Syllabus: MARINE OMICS

Memorial University of Newfoundland

Department of Ocean Sciences

Fall Semester, 2019

Marine Omics, OCSC 4200

Lecture Room: A-1045

Lecture: Tuesday and Thursday, 12:00 – 12:50 pm; Friday 1:00 – 1:50 pm

Prerequisites for OCSC 4200: OCSC 1000 and Biology 2250 (or Biochemistry 2100), or OCSC 3002

Instructor: Matthew Rise, Ph.D., Professor, Department of Ocean Sciences, MUN
Office phone: 709-864-7478; Email: mrise@mun.ca

Office hours: My office is at the Ocean Sciences Centre (1 Marine Lab Road, Logy Bay) in the Annex Building (room AX3001 in the back of my lab). I will be available to meet with you in person in my office, or by phone or Skype, every Friday from 9 am to 11 am. I can also meet with you at other times by appointment if needed. For a rapid response via email, please contact me at the following: mrise@mun.ca

Textbook: There is no required textbook for this course. Reading assignments will be from the textbooks listed below, and from the primary literature [e.g. open access articles in peer-reviewed journals, posted on D2L (i.e. Brightspace)].

Assigned readings will come from the following books. Less than 10% of each book will be assigned reading, and copies of these assigned readings will be provided to students.

- Watson JD et al. 2007. Recombinant DNA: Genes and Genomes – A Short Course. Cold Spring Harbor Laboratory Press, New York.
- Lesk A.M. 2017. Introduction to Genomics (Third Edition). Oxford University Press. ISBN 978-0-19-875483-1
- Beaumont AR, Boudry P, and Hoare K. 2010. Biotechnology and Genetics in Fisheries and Aquaculture (Second Edition). Wiley-Blackwell. ISBN 978-1-4051-8857-9
- Benfey PN and Protopapas AD. 2005. Genomics. Pearson Prentice Hall, New Jersey. ISBN 0-13-047019-8

OCSC 4200 Course Outline, Schedule, and Method of Evaluation

Omics technologies (e.g. genomics, transcriptomics, proteomics, lipidomics) have a profound influence on ocean science research. This course will build on the foundation of introductory biology and genetics, and provide students with information on the theory and application of omics technologies to studies involving marine organisms. Marine Omics (OCSC 4200) is a lecture-based course. Topics to be discussed include:

- Nucleic acids sequencing technologies (e.g. Illumina, PacBio, others) with marine applications
- Sequenced genomes of marine organisms
    - Marine genome editing (CRISPR-Cas9): guest lecture
- Transcriptomics: methods and marine applications
    - RNA sequencing (RNA-seq) techniques and marine applications
    - Microarray techniques: guest lecture
    - Transcriptomics applications in ocean sciences [e.g. aquaculture transcriptomics (e.g. fish, shellfish, algae)]
- Marine bioinformatics (guest lecturers)
- Marine protist genomics
- Marine model species genomics (e.g. sea urchin, cnidaria)
- Marine symbiont omics
- Marine algal omics
- Environmental omics (including eDNA applications in marine environments)
- Marine toxicogenomics
- Marine metagenomics and bioprospecting
- Ocean acidification omics
- Proteomics, lipidomics and metabolomics: methods and marine applications
    - NMR techniques and marine applications: guest lecture
    - Mass spectrometry techniques and marine applications: guest lectures

Background theory on omics techniques will be provided in lectures. The lectures will be based primarily on the content of the assigned reading. Open access papers in peer-reviewed journals that demonstrate the application of omics techniques in ocean sciences research will be placed in “Course Content” on the Desire 2 Learn (D2L) web site as assigned reading, and students will be required to write a summary on one of these papers approximately every two weeks.

Course Schedule

- Note: Research articles that are included as assigned reading are **Open Access** papers. You can access these papers by querying PubMed with key words (e.g. author surnames) or from the journal home pages.
- The web site for PubMed is: http://www.ncbi.nlm.nih.gov/pubmed/

During each week of the semester, we will cover topics from the text books and other assigned readings. (Note: Additional assigned readings, including the papers for written critiques, will be posted on D2L.) Topics to be covered include:

Week 1 (Sept. 5, 6):	Brief review of the principles of genetics and molecular biology. Review: What is a gene/genome? What is a transcript/transcriptome? What is a protein/proteome? What is a lipid/lipidome? What is a metabolite/metabolome?
Assigned reading:	Introduction to Genomics (Lesk 2017) pages 4-7 Review of DNA structure; gene structure; mitochondria. Genomics (Benfey and Protopapas) pages 33-45 (Technical Foundations of Genomics: genomic and cDNA libraries; hybridization, Northern blot)
Marine Omics application:	Eslamloo et al. 2019; Inkpen et al. 2019 (cod genes) cDNA library paper(s): To Be Announced (TBA); marine organism mitochondrial genome paper (TBA).

Guest lecture Sept. 6: Dr. Chris Parrish (Department of Ocean Sciences): Biomolecules in the Sea.

Week 2 (Sept. 10, 12, 13):	Omics techniques (nucleic acids) part 1: molecular techniques used to characterize genes and transcripts in marine organisms (e.g. cloning, PCR, qPCR, electrophoresis, Sanger sequencing); examples of gene identification studies in marine organisms.
Assigned reading:	Genomics (Benfey and Protopapas 2005) pages 46-61 Technical Foundations of Genomics Recombinant DNA (Watson et al. 2007): Fig. 4-12 (Sanger sequencing) and Fig. 6-6 (Topo TA cloning)
Marine Omics application:	cDNA library papers for gene discovery in marine species; expressed sequence tag (EST) studies in marine species (TBA – papers to be placed on D2L)

- The first paper for 2-page written critique will be assigned on September 10th.

Week 3 (Sept. 17, 19, 20): Omics techniques (nucleic acids) part 2a: Genetic maps; DNA structure; Sequencing technologies from Sanger sequencing to Next-Generation Sequencing (NGS, e.g. Illumina, pyrosequencing, PacBio, Ion Torrent).

Assigned reading: Introduction to Genomics (Lesk 2017) pages 99-117 (Genetic maps; DNA structure; Sanger sequencing; Bacterial Artificial Chromosomes (BACs).

Marine Omics application: Genetic map papers involving marine species (TBA); BAC library papers involving marine species (TBA – papers to be placed on D2L).

.

- The first 2-page written critique is due on **September 20th**.

Week 4 (Sept. 24, 26, 27): Omics techniques (nucleic acids) part 2b: Fundamentals of Whole Genome Sequencing

Assigned reading: Recombinant DNA (Watson et al. 2007): pages 249-289 (BAC map-based versus shotgun sequencing of whole genomes; BAC fingerprinting; BAC maps; sub-clone libraries; review of Sanger sequencing; Phred; large-insert cloning systems.

Marine Omics application: BAC library resources for various marine species (TBA); Physical maps of various marine species (TBA – papers to be placed on D2L).

- Echinoderm genomes
- Marine algal genomes
- Marine fish genomes (e.g. aquaculture relevant)

- The second paper for 2-page written critique will be assigned on September 24th.

Wk 5 (Oct. 1, 3, 4): Omics techniques (nucleic acids) part 2c: NGS [Next Generation Sequencing, e.g. Illumina, pyrosequencing (454), PacBio, Ion Torrent]; examples of DNA sequencing based studies in marine organisms.

Assigned reading: Introduction to Genomics (Lesk 2017) pages 118-133 (Roche 454; Illumina; Ion Torrent; PacBio; Nanopore; databases; expressed sequence tags (ESTs).

Marine Omics applications:

- Marine environmental genomics (e.g. eDNA)
- Marine metagenomics and bioprospecting
- Marine applications of PacBio sequencing
- Marine applications of Illumina sequencing
- Marine applications of 454 pyrosequencing

- The second 2-page written critique is due on **October 4th**.

Midterm Exam 1 (October 4th)

Week 6 (Oct. 8, 10, 11): Marine Transcriptomics: techniques (e.g. microarrays, RNA sequencing) and marine applications

Assigned reading: Genomics (Benfey and Protopapas 2005) pages 124-144 (RNA Expression Analysis)

Additional readings on RNA sequencing (RNA-seq): TBA – papers to be placed on D2L

Marine Omics applications:

- Marine symbiosis transcriptomics
- Echinoderm developmental transcriptomics
- Ocean acidification related transcriptomics
- Marine aquaculture related transcriptomics

- The third paper for 2-page written critique will be assigned on October 8th.

October 11: Guest lecture on Marine Aquaculture RNA-seq and Bioinformatics

Week 7 (Oct. 17, 18): Aquaculture Omics: techniques and applications

NOTE: No lecture on October 15th due to Thanksgiving Holiday.

- **Papers for student oral presentations will be assigned by October 17th.**

Assigned reading: Biotechnology and Genetics in Fisheries and Aquaculture (Beaumont et al. 2010) pages 129-143 (From genetics to genomics) [Aquaculture species linkage maps (i.e. genetic maps), BAC-based physical maps, fluorescence in situ hybridization (FISH), whole genome sequencing, quantitative trait locus (QTL) mapping, marker-assisted selection (MAS), and transcriptomics]

Marine Omics applications (assigned readings TBA – papers to be placed on D2L):

- Aquaculture species genetic and physical maps
- Aquaculture QTL studies
- Genome-wide association studies (GWAS)

- The third 2-page written critique is due on **October 18th**.

Week 8 (Oct. 22, 24, 25): Comparative Genomics

Assigned reading: Introduction to Genomics (Lesk 2017) pages 234-245 (DNA barcoding; sizes of genomes; duplication of genes; K_a/K_s; orthologues and paralogues)

Assigned reading: Recombinant DNA (Watson et al. 2007) pages 311-329 (Comparing and Analyzing Genomes: databases; sequence similarity; protein domains; orthologues and paralogues; sequence alignments; BLAST; synteny).

Marine Omics applications (assigned readings TBA – papers to be placed on D2L):

- Marine eDNA (environmental DNA) applications
- Salmon genomes: models for comparative genomics
- Genome duplication events: evolution of marine genomes

- The fourth paper for 2-page written critique will be assigned on October 22nd.

Wk 9 (Oct 29, 31; Nov. 1): Marine proteomics techniques and applications

Assigned reading: Genomics (Benfey and Protopapas 2005) pages 231-244 [Proteomics: 2-D gel electrophoresis; mass spectrometry (MS); liquid chromatography – tandem mass spectrometry (LC-MS/MS)]

Marine Omics applications (assigned readings TBA – papers to be placed on D2L):

- Marine drugs: supported using proteomics and transcriptomics
- Proteomics to study marina animal responses to environmental stressors
- Proteomics to study development of marine animals
- Aquaculture proteomics studies

Midterm Exam 2 (November 1st)

- The fourth 2-page written critique is due on **November 1st.**

Week 10 (Nov. 5, 7, 8): Marine proteomics and lipidomics

Assigned reading: TBA (papers to be posted on D2L)

November 5: Guest lecture on NMR techniques and marine applications

November 7 and 8: Guest lectures on lipidomics techniques applied to marine sciences

Note: Information in all guest lectures will be included in the Final Exam.

- The fifth paper for 2-page written critique will be assigned on November 5th.

Week 11 (Nov. 12, 14): Topics in Marine Omics

November 12: Guest lecture on Marine Aquaculture Transcriptomics

November 14: Guest lecture on Marine Fish Transcriptomics and microRNA (miRNA)

Note: Information in all guest lectures will be included in the Final Exam.

Assigned reading: TBA (papers to be posted on D2L)

- The fifth 2-page written critique is due on **November 14th**.

NOTE: No lecture on November 15th as lectures follow the Monday schedule.

Wk 12 (Nov. 19, 21, 22): Student presentations will occur during the lecture times this week.

Wk 13 (Nov. 26, 28, 29): Additional topics in marine omics; guest lectures.

Assigned reading: TBA (papers to be posted on D2L)

November 26: Guest lecture on CRISPR-Cas9 genome editing techniques and marine applications

November 28: Guest lecture on genomic approaches to assess impact of escaped farm salmon on wild salmon populations

Note: Information in all guest lectures will be included in the Final Exam.

Other Topics in Marine Omics:

- Marine toxicogenomics/toxico-omics

Final Exam: Date and location to be announced.

Assignments: Written Critiques

Each student will be required to write a 2-page (double-spaced) critique of one open-access marine omics-related paper approximately every two weeks (see "5 assignments" below). Each student must work independently on these written critiques. They are not group assignments.

The 5 assignments (i.e. written critiques of marine omics related articles) will be evaluated based on the following criteria:

- Summary (i.e. overview) of the paper (including hypotheses/objectives, methods, experimental design, primary results, and conceptual advancement);
- Outline and justify strengths and weaknesses of different parts of the paper (e.g. abstract, introduction, methods, results, discussion, conclusions), including comments on the organization and writing quality/style;
- The quality of your writing (e.g. grammar, spelling, sentence structure, organization, etc) will also be evaluated.

Finally, each student will give a Powerpoint presentation on an **open access paper in the field of Marine Omics** (see "Student presentation" below). Guidelines for the student presentations will be provided in class. The articles for these presentations will be assigned by October 17th, and student presentations will occur during the lecture times on November 19th, 21st, and 22nd.

OCSC 4200 Evaluation		
	Midterm Exam 1 (in Week 5):	20%
	Midterm Exam 2 (in Week 9):	20%
	Comprehensive Final Exam:	30%
	5 assignments (5% each):	25%
	Student oral presentation:	5%
	Total:	**100%**

The following statement is in regard to Memorial University's commitment to accommodation of students with disabilities:
"Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within the scope of the University Policies for the Accommodations for Students with Disabilities (www.mun.ca/policy/site/policy.php?id=239). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity (www.mun.ca/blundon)."

The following statement is in regard to Memorial University's policy on academic integrity:
"Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar."