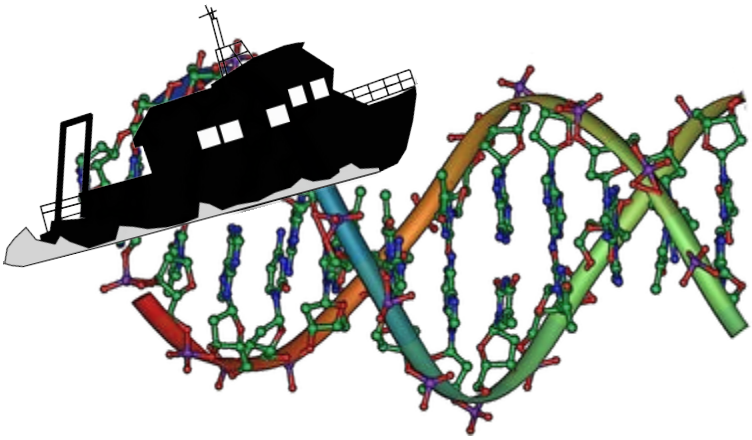
Marine Genomics

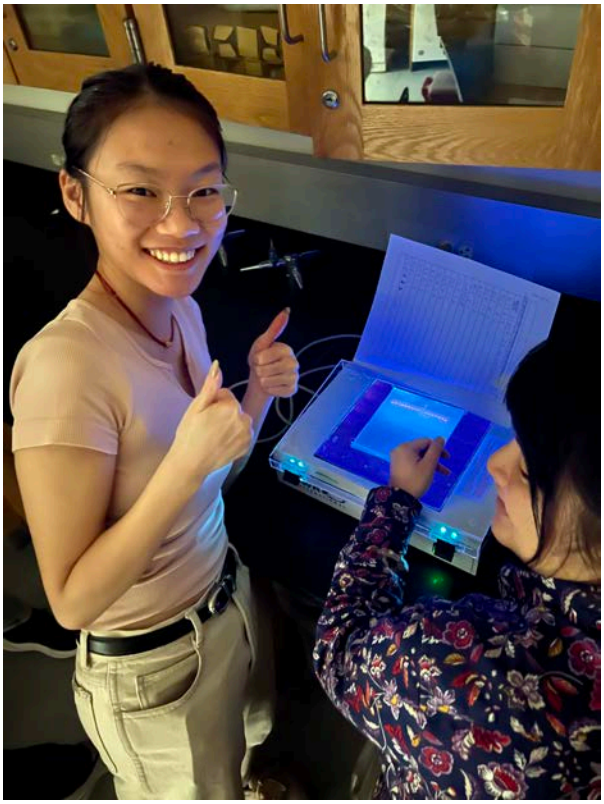


CAS BI 550 (4 credits)
Spring 2025
Tue/Thu: 12:30-3:15
Location: Biology Research Building B25 (“The BUMP Lab”)

Instructors	**John R. Finnerty**	**Shalom Entner (teaching fellow)**
Office	BRB 425	BRB 317
Office Hours	By appointment	By appointment
E-mail	jrf3@bu.edu	sentner@bu.edu

Course Description: Marine Genomics involves the application of genomic techniques to investigate the phenotype of marine organisms and the function of marine ecosystems. For example, (1) **metagenomic** approaches help reconstruct the microbial communities that drive nutrient cycling in marine ecosystems, (2) **transcriptomic** approaches are increasingly being utilized to understand how marine organisms respond to environmental stress at the level of gene expression, and (3) **population genomic** approaches are being used to investigate the microevolution of animal populations. The theoretical portion of this course will cover the evolution of genomes, the architecture of gene networks, the complexity of gene regulation, the connection between genotype and phenotype, and the basics of population genetics. In the computational portion of the course, you will computationally “mine” the genomes and transcriptomes of marine animals to gain insights into genome evolution. In the laboratory portion of the course, you will apply metagenomic and population genomic techniques to the DNA of marine organisms. Our focal animals will be corals.

Topics and techniques we will cover in BI550:
Fundamentals of genome organization // molecular evolution // molecular phylogenetics // mechanisms governing gene expression and function // DNA isolation from animal tissues // amplification of DNA using the polymerase chain reaction // analysis of DNA using electrophoresis and spectrophotometry // DNA barcoding & metabarcoding // population genomics // genome annotation // navigation and utilization of online molecular databases // bioinformatic analysis of DNA and proteins // development of scientific graphs and figures // scientific presentation //



Course Resources:
Slideshows of lecture presentations, lab protocols, bioinformatics protocols, and past student presentations are available through the BU Marine Program Media Library: https://bumarine.smugmug.com/COURSES/Marine-Genomics.

Handouts for lecture, lab, bioinformatics exercises, and literature discussions, as well as a copy of all assigned readings can be obtained through a course folder on Google Drive: https://drive.google.com/drive/folders/119mAP5Uua_Uuu_M5blrS_nDQ7nz3Ws3y

Assignments and Grading
During the course, you will be involved in lab-based and computational research. The computational project, which will be accomplished with your small group, will serve as the basis for your final oral research report. Each group will also host a "journal club" where you will lead the class in discussing a paper from the scientific literature that is relevant to your computational project. The lab research will be performed with another small group. Your goal is to generate reliable data from *precious* field-collected samples, and to carefully document your methods and results. You will be graded on the research output (experiments, data, lab notebook entries). In both the lab and computational research, discussion and collaboration among students is encouraged, but I will also be looking for signs of individual effort, scientific logic, and creativity.

Computational project and final report: 50%	**Laboratory Research:** 40%
Interview from the Bench: 5%	**Final Exam:** 5%

Support to Help You Succeed in This Course:

1. This course will be challenging because you will be performing original research, and you will be using computational or laboratory methods you haven't used before. For this reason, everyone in the class will struggle. Please ask questions when you do not understand something, whether that happens during lecture, journal club, or in the course of your computational or lab research. If you need help outside of the scheduled course meetings, please make an appointment with either John or Shalom.
2. Accommodations for Students with Documented Disabilities: If you are a student with a disability or believe you might have a disability that requires accommodations, please contact Disability and Access Services at (617) 353-3658 or access@bu.edu to coordinate any reasonable accommodation requests.

Academic Requirements Satisfied by the Course

1. **For Biology majors**, BI550 counts as an upper-level lab course and an upper-level elective.
2. **For Biology majors concentrating in Cell Biology, Molecular Biology and Genetics**, BI550 counts as a CMG elective.
3. **For Marine Science majors**, BI550 counts as a Marine Breadth Course.
4. **For the HUB**, BI550 supplies a HUB credit in **Teamwork/Collaboration**
    - While conducting laboratory and bioinformatic research in this course, students will collaborate with peers in small research teams under the mentorship of the instructors. These student-led groups will jointly formulate and execute research plans, conduct data analyses, and compose and deliver scientific presentations.

Community of Learning: Class and University Policies

1. **Attendance & Absences.** Attendance at all scheduled class activities is mandatory unless you have been previously excused. Your final grade will be penalized 2.5% for each unexcused absence.
2. **Assignment Completion & Late Work**. Late assignments will be penalized 5% per day late.
3. **Individual Contributions to Group Assignments.** Each member of a research team is expected to contribute substantively and equitably to the group's research and presentation. For the computational project and final presentation, the contributions of individual team members should be clearly stated.
4. **Academic Conduct Statement. Data integrity is essential to the scientific process.** It is each student's responsibility to know and understand the provisions of the Academic Conduct Code at Boston University. The Code is available online at https://www.bu.edu/academics/policies/academic-conduct-code/. Cases of suspected misconduct will be referred to the Dean of the College. If the Dean's office comes to the conclusion that cheating or plagiarism have occurred, a grade of zero will be awarded for the assignment in question.
5. **Collegiality and respect for diversity.** Treat everyone you encounter during the class (classmates, teaching fellows, instructors, staff, bystanders, etc.) with the courtesy due to professional colleagues. Refrain from intemperate language or conduct. Follow BU's policy prohibiting discrimination.* Embrace and respect the diversity of backgrounds, experiences, personalities, and perspectives that everyone brings to the course. Do your share of the work. Express your scientific views, but don't dominate the conversation. Listen as much as you talk. In the lab, keep an eye out for your colleagues' safety. Arrive on time for all course activities.
   *Boston University prohibits discrimination against any individual on the basis of race, color, religion, sex, age, national origin, physical or mental disability, sexual orientation, gender identity, genetic information, military service, pregnancy or pregnancy-related condition, or because of marital, parental, or veteran status.

SCHEDULE OF COURSE ACTIVITIES

Tuesday, January 21
- **COURSE INTRODUCTION**
- **TEST of TOOLS & CONCEPTS**
- **LECTURE 1**
  - Genomics as a Way to Characterize Marine Biodiversity

READINGS: Course Overview Handout; Lecture 1 handout;
OTHER RESOURCES: Course Overview slideshow; Lecture 1 slideshow;

Thursday, January 23
- **LECTURE 2**
  - Animal Characters & Phylogeny
- **BIOINFORMATICS RESEARCH SESSION 1**
  - Overview of Molecular Evolution Projects; Selection of Projects

READINGS: Lecture 2 handout; Lecture 3 handout; Bioinformatics Session 1 handout;
OTHER RESOURCES: Lecture 2 slideshow; Lecture 3 slideshow; Bioinformatics Session 1 slideshow;

BIOINFORMATICS RESEARCH PROJECTS — BACKGROUND READINGS:
Axial Patterning; Biomineralization *readings*; Stress *readings*; Symbiosis *readings*;

Tuesday, January 28
- **LECTURE 3**
  - The Phylum Cnidaria — Corals, Sea Anemones, Jellyfishes, Hydras & Relatives
- **BIOINFORMATICS RESEARCH SESSION 2**
  - BLAST searches of the NCBI Protein Database

READINGS: Lecture 4a handout, Lecture 4b handout, Laboratory Research Planning Session 1 handout, Bioinformatics Session 2 handout;
ADDITIONAL RESOURCES: Lecture 4a slideshow; Bioinformatics Session 2 slideshow;

Thursday, January 30
- **BIOINFORMATICS RESEARCH SESSION 3**
  - Small group meetings with Professor Finnerty. Collaborate with your small groups to compile the dataset you will use for phylogenetic and molecular evolutionary analyses.

Tuesday, February 4

- **LECTURE 5**
  - Architecture of the Genome
- **LECTURE 6**
  - Evolution of DNA Sequencing
- **BIOINFORMATICS RESEARCH SESSION 4**
  - Finish your reciprocal BLASTs and compiling your FASTA file of protein sequences.
- ***READINGS*: Lecture 5 handout, Lecture 6 handout,**

ADDITIONAL RESOURCES: Lecture 5 slideshow, Lecture 6 slideshow,

Background Reading:

- Maxam AM, Gilbert W (1977) A new method for sequencing DNA. *PNAS* **74** (2): 560–4.
- Sanger F, Nicklen S, C oulson AR (1977). DNA sequencing with chain-terminating inhibitors. *Proc. Natl. Acad. Sci. U.S.A.* **74** (12): 5463–7.
- Luckey JA, et al. (1990) High speed DNA sequencing by capillary electrophoresis. *Nucleic Acids Research*. **18**, 4417-4421.
- Shendure J, Ji H. (2008) Next-generation DNA sequencing. *Nature Biotechnology* **26**, 1135 - 1145.
- Eid J., et al. (2009) Real-time DNA sequencing from single polymerase molecules. *Science* 323: 133-138.
- van Dijk et al., (2018) The Third Revolution in Sequencing Technology. *Trends in Genetics*. 34: 666-681

Thursday, February 6

- **BIOINFORMATICS RESEARCH SESSION 5**
  - PROTOCOL: BLAST against the *Porites divaricata* transcriptome
  - PROTOCOL: Translate *Porites divaricata* transcripts
- **JOURNAL CLUB 1**
  - Hebert et al., (2003) Biological Identifications Through DNA Barcodes. Proc Roy Soc. 270:313-321
- **LABORATORY RESEARCH SESSION 1**
  - PROTOCOL: Pipetting Basics
  - PROTOCOL: DNA Isolation

READINGS:

- Bioinformatics Protocol—BLAST versus Porites divaricata transcriptome handout
- Bioinformatics Protocol—Translation of nucleotide sequences
- Hebert et al., (2003) Biological Identifications Through DNA Barcodes. Proc Roy Soc. 270:313-321
- Lab Protocol—Pipetting Basics handout
- Lab Protocol—DNA Isolation handout
- Bioinformatics Protocol—BLAST versus Porites divaricata transcriptome handout
- Protocol—Translation of nucleotide sequences

ADDITIONAL RESOURCES:

- Protocol—BLAST versus Porites divaricata transcriptome slideshow
- Protocol—Translation of nucleotide sequences
- Lab Protocol—Pipetting Basics slideshow
- Lab Protocol—DNA Extraction slideshow

- **LECTURE 4a**
  - Corals Across Habitats in Turneffe Atoll — Reef, Lagoon & Mangrove
- **LECTURE 4b**
  - Effects of Plastic Derived Chemical Pollution on an Estuarine Sentinel Species
- **LABORATORY RESEARCH SESSION 1**
  - Introduction to laboratory research projects and formation of research teams

Thursday, February 6

- **LABORATORY RESEARCH SESSION 3**
  - DNA Isolation
  - Spectrophotometric analysis of DNA purity and concentration

READINGS:

- Lab Protocol—Spectrophotometric Analysis of DNA handout

ADDITIONAL RESOURCES:

- Lab Protocol—Spectrophotometric Analysis of DNA slideshow

Tuesday, February 11

- **LABORATORY RESEARCH SESSION 4: "LAB MEETING"**
  - Review of results from DNA Extraction
- **BIOINFORMATICS RESEARCH SESSION 4**
  - PROTOCOL: Detection of conserved protein motifs using MEME

READINGS:

- Bioinformatics Protocol—Motif Detection handout

ADDITIONAL RESOURCES:

- Bioinformatics Protocol—Motif Detection slideshow
- Sample MEME input data

Thursday, February 13

- **JOURNAL CLUB 2**
  - Hebert et al., (2003) Biological Identifications Through DNA Barcodes. Proc Roy Soc. 270:313-321
- **LABORATORY RESEARCH SESSION 5**
  - PCR for DNA Barcoding

READINGS:

- Hebert et al., (2003) Biological Identifications Through DNA Barcodes. Proc Roy Soc. 270:313-321
- Protocol—PCR handout

ADDITIONAL RESOURCES:

- Protocol—PCR slideshow

Tuesday, February 18
NO CLASS — Substitute Monday Schedule

Thursday, February 20

- **LABORATORY RESEARCH SESSION 6**
  - Electrophoretic analysis of barcoding PCRs
  - Cleanup of barcoding PCR reactions

READINGS:

- Protocol—Electrophoresis handout
- Protocol—PCR cleanup handout

ADDITIONAL RESOURCES:

- Protocol—Electrophoresis slideshow
- Protocol—PCR cleanup slideshow

Tuesday, February 25

- **JOURNAL CLUB 3**
  - Scavo Lord K, Lee J, et al. (in prep) Microbiome varies by species and environment in two widespread Caribbean corals (Porites astreoides and Siderastrea siderea) from mangrove and lagoon habitats [a collaboration of students from BI550 (2021) and BI569 (2019 & 2021)]
- **LABORATORY RESEARCH SESSION 7: "LAB MEETING" / Review the Barcoding Results**
- **BIOINFORMATICS RESEARCH SESSION 5: "LAB MEETING" / Group meetings with John**

READINGS:

- Scavo Lord KS, Lee J, et al. (in prep)

Thursday, February 27

- **LECTURE 8**
  - The Coral Microbiome and tag-based metagenomic approaches
- **LABORATORY RESEARCH SESSION 8**
  - PROTOCOL: Coral/Anemone DNA Extractions
  - RESEARCH: DNA Extraction / Spectrophotometric analysis of DNA

READINGS:

- Lecture 8 handout

Tuesday, March 4

- **LABORATORY RESEARCH SESSION 9**
  - RESEARCH: Spectrophotometric analysis of DNA / 16s PCR amplification

Thursday, March 6

- **LECTURE 9.**
  - Example Bioinformatics presentation
- **BIOINFORMATICS RESEARCH SESSION 6**
  - PROTOCOL: BLAST against the *Porites divaricata* transcriptome
  - PROTOCOL: Translate *Porites divaricata* transcripts

READINGS:

- Lecture 9 handout
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ADDITIONAL RESOURCES:

- Lecture 9 slideshow
- Protocol—BLAST versus Porites divaricata transcriptome slideshow
- Protocol—Translation of nucleotide sequences

March 8 — March 16 SPRING BREAK

Tuesday, March 18

- **LABORATORY RESEARCH SESSION 10**
  - Gel electrophoresis of 16s PCR amplifications

◆ **BIOINFORMATICS RESEARCH SESSION 7**
- PROTOCOL: Use of MAST to scan sequences for previously identified motifs
- RESEARCH: Work on research project; meet with John

READINGS:
- Bioinformatics Protocol — Motif Scanning Using MAST (handout)

OTHER RESOURCES:
- Bioinformatics Protocol — Motif Scanning Using MAST (slideshow)

Thursday, March 20
Lecture 10. Molecular Evolution and the Development of Population Genomics Markers
MOLECULAR EVOLUTION PROJECTS
- Convene with your group. Meet with John.

READINGS:
- Lecture 10 handout
- Original References:
  - Origin of RFLP Approach: Potter et al. (1975) Proc Natl Acad Sci USA
  - Origin of AFLP Approach: Vos et al. (1995) Nucl Acids Res
  - Origin of RAPD Approach: Williams et al. (1990) Nucl Acids Res
  - Origin of Microsatellite Approach: Weber & May (1989) Am J Human Genetics
  - Origin of 2bRAD Approach: Wang et al (2012) Nat Methods

OTHER RESOURCES:
- Lecture 10 slideshow

Tuesday, March 25
LABORATORY & BIOINFORMATIC RESEARCH

Thursday, March 27
LABORATORY & BIOINFORMATIC RESEARCH

Tuesday, April 1
LABORATORY & BIOINFORMATIC RESEARCH

Thursday, April 3
LABORATORY & BIOINFORMATIC RESEARCH

Tuesday, April 8
LABORATORY & BIOINFORMATIC RESEARCH

Thursday, April 10
LABORATORY & BIOINFORMATIC RESEARCH

Tuesday, April 15
LABORATORY & BIOINFORMATIC RESEARCH

Thursday, April 17
LABORATORY & BIOINFORMATIC RESEARCH

Tuesday, April 22
LABORATORY & BIOINFORMATIC RESEARCH

Thursday, April 24
DATA ANALYSIS & TALK PREPARATION

Tuesday, April 29
DATA ANALYSIS & TALK PREPARATION

Thursday, May 1
TALKS and COURSE WRAP-UP