

BIOINF 525 Winter 2016
Foundations of Bioinformatics and Systems Biology
<http://tinyurl.com/bioinf525-w16>

Course Director: Dr. Barry Grant (DCM&B, bjgrant@med.umich.edu)

Description: This is a three module course covering (1) *Foundations of Bioinformatics*, (2) *Statistics in Bioinformatics*, and (3) *Systems Biology*. Each module is 1 credit and should be registered for separately.

Module 1:	January 12 – February 5	(four lectures and four labs).
Module 2:	February 9 – March 18	(five lectures and five labs).
Module 3:	March 22 – April 15	(four lectures and four labs).

Schedule: In addition to Tuesday lectures students should attend one lab session per week. Please note that students must register under either the Thursdays or Fridays lab session they wish to attend.

Lectures: Tuesdays 2:30 - 4:00 PM, Rm. 2062 Palmer Commons Bldg.

Labs: 2:30 – 4:00 PM Thursdays (**Session I**) or
10:30 - 12:00 PM Fridays (**Session II**).
Rm. 2036 Palmer Commons Bldg.

Prerequisites: A familiarity with basic biomedical concepts and basic knowledge of computer usage. No programming skills are needed. You should bring your own wifi enabled laptop to lectures to fully benefit from the hands-on components of each lecture.

Grading: Satisfactory/unsatisfactory grading will be based on a combination of lecture and lab involvement together with weekly homework and quiz assignment performance.

Module 1 (1 credit): **Foundations of Bioinformatics**

Module 1 Director: Dr. Barry Grant (DCM&B, bjgrant@med.umich.edu)

Bioinformatics is driving the collection, analysis and interpretation of big data for biomedicine and the biosciences. This module provides an introduction to practical issues of computer-based handling and interpretation of biomolecular and genomic datasets. We specifically target bioinformatics software and data resources freely available on the Internet.

Lecture (1-1): ***Introduction to bioinformatics***

Instructor: Dr. Barry Grant

Time: Jan 12 (Tuesday), 2:30 - 4:00 PM

Topics:

What are bioinformatics and computational biology? Major NCBI and EBI bioinformatics resources. How do we actually do bioinformatics? Major areas of research and application.

Lab (1-1): **Bioinformatics databases and major online resources**

Instructor: Dr. Barry Grant

Time: 2:30 – 4:00 PM, Jan 14 (Thursday) or Jan 15, 10:30 - 12:00 PM, (Friday)

Topics:

The purpose of this lab session is to introduce a range of core bioinformatics databases and associated online services whilst investigating the molecular basis of several common human disease.

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Lecture (1-2): *Sequence alignment and database searching*

Instructor: Dr. Barry Grant

Time: Jan 19 (Tuesday), 2:30 - 4:00 PM

Topics:

Homology and sequence alignments, Dynamic programming, Sequence similarity and database searching, Interpreting search results – E value, Needleman and Wunsch, Smith and Waterman, The BLAST algorithm.

Lab (1-2): *Sequence alignment algorithms and applications*

Instructor: Dr. Barry Grant

Time: 2:30 – 4:00 PM, Jan 21 (Thursday) or Jan 22, 10:30 - 12:00 PM, (Friday)

Topics:

Aligning novel sequences with previously characterized genes or proteins provides important insights into their common attributes and evolutionary origins. In this lab session we will explore the principles underlying the computational tools that can be used to compute and evaluate sequence alignments.

Lecture (1-3): *Structural bioinformatics*

Instructor: Dr. Barry Grant

Time: Jan 26 (Tuesday), 2:30 - 4:00 PM

Topics:

Major goals, current research challenges, and application areas of structural bioinformatics. Key concepts covered include: Sequence-structure-function relationships; Energy landscapes; Physics and knowledge based modeling approaches for describing the structure, energetics and dynamics of biomolecules computationally.

Lab (1-3): *Protein structure visualization, analysis and small molecule docking*

Instructor: Dr. Barry Grant

Time: 2:30 – 4:00 PM, Jan 28 (Thursday) or Jan 29, 10:30 - 12:00 PM, (Friday)

Topics:

The RCSB PDB resource. Interactive biomolecular structure visualization with VMD. Structural analysis of protein families and prediction of protein flexibility with Bio3D. *In silico* docking and virtual screening strategies for drug design.

Lecture (1-4): *Genome informatics*

Instructor: Dr. Ryan Mills

Time: Feb 2 (Tuesday), 2:30 - 4:00 PM

Topics:

High throughput sequencing technologies, biological applications and bioinformatics analysis methods. Web interfaces to genome databases at Ensembl and UCSC.

Lab (1-4): *Web resources for analyzing genomic data*

Instructor: Drs. Ryan Mills and Barry Grant

Time: 2:30 – 4:00 PM, Feb 4 (Thursday) or Feb 5, 10:30 - 12:00 PM, (Friday)

Topics:

The Galaxy web-based platform for genomic data analysis. Manipulation and analysis of next generation sequencing data sets.

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Module 2 (1 credit): **Introduction to Statistics in Bioinformatics**
Module 2 Director: Dr. Niko Kaciroti (Biostatistics, nicola@umich.edu)

Basic statistics as used in bioinformatics, especially standard statistical tests of significance and when they apply. Applications to genetics, experimental and observational medical data, as well as exploration of multiple testing issues that arise in bioinformatics and other experimental settings. NOTE: Dr. Kaciroti is the instructor for all Module 2 lectures and labs.

Lecture (2-1): *Framework for statistical analysis of biomedical data*

Time: Feb 9 (Tuesday), 2:30 - 4:00 PM

Topics:

Probability distributions, quantifying central values and variability, quantifying association, graphical displays of data

Lab (2-1): Descriptive statistics and summarizing data

Time: 2:30 – 4:00 PM, Feb 11 (Thursday) or Feb 12, 10:30 - 12:00 PM, (Friday)

Topics:

Probability distributions, quantifying central values and variability, quantifying association, graphical displays of data

Lecture (2-2): *Approaches to statistical estimation and testing*

Time: Feb 16 (Tuesday), 2:30 - 4:00 PM

Topics:

Estimation and standard errors, standard errors for means, correlations, and log odds ratios, formal hypothesis testing, tests involving means, correlations, and log odds ratios, power.

Lab (2-2): Statistical estimation and hypothesis testing

Time: 2:30 – 4:00 PM, Feb 18 (Thursday) or Feb 19, 10:30 - 12:00 PM, (Friday)

Topics:

Estimation and standard errors, standard errors for means, correlations, and log odds ratios, formal hypothesis testing, one and two sample tests involving means, power.

Lecture (2-3): *Analyses involving associations*

Time: Feb 23 (Tuesday), 2:30 - 4:00 PM

Topics:

Pearson correlation, t-test, odds ratios, discussion of a research article

Lab (2-3): Pearson correlation, t-test, and log odds ratios

Time: 2:30 – 4:00 PM, Feb 25 (Thursday) or Mar 26, 10:30 - 12:00 PM, (Friday)

Topics:

Tests based on Pearson correlation t-test, and log odds ratios

Lecture (2-4): *Linear regression*

Time: Mar 8 (Tuesday), 2:30 - 4:00 PM

Topics:

Single and multiple variable linear regression, Bonferroni correction, power for regression analysis

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Lab (2-4): Regression models

Time: 2:30 – 4:00 PM, Mar 10 (Thursday) or Mar 11, 10:30 - 12:00 PM, (Friday)

Topics:

Fitting regression models for prediction and effect estimation, inference for regression effects, R^2 , diagnostics, comparing models

Lecture (2-5): *Introduction to graphical methods for multivariate data analysis*

Time: Mar 15 (Tuesday), 2:30 - 4:00 PM

Topics:

Clustering methods, Multidimensional scaling and Principal component analysis

Lab (2-5): Clustering and principal component analysis

Time: 2:30 – 4:00 PM, Mar 17 (Thursday) or Mar 18, 10:30 - 12:00 PM, (Friday)

Topics:

Multivariate data, Heat maps and dendrograms, clustering methods, principal component analysis

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Module 3 (1 credit): Bioinformatics and Systems Biology

Module 3 Director: Dr. Kayvan Najarian (DCM&B/Emergency Medicine, kayvan@umich.edu)

Computational analysis of OMICs data (genomics, transcriptomics, proteomics). Analysis of protein-protein interactions and gene expression data. Pathways and networks, machine learning. Example applications from translational medicine and cell biology.

Lecture (3-1): *Introduction to systems biology*

Instructor: Dr. Brian Athey [or potentially Dr. Gerry Higgins / Dr. Steven Parker]

Time: Mar 22 (Tuesday), 2:30 - 4:00 PM

Lab (3-1): Network analysis for systems biology

Instructors: Marci Brandenburg and Viji Nair

Time: 2:30 – 4:00 PM, Mar 24 (Thursday) or Mar 25, 10:30 - 12:00 PM, (Friday)

Topics:

Representation of data as graphs. Pathway and network exploration and visualization with Cytoscape, including the MetScape app, in addition to ConceptGen.

Lecture (3-2): *Computational approaches to clinical decision support systems*

Instructor: Dr. Kayvan Najarian

Time: Mar 29 (Tuesday), 2:30 - 4:00 PM

Topics:

Introduction to computational clinical decision support systems. Machine learning and its application to biomedical informatics.

Lab (3-2): WEKA for machine learning and feature analysis

Instructors: Dr. Kayvan Najarian

Time: 2:30 – 4:00 PM, Mar 31 (Thursday) or Apr 1, 10:30 - 12:00 PM, (Friday)

Topics:

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Introduction to WEKA, using machine learning methods such as SVM, Random Forest, Neural Networks for simple examples in systems biology, using WEKA for feature extraction and analysis.

Lecture (3-3): *Systems biology approaches in pharmacogenomics*

Instructor: Dr. Gerry Higgins [\[or Dr. Steven Parker on Epigenomics\]](#)

Time: Apr 5 (Tuesday), 2:30 - 4:00 PM

Topics:

Studying variations of human genome characteristics as related to drug responses. System biology approaches integrating interacting networks of genes, proteins and biochemical reactions to inform drug treatment regimens. Adverse drug reactions. Towards personalized and systems medicine.

Lab (3-3): Introduction to pharmacogenomics

Instructors: Dr. Gerry Higgins

Time: 2:30 – 4:00 PM, Apr 7 (Thursday) or Apr 8, 10:30 - 12:00 PM, (Friday)

Topics:

Introduction to drug databases used in pharmacogenomic decision support. DrugBank, PharmGKB, ...[\[Or Steven Parker on Epigenomics, GWAS, CHIP-seq etc.\]](#)

Lecture (3-4): *Application of systems biology to translational medicine*

Instructor: Dr. Matthias Kretzler

Time: Apr 12 (Tuesday), 2:30 - 4:00 PM

Topics:

Integrating genome wide data sets with high-resolution clinical phenotypes, molecular marker definition, regulatory network generation in patient samples.

Lab (3-4): Systems biology resources for translational medicine

Instructor: Viji Nair

Time: 2:30 – 4:00 PM, Apr 14 (Thursday) or Apr 15, 10:30 - 12:00 PM, (Friday)

Topics:

Introduction to web based systems biology resources including Oncomine and Nephromine.
