BI 416L Cellular and Molecular Biology Laboratory Syllabus
University of Guam, Spring Semester 2023

Units: 1

Laboratory Schedule: Sc250 a & b; Section 01: Tuesday, 11.0 AM – 1.50 PM; & Section 02: Thursday, 11 AM – 1.50 PM.

Instructor: *Shubir Ghosh, Ph.D.,* Professor, Molecular Biology & Biochemistry, Natural Sciences, University of Guam

Office Location & Hours:

Room Sc223; By Appointment; M, W, T, Th: 9 – 9.30 AM; 4 - 5 PM
E-Mail: sghosh@triton.uog.edu

UOG Moodle: All students are required to register with UOG's Moodle service – please use only an active E-Mail address where you can be contacted. **Students should check Moodle every week for the latest updates.** All material related to the course will be uploaded on Moodle – handouts, PowerPoints, exam schedule, exam reading list, news information, announcements, etc. Students should send electronic correspondence to the Instructor directly to: sghosh@triton.uog.edu (not through Moodle); the best way to contact Instructor is immediately before or after class.

Catalog Course Description & Prerequisites:

This course focuses on the advanced molecular cell biology approaches including recombinant DNA technology, advanced microscopy, protein interaction technologies, and model in vivo & in vitro experimental systems that have led to an unprecedented level of understanding of the structure and function of the cell, the fundamental unit of life. Student will learn to find rational explanations and unifying concepts from a large and rapidly evolving body of knowledge, in order to understand the mechanism by which the cell functions as well as the molecular basis of disease. Principle topics include cellular macromolecules& regulatory factors, membrane structure & membrane transport, cell nucleus & gene expression, cell signaling, the immune system, and cancer biology. This course prepares students for careers in bio-medical research, medicine, biotechnology & agriculture related industry. The lab, BI416L must be taken concurrently. Prerequisites: CH102, CH102L, CH103, CH103L, BI315 & BI315L. Corequisite: BI416L

COVID Statement: The University of Guam is experiencing continued disruption to delivery of instruction during the global coronavirus pandemic. The University will follow executive orders and may be forced to close again, causing more modifications as the semester progresses. All changes will be posted on the UOG website, www.uog.edu.

- Contact OIT for technical support at 735–2630 or oit@triton.uog.edu
- Contact the Triton Advising Center at 735–2271 or tac@triton.uog.edu
- Contact Isa Psychological Services center at 735–2883 or isa@triton.uog.edu

In face to face courses, wearing masks and social distancing is required. Anyone who has a fever, or any other symptom, should stay home. If you do not comply with these directions, you will be asked to leave, and if you do not, class will be cancelled.
Patience, respect, and cooperation are needed from all of us to persist through these uncomfortable times.

Disability Statement, Special Accommodations (ADA):

In accordance with the Americans with Disabilities Act (ADA) of 1990 and the Rehabilitation Act of 1973, the University of Guam does not discriminate against students and applicants on the basis of disability in the administration of its educational and other programs. The University offers reasonable accommodations for a student or applicant who is otherwise qualified, if the accommodation is reasonable, effective and will not alter a fundamental aspect of the

University's program nor will otherwise impose an undue hardship on the University, and/or there are not equivalent alternatives. Students are expected to make timely requests for accommodation, using the procedure below*. If appropriate, the University may choose to consult with such individuals, at or outside the University, to provide expertise needed to evaluate the request for accommodation. Each student bears the responsibility for initiating and then documenting a disability-related request for accommodation in the manner requested in this Policy.
[*full text at:www.uog.edu/dynamicdata/EqualEmploymentOffice.aspx?siteid=1&p=66]

If you are a student with a special need who will require an accommodation(s) to participate in this course, please contact me privately to discuss your specific needs. You will need to provide me with documentation concerning your need(s) for accommodation(s) from the EEO/ADA Office. If you have not registered with the EEO/ADA Office, you should do so immediately at 735-2244/2971/2243 (TTY) to coordinate your accommodation request. For more information visit: http://www.uog.edu/administration/office-of-the-president/eeoadatitle-ix-office

Family Educational Rights And Privacy Act (FERPA):

The Family Educational Rights and Privacy Act (FERPA) affords students certain rights with respect to their education records. These rights for students, parents and school officials can be viewed at:http://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html

Tobaccco-Free/Smoke-Free Campus:

Pursuant to Board of Regents Resolution No. 13-24, the University of Guam (UOG) has a total ban on the sales, smoking and the distribution and use of tobacco and tobacco-based products on the UOG Campus, and properties. The purpose of this policy is to protect the public health and welfare by prohibiting smoking and the use of tobacco products or simulated smoking devices, including but not limited to E-cigarettes, on the UOG campus and properties; to guarantee the right of nonsmokers to breathe smoke-free air, while recognizing that the need to breathe smoke-free air shall have priority over the desire to smoke; and to encourage a healthier, more productive living/learning environment for all members of our University community.

UOG is a tobacco-free campus. Thank you for not using tobacco products on campus, and for helping make UOG a healthy learning and living environment. For more information visit: http://www.uog.edu/smoke-free-uog

Academic dishonesty:

The University of Guam takes plagiarism very seriously.
Please pay attention to the following class exam rules that will be taken:

Closed book, closed cellphone/electronic devices, closed dialog.
Tests should not be taken out of room.
Tests should be returned back to the Instructor after a post exam review is conducted (cell phones/cameras should be kept away during the review).
Seating arrangement will be determined randomly by the Instructor – maintaining a gap between students.

All assignments and tests must be your own work. The term "**plagiarism**" includes, but is not limited, to, the use, by paraphrase or direct quotation, of the published or unpublished work of another person without full and clear acknowledgment. It also includes the unacknowledged use of materials prepared by another person or agency engaged in the selling of term papers or other academic materials. Plagiarizing in your assignments or cheating on tests will result in reporting to the administration. If you are not sure what plagiarism is and how to avoid it in using sources for your work, see www.indiana.edu/~wts/pamphlets/plagiarism.shtml - but be careful when paraphrasing not to change the meaning of scientific information. Answers you write on the tests must come only from in your head or the information supplied in the test papers; anything else is cheating. The term "**cheating**" includes, but is not limited to: (1) use of any unauthorized assistance in taking quizzes, tests, or examinations, e.g., looking at other students' answers, using crib notes (including electronic), getting information from another person via any kind of communication; (2) dependence upon the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments; or (3) the acquisition, without permission, of tests or other academic material belonging to a member of the University faculty or staff. If you need to use an electronic translator, you must discuss this with me in advance.

Liability Waiver:

A signed liability waiver will be required from all students for the laboratory course.

Laboratory safety procedures involves working in an efficient, orderly, and safe manner and using appropriate safety equipment (example, 70% alcohol disinfectant, safety googles, lab coat, UV goggles, gloves, etc.).
The lab involves the use of microbes, acids/alkali, organic reagents, bunsen burner, glass labware, etc.
Polytene chromosome preparation involves dissection with sharp needles and forceps – can cause needle sticks. All dissection needles and forceps should be sterilized with 70% alcohol prior to use.

In the first day of lab class all safety issues will be discussed. It is important that students clearly understand all the rules and regulations – please do not hesitate to ask for clarification regarding any safety related questions.

Lab Manual:

- There is no required Lab Manual.
- Your Cell & Molecular Biology textbook (& General Chemistry for buffer preparation) has all the necessary background theoretical information required for understanding the basis of your lab work.
- Protocols will be discussed prior to performing lab work and appropriate handouts will be provided. In some cases, protocols will be dictated – you would have to write them down in your lab notebook.
- Keep track of the handouts. **Contact the Instructor directly for any questions regarding lab work, protocols, handouts, etc.**
- **The lecture class will serve as pre-lab for some of the experiments planned for lab class.**

Lab Notebook:

- Record your Lab work in Laboratory Notebook during the lab – Mandatory.
- **This logbook has to be turned in when requested.**

Methods for Evaluation and Grading:

- **Students are advised to come by for office hours to discuss lab work, nature of the exams and the manner in which answers are expected as well as grading methods, etc.**

<u>Final Examination Schedule</u>:

- **There will be one Final Examination.**
- **You will be informed of the examination schedule at least two weeks ahead of the exams. <u>Typically, it is held during the last lab class.</u> The Final Lab Exam may also be held during UOG Final Exam Week.**

Grades will be based on:

- **Punctual and satisfactory performance of all laboratory work**
- **Lab Quizz**
- **Laboratory Logbook**
- **Laboratory Investigative Report**
- **Final Lab Exam**

***** All the above components are equally important**

Grading Summary:

Letter Grade	Percent
Grade A+:	**98 - 100%**
Grade A:	**93 - 97%**
Grade A-:	**90 - 92%**
Grade B+:	**87 - 89%**
Grade B:	**83- 86%**
Grade B-:	**80 - 82%**
Grade: C+:	**77 - 79%**
Grade C:	**70 - 76%**

***Note: No "Incomplete" Grade will be given for this course**

Please Note:

The nature of the questions generally will be:

- simple review factual/conceptual questions
- thought questions
- problems based on experimental data
- questions may involve explaining and providing diagrams for a process, analyzing data, proposing a mechanism, etc.

The format of the Questions:

- Multiple-choice
- Written-type
- Figures, Graphs, & Schematic Diagrams

Sample Questions & Answers: Quiz

- Sample Questions will be provided in the class in the form of a Quiz followed by a discussion of the appropriate answers expected. Please do not hesitate to contact Instructor if you have any questions regarding the nature of the exams and the answers expected from students.

Important:

- In the "written" Final Exam, students must provide indepth answers to the questions accompanied by figures, models, molecular explanation, design of experiments, graphs, analysis & interpretation of data, etc (as appropriate). The "written" answers will be given points based on scientific logic/specific detailed explanation and precision. Incomplete/incoherent/wrong answers will not receive any score. Generic key words and sentences will not suffice.

- Most written questions will be "thought-based" - so please think about the question and frame an answer directly addressing the question with specific mechanisms and experimental evidence - "using learning objectives discussed in class & textbook".

- Note: Please do not start writing an essay style textbook description of a process as your answer. Minimum credit will be given for such an answer for a "thought-based" question - the answer will be considered incomplete.

- **<u>Important: Please Address all questions that you may have regarding nature of exams, & grading policies by the first two weeks of the semester.</u>**

- An example of the scoring rubric for the "written component" will be provided on the first day of the semester as part of the discussions on the syllabus.
- A pre-exam review of the material for the exam will be conducted prior to the exam.
- No questions regarding grades will be accepted once the Final grade is provided. Grades are based on the scoring rubrics and grading policy. However, the student is encouraged to "request a review of their exam performance & grade" if they feel that an error may have inadvertently been made - please send me an E-Mail. Important: An "A" grade reflects robust perfromance in the written exams.

<u>Lab Course Policy</u>

- **The primary requirement for qualifying for this course is student's punctual attendance, use of proper language (<u>no slang/vulgar language</u>), sincerity in performing lab work, and orderly conduct in the laboratory maintaining all the rules & regulations of laboratory safety, conduct, and courtesy to fellow lab mates.**

- **To receive a grade for the Cellular and Molecular Biology Lab course, students will have to prepare appropriate reagents as directed, and perform all the experiments planned for the class. If a student cannot complete all the requirements for the course, no grade will be given to that student at the end of the semester.**

- **No "make up" labs will be conducted. No "Incomplete" Grade will be given in this course.**

- **Students are required to bring your syllaus and lab log book for every lab class. Students will also need to turn in their Lab Notebook, when requested.**

- **Attendance & Performance will be recorded for each lab.**

- **A Liability Waiver for the lab course is required from each student and will be collected on the first day of lab class.**

- **The lecture class will serve as pre-lab for some of the lab experiments to be conducted in the lab.**

- **Please do not hesitate to contact Instructor if you have any questions regarding lab work, protocols, handouts, etc.**

Lab Course Evaluation:

- **<u>Student Evaluation of Instructor should be based solely on the efforts made by the Instructor in the lab class to enhance the learning experience and not on the infrastructure or availability of equipment, reagents and other considerations that are not in the control of the Instructor. If the material needed for conducting the experiments provided in the syllabus are not available, then chalkboard simulations of lab experiments will be presented along with an interactive discussion session with student participation</u>.**

Spring 2023 B416L Cellular and Molecular Biology Lab

Laboratory Safety

Please Read before you Proceed.

A signed liability waiver form will be required from all students.

This is to remind you that laboratory safety procedures involves working in an efficient, orderly, and safe manner -

Generally, you should stay in your lab station and you and your lab partner are responsible for the materials including the **operation of the Bunsen burner** in your lab station. When you need to leave your station, you should do this in a unhurried manner so as not to bump into anyone else. Please do not leave your station and go to a neighbor's lab bench and switch on their Bunsen burner and use their reagents, etc. Please do not use latex gloves while operating the bunsen burner. The area where you have the Bunsen burner should be free of all paper, books, flammable material (alcohol, etc.). Appropriate clothing should be worn including labcoat and do not use hair sprays - those who have long hair should take the necessary precautions while operating the bunsen burner.
You should wear safety goggles while using regaents like acids and stains, amd microbiological agents (bacteria, yeast, bacteriphage virus), etc. You should wear the prescribed UV safety glasses when UV is in use.

If you need help or have any questions during the lab, you should not hesitate to ask the Instructor.

For every lab class, before you start your lab work, review the safety precautions that need to be followed – Instructor will discuss all safety precautions that need to be taken.

Do not start lab work if you are unsure of the safety instructions – please ask for the Instructor's assistance.

No food or drinks allowed in the lab.
Lab tables must be cleaned/disinfected before and after each lab class.
No bags or books should be placed on the floor.
Do not hold regarent bottles/microbial culture tubes by their caps (caps may be loose).
All materials used for a lab exercise must be returned to the proper storage area.
Microscopes must be cleaned and oil immersion lens using proper lens paper, with care prior to returning to the microscope storage cabinet.
Test tubes and other glassware must be rinsed after use and placed in the designated area.
Lab chairs must be returned to the lab table.
Tops to solution bottles must be secured and bottles returned to the proper storage area.
Regular trash must be placed in the proper waste container.
The lab instructor must be informed of any spills, broken glassware, or broken slides – there is a special container for broken glass.
No materials can leave the laboratory.

Computer/Cell Phone/Electronic Devices:

Please do not use electronic devices during Lecture class for personal work – distracts the Instructor & students – Only regular scientific calculator is allowed during quizzes/exams. All electronic devices (cell phones, laptops, etc.) are to be kept away during quizzes and exams. Thank You.

Spring 2023 BI 416L: Cellular and Molecular Biology Laboratory Work Syllabus

- ***Modifications to the syllabus (in terms of experiments and change in schedule, etc) may be made depending on availability of equipment, reagents, staff technician's assistance, and other considerations.***
- ***Lab work begins with a pre-lab discussion. Please take the first 5 minutes to settle down and arrange your notes, protocols, etc.***

Lab 1 :

Safety: take appropriate microbiological precautions working with E.coli & Yeast (eyeglass/gloves/labcoat)

- Introduction to Cellular and Molecular Biology Lab – logic and flow of syllabus.
- **Lab Safety & Conduct**
- Equipment Operation and Care
- Lab Notebook & Lab Report
- Preparation of Biochemical Buffers – Henderson-Hasselbach Equation

- Oil-immersion Phase Contrast Microscopy:

  - Dimensions and Units of cells and subcellular organelles
  - Bacteria (Prokaryote) & Yeast (Eukaryote) – **use precautions working with microbes**.
  - Staining of Human (self) cheek cells with Methylene Blue – **sanitize hands/wear gloves/sterile swab**
  - Examination of histological slides of brain/nerve cell; small intestinal cell showing microvilli; lung.

Lab 2 :

Safety: take appropriate microbiological precautions working with E.coli & Yeast (eyeglass/gloves/labcoat)

- Procedures useful for Recombinant DNA Technology: *A General Discussion*
  - Bacterial Culture Media & Methods and Pure Culture technique
  - Bacterial Growth Kinetics
  - Determining Bacterial Population Counts using Spectrophotometer
  - UV Spectrophotometry determination of concentration of isolated DNA

- Introduction on how biology of eukaryotes are investigated experimentally:
  - Cell Cultures & Animal Models; Phase Contrast & Fluorescence Microscopy

- Cell culture facility video tour
- Time-lapsed Video Microscopy Clips

Lab 3:

Safety: take appropriate precautions (gloves, eyeglasses, labcoat) when working with viruses and antibody

- Immunology & Viruses:
  - Antigen - Antibody reactions using double diffusion technique in agar.
    Check plates the next day.
  - Bacteriophage Virus detection (**use gloves and precaution**) – check for bacteriophage virus the next day.
  - Antibody inhibition of viruses– manufacturer has discontinued sale of antibody – so we will have a general discussion on Immunotherapy.

Lab 4:

Safety: take appropriate precautions (gloves, eyeglasses, labcoat) when working with antigen/antibody

- ELISA Immunological diagnostic/detection technique
- Western Blot – a general demonstration of method

Lab 5:

Safety: take appropriate precautions working with microbes; SDS-PAGE gels, buffers etc.

- Proteins: Protein Fingerprinting; Prokaryote (Bacteria) and Eukaryote (Yeast) Proteome
  - Extraction of Proteins from Cell Nucleus and Cytoplasmic fractions – general discussion
  - Extraction of proteins from bacteria/yeast and other sources of your choice.
  - Protein Analysis using SDS-PAGE method (**use gloves/eyeglasses/lab coat**)

Lab 6 & 7:

Safety: Wear safety eye goggles at all times while working with acetic acid, stains, etc.
Disinfect all your dissecting needles and forceps that you will be using for polytene chromosome preparation – these sharp instruments may easily cause needle sticks.

- Drosophila Polytene Chromosomes: An examination of chromatin
  - Drosophila Polytene Chromosome Squash Preparation: Aceto-orcein Staining

Lab 8 & 9:

Safety: Wear safety eye goggles at all times while working with acetic acid, stains, etc.
Please disinfect all your dissecting needles and forceps that you will be using for polytene chromosome preparation – these sharp instruments may easily cause needle sticks.

- Chromatin: Drosophila Polytene Chromosome Squash Preparation
  - Azure B staining (DNA & RNA)
  - Fast Green staining (Protein)
  - Inquiry-based Project Work

Lab 10 :

Safety: Wear "UV specific eye goggles" (not chemistry splash goggles) at all times while working with UV, & appropriate microbiological precautions working with E.coli.

- Recombinant DNA Technology:
  - Isolation of Recombinant Plasmid DNA containing the Jelly Fish Green Fluorescent Protein Gene (GFP) from E. coli bacterial host using Alkaline Lysis Mini-Prep Method.
  - Restriction Endonuclease Digestion & Gel Electrophoresis Analysis and Mapping of isolated GFP plasmid DNA.
  - Restriction Endonuclease Digestion of Genomic DNA

Lab 11:

Safety: wear UV specific eye goggles while working with UV & precautions working with E.coli

- Yeast/Human/Mouse Genomic Library Construction Project: Cloning Yeast or Mouse or human Genomic DNA fragments into plasmid vector, using insertional inactivation strategy for selection of transformants.
- **Focus on Experimental Strategy and Design of Experiment.**
    - Strategy for Genomic Library Construction Project
    - Restriction Digestion of Genomic DNA and Plasmid Vector DNA
    - Gel Electrophoresis of restricted Genomic DNA fragments, and Plasmid Vector DNA
    - Purification of Genomic Insert & Vector DNA fragments from agarose gels
    - Ligation of Genomic Insert DNA fragments to Vector DNA
    - Transformation of host E. coli with Ligation Mix
    - Selection and Analysis of Transformants

Lab 12 & 13:

Safety: wear UV specific eye goggles while working with UV & precautions working with E.coli

- "Genomic Library Construction Project" continues:
    - Separation of Restricted Genomic DNA, and Plasmid Vector DNA by Agarose Gel Electrophoresis.
    - Purification of Size-Selected Genomic DNA Insert fragments & Vector DNA fragment from agarose gels using Gene Clean Method.
    - Ligation of Genomic DNA inserts into Vector DNA.
    - Transformation of Competent E.coli host cells with Ligation Mix
    - Plating on Selective Media for Selection of Transformants.

    - **Analysis of Transformants for Determining Genomic Library Construction Success!**

Lab 14: Final Lab Exam

Student Learning Outcomes (SLOs):

COURSE SLOs	PLOs*	ILOs*	Assessment Method
1.To learn to launch a scientific investigation in understanding the cell, the basic unit of life.	**1,2,5,6**	**1,3**	Exams Verbal/Written Quizzes Lab work & Report
2.To learn the concept and preparation of biological buffers.	**1,2,3,4**	**1,2**	Exams Verbal/Written Quizzes Lab work & Report
3.To learn the use of oil immersion light microscopy, phase contrast microscopy, and fluorescence microscopy to examine prokaryotic and eukaryotic cells.	**1,4**	**1**	Exams Verbal/Written Quizzes Lab work & Report
4.To learn basic methodologies for culturing bacterial and yeast cells used routinely in gene cloning.	**1,4**	**1**	Exams Verbal/Written Quizzes Lab work & Report
5.To learn the preparation of Drosophila polytene chromosome squashes and the use of differential stains to identify the key biological macromolecules, DNA, RNA, and Proteins present in polytene chromosomes, in order to understand the concepts of chromatin and gene replication and expression.	**1,2,4**	**1,2,3**	Exams Verbal/Written Quizzes Lab work & Report
6.To learn gene expression & control, performing experiments using the E.coli arabinose operon as a model system.	**1,2,3,4**	**1,2,3**	Exams Verbal/Written Quizzes Lab work & Report
7.To learn and experience firsthand the fundamental concept and power of "recombinant DNA technology" that makes possible investigation and probing of the molecular basis of cell function in humans and other biological systems.	**1,2,3,4,6**	**1,2,3,5,7**	Exams Verbal/Written Quizzes Lab work & Report
8.To learn the use of instrumentation like the UV/Visible Spectrophotometer, DNA & protein gel electrophoresis apparatus, Table-top Centrifuges, UV transilluminator, and Electroporator to introduce DNA into host cells.	**1,2,3,4.7**	**1,2,5**	Exams Verbal/Written Quizzes Lab work & Reports
9.To learn identification, isolation, and manipulation of cellular macromolecules (genomic DNA, plasmid DNA, RNA, Proteins).	**1,2,3,4**	**1,2,5**	Exams Verbal/Written Quizzes Lab work & Report
10.To learn to construct a genomic library and screening strategies for cloning and isolation of genes.	**1,2,3,4**	**1,2,5**	Exams Verbal/Written Quizzes Lab work & Report Homework problems
11.To learn the key immunological concept of antigen-antibody reaction using diffusion agar plates and the ELISA technique for molecular diagnostics.	**1,2,3,4**	**1,2,5**	Exams Verbal/Written Quizzes Lab work & Report
12.To learn to interact with fellow students and take responsibility for their part in the group work conducted in the laboratory.	**4,5,7**	**1,3,7**	Group Lab work
13.To learn to design and perform a molecular cell investigative project and write concept-based laboratory reports.	**1,2,3,4,5,6**	**1,2,3**	Exams Verbal/Written Quizzes Lab work & Report

*Please see below for a list of Program and Institutional Learning Outcomes
Program Learning Outcomes:

BI PR-1: Disciplinary Knowledge and Skills
A. Graduates have advanced understanding of the nationally-recognized core competencies in biology. Students taking biology for GE will have a basic grasp of some of these concepts, especially those relating to the interface of science and society, and will advance their scientific literacy. Students contribute to the public good by using their knowledge and skills in internships, research and volunteering, and in responsible use of natural resources and technology.
B. Graduates use their knowledge and skills to solve problems in ecology, genetics, molecular biology, systematics, and evolution. They can apply their knowledge and skills to locally important issues such as island biogeography, conservation, and endangered species problems; they are also prepared to address broader questions such as biomedical research. They apply elements of thought and intellectual standards to problem solving and effectively judge the usefulness and accuracy of external sources of information.
C. Graduates approach scientific questions using scientific criteria and know how these criteria differ from those in other disciplines and other worldviews.
D. Graduates and GE students have metaknowledge of the diverse ways in which scientists in varous disciplines think and work, and how these ways differ from and are useful to public policy making.

BI PR-2: Interdisciplinary Knowledge and Skills
Graduates apply relevant concepts from chemistry and physics to biology problems; they approach problems in terms of interdisciplinary teams, where appropriate, aware of how other branches of biology and other sciences could be used to "come from the question"

BI PR-3: Quantitative Skills
Graduates apply numerical methods in collection and analysis of biological data. They formulate testable hypotheses and create effective experimental designs using their knowledge, understanding, and practical experience of scientific instruments and statistics.

BI PR-4: Research Skills for Laboratory and Field
Graduates are competent in basic biology procedures and safety in the laboratory and field.

BI PR-5: Communication Skills
Graduates use scientific literature and diagrams as a source of information, properly cite sources and avoid plagiarism, and use computer software to create text and graphics to communicate results effectively through print and oral presentations. They take initiative in searching for relevant sources in the scientific literature and assess evidence in writing scientific proposals and reports.

BI PR-6: Digital Literacy
Graduates have experience with contributing to and using large databases in bioinformatics, environmental sciences, and biological collections and have the general knowledge and confidence to mine "big data" sources.

BI PR-7: Professionalism
Graduates follow ethical principles involved in science, ranging from integrity and honesty to authorship criteria;
ownership of samples and data; appropriate manipulation of data and images; and (where appropriate) ethical issues in human subject and animal research.

Institutional Learning Outcomes:
ILO-1: Mastery of Critical Thinking and Problem Solving
ILO-2: Mastery of Quantitative Analysis
ILO-3: Effective Oral and Written Communication
ILO-4: Understanding and Appreciation of Culturally Diverse People, Ideas and Values in a Democratic Context
ILO-5: Responsible Use of Knowledge, Natural Resources, and Technology
ILO-6: An Appreciation of the Arts and Sciences
ILO-7: An Interest in Personal Development and Lifelong Learning