University of Guelph
College of Biological Science
Department of Molecular and Cellular Biology
COURSE OUTLINE

Genomic Methods for Bioinformatics (BINF*6110)
Winter, 2018

Teaching team

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RNA-Seq
Please, prior to March 1, apply for a SHARCNET account. More instructions will be provided in class before then.
Please send your SHARCNET username to Elie via email.
If you are using a computer with a Windows operating system, you will need to install PuTTY (http://www.chiark.greenend.org.uk/~sgtatham/putty/) and WinSCP (https://winscp.net/eng/index.php) prior to the first RNA-seq class (you will need these to access Sharcnet and transfer files between Sharcnet and your computer).
Please bring a laptop to all sessions. Please also install R (https://www.r-project.org/) on your computer.

Course schedule
Lectures: **Thursdays, 1:30 – 4:20 PM   SSC 2315**

Learning goals and rationale
        Overall, it is our objective for students to be able to generate information about their gene of interest using genomics related databases, use the tools to analyze large datasets such as RNA-seq, and use the tools to analyze protein structure datasets.

By the end of the course, students should be able to:
1) Explain the different types of information that can be obtained from a genome project.
2) Understand the tools in use to generate genomic data.
3) Integrate different databases, such as a genome browser and its associated databases (e.g. Human Genome Browser, Ensembl) with other databases (e.g. Genbank), and synthesize the various elements displayed in these databases.
4) Apply information gathered from various databases to a region of interest.
5) Understand methods to manipulate genomes.
6) Use the UNIX command-line to run basic commands.
7) Manage large biological datasets such as RNA-Seq.
8) Use tools to analyze RNA-Seq data to identify differentially expressed genes and test a biological hypothesis.
9) Understand protein structure and the representation of protein structures.
10) Use online and command-line tools to analyze protein structures.

Course Resources

The following textbooks, which will be on reserve in the library:

Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, by A. Malcolm Campbell and Laurie J. Heyer

Genomes 3, T.A. Brown

The readings are meant to help those students with a weaker biochemistry background.

Protein structures: Any introductory biochemistry textbook that discusses amino acids, protein sequences, secondary and tertiary structure.

X-ray crystallography:
http://chemwiki.ucdavis.edu/Analytical_Chemistry/Instrumental_Analysis/Diffraction/X-ray_Crystallography
Protein NMR review:
Barrett, P. J. et al. The Quiet Renaissance of Protein Nuclear Magnetic Resonance. Biochemistry 52, 1303–1320 (2013).

Course Content
This course will be run using CourseLink.

Major course components:
1) Lecture

2) Assignments

Tentative Schedule

Week	Topics Covered in Lecture (Subject to Change)
1 January 8th	What constitutes a genome? Structure of the Human Genome Genome Analysis Databases
2 January 15th	Genome Assembly Comparative Genomics Genomic Web Servers Databases continued
3 January 22nd	Functional Genomics Methods for Functional Analysis Chromatin Epigenomics Gene Editing
4 February 1st	A Brief Introduction to Protein Structure and Methods Amino acids, secondary and tertiary structure X-ray crystallography, Protein NMR
5 February 8th	Protein Sequence Bioinformatics Pairwise alignment, multiple-sequence alignment, motif discovery
6 February 16th	Protein Structure Bioinformatics 1 Visualization of protein structures Aligning protein structures Fold identification
February 19-23th	Reading Week – no classes
7 March 1st	Protein Structure Bioinformatics 2 Docking proteins to ligands Modelling protein structures
8 March 8th	Introduction to the UNIX command-line/BIO-tour (tentative)
9 March 15th	Introduction to mRNA Biology and RNA-Seq Quality Control and Assessment of RNA-seq
10 March 22nd	Aligning sequences and mapping reads to a genomic sequence Finding and Using Reference Genomes
11 March 29th	Review of genes, isoforms and splice variants Quantification of mRNA using RNA-Seq data

12 April 5th	Understanding Biology using Gene Ontology Identification of genes with shared biological roles

Methods of Assessment

Assessment				
Form of Assessment	Weight of Assess-ment	Due Date of Assessment	Course Content /Activity	Learning Outcome Addressed
Assignment #1	5%	January 18th	Lecture and Tutorial	2,3
Assignment #2	10%	January 25th	Lecture and Tutorial	1,2,3,4
Assignment #3	10%	February 1st	Lecture and Tutorial	1,2,3,4,5
Structure Representation	10%	March 1st	Lecture and Tutorial	9, 10
Structure Alignment	15%	March 15th	Lecture and Tutorial	9, 10
Courselink Quizzes	10%	TBD	Lecture and Tutorial	6, 7, 8
RNA-Seq Project	40%	TBD	Lecture and Tutorial	6, 7, 8

Assignment #1

Here you will use some basic Graphical User Interface (GUI, pronounced Gooey) tools to analyze some DNA that you will be provided. This will introduce you to the numerous databases that exist that contain information about the sequence.

Assignment #2

Students will assemble a bacterial genome from Illumina PE reads.

Assignment #3

Students will use genomic webservers to explore regulatory features in the human genome.

RNA-Seq Project: Analysis of RNA-Seq data for differential expression. You will be provided with raw read counts, and you will be assigned a research hypothesis. You will perform analyses on data to identify differentially expressed genes using edgeR and DESeq2, which are two R packages. You will then use a

variety of tools to identify the genes (or groups of genes) that pertain to your research hypothesis. Be sure to place your findings in the context of established biology, and describe how your findings relate to other relevant work in the field. Your paper should be no more than 15 pages, double-spaced not including figures and references, and should follow standard journal format (Abstract, Introduction, Materials & Methods, Results, Discussion, References) with figures attached at the back of the document.

Software used:
Software used:
FastQC:
Andrews S: FASTQC. A quality control tool for high throughput sequence data. [http://www.bioinformatics.bbsrc.ac.uk/projects/fastqc/].

STAR:
Dobin A, Davis CA, Schlesinger F, Drenkow J, Zaleski C, Jha S, Batut P, Chaisson M, Gingeras TR. STAR: ultrafast universal RNA-seq aligner. Bioinformatics 2013, 29:15-21.

FeatureCounts:
Liao Y, Smyth GK, Shi W. featureCounts: an efficient general purpose program for assigning sequence reads to genomic features. Bioinformatics 2014, 30:923-30.

EdgeR:
Robinson, M.D., McCarthy, D.J., and Smyth, G.K. EdgeR: a Bioconductor package for differential expression analysis of digital gene expression data. Bioinformatics 2010, *26*: 139–140.

DESeq2:
Love MI, Huber W, Anders S. Moderated estimation of fold change and dispersion for RNA-seq data with DESeq2. Genome Biology 2014, 15:550

Cytoscape:
Cline MS, Smoot M, Cerami E, Kuchinsky A, Landys N, Workman C, Christmas R, Avila-Campilo I, Creech M, Gross B, Hanspers K, Isserlin R, Kelley R, Killcoyne S, Lotia S, Maere S, Morris J, Ono K, Pavlovic V, Pico AR, et al. Integration of biological networks and gene expression data using Cytoscape. Nat Protoc 2007, 2:2366-82.

PANTHER:
Mi H, Muruganujan A, Thomas PD. PANTHER in 2013: modeling the evolution of gene function, and other gene attributes, in the context of phylogenetic trees. Nucleic Acids Res. 2013, 41:D377-86.

Structure Representation Assignment:
Students will learn how to obtain protein structure files from the PDB database (http://rcsb.org) and to show key structural features of proteins.

Software used:
Pymol: http://www.pymolwiki.org/index.php/Main_Page
Structure Alignment Assignment:
A central dogma of biochemistry is that the sequence of a protein determines its structure, which in turn determines its function. Often the structural conservation occurs even after sequence conservation is no longer obvious. In this assignment you will align a family of functionally related proteins and create figures to highlight their similarity and differences.

Software used:
Dalilite: http://ekhidna.biocenter.helsinki.fi/dali_lite/start

Course and University Policies

When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course coordinator in writing, with your name, id#, and e-mail contact, and be prepared to provide supporting documentation. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Late assignments will be penalized 10 percentage points for every 24 hour period starting at 00:01 AM on the day after the assignment is due. Assignments will not be accepted after 5 days. If there is a valid reason why this cannot be achieved see below for the university guidelines.

Accessibility

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability or a short-term disability should contact Student Accessibility Services (and Centre for Students with Disabilities) as soon as possible.

For more information, contact Student Accessibility Services at 519-824-4120 ext. 56208 or email mailto:csd@uoguelph.ca or see the website:
http://www.csd.uoguelph.ca/csd/

Academic Misconduct
The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community – faculty, staff, and students – to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

E-mail Communication
As per university regulations, all students are required to check their <mail.uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

Drop Date
The last date to drop one-semester courses, without academic penalty, is the 40th class day. To confirm the actual date please see the schedule of dates in the Undergraduate Calendar. For regulations and procedures for Dropping Courses, see the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Copies of out-of-class assignments
Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

Recording of Materials
Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Campus Resources

The Academic Calendar is the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs:
http://www.uoguelph.ca/registrar/calendars/index.cfm?index

If you are concerned about any aspect of your academic program:

- make an appointment with a program counsellor in your degree program. http://www.bsc.uoguelph.ca/index.shtml or https://www.uoguelph.ca/uaic/programcounsellors

If you are struggling to succeed academically:

- There are numerous academic resources offered by the Learning Commons including, Supported Learning Groups for a variety of courses, workshops related to time management, taking multiple choice exams, and general study skills. You can also set up individualized appointments with a learning specialist. http://www.learningcommons.uoguelph.ca/

If you are struggling with personal or health issues:

- Counselling services offers individualized appointments to help students work through personal struggles that may be impacting their academic performance. https://www.uoguelph.ca/counselling/
- Student Health Services is located on campus and is available to provide medical attention. https://www.uoguelph.ca/studenthealthservices/clinic
- For support related to stress and anxiety, besides Health Services and Counselling Services, Kathy Somers runs training workshops and one-on-one sessions related to stress management and high performance situations. http://www.uoguelph.ca/~ksomers/

If you have a documented disability or think you may have a disability:

Student Accessibility Services (formerly Centre for Students with Disabilities) can provide services and support for students with a documented learning or physical disability. They can also provide information about how to be tested for a learning disability. For more information, including how to register with the centre please see: