Syllabus: MARINE OMICS

Memorial University of Newfoundland
Department of Ocean Sciences
Fall Semester, 2020

Marine Omics, OCSC 4200

- This course will be delivered remotely this semester due to COVID-19.

Lectures: Asynchronous (Powerpoint files with recorded audio for each slide; lectures posted on Brightspace)

- ~ 3 lectures with recorded audio (~ 50 minutes each lecture) will be posted on Brightspace each week.

- Assigned readings will be posted on Brightspace to complement the lectures.

- It will be helpful if you can keep up with the material (i.e. assigned readings and lectures on Brightspace) and not fall behind.

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 and class meetings: Fridays from 1 pm to 3 pm (except for October 2) will be set aside for office hours and other “in-person” aspects of this course. If there are class meetings (e.g. discussions or tutorials), they will be scheduled for Fridays between 1 pm and 2 pm (i.e. a regular meeting time for OCSC 4200 in past years); notification of a class meeting will be sent out to all students by Brightspace email several days in advance. Class meetings will be via Zoom or WebEx (with links sent to students via Brightspace email), and office hours will be by appointment (and using Zoom, WebEx, Skype or phone). My office hours can be extended 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 Brightspace).

Assigned readings will come from the following books. Less than 10% of each book will be assigned reading, and reading assignments will be posted on Brightspace.


**OCSC 4200 Course Outline, Schedule, and Method of Evaluation**

Omics technologies (e.g. genomics, transcriptomics, proteomics, lipidomics) have a profound influence on ocean sciences 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 – applications in ocean sciences
- Transcriptomics: methods and marine applications
  - RNA sequencing (RNA-seq) and DNA microarray techniques
  - Transcriptomics applications in ocean sciences [e.g. aquaculture transcriptomics (e.g. fish, shellfish, algae); transcriptomics-based studies of marine organism responses to environmental stressors]
- Marine symbiont 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

Background theory on omics techniques will be provided in lectures. 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 Brightspace as assigned reading, and students will be required to write a two-page critique (double-spaced) 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; key words in titles) or from the journal home pages.
- **Note:** Information in all guest lectures will be included in the Take-home Exams.

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

**Week 1 (Sept. 9-11):**
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: Gene structure and cDNA library paper(s): To Be Announced (TBA); marine organism mitochondrial genome paper (TBA).

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

**Week 2 (Sept. 14-18):**
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 Brightspace)

- The first paper for 2-page written critique will be assigned on **September 15th**.
**Week 3 (Sept. 21-25):** 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 Brightspace).

- The first 2-page written critique is due on **September 25**th.

**Week 4 (Sept. 28-Oct. 2):** 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). For example:

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

- The second paper for 2-page written critique assigned on **September 29**th.

**Week 5 (Oct. 5-9):** 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 include:

- 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
Take-home Midterm Exam 1:

- Posted on Brightspace October 5th
- Due 2 pm October 9th (Send to Dr. Rise via Brightspace email.)

Week 6 (Oct. 12-16): Marine Transcriptomics: techniques [e.g. microarrays, RNA sequencing (RNA-seq)] and marine applications

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

Additional readings on RNA-seq: TBA – papers to be placed on Brightspace

Marine Omics applications include:

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

- The second 2-page written critique is due on October 15th.
- The third paper for 2-page written critique will be assigned on October 15th.
- NOTE: Due to Thanksgiving Holiday, only 2 lectures will be posted on Brightspace this week.

Week 7 (Oct. 19-23): Aquaculture Omics: techniques and applications

- Papers for student presentations will be assigned by October 20th.

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 placed on Brightspace):

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

- The third 2-page written critique is due on October 23rd.
**Week 8 (Oct. 26-30):** Comparative Genomics

Assigned reading: Introduction to Genomics (Lesk 2017) pages 234-245 (DNA barcoding; sizes of genomes; duplication of genes; 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 placed on Brightspace):

- 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 27th**.

**Week 9 (Nov. 2-6):** 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 placed on Brightspace):

- 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

**Take-home Midterm Exam 2:**

- Posted on Brightspace November 2nd.
- Due 2 pm November 6th (Send to Dr. Rise by Brightspace email.)

**Week 10 (Nov. 9-13):** Marine proteomics and lipidomics

Assigned reading: TBA (papers to be posted on Brightspace)
Guest lectures on lipidomics techniques applied to marine sciences from Dr. Christ Parrish (MUN Department of Ocean Sciences)

- The fourth 2-page written critique is due on **November 10th**.
- The fifth paper for 2-page written critique will be assigned on **November 10th**.

**Week 11 (Nov. 16-20):** Topics in Marine Omics

- Guest lectures on Marine Aquaculture Transcriptomics

**Note:** Information in all guest lectures will be included in the Take-home Exams.

Assigned reading: TBA (papers to be posted on Brightspace)
- The fifth 2-page written critique is due on **November 20th**.

**Week 12 (Nov. 23-27):** Student presentations (Powerpoint and text files for selected articles) posted on Brightspace this week. Please review all student presentations. Content from student presentations will be included on the Take-home Final Exam.

**Week 13 (Nov. 30 - Dec. 4):** Additional topics in marine omics; guest lectures.

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

Other topics to be considered:
- Marine toxicogenomics/toxico-omics
- CRISPR-Cas9 genome editing techniques and marine applications

**Note:** Information in all guest lectures will be included in the Take-home Final Exam.

**Take-home Final Exam:** Posting and due dates to be announced.
Assignments: Written Critiques

Each student is required to write a 2-page (double-spaced) critique of one open-access marine omics-related article approximately every two weeks (see “5 assignments” below, and page 10 of this document). Students may choose between two or three options (placed on Brightspace) for each article critique. 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);
- **Analysis/evaluation**: 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;
- **Organization/quality of writing** (e.g., grammar, spelling, sentence structure, organization, etc).
- **For additional details on critique guidelines, please see page 10 of this document.**

Finally, each student will create a Powerpoint presentation on an open access paper in the field of Marine Omics (see “Student presentation” below); this will be accompanied by a Doc file that provides a script (i.e., text of what you would say about each slide if you were giving an oral presentation). Guidelines for the student presentations will be provided on Brightspace. The articles for these presentations will be assigned by **October 20th**, and student presentations should be submitted to Dr. Rise via Brightspace email by **November 23rd**. Student presentations will be posted on Brightspace, and content from these presentations will be included on the Final Exam.

**OCSC 4200 Evaluation**

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<tr>
<th>Assessment</th>
<th>Percentage</th>
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<tr>
<td>Take-home Midterm Exam 1 (Week 5):</td>
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<tr>
<td>Take-home Midterm Exam 2 (Week 9):</td>
<td>20%</td>
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<tr>
<td>Take-home Final Exam (Date TBA):</td>
<td>25%</td>
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<tr>
<td>5 assignments (5% each):</td>
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<tr>
<td>Student presentation:</td>
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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.”
How written critiques of articles are evaluated (10 points total per critique)

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**Length of critique:** 2 pages double-spaced

**Summary (4 points out of 10)**

Expected: a brief, accurate outline of the general subject/problem/research and its central idea, including a summary of the major findings and conclusions. Key omics methods utilized in the research should be mentioned. This section should be approximately one page double-spaced.

**Analysis/Evaluation (4 points out of 10)**

This component of the grade is based on how you analyzed the various parts of the paper to assess its strengths and weaknesses (accounting for your level of knowledge). Considering both strengths and weaknesses generally allows a more thorough and more persuasive critique by presenting a balanced view. The grade is based on the following criteria: the variety of aspects you analyzed and critiqued (coverage, 1 point), your ability to find and present both strengths and weaknesses (balance, 1 point), and how well you supported your arguments (2 points). This section should be approximately one page double-spaced.

Some questions you might consider (of course, not all are appropriate for every paper):

- Did the title adequately convey the main subject or message of the paper?
- What was the main objective/purpose of the research, study or work? Did the author(s) meet this objective?
- As far as you know, did the paper describe new work, new results, or a new theory or interpretation? Or did the paper provide valuable confirmation of previously published information?
- Were the different sections of the article well balanced? Did the paper read well?
- Were the methods sufficiently detailed to understand or replicate the study? How adequate were the methods and the controls used?
- Who was the intended audience? Was the writing style appropriate for this audience?
- Did the author(s) properly define any jargon they used?
- Were illustrations, tables or figures used to good effect? Did they complement the text? Were they the best method to present data or were they unnecessary or overly complex?
- Were the conclusions justified? Was interpretation adequate, or perhaps not fully warranted by the data (e.g. important omissions or loose generalization).
- Did the author(s) suggest areas for further research or discussion?
- What was the size of the reference section? Were recent references included? Were references used for both support and rebuttal? Was proper respect given to pioneer work on the topic?
- What did you take out of this paper? Any suggestions for future work in this field?

**Organization (2 points out of 10)**

Critical reviews should be coherent and allow the reader to go smoothly from one part to another and follow your arguments. You do not necessarily need to use formal sections or subheadings; more importantly, transitions between sentences and paragraphs must provide logical flow.

**Typos/grammatical errors**

2-5: -0.25 of a point  
5-10: -0.5 of a point  
>10: -0.75 of a point