Syllabus: Fall 2021 Applied Quantitative Techniques for the Biological Sciences

Lecture: Day/time Weill C200
Workshop: Day/time

Course directors:
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Course teaching assistants:
TBD

Credits: 2

Dates: August 23, 2021 to October 22, 2021. Tuesday and Thursday, 5:30pm – 7:00pm.

Student Body: Year 2 students from the BCMB, IMP, NEURO and PHARM PhD Programs.

Course objective and goals:

This course is a primer on applied quantitative biology with a focus on proper methodology for study design and statistical analysis in biological research. The course requires basic knowledge of statistics and research methods.

Course structure:

The course will meet twice a week for 1.5 hours each class time. All students will attend the lecture portion of the class in Weill C200. The problem-based workshops will be split by department and meet in the lettered classrooms in the hallway beside C200.

Program	Room #
BCMB	200 A
IMP	200 B
NEURO	200 C
PHARM	200 D

Homework will be assigned on the lecture day and will be due on the following class meeting. The workshops will allow students to apply the information provided in the lecture using sample data analyzed utilizing GraphPad Prism or "R" (lecture #4).

Required materials:

All students should bring their own computers to the lectures/workshops and have the following programs downloaded onto their computers by the first class:

1. GraphPad Prism
2. R
3. Image J

The statical software is available free of charge and can be obtain from Cornell's software service library: https://library.weill.cornell.edu/node/1051
Image J software can be download at: https://imagej.nih.gov/ij/download.html

The following books are **not required** but are useful statistical references for the material that will be covered in class:

1. *Design and Analysis: A Researcher's Handbook.* Keppel G. and Wickens T.D. (2004), fourth edition, Person College Div. ISBN-13: 978-0135159415.
2. *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. Cohen J., Cohen P., West S.G., Aiken L.S. (2002), third edition, Routledge. ISBN-13: 978-0805822236.

Grading and Assessment:
The grading will be on a Pass/Fail basis. The grading will be based on homework assignments and participation in the workshops. There will be no final exam.

Course Policies:
While group study is permitted (and encouraged), all assigned work must be your own. On-line resources may be used to assist in completing assignments. Submitting work that is not original (*i.e.*, not your own) is cheating, and will result in a failure for that assignment and possible referral to the Academic Integrity Hearing Board of the Graduate School. In the event that you consider this determination unreasonable, you are entitled to have the case brought before the Academic Integrity Hearing Board of the Graduate School. We ask that you review the Weill Cornell Graduate School of Medical Sciences Code of Legislation (Link 1) and Cornell University's Code of Academic Integrity (Link 2) policies as these are the standards that will apply throughout your education in the Graduate Program.

1. https://gradschool.weill.cornell.edu/sites/default/files/code_of_legislation_weill_cornell_graduate_school_of_medical_sciences_-_june_16_2020_1.pdf
2. http://theuniversityfaculty.cornell.edu/academic-integrity/code-of-academic-integrity/

Course Schedule:

Week 1 - Basic elements of statistics (Diane Lane, PhD)		
Lecture:	Date/time C200	Central tendencies/descriptive statistics - Variance - Assumptions for statistics - Best practices for handling data/visualizing data Data transformation/scaling/difference from controls
Workshop:	C200 A-D	Calculate variance with different datasets to understand how unequal, large, or skewed data effects the final outcome of a statistical analysis.
Week 2 - Selecting appropriate statistical tests for your dataset (Diane Lane, PhD)		
Lecture:	Date/Time C200	- Descriptive statistics - Univariate tests - Multivariate tests - Large datasets - Parametric vs. non-parametric tests
Workshop:	Date/time C200 A-D	Provide various "real world" datasets and determine the proper statistical tests for each with discussion on different approaches and alternatives. Demonstrate how to calculate in Prism.
Week 3 - Study design and analysis (Audrey Mauguen, PhD)		
Lecture:	Date/Time C200	Source of variability and experimental design - Biological vs. technical replicates - Plan a study to test an hypothesis Statistical test and p-value Power and sample size - Special cases Non-normative data Survival data
Workshop:	Date/Time C200 A-D	
Week 4 – Introduction to "R"		
Lecture:	Date/Time	

	C200	
Workshop:	Date/Time C200 A-D	
Week 5 – **Automated figure analysis using Image J (Csaba Konrad, PhD)**		
Lecture:	Date/Time C200	Basics of Image J scripting Writing macros for automated functions Methods for cell identification/isolation - Measuring ROIs - Cell counting - Separating and measuring fluorescent channels - Segmentation of cell profiles Plugin use
Workshop:	Date/Time C200 A-D	Application of Image J techniques
Week 6 - Introduction to biomedical image quantification (Luke Carter, PhD)		
Lecture:	Date/Time C200	Data types and format – what data is in an image? Common imaging modalities and data origin - Image data formats - Raw data, DICOM, etc. - Rendering & visualization/how can we look at image data? - Color mapping, glyphs 3D data: slice view vs. projections vs. volume rendering Registration – how to spatially align image data? Segmentation – how to define structures/regions in an image? Manual methods Semi-automated and automated methods Image processing - how to manipulate images or extract information? Image math Summary statistics (ROI mean, max, etc.) - Filtering - Masking - Histogram - Radiomics Image presentation - making your data tell a story elegantly and ethically Mouse MRI - delineate tumor margin and calculate tumor volume Clinical PET - calculate maximal tumor uptake, metabolic tumor volume
Workshop:	Date/Time C200 A-D	Application of biomedical imaging techniques
Week 7 - Approaches and analysis of brain connectivity studies (Amy Kuceyeski, PhD)		
Lecture:	Date/Time C200	Basics of elements of MRI analysis - what does it measure - how are the measurements are extracted - functional and diffusion MRI specifically Quantification approaches to brain connectivity - connectome approaches Mapping brain connectivity and dysconnectivity to behavior and impairments - Some examples of the latter
Workshop:	Date/Time	Application of MRI analysis

	C200 A-D	
Week 8 - General principles of cancer genomics data analysis and the cBioPortal for Cancer Genomics		
Lecture:	Date/Time C200	Identifying recurrent genomic alterations - Recurrently mutated genes - Recurrently mutated amino acids - Recurrent copy-number alterations - Epigenetic silencing events Pathway analysis Visualization and analysis of genomic data using the cBioPortal for Cancer Genomics and OncoKB
Workshop:	Date/Time C200 A-D	Application of genomics data analysis
Week 9 – Gene expression analysis		
Lecture:	Date/Time C200	Bulk gene expression analysis - Gene Set Enrichment analysis - Identifying differentially expressed genes - Unsupervised clustering of expression data Single cell expression analysis
Workshop:	Date/Time C200 A-D	Application of gene expression analysis