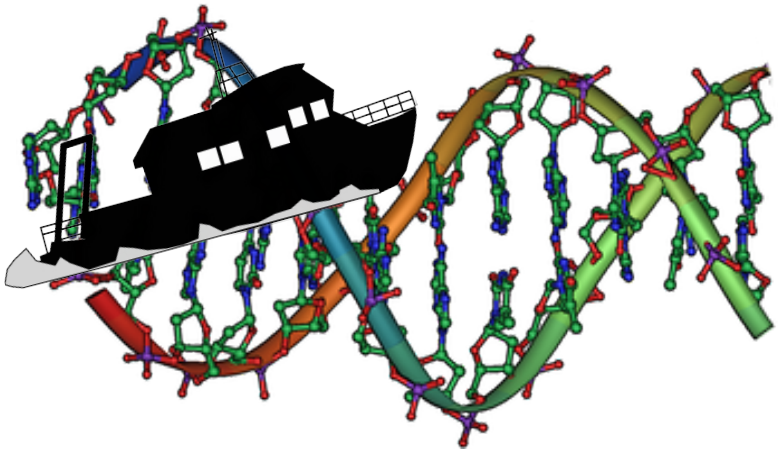
# Marine Genomics

## CAS BI 550
## Marine Semester 2017



**I. Course Description:**

Marine Genomics is a young scientific discipline that involves the application of genomic techniques to investigate the phenotype of marine organisms and the function of marine ecosystems. For example, (1) "metagenomic" approaches are now deemed essential for reconstructing 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 connection between genotype and phenotype, and the basics of population genetics. The computational portion of this course will include a bioinformatic and phylogenetic analyses of RNAs that are differentially expressed in cnidarians, such as sea anemones and corals, in response to oxidative stress. In the laboratory portion of the course, students will use "next generation sequencing" to analyze coral tissue samples collected in Belize by students participating in the Marine Semester.

**II. Training you will receive in BI550:**

Fundamentals of genome organization and architecture // molecular evolution // molecular phylogenetics // mechanisms governing gene expression and function // DNA and RNA isolation from animal tissues // amplification of DNA using the polymerase chain reaction // analysis of DNA using electrophoresis and spectrophotometry // production of libraries for "next-generation" DNA sequencing // assembly of transcriptomes and genomes // differential gene expression analysis // gene annotation // navigation and utilization of online molecular databases // bioinformatic analysis of DNA and proteins // development of scientific graphs and figures // scientific presentation //

**III. Prerequisites:** Admission to the Marine Semester and permission of instructor.

**IV. Instructors:**


| | **John R. Finnerty** | **Linda Nguyen (TF)** |
|---|---|---|
| **Office** | BRB 425 | BRB 413 |
| **Office Hours** | Mon: 9:00-10:00; Tu: 9:00-10:00 | By appointment |
| **Phone** | 353-6984 | contact via e-mail |
| **E-mail** | jrf3@bu.edu | nguyenl@bu.edu |


**V. Grading**

- During the course, you will be involved in lab-based and computational research. The computational project will serve as the basis for your final oral research report. We will also hold several "journal clubs" where we discuss papers from the scientific literature. Discussion and collaboration among students is encouraged, but I will also be looking for signs of individual effort, scientific logic, and creativity. Hard work and enthusiastic

participation will be well rewarded. 55% of your grade will be based on the computational project and final report; 30% of your grade will be based on your laboratory research. 10% of your grade will be based on class participation; 5% of your grade will be based on the final exam.

**VI. Readings**

- Selected readings from the primary & secondary scientific literature (listed by lecture).

**VII. Lecture & Laboratory Schedule**

Attendance at all lectures, collecting trips, and laboratory sessions is mandatory. Your final grade will be penalized 2.5% for each unexcused absence from a lecture or lab session.

## Tuesday, October 3

**1:00-4:00**

**Course Introduction and "Final Exam"** (testing your existing knowledge of concepts and methods you will be familiar with by the end of the course)

**Lecture 01.** Genomics as a Way to Characterize Marine Biodiversity

**Reading**:

- Lecture 1 Handout.

**Background reading (key references, but do not have read prior to lecture)**:

- Hebert, P. D., et al. (2003) "Biological identifications through DNA barcodes." Proc Biol Sci **270**: 313-321.
- Morin, P. A. et al. (2004) "SNPs in ecology, evolution and conservation." Trends Ecol Evol 19: 208-216

## Wednesday, October 4

**10:00-12:00**

**Lecture 02.** The phylum Cnidaria.

**Lecture 03.** Introduction to focal cnidarian species.

**Reading**:

- Lecture 2 Handout. The Phylum Cnidaria.
- Lecture 3 Handout. Introduction to focal cnidarian species

**1:00-4:00**

**Lab Research**

## Thursday, October 5

**10:00-11:00**

**Lecture 04**. Architecture of the genome.

**Reading**:

- Lecture 4 Handout. Architecture of the Genome.

**11:00-12:00**

**Lecture 05**. The Evolution of DNA sequencing.

**Reading**:

- Lecture 5 Handout. The Evolution of DNA sequencing.
- Shendure J, Ji H. (2008) "Next-generation DNA sequencing." *Nature Biotechnology* **26**, 1135 - 1145.

Background Reading:

- Maxam AM, Gilbert W (1977). "A new method for sequencing DNA". *Proc. Natl. Acad. Sci. U.S.A.* **74** (2): 560–4.
- Sanger F, Nicklen S, Coulson 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.

**1:30-4:00**

**Lab Research**

## Friday, October 6

**10:00-11:00**

**Lecture 06**. Gene function and expression.

**Reading**:

- Lecture 6 Handout. Gene function and expression

**Lecture 07.** Oxidative stress and Coral Bleaching.

- Lecture 7 Handout. Oxidative Stress and Coral Bleaching.
- Lesser (1997) Oxidative stress causes coral bleaching during exposure to elevated temperatures. Coral Reefs 16:187-192
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**11:00-11:45**

**Literature Research**: What genes are known to exhibit altered gene expression in response to hydrogen peroxide exposure (or other ROS) in cnidarians? other animals? non-animal models?

**1:00-4:00**

**Bioinformatics Research Planning**

- Summary of a paper on differential gene expression in response to peroxide exposure / oxidative stress.
- Compilation of a list of genes that are implicated in the oxidative stress response of animals.
- Assignment of specific genes to research groups.

**Bioinformatics Research**:

Identification of homologous genes using reciprocal BLAST searches.

## Monday, October 9

**9:00-12:00**

**Field Collection of *Nematostella vectensis* / Belle Isle Marsh, Boston**

- Collection of benthic infauna from salt marsh pools.

**2:00-5:00**

**Lab Research**

- Evaluation of field collection samples.

## Tuesday, October 10

**10:00-11:00**

**Lecture 08**. Gene function and expression.

**Reading**:

- Lecture 8 Handout. Gene function and expression

**Lecture 09**. What is a gene?

**Reading**:

- Lecture 9 Handout. What is a gene?
- Gerstein MB, et al. (2010) "What is a gene, post-ENCODE? History and updated definition." *Genome Research* **17**, 669-681.

**11:00-12:00**

**Lecture 10.** Differential response of *Nematostella vectensis* genets to peroxide exposure

**Reading**:

- Nguyen L, Friedman L, Gilmore T., Finnerty JR (in review) Intraspecific variation in oxidative stress tolerance in a model cnidarian: differences in peroxide sensitivity within and between populations of *Nematostella vectensis*.

**1:30-4:30**

**Laboratory Research**

- Establishment of clonal stocks: Bisection of anemones to induce regeneration.

## Wednesday, October 11

**10:00-12:00**

**Bioinformatics Research**:

Assembling a file of protein sequences for motif and phylogenetic analysis.

**1:30-4:30**

**Laboratory Research**

- ✦ DNA extraction from anemones.

## Thursday, October 12

**10:00-11:00**

**Lecture 11**. "Omic" analysis of gene expression.

**Reading**:

- ✦ Marioni JC, et al. (2008) RNA-seq: An assessment of technical reproducibility and comparison with gene expression arrays. *Genome Research.* **18**: 1509-1517.

**11:00-12:00**

**Literature review.**

**Reading**:

- ✦ Friedman, LE. (2014) Transcriptional response to oxidative stress in *Nematostella vectensis*. chapter 3 in *PhD Dissertation, Boston University, Department of Biology*

**1:30-4:30**

**Laboratory Research**

- ✦ Production of "RAD tags" for population genetics analysis.

## Friday, October 13

**10:00-11:00**

**Lecture 12.** Molecular responses to environmental stress

**Reading**:

- ✦ DeSalvo MK, et al. (2008) "Differential gene expression during thermal stress and bleaching in the Caribbean coral Montastrea faveolata." *Molecular Ecology* **431**, 1952-3971.

**11:00-12:00**

**Literature Review.**

**Reading**:

- ✦ Palumbi, SR, et al. (2014) "Mechanisms of reef coral resistance to future climate change." *Science* **344**, 895-898.

**1:30-4:30**

**Laboratory Research**

- ✦ Production of "RAD tags" for population genetics analysis.

## Monday, October 16

*84h Annual Marine Genomics Super-cereal Breakfast*

**10:00-12:00**

**Bioinformatics Research**:

Phylogenetic analysis & motif analysis.

**1:30-4:30**

**Laboratory Research**

- ✦ Production of library for "RNA-seq."

## Tuesday, October 17

**10:00-11:00**

**Literature review.**

**Reading**:

- Oshlack et al., (2010) From RNA-seq reads to differential expression results. *Genome Biology* **11** 220.

**11:00-12:00**

**Lecture 13.** Gene splicing: evolution, mechanism, and biological significance

**Reading**:

- Ben-Dov C, et al. (2008) "Genome-wide analysis of alternative pre-mRNA splicing." *Journal of Biological Chemistry* **283**, 1229-1233.

**1:30-4:30**

**Laboratory Research /** Production of library for "RNA-seq."

## Wednesday, October 18

**10:00-11:00**

**Lecture 14.** MicroRNAs

**Reading**:

- Chen K, Rajewsky N (2007) "The evolution of gene regulation by transcription factors and microRNAs." *Nature Reviews Genetics* **8**, 93-103.

**11:00-12:00**

**Bioinformatic Research**

Phylogenetic and motif analysis

**1:30-4:30**

**Laboratory Research /** Production of library for "RNA-seq."

## Thursday, October 19

**10:00-11:00**

**Lecture 16.** Genome complexity & organismal complexity

**Reading**:

- Peterson K, et al, (2009) "MicroRNAs and metazoan macroevolution: insights into canalization, complexity, and the Cambrian explosion." *BioEssays* **31**: 736-747.
- Cock et al., pp. 143-178; ("Metazoan Complexity")

**11:00-12:00**

**Bioinformatic Research**

Phylogenetic and motif analysis

**1:30-4:30**

**Laboratory Research /** Production of library for "RNA-seq."

## Friday, October 20

**10:00-11:00**

**Lecture 17.** Metagenomics.

**Reading**:

- Venter JC, et al. (2004) "Environmental shotgun sequencing of the Sargasso Sea." *Science* **304**, 66-74.

Supplemental Reading:

- Woyke T, et al. (2009) "Assemblling the marine metagenome, one cell at a time." *PLoS* ONE **4**, E5299.
- Frias-Lopez, et al. (2008) "Microbial community gene expression in ocean surface waters." *PNAS* **105**, 3805-3810.

**11:00-12:00**

**Bioinformatic Research**

Phylogenetic and motif analysis

**1:30-4:30**

**Laboratory Research /** Production of library for "RNA-seq."

## Monday, October 23

**10:00-11:00**

**Lecture 18.** Marine animals as microbial communities—the "holobiont" concept

**Reading**:

- Thurber RV, et al. (2009) "Metagenomic analysis of stressed coral holobionts." *Environmental Microbiology* **11**, 2148-2163.

Supplemental Reading:

- Mieog, et al. (2009) "The roles and interactions of symbiont, host, and environment in determining coral fitness." *PLoS ONE* **4**, e6364.

**11:00-12:00**

**Bioinformatic Research**

Phylogenetic and motif analysis

**1:30-4:30**

**Laboratory Research**

## Tuesday, October 24

**10:00-11:00**

**Lecture 19.** Marine origins of life and the genome?

**Reading**:

- Koonin EV, Martin W (2005) "On the origin of genomes and cells within inorganic compartments." *Trends in Genetics* **21**, 647-654.

**11:00-5:00**

Phylogenetic analysis & motif analysis. Seminar & poster preparation.

## Wednesday, October 25

**10:00-5:00**

Phylogenetic analysis & motif analysis. Seminar & poster preparation.

## Thursday, October 26

*27th Annual Marine Genomics Johnny-cake Breakfast*

**10:00-5:00**

Phylogenetic analysis & motif analysis. Seminar & poster preparation.

## Friday, October 27

**10:00-12:00**

Talks

**12:00-1:00**

Celebration

### VIII. Academic Conduct

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.