Statistics and Experimental Design for the Biomedical Sciences

MCP8050C
Summer Term 2020
Syllabus & Schedule

Statistics and Experimental Design for the Biomedical Sciences is a practical course designed to provide students with a solid foundation and intuitive understanding of statistics for the biomedical sciences. The course covers key concepts and methods. The course deals with best practice in experimental design and statistical analysis, ensuring scientific rigor and reproducibility. The course emphasizes parametric and nonparametric statistics used in making between-group inferences, linear and nonlinear regression used in modeling physiological phenomena, effective data presentation, transparency, and graphic integrity.

Summer 2020, the class is offered online in a flipped-classroom and active-learning format. Students will view lectures, learning objectives, and reading materials prior to the class meeting (Tuesdays 2:00 pm) which takes the form of a discussion and review with quizzes. Students will then work on experimental design and statistical analysis problems which they will present to the class at the online workshop (Thursdays 2:00 pm). Attendance at these online class sessions is required.

Learning Outcomes

1. Calculate the probability of random events
2. By using probability distributions, judge whether an observation is unlikely to have arisen randomly and whether we can safely declare an effect real
3. Design powerful experiments in the biomedical sciences, incorporating appropriate controls and accounting for confounding variables
4. Estimate sample size required for sufficient power and calculate post hoc the power of a statistical test
5. Identify the factors and levels in a multifactorial experimental design, and define the family of comparisons of interest in any experiment
6. Collect, organize, summarize, analyze, and communicate data honestly and effectively
7. Make inferences (reach conclusions) about the population(s) when only sample data are known
8. Select and execute the most appropriate statistical test to make inferences from available data, frame the null hypothesis, and declare the significance of the effect if one exists
9. Fit observed data by an appropriate linear or nonlinear function in order to describe physiological phenomena

Instructors

Course Director | Bryan Mackenzie, PhD ● Email: bryan.mackenzie@uc.edu

Lecturer | Learning Module 7 | John N Lorenz, PhD ● Email: john.lorenz@uc.edu

Lecturer | Learning Module 12 | Alex Ruwe, BS ● Email: ruweta@mail.uc.edu

Teaching Assistant | Corbin Azucenas, BS ● Email: azucencr@mail.uc.edu
Online SI Review Sessions: TBA ● Online Office Hours: TBA

Registration

Course #	Section	Credits	Class #	Class Schedule	Location
MCP8050C GRADUATE	**001**	**3 U**	**73342**	Tuesdays 2:00 – 3:20 pm Thursdays 2:00 – 3:50 pm	Online Conference Online Conference

Assessment

Assessment in this course comprises both formative and summative assessment, intended to provide a holistic view of how well the student is assimilating and synthesizing information, developing both a theoretical and practical understanding of experimental design, statistical analysis and interpretation, and developing critical skills. Formative assessment offers the student continuous feedback and guidance. Summative assessment provides the course director with a means of evaluating knowledge gained and proficiency achieved by the student.

Assessment	Details	Assessment type	Graded/Contribution to overall course grade*
Class Discussion	Class participation[1]	Formative	Required, nongraded
Workshops	Class participation[1]	Formative	Required, nongraded
Office Hours/SI Review Sessions	See Canvas	Formative	Not required, nongraded
Assignments[2]	See Canvas	Formative	} Graded (15%)
Pop Quizzes	During lecture	Formative	
Midterm Exam	Multiple-choice and short-answer format	Summative[3]	Graded (30%)
Final Exam	Multiple-choice and short-answer format	Summative[3]	Graded (40%)

[1]Required participation includes (1) participating in online class discussions and (2) presenting solutions to problems given in the weekly workshops.

[2]Assignments will be administered via Canvas. Your assignment must be submitted in Canvas. Late submissions will not be awarded credit.

[3]Summative assessments will not be made available to the student for review after the exam.

Grading

Grades will be assigned as follows, with no adjustment for the distribution of scores.

A	90.0%–100%	**B+**	82.0%–84.9%	**B–**	74.0%–76.9%	**C***	67.0%–69.9%
A–	85.0%–89.9%	**B**	77.0%–81.9%	**C+**	70.0%–73.9%	**Fail**	Below 67.00%

***NB:** To obtain a passing grade of C or better, you must earn from the three formal examinations (midterm, final part I, final part II) an aggregate score that is equivalent to a satisfactory grade, i.e. 67%. Even if your total score for the course (including regular assignments and any make-up assignments) is ≥ 67%, if your aggregate score for the formal examinations is < 67%, you will receive an F grade.

Attendance

Attendance at Tuesday and Thursday online sessions is required

Prerequisites

None

Auditing

Auditing requires advance permission of the Course Director

Web Page

http://med.uc.edu/systemsbiology/studycourse/statistics or
http://med.uc.edu/msinphysiology/curriculum/statistics-and-experimental-design

Canvas & Email Policy

Announcements and messages sent via Canvas or via UC email will be considered sufficient notice. It is your responsibility to check notification settings in your Canvas account to ensure that you receive announcements. You should not communicate with instructors from a non-UC email account—any such communication will be ignored.

Workshop, Practical Exam, and Required Software

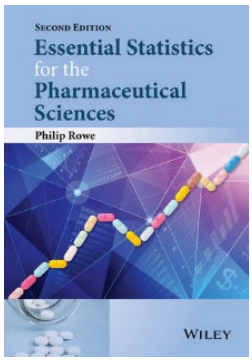
You must have a professional laptop computer on which you have installed SigmaPlot (v14 preferred; If you have an earlier version of SigmaPlot, you may find it difficult to follow along in workshops) or access SigmaPlot remotely at UC's Virtual Lab. Under exceptional circumstances, you may use an alternative software package*.

1. **Purchase UC site-licensed software online:** Purchase a UC site-licensed copy of SigmaPlot at https://secure.touchnet.net/C21575_ustores/web/product_detail.jsp?PRODUCTID=757&SINGLESTORE=true for $37 from the UC TouchNet web store. The license expires July 31, 2020, after which you might consider installing a 30-day trial version for the remainder of the course.
2. **Purchase a 1-year personal student license directly from Systat software:** Visit https://systatsoftware.com/products/sigmaplot/sigmaplot-student-licenses/, cost $100/year.
3. **Access SigmaPlot remotely at UC's VirtualLab:** You can connect to UC's VirtualLab and remotely use SigmaPlot on a UC computer. Be advised that VirtualLab is subject to concurrent-user capacity limits. (i) Save the SigmaPlot data files that you will need on your UC OneDrive; (ii) Go to https://mydesk.uc.edu and log in (you do not need to install the client); (iii) Click on the "Student Desktops" icon; (iv) Log in to OneDrive; (v) You will find the SigmaPlot icon on the desktop; (vi) Be sure to save your analyses to your OneDrive, export reports or figures (e.g. as jpeg) as necessary.
4. **Using a mac:** SigmaPlot runs on the Windows OS. To run SigmaPlot on your mac you will have to either (i) use a Windows compatibility layer (e.g. CrossOver Mac) in which you run SigmaPlot, or (ii) partition your disk (using Bootcamp) and install Windows on that partition. For more information, visit https://systatsoftware.com/products/sigmaplot/run-sp-on-a-mac/.

*Note about alternative statistics software: Minitab, SAS, SPSS, and SYSTAT input data formats are supported in SigmaPlot. You may elect to use an alternative statistics software package (e.g. Minitab, Prism, SAS, SPSS, SYSTAT) instead of SigmaPlot. Should you choose to do so you acknowledge the following: (1) no provision will be made to ensure that data files are compatible, (2) you are responsible for any reformatting or reorganization of data that may be required, (3) following along at the workshop may be difficult; and (4) no troubleshooting or instruction will be provided for alternative software.

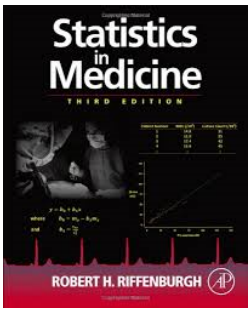
Textbooks

Reference to textbooks (provided to you free via UC Libraries) and online eTexts is strongly recommended as you study for this course. Each module lists/links additional reading material. Textbooks and some recommended eTexts can be accessed from the Canvas class under Resources. Recommended textbooks include:



Philip Rowe (2016) *Essential Statistics for the Pharmaceutical Sciences*, 2e, Wiley, Chichester
ISBN: 9781118913383 (cloth)
ISBN: 9781118913390 (paperback)
ISBN: 9781119109075 (e-book)
Free online access (on-campus or connected to UC via VPN):
http://onlinelibrary.wiley.com/book/10.1002/9781119109075

A very accessible, easy-to-read textbook *Essential Statistics* will help you gain a solid understanding of statistics and good practice. Rowe walks the reader through the most common statistical tests and is careful to point out the many pitfalls that researchers can encounter.



Robert Riffenburgh (2013) *Statistics in Medicine*, 3e,
Academic Press/Elsevier, San Diego
ISBN: 9780123848642 (hardback)
ISBN: 9780123848659 (e-book)
Free online access (on-campus or connected to UC via VPN):
http://www.sciencedirect.com/science/book/9780123848642

A thorough and comprehensive statistics manual for biomedical and clinical research, *Statistics in Medicine* will also serve as an excellent reference for many of the tests that are beyond the scope of this course.

Special Needs Policy If you have any special needs related to your participation in this course, including identified visual impairment, hearing impairment, physical impairment, communication disorder, and/or specific learning disability that may influence your performance in this course, you should meet with the instructor to arrange for reasonable provisions to ensure an equitable opportunity to meet all the requirements of this course. At the discretion of the instructor, some accommodations may require prior approval by Disability Services.

Academic Integrity Policy The University Rules, including the Student Code of Conduct, and other documented policies of the department, college, and university related to academic integrity will be enforced. Any violation of these regulations, including acts of plagiarism or cheating, will be dealt with on an individual basis according to the severity of the misconduct.

Counseling Services Students have access to counseling and mental health care through the University Health Services (UHS), which can provide both psychotherapy and psychiatric services. In addition, Counseling and Psychological Services (CAPS) can provide professional counseling upon request; students may receive five free counseling sessions through CAPS without insurance. Students are encouraged to seek assistance for anxiety, depression, trauma/assault, adjustment to college life, interpersonal/relational difficulty, sexuality, family conflict, grief and loss, disordered eating and body image, alcohol and substance abuse, anger management, identity development and issues related to diversity, concerns associated with sexual orientation and spirituality concerns, as well as any other issue of concerns. After hours, students may call UHS at 513-556-2564 or CAPS Cares at 513-556-0648. For urgent physician consultation after hours, students may call 513-584-7777.

Title IX Title IX is a federal civil rights law that prohibits discrimination on the basis of your actual or perceived sex, gender, gender identity, gender expression, or sexual orientation. Title IX also covers sexual violence, dating or domestic violence, and stalking. If you disclose a Title IX issue to me, the course director, I am required to forward that information to the Title IX Office. They will follow up with you about how the University can take steps to address the impact on you and the community and make you aware of your rights and resources. Their priority is to make sure you are safe and successful here. You are not required to talk with the Title IX Office. If you would like to make a report of sex or gender-based discrimination, harassment or violence, or if you would like to know more about your rights and resources on campus, you can consult the website www.uc.edu/titleix or contact the office at 513-556-3349.

Statistics and Experimental Design for the Biomedical Sciences — MCP8050C-001
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Section Meets Online: Tuesdays 2:00 – 3:20 pm and Thursdays 2:00 – 3:50 pm

Date	Format	Topic	Instructor
Week 1	**Learning Module 1 | Introduction to Statistics I: Basic Concepts; Probability and Distributions**		
Tue 12 May	Discussion	Review Lecture 1	Mackenzie
Thu 14 May	Workshop	Probability and Probability Distributions; Introduction to SigmaPlot 14	Mackenzie
Week 2	**Learning Module 2 | Introduction to Statistics II: Descriptive Statistics; Hypothesis Testing**		
Tue 19 May	Discussion	Review Lecture 2	Mackenzie
Thu 21 May	Workshop 2	Descriptive Statistics; Hypothesis Testing	Mackenzie
Week 3	**Learning Module 3 | Between-Group Inferences I: Student's *t* Tests (One-Sample, Two-Sample, Paired)**		
Tue 26 May	Discussion	Review Lecture 3	Mackenzie
Thu 28 May	Workshop 3	Between-Group Inferences I: Student's *t* Tests (One-Sample, Two-Sample, Paired)	Mackenzie
Week 4	**Learning Module 4 | Between-Group Inferences II: Nonparametric Testing (Rank-Sum Test, Signed-Rank Test, and Sign Test)**		
Tue 2 Jun	Discussion	Review Lecture 4	Mackenzie
Thu 4 Jun	Workshop 4	Between-Group Inferences II: Nonparametric Testing (Rank-Sum Test, Signed-Rank Test, and Sign Test)	Mackenzie
Week 5	**Learning Module 5 | Between-Group Inferences III: Chi-Square Test, Fisher's Exact Test, and Analysis of Frequencies; Odds Ratios and Relative Risk; ROC Analysis**		
Tue 9 Jun	Discussion	Review Lecture 5	Mackenzie
Thu 11 Jun	Workshop 5	Between-Group Inferences III: Chi-Square Test, Fisher's Exact Test, and Analysis of Frequencies; Odds Ratios and Relative Risk; ROC Analysis	Mackenzie
Week 6	**Learning Module 6 | Between-Group Inferences IV: Analysis of Variance and Multiple Comparisons**		
Tue 16 Jun	Discussion	Review Lecture 6	Mackenzie
Thu 18 Jun	Workshop 6	Between-Group Inferences IV: Analysis of Variance and Multiple Comparisons	Mackenzie
Week 7	**Learning Module 7 | Experimental Design; Multifactorial Analysis** Lorenz		
Tue 23 Jun	Discussion	Review Lecture 7 (Lorenz)	Lorenz
Thu 25 Jun	Workshop 7	Experimental Design; Multifactorial Analysis	Lorenz
Week 8 **Tue 30 Jun**	**Mid-Term Exam:** Multiple-Choice and Short Answer Format, 2:00 pm | **Administered in Canvas** (Mid-Term Exam covers material from Modules 1–6. Time limit: 1 h.)		
Week 8	**Learning Module 8 | Survival Analysis; False-Discovery Rate Procedure; Permutation Methods; Normalization; Analysis of qPCR Data**		
Thu 2 Jul	Workshop 8	Review Lecture 8 | Workshop: Survival Analysis; False-Discovery Rate Procedure; Permutation Methods; Normalization; Analysis of qPCR Data	Mackenzie
Week 9	**Learning Module 9 | Power Analysis; Sample-Size Estimation; Transparency, Rigor and Reproducibility**		
Tue 7 Jul	Discussion	Review Lecture 9	Mackenzie
Thu 9 Jul	Workshop 9	Power Analysis; Sample-Size Estimation; Transparency, Rigor and Reproducibility	Mackenzie

Week 10	**Learning Module 10 | Correlation and Regression**		
Tue 14 Jul	Discussion	Review Lecture 10	Mackenzie
Thu 16 Jul	Workshop 10	Correlation and Regression	Mackenzie
Week 11	**Learning Module 11 | Multiple Linear Regression; Model Improvements**		
Tue 21 Jul	Discussion	Review Lecture 11	Mackenzie
Thu 23 Jul	Workshop 11	Multiple Linear Regression; Model Improvements	Mackenzie
Week 12	**Learning Module 12 | Statistical Reporting, Data Presentation, and Graphic Integrity**		
Tue 28 Jul	Discussion	Review Lecture 12 (Ruwe)	Mackenzie
Thu 30 Jul	Workshop 12	Workshop 12: Statistical Reporting, Data Presentation, Reporting Results	Mackenzie
Week 13	**Learning Module 13 | Critiquing Experimental Design and Statistical Analyses of Published Articles**		
Tue 4 Aug	Discussion	Student Presentations	Mackenzie
Thu 6 Aug	**Final Exam:** Multiple-Choice and Short-Answer Format, 2:00 pm | **Administered in Canvas** (Final Exam covers material from the entire course with an emphasis on Modules 7–12. Time limit: 1.5 h.)		