BE 160: Chemical and Molecular Bioengineering Techniques

Instructor: Professor Brian Aguado, PhD

Email: baguado@eng.ucsd.edu. Please label email subjects with "BENG 160" or your email may be missed.

Term: Spring 2023

Lecture Time: Mondays, 9:00 am – 9:50 am, Warren Lecture Hall 2204

Lab Time: Mondays/Tuesdays: 11:00 am – 12:50 pm, 1:00 pm – 2:50 pm, 3:00 pm – 4:50 pm, PFBH 108

Discussion Time: Mondays, 5:00 pm – 5:50 pm, Franklin Antonio Hall 1101

Instructor Office Hours: Wednesdays 3-4 PM or by appointment (SCRM 4003)

Teaching Assistants (TA):
Talia Baddour (PhD Student, Bioengineering), tbaddour@ucsd.edu
Rayyan Gorashi (PhD Student, Bioengineering), rgorashi@ucsd.edu
Maria Karkanitsa (PhD Student, Bioengineering), mkarkani@ucsd.edu
Samuel Park (MS Student, Bioengineering), ssp045@ucsd.edu

TA Office Hours: By appointment

Format: Classes and labs will be in-person. As much advance notice as possible will be provided if a transition to virtual instruction is necessary.

Materials needed: Laptop/smart phone for in-person lecture questions. Notebook for lab. No textbook.

Course description: Introductory laboratory course in current principles and techniques of chemistry and molecular biology applicable to bioengineering. Quantitation of nucleic acids by spectrophotometric, enzymatic, and computational methods. Separations and purification by centrifugation, chromatographic, and electrophoretic methods.

Course objectives: At the conclusion of this course, students will be able to:

1. Understand the biological concepts necessary to perform basic laboratory techniques related to DNA and RNA analysis (purification, detection, amplification, digestion, etc).
2. Perform basic laboratory techniques including sterile technique for bacterial culture, micro-pipetting, DNA digestion, gel electrophoresis, real time PCR, and RNA sequencing.
3. Get familiar with instrumentations used in chemistry and molecular biology including a centrifuge, spectrophotometer, thermocycler, bacterial incubator, water bath, dry bath, power supply and gel electrophoresis system, image analyzer, micropipetter, electronic balance, and water purification system.
4. Learn to handle biological and chemical samples with precision in small scales (microliters, miniliters, nanometers, minimeters).

5. Understand and follow safety rules and regulations (using personal protective equipment and proper waste management) when handling biological samples, chemical samples, and biohazard materials.
6. Write technical lab reports that contextualize experimental methods performed in the wet and dry lab and discuss key experimental findings.
7.

Grading Scheme:

Assignments	Weight
6 wet lab reports (Weeks 1-7)	60%
1 dry lab report (Weeks 8-10)	30%
Lecture Participation Questions/Slide About You	10%

Schedule:

Week	Date	Topic	
I	4/3	**Lecture 1**	**Introduction & Safety in the Lab**
		Lab 1	1. Sterile techniques and bacterial culture
	4/4		2. Measurements and micro-pipetting
	4/3	Discussion	How to write a lab report
II	4/10	**Lecture 2**	**DNA Fragment Analysis**
		Lab 2	1. Phage λ DNA digestion, restriction mapping
	4/11		2. Gel electrophoresis of DNA fragments
III	4/17	**Lecture 3**	**Plasmid DNA, Bacterial Transformation & Selection**
		Lab 3	1. Transformation of *E. coli* with plasmid DNA
	4/18		2. Plasmid DNA purification and gel verification
IV	4/24	**Lecture 4**	**Protein Expression and Purification**
		Lab 4	1. Protein extraction (Taq polymerase).
	4/25		2. Protein product verification by gel electrophoresis
V	5/1	**Lecture 5**	**Real-time PCR**
		Lab 5	1. PCR with purified Taq Polymerase
	5/2		2. PCR product checks
VI	5/8	**Lecture 6**	**Gene Expression**
		Lab 6	1. RNA extraction, characterization by electrophoresis
	5/9		2. cDNA optimization
VII	5/15	**Lecture 7**	**Bioinformatics I: Sequencing methods**
		Lab 7	1. RT-PCR
	5/16		2. RT-PCR data analysis
VIII	5/22	**Lecture 8**	**Bioinformatics II: Sequencing methods**
		Lab 8	1. RNA seq software tutorial
	5/23		2. RNA seq software tutorial
IX	5/29	**No Lecture**	**Memorial Day**
		No Lab	Memorial Day
	5/30	Comp Lab	RNA seq software tutorial, lab office hours
X	6/5	**Lecture 9**	**Emerging Technologies (CRISPR, Single Cell)**
		Comp lab	1. CRISPR Ethics Discussion
	6/6		2. Prepare final lab reports for submission

Due Dates for All Assignments (All students must submit their individual assignments):

Assignments	Due Date (submitted on Canvas by 11:59 pm PT)
Lecture Participation Questions	In class on Mondays (live questions, no Canvas)
Slide About You	Wednesday 4/5
Lab Report (Week 1)	Wednesday 4/12
Lab Report (Week 2)	Wednesday 4/19
Lab Report (Week 3)	Wednesday 4/26
Lab Report (Week 4)	Wednesday 5/3
Lab Report (Week 5)	Wednesday 5/10
Lab Report (Week 6-7)	Wednesday 5/24
Final Lab Report (Weeks 7-10)	Wednesday 6/7

Expectations:

1. Active participation and classroom engagement is important to learning the fundamentals of DNA and RNA biology/bioengineering. All students are expected to participate in class discussions and questions during class.

2. Academic dishonesty will not be tolerated. The Department of Bioengineering adheres to the UCSD Policy on Integrity of Scholarship. An excerpt of this Policy states that "Students are expected to complete the course in compliance with the instructor's standards. No student shall engage in any activity that involves attempting to receive a grade by means other than honest effort." Any suspected incident (including but not limited to plagiarism on writing assignments, use of ChatGPT or other AI software, copying assignments from others in class, etc) will be dealt with in accordance with UCSD policy, which includes reporting the misconduct to the Dean. More information on UCSD's academic dishonesty policy can be found at: http://senate.ucsd.edu/Operating-Procedures/Senate-Manual/Appendices/2

Graded assignment instructions:

1. **Weekly lab report (60%): Reports 1-6 must be typed using the templates provided in Canvas. Page limit: 2 pages of text, unlimited pages of figures/calculations/graphs.**
   Reports must be structured in the following way:
   - **Objective:** Must include goals of the experiment performed (<3 sentences)
   - **Introduction:** Basic biological background of the molecular process occurring during experiment as well as background of the tests performed. Information directly copied from websites (wiki, google, etc) is not acceptable and will be reported to the Dean's office for academic dishonesty.
   - **Materials and Methods:** Includes the process and materials used in the experiment. This section is not a copy of the protocol, however you may site the specific book protocols, and provide a summary. Any deviations from the established protocol should be mentioned (such as concentrations, last minute changes, repetitions).
   - **Results:** Present your data in a useable, clearly readable, and succinct form. Results may include annotated pictures (of gels, and other necessary images), graphs, useful numbers (counts, averages, standard deviations), any complex equations used to generate numbers from the raw data (and the variables in these equations). The expected results should be stated, and how the actual results compared to these should be mentioned (such as transformation efficiency). Any calculations performed should be attached in the raw data, either written in the lab notebook or as attached computer printouts (as those constitute "virtual" notebook material).

- **Discussion:** Elaborate whether the goal has been achieved. If yes, congratulations, you did a great job, now indicate how your results support the original goal. If not, indicate why and what could have gone wrong (human error, equipment failure, etc…).
- **Conclusion:** A brief statement about the successfulness of the experiment and topics learned.
- **Raw data (this is not included in the page limit, but may be referred to directly in the lab report) –** Attached copies of data from your notebook and any necessary images or pieces of information from which the Results were derived. Pages from the notebook need to be labeled with *date, group,* and *name*, and should contain the detailed protocol that you followed (including the TA signed prelab) and *all* results which information could be drawn.
- **All students will be submitting individual lab reports.** Students will be working in pairs during the wet lab portion of the course.

2. Final Lab Report (30%)

Students will submit an individual final report covering bioinformatics topics from Week 7 to Week 10. The structure of this report will be similar to the weekly reports, but longer (no more than 10 pages) and more in depth. Templates will be provided to structure the assignment.

3. Attendance Questions (10% during lecture on Mondays)

During lecture, students will be expected to answer questions related to the course topic of the week. To keep track of attendance in lecture, students will log in to the daily Kahootz link provided in class and answer questions using their personal phone or laptop. Notecards will also be provided as an alternative to answer questions if folks cannot bring their device to class. Grades will be determined based on attendance.

Laboratory Safety Rules:
Your health and safety are paramount concerns; disregard for them through violation of the following guidelines can constitute sufficient grounds for expulsion from the laboratory until remedial measures are taken.

1. Never work alone in the lab.
2. Familiarize yourself with the layout of the building; know where the exits and staircases are in the building. Know the location of the fire extinguishers.
3. Food and drink (including water) are not to be brought into the lab at any time.
4. Wear appropriate clothing in the lab, e.g., no open-toe shoes or flowing sleeves should be worn. Long hair must be pulled back away from the face. **We are providing lab coat and safety glasses and you are required to wear them. You are also required to wear gloves when performing experiments.**
5. Laboratories contain potentially dangerous chemicals, correct and careful handling of them is essential for safe laboratory environment. Ask questions if you don't know how to handle certain chemicals.
6. Keep hands away from face and mouth when working with chemical solution. **Do not use your cell phone or laptop in the lab, especially when wearing gloves.** Your cell phone can be used for photos to collect data without gloves. Wash your hands thoroughly at the beginning and at the conclusion of the lab period.
7. Do not pipette by mouth. Use mechanical pipette only.

8. Report any injuries or unusual occurrences to the TA and the Instructor immediately. Each lab is equipped with the First Aid Kit. Know where the water fountain is.
9. If you have any questions feel free to ask.
10. Slides used by Doug Gurevitch [dgurevit@bioeng.ucsd.edu] are available on Canvas.

Hazardous Materials:
Potentially hazardous compounds or organisms include:

1. NaOH
2. Methanol
3. Ethidium bromide
4. *Escherichia coli* (*E. coli*, non-pathogenic strain)
5. *Saccharomyces cerevisiae* (S. cerevisiae, non-pathogenic strain)
6. Any bacterial cells transformed with plasmids containing antibiotic resistance genes