 and/or permission of instructor. Introduction to fundamental physical principles light interaction with matter, separation (by charge, size, conformation) and detection techniques utilized in the field of bioengineering. These include absorbance and fluorescence spectroscopy, light and fluorescence microscopy, flow cytometry, electrophoresis, PCR, Blotting, and ELISA. Students will learn and apply several techniques commonly used in biotechnology settings to evaluate molecular level markers. Students will also learn experimental design and apply it to an in-course problem. This course will require students to come in outside of assigned class time on several occasions.

**Prerequisites:**

BIOS 341 Cell Biology and BIOE 342 Laboratory in Tissue culture.

**Objectives:**

1. To understand the fundamental physical principles and their application in molecular laboratory methods commonly used in the bioengineering field.
2. To develop an understanding of the fundamentals of the interaction of light with matter, microscopy, electrophoretic mobility and PCR.
3. To understand and perform analysis for data collected using molecular techniques.
4. To design and develop experimental plans and protocols for evaluating various factors in biological systems utilizing molecular techniques.
5. To reinforce understandings of the cell and molecular functions through the direct evaluation of cellular expression of DNA, RNA, proteins, and other molecules.

**Office Hours:**
By appointment. Appointments can be scheduled by phone or email.

**Text:**
No text required. Students will be supplied lecture notes and various excerpts via electronic format prior to each class. Students are encouraged to consult texts listed below as well as their own online research for relevant material. Students are also encouraged to check on online source validity with the instructor.

*Recommended texts for reference:*

Ninfa, A.J., Ballou, A. J. N. D. P., and M. Benore. (2009). Fundamental Laboratory Approaches for Biochemistry and Biotechnology. 2nd Edition. Hoboken, NJ. John Wiley and Sons.

Johnson, I. and Spence. M. T. Z. (2010). Molecular Probes Handbook: A Guide to Fluorescent Probes and Labeling Technologies. Life Technologies.

Hermanson, G. T. (2008). Bioconjugate Techniques. 2nd Edition. Boston, MA. Elsevier Academic Press.

**Grading Policy:**
The course grades will be determined by a combination of homework assignments, lab reports, course project, and final exam. Grades will be broken down as follows:

| | |
|---|---|
| Homework/Labs* | 20% |
| Quizzes/Attendance (unannounced) | 5% |
| Course Project Report and Presentation | 15% |
| Exams (2) | 60% |

Late materials for homework will result in a 20% grade deduction (i.e. 1 day late starts at 80%, 2 days late as 60% as highest, etc) in the grade except in the case of acceptable documented personal or medical emergencies. Concerns on potential conflicts should be discussed with the instructor prior to the assignment deadline if possible.

* Homework/Lab grades will include the Technique Review Report for BIOE 648 students. See assignment description below.

**Breakdown of Graded materials:**
Students will receive grades on the material described in the grading policy of this syllabus.

Students will be assigned 5 homework assignments during the semester covering the material taught and experiments undertaken over a given 2-3 week period. Assignments will be graded based not only on providing adequate responses, but also on the legibility and organization of the student's work.

Students (in groups of 2) will be assigned a project topic in the beginning of the course regarding the design of experiments for a given system to be chosen by each group. Students will prepare a report (10% of total course grade) and a presentation (5% of total grade) to be submitted towards the end of the semester. Students again will be grading on the quality of their designed experiments and their ability to coherently express their story both in written and oral form.

*BIOE 648 Only:* Students will be assigned with a written technique review report. In this assignment, students will be asked to write a technical review report on recent advancements in one of the techniques discussed in this course. Further details on this assignment will be provided during the semester. This is an individual assignment and will be counted towards the Homework/Labs portion of the student's overall grade.

A final examination will be given during the final examination period. The date and time of the exam will be released at a later date. This exam will cover techniques learned throughout the semester and their application in several example studies described within the exam.

**Expectations for Students Outside of Regularly Class Time:**

Students are expected to review videos of laboratory demonstrations and data collection for those experiments outside of class. We may also have lab opportunities that will run over course time slightly.

**Academic Integrity:**

Students are expected adhere to the Rice Honor Code at all times. All graded work will be covered by the code, which will be distributed to students on the first day of class. It is the responsibility of the students to inquire with the instructor on any concerns, questions, or needed clarifications on the expectations about academic integrity.

Failure to comply with the Rice Honor code can result in a zero grade on the offending assignment/material and students will be reported to the honor council for further evaluation.

Any student with a documented disability needing academic adjustments or accommodations is requested to speak with me during the first two weeks of class. All discussions will remain confidential. Students with disabilities should also contact Disability Support Services in Allen Center.

**Course Topics and Daily Schedule (Tentative)**

| ***Date*** | ***Class Day*** | ***Class Week*** | ***Topics*** | ***Assignments*** |
|---|---|---|---|---|
| 1/8/2024 | 1 | 1 | Course Introduction, Overview of methods | |
| 1/10/2024 | 2 | | Review of Experimental Design | |
| 1/12/2024 | 3 | | Absorbance of Light | |
| 1/15/2024 | 4 | 2 | Absorbance of Light | |
| 1/17/2024 | 5 | | Spectroscopy and Absorbance | |
| 1/19/2024 | 6 | | Spectroscopy and Absorbance **Lab/Demo #1** | HW#1 Assigned |
| ***1/22/2024*** | | ***3*** | ***HOLIDAY (MLK)*** | |
| 1/24/2024 | 7 | | Principles of Fluorescence | Assign Groups/Topics |
| 1/26/2024 | 8 | | Principles of Fluorescence | |
| 1/29/2024 | 9 | 4 | Fluorescence Spectroscopy | |
| 1/31/2024 | 10 | | Fluorescence Spectroscopy (Cont'd) | |
| 2/2/2024 | 11 | | FRET/Luminescence/Principle of photomultiplier tubes (PMTs) | |
| 2/5/2024 | 12 | 5 | Methods of Synthesis of labeled materials | HW#1 Due/HW #2 Assigned |
| 2/7/2024 | 13 | | Light Scattering/Optical Imaging Basics | |
| ***2/9/2024*** | | | ***HOLIDAY (Spring Recess)*** | |
| 2/12/2024 | 14 | 6 | Light Scattering/Optical Imaging Basics (Cont'd) | |
| 2/14/2024 | 15 | | Microscopy/Fluorescence Microscopy | |
| 2/16/2024 | 16 | | Microscopy/Fluorescence Microscopy | |
| 2/19/2024 | 17 | 7 | Fluorescence Microscopy (Cont'd) | HW #2 Due/HW#3 Assigned |
| 2/21/2024 | 18 | | Confocal Microscopy | |
| 2/23/2024 | 19 | | Principles of Separation | |
| 2/26/2024 | 20 | 8 | Principles of Chromatography | |
| 2/28/2024 | 21 | | Principles of Gel Electrophoresis for Nucleic Acids | |
| 3/1/2024 | 22 | | *Chromatography (Cont'd) (Lab/Demo )* | |
| 3/4/2024 | 23 | 9 | Principles of Gel Electrophoresis for Proteins | HW#3 Due |
| 3/6/2024 | 24 | | **Review** | |
| 3/8/2024 | 25 | | ***Mid-term Exam*** | |
| ***3/11/2024*** | | ***10*** | ***HOLIDAY*** | |
| ***3/13/2024*** | | | ***HOLIDAY*** | |
| ***3/15/2024*** | | | ***HOLIDAY*** | |
| 3/18/2024 | 26 | 11 | Antibodies in Molecular Methods | |
| 3/20/2024 | 27 | | Principles of Blotting | |
| 3/22/2024 | 28 | | *Applications of Gel Electrophoresis (Demo/Lab)* | HW#4 Assigned |

| | | | | |
|---|---|---|---|---|
| 3/25/2024 | 29 | 12 | Western Blotting and its applications | |
| 3/27/2024 | 30 | | Enzyme-Linked Immunosorbent Assay (ELISA) | |
| 3/29/2024 | 31 | | Principles of RNA isolation, Fundamentals of Polymerase Chain Reaction | |
| 4/1/2024 | 32 | 13 | End point PCR | |
| 4/3/2024 | 33 | | *Group Work* | HW#4 Due |
| 4/5/2024 | 34 | | ELISA Lab (Lab/Demonstration) | |
| ***4/8/2024*** | ***35*** | 14 | ***HOLIDAY (Solar Eclipse)*** | |
| 4/10/2024 | 36 | | Principles of Quantitative PCR | |
| 4/12/2024 | 37 | | Flow Cytometry | |
| 4/15/2024 | 38 | 15 | Project Presentations | |
| 4/17/2024 | 39 | | Project Presentations | Projects Due |
| 4/19/2024 | 40 | | Final Review | |

# Flex Days represent days that may be used for shifting lectures or to provide opportunity to work in groups for project work.

** Date is the Monday following Completion of the course.

| ***Topics*** | |
|---|---|
| Course Introduction, Overview of methods | Overview and Experimental Design |
| Review of Experimental Design | |
| Introduction to light and its interactions with Matter<br>Absorbance of Light | Light interaction with matter |
| Spectroscopy and Absorbance | |
| Principles of Fluorescence | |
| Principles of Fluorescence and Fluorescence Spectroscopy | |
| FRET/Luminescence/Principle of photomultiplier tubes (PMTs) | |
| Light Scattering/Optical Imaging Basics | Microscopy Basics |
| Microscopy/Fluorescence Microscopy | |
| Confocal Microscopy | |
| ***Exam #1 (Materials Above Covered)*** | |
| Methods for Synthesis of labeled materials | Separation/Absorbance/Fluorescence |
| Principles of Separation / Principles of Chromatography | |
| Principles of Gel Electrophoresis for Nucleic Acids and Proteins | |
| Chromatography/Electrophoresis Demo Lab | |
| Antibodies in Molecular Methods/Blotting | Separation and Detection of proteins |
| Principles of Blotting | |
| Western Blotting and its applications | |
| Enzyme-Linked Immunosorbent Assay (ELISA) | |
| Principles of RNA isolation, Fundamentals of Polymerase Chain Reaction | Isolation and Detection of RNA/DNA |
| End point PCR | |
| Principles of Quantitative PCR | |
| Flow Cytometry | Characterization of Cells |
| ***Exam #2 (All Materials Covered)*** | |