

PUBHBIO 5280 – Introduction to Genomic Data Analysis
3 credits – Fall 2025
Online, Asynchronous

Course Instructor

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Instructor's Office Hours

Optional office hour are held each week **via Zoom**. Generally, office hours are on Thursdays from 11AM-noon. Because Fall break and Thanksgiving fall on a Thursday, those weeks office hours will be on Tuesday from 9AM-10AM. See the course Carmen site for links for all office hour dates/times.

Faculty Feedback & Response Time

The following gives you an idea of our intended availability during the course:

- **Grading:** You can generally expect feedback within 7 days.
- **E-mail:** I will respond to e-mails (sent via Carmen) within 24 hours on school days.
- **Discussion boards:** The instructor will check and reply to messages in the discussion boards at least every 12 hours on school days, and every 24 hours on weekends, unless a different turnaround time (due to travel, etc.) is announced.

Graduate Teaching Assistant (GTA) Not applicable

Course Description

This course is aimed at both graduate and advanced undergraduate students. This course provides an introduction to different high-throughput genomic assays (e.g., custom spotted and oligonucleotide microarrays, sequencing assays, methylation assays) and related pre-processing methods including image analysis, normalization, alignment, and expression summary/quantification methods. Various statistical methods including supervised and unsupervised methods for genomic data analysis and their software implementation will be illustrated using datasets from different platforms.

A substantial component of this course is use of the R programming environment. I will be providing some resources and remediation to help familiarize you with R. Coding in R requires a lot of time and patience. Nonetheless, learning R is a great skill both to empower you as a researcher and to support your career. I recommend that you spend some time getting comfortable with R if you are not already familiar with it.

Prerequisites

Junior standing or above, and Math 1151 or 1156, Stats 2450 or 2480, and Biology 1113 or MolGen 5660; or Grad standing; or permission of instructor.

Course Learning Objectives

Upon successful completion of the course, students will have the knowledge, comprehension and/or skills to be able to apply commonly used statistical analysis methods to genomic data. Particularly, the students will be able to:

1. Describe different high-throughput genomic technologies.
2. Apply pre-processing methods to translate raw data to analyzable numerical quantities.
3. Use software to perform differential expressed gene detection, p-value adjustment, false discovery rate estimation, unsupervised/supervised machine learning, and dimension reduction for general genomic datasets.
4. Apply the statistical methods for summarizing, visualization and analysis of data from high-throughput platforms, including microarray and RNA sequencing technologies.
5. Describe the basic principles of genomic data annotation, linkage, and storage.
6. Interpret the results of a statistical analysis in the context of relevant biological and public health questions.
7. Propose experimental and statistical approaches to address unanswered biological and public health questions using genomic methods.

Competencies:

Public Health Foundational Knowledge Objectives (PHK):

3. Explain the role of quantitative and qualitative methods and sciences in describing and assessing a population's health.
8. Explain biological and genetic factors that affect a population's health

MPH Foundational Public Health Competencies (PHFC):

2. Select quantitative and qualitative data collection methods appropriate for a given public health context
3. Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate
4. Interpret results of data analysis for public health research, policy or practice

MPH in Biostatistics Competencies:

1. Address problems arising in public health and medicine through appropriate statements of hypotheses, study design, data collection, data management, statistical analysis, and interpretation of results.
4. Describe basic concepts of probability, random variation and commonly used statistical probability distributions.
5. Use computational methods to effectively analyze complex public health and medical data.

MS in Biostatistics Competencies:

6. Address problems arising in public health and medicine through appropriate statements of hypotheses, study design, data collection, data management, statistical analysis, and interpretation of results.
8. Explain core concepts of probability, random variation and commonly used statistical probability distributions and how they relate to statistical inference.
9. Use computational methods to effectively analyze complex public health and medical data.

Interdisciplinary PhD in Biostatistics Competencies:

1. Understands the theoretical foundations of statistical methods.
4. Design biological or health-related research studies and construct and implement statistical analysis plans appropriate for such studies
5. Effectively communicate the results of statistical analyses to statistical and non-statistical audiences

A complete list of College of Public Health Competencies is located on the College of Public Health website: <https://cph.osu.edu/students/competencies>.

Text/Readings

There is no required textbook for this class. Readings from free online sources will be provided via Carmen. Some of these resources will require you to be logged in to the library website (<http://library.osu.edu>) with your OSU name.#.

Carmen

There is a Carmen site for this course: <https://carmen.osu.edu>. All course materials are available via Carmen.

You will need to use BuckeyePass (buckeyepass.osu.edu) multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you take the following steps:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device help article for step-by-step instructions (<https://admin.resources.osu.edu/buckeyepass/adding-a-device>)
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter a Passcode** and then click the **Text me new codes** button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Download the Duo Mobile application (<https://admin.resources.osu.edu/buckeyepass/installing-the-duo-mobile-application>) to all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357(HELP) and IT support staff will work out a solution with you.

Class Format: How this online course works

- **Mode of delivery:** This course is 100% online delivery via asynchronous Distance Learning (DL) mode. There are **no required sessions when you must be logged in to Carmen at a scheduled time**.
- **Pace of online activities:** This course is divided into **weekly modules**. Students are expected to keep pace with weekly deadlines but may freely schedule their efforts within that time frame. Each week the Module will open on Monday and all activities for that Module must be completed by 11:59PM the following Sunday.
- **Credit hours and work expectations:** This is a **3-credit-hour course**. According to Ohio State policy (go.osu.edu/credithours), **students should expect around 3 hours per week of time spent on direct instruction (e.g., watching recorded lectures, completing active learning activities such as computer labs, taking quizzes) in addition to 6 hours of homework (reading and assignment preparation) to receive a grade of (C) average.**
- **Attendance and participation requirements:** Because this is an online course, your attendance is based on your online activity and participation. The following is a summary of students' expected participation:
 - **Participating in online activities for attendance: AT LEAST ONCE PER WEEK**
You are expected to log in to the course in Carmen every week. (During most weeks you

will probably log in many times.) If you have a situation that might cause you to miss an entire week of class, discuss it with the instructor *as soon as possible*.

- **Virtual office hours: OPTIONAL**
Live scheduled events for the course, which are restricted to office hours, are optional.
- **Participating in discussion forums: OPTIONAL**
Discussion boards will be a place to interact with the instructor and your peers, for example, to ask questions about the material and assignments. Participation is optional, but highly encouraged.

Course Technology

Technology skills needed for this course

- Basic computer and web-browsing skills
- Navigating Carmen (go.osu.edu/canvasstudent)
- CarmenZoom virtual meetings (go.osu.edu/zoom-meetings) - optional

Required equipment

- **Computer:** current Mac (MacOs) or PC (Windows 10) with high-speed internet connection
- **Other:** a mobile device (smartphone or tablet) to use for BuckeyePass authentication

Optional equipment (for participation in optional live office hours)

- **Webcam:** built-in or external webcam, fully installed and tested
- **Microphone:** built-in laptop or tablet mic or external microphone

Required software

- R (<http://www.r-project.org/>), which is available free online. You will be provided with installation instructions the first week of the semester.
- Select Bioconductor packages (<https://www.bioconductor.org/>) which will be installed in R.
- Microsoft Office 365: All Ohio State students are now eligible for free Microsoft Office 365. Full instructions for downloading and installation can be found at go.osu.edu/office365help.

Technology support

For help with your password, university email, Carmen, or any other technology issues, questions, or requests, contact the Ohio State IT Service Desk. Standard support hours are available at and support for urgent issues is available 24/7.

- **Self-Service and Chat support:** <http://it.osu.edu/help>
- **Phone:** 614-688-4357(HELP)
- **Email:** servicedesk@osu.edu

Assignments/Assessments

Active Learning Labs: 44%

Each week has an associated active learning lab assignment. These provide an opportunity for you to implement the concepts covered in the lectures (using R), and completion of these exercises is a key component of this course. **Students are permitted to work together on labs but submitted assignments must be completed independently.** Students may take up to two attempts at each active learning lab; the highest active learning lab score will be kept. Each weekly active learning lab must be completed on or before Sunday at 11:59PM.

Any lab not completed by the end of the week will be given a 0. There are no exceptions to this rule.

Quizzes: 20%

Each week has a short online multiple-choice/fill in the blank quiz (taken via Carmen) to help reinforce understanding of the covered concepts. Students may take up to two attempts at each quiz; the highest quiz score will be kept. Please note that quiz questions may be slightly different on the second attempt. You cannot stop a quiz, logout/login and resume at a later time. **Quizzes must be completed without the help of other individuals, but books and notes are permitted.** Each weekly quiz must be completed on or before Sunday at 11:59PM.

Data Analysis Assignments: 15%

Data analysis assignments are homework that will assess student understanding of the underlying biological principles leveraged in genomic assays and pre-processing methods and statistical analyses of genomic data. The due dates for assignments will be announced and all assignments are due on the assigned date by 11:59PM. **Students are permitted to work together but submitted assignments must be written independently.**

In order for homework assignments to be graded and returned as quickly as possible, late homework will not be accepted and will receive a 0.

Reflection Learning Check-Ins: 6%

Every week you will complete a short online reflection of your learning for that week's material. This short, three-question questionnaire is meant to help you reflect on your learning (metacognition) and to provide us with valuable feedback on what topics are the "muddiest." Points will be automatically awarded for a "good faith" effort answering the three questions. **Students are not permitted to work together on the Reflection Learning Check-in.** Each weekly reflection must be completed on or before Sunday at 11:59PM.

Final Project: 15%

The final project will showcase students understanding of methods in genomic data analysis in their appropriate biological context. **Students are not permitted to work together on the Final Project.** Each student will submit a written project due on Friday, December 6 at 11:59PM.

Exams: 0%

There are no exams.

Grading

Assignment Scoring: Clear and effective communication is crucial in biostatistics. This rule is applied to all assignments (e.g., homework, project). In any problem-solving question it is the student's responsibility to make sure that he/she/they justifies his/her/their answer and provides enough detail for the instructor to understand. Points may be deducted for answers that are not well-justified, even if they are correct.

Any questions regarding grading must be addressed **within one week** of the return of the assignment. As a general policy, when requested, the regrading will apply to the whole assignment, not just to the specific part which the student thinks there might be a mistake. Consequently, regrading may lead to a lower overall score. **Any questions regarding grading must be directed to the professor as there is no TA.**

The weight assigned to each assessment for assigning final class grades will be as follows:

Quizzes	20%
Data Analysis Assignments	15%
Active Learning Labs	44%
Reflection Learning Check-Ins	6%
Final Project	15%

Grading Scale:

A	94 to 100	Outstanding work that reflects mastery of the material and the ability to apply it
A-	90 to <94	Excellent work that reflects mastery of the material
B+	87 to <90	Good work that reflects mastery of most of the material
B	83 to <87	Good work that reflects mastery of some of the material
B-	80 to <83	Good work that reflects mastery of a few aspects of the material
C+	77 to <80	Mediocre work that reflects familiarity with, but not mastery of the material
C	73 to <77	Mediocre work that reflects familiarity with most of the material
C-	70 to <73	Mediocre work that reflects little familiarity with the material
D+	67 to <70	
D	60 to <67	
E	Below 60	

Class Policies

- **Quizzes:** Quizzes must be completed without the help of other individuals, but books and notes are permitted.
- **Data Analysis Assignments:** Students are permitted to work together on homework, but submitted assignments must be written independently.
- **Active Learning Lab Assignments:** Students are permitted to work together on lab assignments but submitted assignments must be completed independently. Since these are an active learning component through which students will learn to use the statistical methods described in lecture, it is to the student's benefit to initially attempt these independently.
- **Final Project:** This course includes a final project, which must be completed independently. Books, notes, and other outside materials are permitted.
- **Reflect Learning Check-Ins:** These reflections should be completed individually (without collaboration).

Copyright Statement

This syllabus and all course materials (e.g., quizzes, labs, homework assignments, solution keys, course materials) are under copyright by the instructor and cannot be posted elsewhere without written permission.

Generative AI Policy

Given that the learning goals of this class are to be able to apply commonly used statistical analysis methods to genomic data using the R programming environment, in this course, students are welcome to explore innovative tools and technologies for completing labs, quizzes, and data analysis assignments, including generative artificial intelligence (GenAI). Students are permitted to use GenAI tools for most course assignments, **except** for reflection assignments and your final project. Your written assignments, including reflection assignments, final project, and discussion posts, should be your own original work.

If I suspect that you have used GenAI on an assignment for which it is prohibited, I will ask you to explain your process for completing the assignment in question. Submission of GenAI-generated content as your own original work is considered a violation of Ohio State's Academic Integrity policy and [Code of Student Conduct](#)(opens in new window) because the work is not your own. The unauthorized use of GenAI tools will result in referral to the [Committee on Academic Misconduct](#)(opens in new window).

Office of Student Life: Disability Services

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. 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.

If you are ill and need to miss class, including if you are staying home and away from others while experiencing symptoms of a viral infection or fever, please let me know immediately. In cases where illness interacts with an underlying medical condition, please consult with Student Life Disability Services to request reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or slds.osu.edu.

Mental Health Services

As a student you may experience a range of issues that can cause barriers to learning, 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 Beliefs or Practices Accommodations

Ohio State has had a longstanding practice of making reasonable academic accommodations for students' religious beliefs and practices in accordance with applicable law. In 2023, Ohio State updated its practice to align with new state legislation. Under this new provision, students must be in early communication with their instructors regarding any known accommodation requests for religious beliefs and practices, providing notice of specific dates for which they request alternative accommodations within 14 days after the first instructional day of the course. Instructors in turn shall not question the sincerity of a student's religious or spiritual belief system in reviewing such requests and shall keep requests for accommodations confidential.

With sufficient notice, instructors will provide students with reasonable alternative accommodations with regard to examinations and other academic requirements with respect to students' sincerely held religious beliefs and practices by allowing up to three absences each semester for the student to attend or participate in religious activities. Examples of religious accommodations can include, but are not limited to, rescheduling an exam, altering the time of a student's presentation, allowing make-up assignments to substitute for missed class work, or flexibility in due dates or research responsibilities. If concerns arise about a requested accommodation, instructors are to consult their tenure initiating unit head for assistance.

A student's request for time off shall be provided if the student's sincerely held religious belief or practice severely affects the student's ability to take an exam or meet an academic requirement and the student has notified their instructor, in writing during the first 14 days after the course begins, of the date of each absence. Although students are required to provide notice within the first 14 days after a course begins, instructors are strongly encouraged to work with the student to provide a reasonable accommodation if a

request is made outside the notice period. A student may not be penalized for an absence approved under this policy.

If students have questions or disputes related to academic accommodations, they should contact their course instructor, and then their department or college office. For questions or to report discrimination or harassment based on religion, individuals should contact the [Civil Rights Compliance Office](#). (Policy: [Religious Holidays, Holy Days and Observances](#))

Academic Misconduct

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 3335-5-48.7 \(B\)](#)). For additional information, see the [Code of Student Conduct](#).

Grievances and Solving Problems

A student who encounters a problem related to his/her educational program has a variety of avenues available to seek resolution. According to University Policies, if you have a problem with this class, you should seek to resolve the grievance concerning a grade or academic practice by speaking first with the instructor or professor. Then, if necessary, you may take your case to the department chairperson. Specific procedures are outlined in [Faculty Rule 3335-8-23](#), the [CPH Graduate Student Handbook](#), and the [CPH Undergraduate Student Handbook](#). Grievances against graduate, research, and teaching assistants should be submitted first to the supervising instructor, then to the chairperson of the assistant's department.

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Civil Rights Compliance Office:

Online reporting form at <http://civilrights.osu.edu/>,

Call 614-247-5838 or TTY 614-688-8605,

Or Email civilrights@osu.edu

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Civil Rights Compliance Office to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.

- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP); 2. Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member.

Course Schedule* (with Alignment of Course Learning Objectives, Foundational Knowledge, and Foundational Competencies)

Week	Topics	Assignments	Course Learning Objectives	Foundational Knowledge Areas	Foundational Competencies
8/26 to 8/31	WEEK 1 – Introduction to R	Week Quiz 1 Lab 1 Learning Check-in 1	CLO3, CLO4		PHFC3
9/01 to 9/07	WEEK 2 – Introduction to genomic assays - Principles of hybridization - Custom spotted arrays - Oligonucleotide arrays - RNA-Seq	Week Quiz 2 Lab 2 Learning Check-in 2	CLO1	PHK3 PHK8	PHFC2
9/08 To 9/14	WEEK 3 – Preprocessing genomic data - Image analysis: Computer representation of images, Addressing, Segmentation, Intensity extraction - Alignment - Normalization: MA plots, loess & quantile normalization - Expression quantification: custom spotted arrays, Affymetrix, RNA-Seq	Week Quiz 3 Lab 3 Learning Check-in 3	CLO2	PHK3	PHFC3
9/15 to 9/21	WEEK 4 – DATA ANALYSIS ASSIGNMENT	Data Analysis Assignment	CLO2	PHK3	PHFC3
9/22 to 9/28	WEEK 5 – Differential gene expression analysis - Traditional hypothesis tests - False Discovery Rate - limma	Week Quiz 5 Lab 5 Learning Check-in 5	CLO2	PHK3	PHFC3
9/29 to 10/5	WEEK 6 – Differential gene expression analysis (PART 2) - Poisson and negative binomial regression - edgeR and DESeq2 for count (RNA-Seq) data	Week Quiz 6 Lab 6 Learning Check-in 6	CLO2	PHK3	PHFC3
10/6 to 10/12	WEEK 7 – DATA ANALYSIS ASSIGNMENT	Data Analysis Assignment	CLO3, CLO4, CLO5, CLO6	PHK3 PHK8	PHFC3 PHFC4
10/13 to 10/19	WEEK 8 – Supervised learning methods - LASSO - Elastic Net - Cross-validation	Week Quiz 8 Lab 8 Learning Check-in 8	CLO3, CLO4, CLO5, CLO6	PHK3 PHK8	PHFC3 PHFC4

Week	Topics	Assignments	Course Learning Objectives	Foundational Knowledge Areas	Foundational Competencies
10/20 to 10/26	WEEK 9 – Supervised learning methods (PART 2) - Linear Discriminant Analysis - Kernel Discriminant Analysis - K-nearest neighbors - CART, bootstrap aggregating, and Random Forest	Week Quiz 9 Lab 9 Learning Check-in 9	CLO3, CLO4, CLO6	PHK3 PHK8	PHFC3 PHFC4
10/27 to 11/02	WEEK 10 – DATA ANALYSIS ASSIGNMENT	Data Analysis Assignment	CLO3, CLO4, CLO6	PHK3 PHK8	PHFC3 PHFC4
11/03 to 11/09	WEEK 11 – Unsupervised learning methods - Hierarchical clustering - K-means clustering - Partitioning around medoids	Week Quiz 11 Lab 11 Learning Check-in 11	CLO3, CLO4, CLO6	PHK3 PHK8	PHFC3 PHFC4
11/10 to 11/16	WEEK 12 – Dimension reduction - PCA and MDS - t-SNE - umap	Week Quiz 12 Lab 12 Learning Check-in 12	CLO3, CLO4	PHK3	PHFC3
11/17 to 11/23	WEEK 13 – DATA ANALYSIS ASSIGNMENT	Data Analysis Assignment	CLO1, CLO2, CLO3, CLO4, CLO5, CLO6	PHK3 PHK8	PHFC2 PHFC3 PHFC4
11/24 to 11/30	WEEK 14 – DNA methylation & Microbiome data analysis - Biological background - Assays (array/sequencing) - Preprocessing - Differential methylation analysis - Phyloseq - Alpha and beta diversity - PERMANOVA and MiRKAT	Week Quiz 14 Lab 14 Learning Check-in 14	CLO1, CLO2, CLO3, CLO4, CLO6	PHK3 PHK8	PHFC2 PHFC3
12/01 to 12/07	Week 15 - Final Project Due Friday 12/12	Project	CLO1, CLO2, CLO3, CLO4, CLO5, CLO6, CLO7	PHK3 PHK8	PHFC2 PHFC3 PHFC4

**Any readings for each week will be posted on Carmen*

Alignment of Competencies with Assessments

Competencies	Assessment 1 Active Learning Labs	Assessment 2 Quizzes	Assessment 3 Final Project	Assessment 4 Data Analysis Assignments
PHK3 Explain the role of quantitative and qualitative methods and sciences in describing and assessing a population's health.	X	X	X	X
PHK8 Explain biological and genetic factors that affect a population's health	X	X	X	X
PHFC2 Select quantitative and qualitative data collection methods appropriate for a given public health context			X	X
PHFC3 Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate	X		X	X
PHFC4 Interpret results of data analysis for public health research, policy or practice	X	X	X	X
MPH1 Address problems arising in public health and medicine through appropriate statements of hypotheses, study design, data collection, data management, statistical analysis, and interpretation of results.	X		X	X
MPH4 Describe basic concepts of probability, random variation and commonly used statistical probability distributions.	X	X	X	X
MPH5 Use computational methods to effectively analyze complex public health and medical data.	X		X	X
MS6 Address problems arising in public health and medicine through appropriate statements of hypotheses, study design, data collection, data management, statistical analysis, and interpretation of results.	X	X	X	X
MS8 Explain core concepts of probability, random variation and commonly used statistical probability distributions and how they relate to statistical inference.	X	X	X	X
MS9 Use computational methods to effectively analyze complex public health and medical data.	X		X	X
PhD1 Understands the theoretical foundations of statistical methods.	X	X	X	X
PhD4 Design biological or health-related research studies and construct and implement statistical analysis plans appropriate for such studies			X	
PhD5 Effectively communicate the results of statistical analyses to statistical and non-statistical audiences			X	X