MICROBIAL EVOLUTION; 11:680:479, 16:682:579; FALL 2026; TUESDAY AND FRIDAY 10:20-11:40AM, LIPMAN HALL 202.

Course Number 11:680:479, 16:682:579
3 Credits
Fall 2026
Prerequisites: This course is targeted to advanced juniors or seniors majoring in microbiology, biochemistry, biotechnology, and related fields, as well as graduate students. (11:680:390 General Microbiology AND 01:447:380 Genetics) or (01:447:390 General Microbiology AND 11:447:380 Genetics) or (11:680:201 Introduction to Microbiology AND 11:447:380 Genetics) or (11:447:392 Pathogenic Microbiology AND 01:447:380 Genetics). Juniors and Seniors only.

Meeting Days and Times: Tuesdays and Fridays 10:20am-11:40am
Meeting Location: Lipman Hall 202

CONTACT INFORMATION:

Instructor(s): Prof. Rohan Maddamsetti
Office Location: Lipman Hall 217
Phone: 848-932-9763 Email: rohan.maddamsetti@rutgers.edu
Office Hours: 45 minutes after every class, Friday afternoons 12-5pm.

COURSE WEBSITE, RESOURCES AND MATERIALS:

- Canvas course website TBD
- Course textbook: Evolution, by Carl T. Bergstrom and Lee Alan Dugatkin. W.W. Norton. ISBN 9780393937930

COURSE DESCRIPTION:

This course will cover evolutionary concepts, theory, and applications that are central to biochemistry and microbiology. Two themes of the lecture component are 1) the use of evolution experiments with biomolecules and microbes to develop, test, and apply evolutionary concepts and theory, and 2) the study of "real-time" evolutionary processes, such as the ongoing antibiotic resistance crisis and the COVID-19 pandemic. In the discussion component, students will develop their skills in understanding and discussing primary research papers in microbial evolution. Finally, students will complete a semester-long project in which they will develop their scientific **creativity** in criticizing and extending prior work, asking new questions, and exploring data to find new patterns and research questions. By the end of this course, students will feel more confident in being **active participants in creating new science**. Students in this semester-long theory course are expected to enter with basic training in microbiology and curiosity about, evolution, microbiology and biochemistry, and a willingness to work hard over the semester to develop their scientific skills.

COURSE LEARNING GOALS:

This course addresses Microbiology program learning goals 1, 2, and 3:

PG 1 *"Graduates will be able to illustrate and describe the biology of microorganisms, focusing on microbial processes and their effects on other organisms and the environment, microbial communities, and biogeochemical cycles."*

After taking this course, students will be able to illustrate and describe fundamental evolutionary processes occurring in laboratory culture and natural microbial communities, such as mutation, selection, horizontal gene transfer, and recombination, and describe their implications for human health.

The textbook readings and lecture component of this course will address this goal. The in-class exams will assess students' ability to describe evolutionary processes in microbes (based on the readings and lectures), and illustrate them with examples relevant to microbes.

PG 2 *"Graduates will be able to apply the scientific method to formulate questions and hypotheses, design experiments, employ appropriate methodology to solve problems in microbiology, and be able to analyze, interpret, and present scientific data in microbiology."*

After taking this course, students will have experience in 1) developing hypotheses by searching for patterns in published "exploratory" datasets, using data visualization 2) testing hypotheses using independent "validation" datasets, and in 3) generating a figure that summarizes their findings and analysis.

The final project component of this course will address this goal. Students will be assessed through a short in-class presentation at the end of the course, and by a final written report of their scientific findings.

PG 3 *"Graduates will be able to critically evaluate scientific literature and explain their findings in written and oral format."*

After taking this course, students will have experience in reading and critically evaluating primary scientific papers in microbial evolution, and will be able to logically display and interpret data through oral presentations and written reports.

The in-class paper discussions and final project components of this course will address this goal. Students will be assessed through by their one-page homework assignments answering discussion questions, and their participation in classroom discussions.

ASSIGNMENTS/RESPONSIBILITIES, GRADING & ASSESSMENT:

This course will have two 80 minutes class sessions per week. Each class will be in a semi-flipped format, with 50 minutes of lecture and 30 minutes of paper discussion. Students are expected to read the textbook chapter ahead of time, as preparation for lecture. At the beginning of class (before lecture begins), students will turn in one-page homework assignments answering discussion questions about the assigned paper(s). 45% of the grade of this course is completion of these short responses, and participation in the classroom discussion of the assigned readings. There will be two 80 minute in-class exams, based on the material covered in lecture and in the textbook. In addition, each in-class exam will have a "primary literature reading" component to evaluate critical reading and thinking skills. Each exam is worth 15% of your final grade.

Finally, a major component of this course is the final project, which can be completed solo, or in a group of two people. For the pre-proposal (5% of grade) due for the midterm, students will write a one-page abstract, in which they will find a paper with a "big dataset", or find a big dataset or database online, or use unpublished data (if any is available). Ideally, students will articulate an open question not answered in the paper, articulate why this question matters, and why it hasn't been answered yet, or sufficiently in prior work. If this is challenging, students may also articulate a question answered in the paper and propose to reproduce or replicate an analysis on independent data. At this stage, students should identify independent data to test their question.

One solution is to divide a large dataset into two components ("exploratory" and "validation") before exploring the data.

Evaluation and Grading of Undergraduate Students:

Paper Responses and Participation in class discussions: 45% (450 points)
Exam 1: 15% (150 points)
Final project Pre-proposal: 5% (50 points)
Exam 2: 15%, (150 points)
Final Research Report: 20% (10% written report, 5% oral presentation, 5% peer review) (200 points)

Evaluation and Grading of Graduate Students:

Paper Responses and Participation in class discussions: 40% (400 points)
Exam 1: 15% (150 points)
Pre-proposal: 5% (50 points)
Exam 2: 15% (150 points)
Final Research Report: 25% (15% written report, 5% oral presentation, 5% peer review) (250 points)

Total: 1000 points

Rubric for Evaluation:

In-class discussions:

Full credit: Student came to class, turned in their one-page homework, and made thoughtful efforts to participate in discussions

Partial credit: Student came to class but was ill-prepared for discussion

Zero credit: Student did not come to class, or clear evidence that AI was used for one-page homework without engagement with discussion questions (no real preparation for discussion)

Exam questions:

Full credit: complete response to question, including relevant and sufficient facts and analysis.

Partial credit: partial response, includes some relevant facts, but insufficient analysis.

Zero credit: incomplete or includes irrelevant or false details.

Final project:

Full credit: the student came up with a thoughtful question that was answerable from their dataset, conducted an analysis, appropriately interpreted their findings (regardless of whether the results were conclusive or not), and state interesting and relevant directions for further investigation. High-quality written and oral presentations.

Passing credit: the student came up with some scientific question (perhaps not answerable from their dataset), and conducted some analysis of their data, and drew some sensible conclusions. Acceptable written and oral presentations.

Failing credit: the student failed to analyze or their data, or fail to draw sensible conclusions from their analysis. Unacceptable written and oral presentations.

Zero credit: the student failed to complete or turn in their project on time.

Grading Scale
A 90 – 100%
B+ 86 – 89%
B 80 – 85%
C+ 76 – 79%
C 70 – 75%
D 60 – 69%
F 0 – 59%

ACCOMODATIONS FOR STUDENTS WITH DISABILITIES
Please follow the procedures outlined at https://ods.rutgers.edu/students/getting-registered. Full policies and procedures are at https://ods.rutgers.edu/

ABSENCE POLICY
Students are expected to attend all classes; if you expect to miss one or two classes, please use the University absence reporting website https://sims.rutgers.edu/ssra/ to indicate the date and reason for your absence. An email is automatically sent to me.

COURSE TOPICS:

Class 1: Overview of course, and overview of evolutionary microbiology
Readings:
Articles: "Openness guides discovery", "Teach creativity in science higher education"
Textbook: Chapter 1 and Chapter 2 of Bergstrom (optional)
"Exploring protein fitness landscapes by directed evolution" (optional)
Class 2 and 3: Natural Selection in microbes
Readings:
Textbook: Chapter 3 of Bergstrom
Article (Class 2): "The dynamics of molecular evolution over 60,000 generations"
Article (Class 3): "Continuous evolution of user-defined genes at 1 million times the genomic mutation rate"
Class 4: Phylogeny and Evolutionary History
Readings:
Textbook: Chapter 4 of Bergstrom
Article: "A rooted phylogeny resolves early bacterial evolution"
Class 5: Inferring Phylogeny
Readings:
Textbook: Chapter 5 of Bergstrom

Articles: "IQ-TREE: A Fast and Effective Stochastic Algorithm for Estimating Maximum-Likelihood Phylogenies", "Resurrecting Ancient Genes: Experimental Analysis of Extinct Molecules"

Class 6 and 7: Transmission Genetics and the Sources of Genetic Variation in microbes

Readings:

Textbook: Chapter 6 of Bergstrom

Article (Class 6): "Divergent Evolution of Mutation Rates and Biases in the Long-Term Evolution Experiment with *Escherichia coli*"

Article (Class 7): "Analysis of bacterial genomes from an evolution experiment with horizontal gene transfer shows that recombination can sometimes overwhelm selection"

Class 8 and 9: The Genetics of Populations in microbes

Readings:

Textbook: Chapter 7 of Bergstrom

Article (Class 8): "Mutational and fitness landscapes of an RNA virus revealed through population sequencing"

Article (Class 9): "The Evolutionary Pathway to Virulence of an RNA Virus"

Class 10 and 11: Evolution in Finite populations

Readings:

Textbook: Chapter 8 of Bergstrom

Article (Class 10): "Core genes can have higher recombination rates than accessory genes within global microbial populations"

Article (Class 11): "Discovery of positive and purifying selection in metagenomic time series of hypermutator microbial populations"

Class 12 and 13: Evolution at multiple loci

Readings:

Textbook: Chapter 9 of Bergstrom

Article (Class 12): "Quasispecies diversity determines pathogenesis through cooperative interactions in a viral population"

Article (Class 13): "Compensatory epistasis maintains ACE2 affinity in SARS-CoV-2 Omicron BA.1"

Class 14: In-class exam 1 (15%). Final project pre-proposal deadline (5%)

Class 15 and 16: Microbial Genome Evolution.

Readings:

Textbook: Chapter 10 of Bergstrom

Article (Class 15): "Scaling laws of bacterial and archaeal plasmids"

Article (Class 16): "Most bacterial gene families are biased toward specific chromosomal positions"

Class 17 and 18: The origin and evolution of microbial life

Readings:

Textbook: Chapter 11 of Bergstrom

Article (Class 17): "Evolution of a minimal cell"

Article (Class 18): "Idiosyncratic Purifying Selection on Metabolic Enzymes in the Long-Term Evolution Experiment with *Escherichia coli*"

Class 19 and 20: Major transitions in evolution

Readings:

Textbook: Chapter 12 of Bergstrom

Article (Class 19): "De novo evolution of macroscopic multicellularity"

Article (Class 20): "Genome duplication in a long-term multicellularity evolution experiment"

Class 21: Species and Speciation in microbes

Readings:

Textbook: Chapter 14 of Bergstrom
Article (Class 21): "Ecological speciation of bacteriophage lambda in allopatry and sympatry"

Class 22 and 23: Social evolution of microbes

Readings:

Textbook: Chapter 17 of Bergstrom
Article (Class 22): "The evolution of cooperation within the gut microbiota"
Article (Class 23): "Bacterial species rarely work together"

Class 24 and 25: Coevolution

Readings:

Textbook: Chapter 18 of Bergstrom
Article (Class 24): "Antagonistic coevolution accelerates molecular evolution"
Articles (Class 25): "Repeatability and Contingency in the Evolution of a Key Innovation in Phage Lambda" and "Host control of the microbiome: Mechanisms, evolution, and disease"

Class 26: **In-class exam 2** (15%)
Class 27: **Class presentations on final projects.**
Class 28: **Class presentations on final projects.**

FINAL REPORT DATE AND TIME

Pre-proposal deadline: Thursday March 12, 2026, 5pm

Final report deadline: Thursday May 7, 2026, 5pm

Peer review deadline: Monday May 11, 2026, 5pm

FAIR USE OF AI

AI tools (e.g., ChatGPT, Copilot) may be used to support learning in this course—for example, to clarify concepts, explore data analysis approaches, or improve scientific writing. However, all submitted work must reflect your own understanding and critical thinking. Use AI ethically: do not submit AI-generated responses as your own on assignments, and always cite any substantial AI assistance. Misuse may be considered academic dishonesty.

ACADEMIC INTEGRITY

The university's policy on Academic Integrity is available at https://academicintegrity.rutgers.edu/sites/default/files/pdfs/current.pdf. The principles of academic integrity require that a student:

- properly acknowledge and cite all use of the ideas, results, or words of others.
- properly acknowledge all contributors to a given piece of work.
- make sure that all work submitted as his or her own in a course or other academic activity is produced without the aid of impermissible materials or impermissible collaboration.
- obtain all data or results by ethical means and report them accurately without suppressing any results inconsistent with his or her interpretation or conclusions.
- treat all other students in an ethical manner, respecting their integrity and right to pursue their educational goals without interference. This requires that a student neither facilitate academic dishonesty by others nor obstruct their academic progress.

- uphold the canons of the ethical or professional code of the profession for which he or she is preparing.

Adherence to these principles is necessary to ensure that

- everyone is given proper credit for his or her ideas, words, results, and other scholarly accomplishments.
- all student work is fairly evaluated, and no student has an inappropriate advantage over others.
- the academic and ethical development of all students is fostered.
- the reputation of the University for integrity in its teaching, research, and scholarship is maintained and enhanced.

Failure to uphold these principles of academic integrity threatens both the reputation of the University and the value of the degrees awarded to its students. Every member of the University community therefore bears a responsibility for ensuring that the highest standards of academic integrity are upheld.

In this course, we will take cheating very seriously. All suspected cases of cheating and plagiarism will be automatically referred to the student conduct office (http://academicintegrity.rutgers.edu), and we will recommend penalties appropriate to the gravity of the infraction.

SEBS DEI STATEMENT

I will work to create an inclusive environment in which we all are respected, and in which we all have a voice and can make thoughtful intellectual contributions in a respectful and compassionate learning community. Disrespectful behavior will not be tolerated. If you feel as though you have been disrespected or treated unfairly by the instructor or any other individual please let me know. You can also report the incident anonymously to the Office of Academic Programs at https://sebs.rutgers.edu/academics/meet-our-team.php. In addition, you may also report bias to the Rutgers Diversity and Inclusion initiative using this link: http://inclusion.rutgers.edu/report-bias-incident/.

STUDENT WELLNESS SERVICES

Counseling, ADAP & Psychiatric Services (CAPS)

(848) 932-7884 / 17 Senior Street, New Brunswick, NJ 08901/ www.rhscaps.rutgers.edu/

CAPS is a University mental health support service that includes counseling, alcohol and other drug assistance, and psychiatric services staffed by a team of professionals within Rutgers Health services to support students' efforts to succeed at Rutgers University. CAPS offers a variety of services that include individual therapy, group therapy and workshops, crisis intervention, referral to specialists in the community and consultation and collaboration with campus partners.

Violence Prevention & Victim Assistance (VPVA)

(848) 932-1181 / 3 Bartlett Street, New Brunswick, NJ 08901 / https://vpva.rutgers.edu/

The Office for Violence Prevention and Victim Assistance provides confidential crisis intervention, counseling, and advocacy for victims of sexual and relationship violence and stalking to students, staff, and faculty. To reach staff during office hours when the university is open or to reach an advocate after hours, call 848-932-1181.

Disability Services

(848) 445-6800 / Lucy Stone Hall, Suite A145, Livingston Campus, 54 Joyce Kilmer Avenue, Piscataway, NJ 08854 / https://ods.rutgers.edu/

Rutgers University welcomes students with disabilities into all of the University's educational programs. In order to receive consideration for reasonable accommodations, a student with a disability must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: https://ods.rutgers.edu/students/documentation-guidelines. If the documentation supports your request for reasonable accommodations, your campus's disability services office will provide you with a Letter of Accommodation. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. To begin this process, please complete the Registration form on the ODS web site at: https://webapps.rutgers.edu/student-ods/forms/registration.

DoSomething button through Rutgers Dean of Students office:
http://health.rutgers.edu/do-something-to-help/

Wellness Coaching through Rutgers HOPE:
https://health.rutgers.edu/health-education-and-promotion/health-promotion-peer-education/wellness-coaching

Self-Help Apps found on the Rutgers Student Health website:
https://health.rutgers.edu/health-education-and-promotion/self-help/self-help-apps

NJ Hopeline - (1-855-654-6735) | **National Suicide Hotline** - (1-800-273-8255)

BASIC NEEDS RESOURCES

Any student who has difficulty affording groceries or accessing sufficient food, or who lacks a safe and stable place to live, is urged to contact the Rutgers Student Food Pantry and/or the Dean of Students (details below). Furthermore, please notify the professor if you are comfortable doing so, as they may be able to provide additional support.

Rutgers Student Food Pantry
848-932-5500 / College Ave Student Center, Room 115 (126 College Ave) /
http://ruoffcampus.rutgers.edu/food/
Check their website for hours and additional locations. The Rutgers Student Food Pantry is dedicated to helping all Rutgers students in need of food, no questions asked. Students will be provided with groceries that typically last about one week.

Dean of Students Office
848-932-2300 / 88 College Avenue, New Brunswick, NJ 08901 / https://deanofstudents.rutgers.edu/
Mon-Fri, 8:30am-5:00pm
The Dean of Students Office at Rutgers University-New Brunswick provides solutions, services, and support to help students navigate Rutgers University. The Office serves as a student support network by providing advocacy, problem resolution, and critical incident intervention for those times when additional assistance is needed. Please call to schedule an appointment to meet with a representative from the Dean's office.