



SYLLABUS: STAT 8625

STATISTICAL METHODS FOR ANALYZING GENETIC DATA

AUTUMN 2023

COURSE OVERVIEW

Instructor

Instructor: Shili Lin

Email address: shili@stat.osu.edu

Class website: <http://carmen.osu.edu>

Lectures: EC 226, Thursdays 12:40-2:30 pm

Office hours: Wednesdays and Fridays 1:45-2:45

Prerequisites

STAT 6802, or permission from instructor

Course description

This course discusses statistical methods for analyzing genetic and genomic data. Topics include:

- Principles of population genetics
- Methods for association studies — single trait, multi-traits, single variant and set-based, haplotypes, and summary statistics
- Methods for multi-omics and integration — e.g. transcriptomics and epigenomics
- Common statistical threads — exact and Monte Carlo methods, Likelihood/Bayesian methods, non-parametric tests, Kernel-based methods, regularized regressions, Stochastic and hierarchical modeling

Course learning outcomes

By the end of this course, students should successfully be able to

- Gain a solid understanding of the important role of statistics in genetic and genomic studies
- Master key principles underlying statistical methods for analyzing genetic and genomic data
- Formulate and sketch a suitable solution for a specific research question concerning genetic/genomic data.
- Read literature in the field critically and evaluate a paper in its entirety

COURSE MATERIALS

Textbooks (references)

Lange K (2003) *Mathematical and statistical methods for genetic analysis*. Springer

Lin S & Zhao H (2010) *Handbook on analyzing human genetic data*. Springer

Balding D, Moltke I, and Marioni J (2019) *Handbook of Statistical Genomics*. John Wiley & Sons

Lin S, Scholtens D, and Datta S (2022) *Bioinformatics methods: from microarrays to next-generation sequencing*. CRC Press.

Sample research papers

Price, A. et al. Principal components analysis corrects for stratification in genome-wide association studies. *Nat Genet* **38**, 904–909 (2006). Doi: 10.1038/ng1847

Manolio, T.A. et al. Finding the missing heritability of complex diseases. *Nature* **461**, 747-53 (2009). doi: 10.1038/nature08494.

Wu, M.C. et al. Rare-variant association testing for sequencing data with the sequence kernel association test. *Am J Hum Genet.* 89, 82-93 (2011). doi: 10.1016/j.ajhg.2011.05.029.

Bersanelli, M. et al. Methods for the integration of multi-omics data: mathematical aspects. *BMC Bioinformatics* **17** (Suppl 2), S15 (2016). doi: 10.1186/s12859-015-0857-9

Turley, P. et al. Multi-trait analysis of genome-wide association summary statistics using MTAG. *Nat Genet* **50**, 229–237 (2018). doi: 10.1038/s41588-017-0009-4

Elosua-Bayes, M. et al. SPOTlight: seeded NMF regression to deconvolute spatial transcriptomics spots with single-cell transcriptomes. *Nucleic acids research*, **49**, e50–e50 (2021).

Zhao, Z. et al. The construction of cross-population polygenetic risk scores using transfer learning. *American Journal of Human Genetics*, 109, 1998-2008 (2022)

GRADING AND FACULTY RESPONSE

ASSIGNMENT CATEGORY	PERCENTAGE
Participation in class discussion	10%
Homework	30%
Midterm	15%
Presentation	30%
Final report	15%
Total	100%

Homework: There will be regular homework assignments (see also the next item). Homework must be uploaded to Carmen by the posted deadline on the day it is due. You are encouraged to work together on the homework, but do not copy any part of others' work. Each student must produce his/her own homework to be handed in.

Participation in class discussion: Students will be assigned regular reading material (material from book or journal articles) on a weekly basis, some as part of the formal homework assignments. For certain selected journal articles, students are expected to read them, write a one-paragraph description, and contribute to class discussions on these papers in class.

Exam: There will be one 55-min midterm to test the basic knowledge presented throughout the semester. There are no make-up exams. Tablets, laptops, and cellphones are not allowed.

Presentation and final report: Each student is expected to present a journal article from the topics covered in the class. The final report should contain two components. The first component is a summary of the journal article, including motivation, methodology, and results, in your own words (that is, do not simply copy from passages of the paper). The second component is a critique of the article, which could be on the methodologies, the computational approaches, and/or the writing. Novel ideas on extending statistical methodologies or improving computational algorithms will be viewed as superior.

Logistics and policies. Homework will be submitted through the class website on Carmen. Typically, no late homework will be accepted, and no make-up exams will be given. However, if you are unable to complete an assignment on time or have an emergency that prevents you from taking the exam on the dates specified, please get in touch with the instructor as soon as possible so that a solution can be worked out ahead of time.

Instructor feedback and response time

Grading and feedback

Sample solutions (if appropriate) to homework assignments will be posted soon after all the papers are submitted. You can generally expect feedback within **7 days**, but there may be exceptions.

E-mail

The instructor will reply to e-mails within **24 hours on weekdays**.

OTHER COURSE POLICIES

Academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term “academic misconduct” includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct <http://studentlife.osu.edu/csc/>.

If I suspect that a student has committed academic misconduct in this course, I am obligated by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university’s Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Committee on Academic Misconduct web page (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)

Copyright for instructional materials

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on Title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at <http://titleix.osu.edu> or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu

Commitment to a diverse and inclusive learning environment

The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited.

Land Acknowledgement

We would like to acknowledge the land that The Ohio State University occupies is the ancestral and contemporary territory of the Shawnee, Potawatomi, Delaware, Miami, Peoria, Seneca, Wyandotte, Ojibwe and Cherokee peoples. Specifically, the university resides on land ceded in the 1795 Treaty of Greenville and the forced removal of tribes through the Indian Removal Act of 1830. I/We want to honor the resiliency of these tribal nations and recognize the historical contexts that has and continues to affect the Indigenous peoples of this land.

More information on OSU's land acknowledgement can be found at <https://mcc.osu.edu/about-us/land-acknowledgement>

Your mental health

As a student you may experience a range of issues that can cause barriers to learn, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling [614-292-5766](tel:614-292-5766). CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You

can reach an on call counselor when CCS is closed at [614-292-5766](tel:614-292-5766) and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

Religious accommodations

It is Ohio State's policy to reasonably accommodate the sincerely held religious beliefs and practices of all students. The policy permits a student to be absent for up to three days each academic semester for reasons of faith or religious or spiritual belief.

Students planning to use religious beliefs or practices accommodations for course requirements must inform the instructor in writing no later than 14 days after the course begins. The instructor is then responsible for scheduling an alternative time and date for the course requirement, which may be before or after the original time and date of the course requirement. These alternative accommodations will remain confidential. It is the student's responsibility to ensure that all course assignments are completed.

Disclaimer

This syllabus should be taken as a fairly reliable guide for the course content. However, you cannot claim any rights from it and in particular we reserve the right to change due dates, exam dates or the methods of grading and/or assessment if necessary. Any changes will be communicated to you through official course announcements.

ACCESSIBILITY ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Requesting accommodations

The university strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process, managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. **SLDS contact information:** slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Accessibility of course technology

This course requires use of CarmenCanvas (Ohio State's learning management system) and other communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Canvas accessibility (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- CarmenZoom accessibility (go.osu.edu/zoom-accessibility)

COURSE SCHEDULE

Refer to the Carmen course for up-to-date assignment due dates.