North Carolina State University
Department of Chemical and Biomolecular Engineering

CHE 596-043 and 596-643: Microbial Community Engineering – Fall 2024

Section 043: Tuesday/Thursday 10:15AM – 11:30AM, FWH 04134
Section 643: Online

Instructor: Dr. Crook (nccrook@ncsu.edu) EB1 2026, (919) 513-2429
Office Hours: By appointment.

Course purpose: This course will cover quantitative frameworks and techniques for engineering microbial communities. A brief overview of the major processes and engineering targets in microbial communities will be presented, followed by hands-on practice with computational tools for performing simulations. Safety and ethical considerations will be discussed throughout the course, and students will use course concepts to critically evaluate current literature and synthesize a research proposal.

Course Objectives: By the end of the course, you should be able to do the following things:

- Understand the major routes by which microbial communities impact their surroundings, and be able to enumerate mechanistic targets for engineering interventions.
- Understand the various approaches (e.g. community, strain, and gene-level) for engineering microbiomes.
- Use numerical methods (e.g. flux balance analysis, lotka-volterra equations, agent-based) to simulate the behavior of a microbial community.
- Understand and know how to address safety and ethical concerns in microbial community engineering.
- Critically evaluate current literature in microbial community engineering
- Synthesize and evaluate research proposals involving microbial community engineering.

Course prerequisites: None

Course Text: None. Required readings will be posted on Moodle.

POLICIES AND PROCEDURES
Students are responsible for reviewing the PRRs which pertain to their course rights and responsibilities. These include: http://policies.ncsu.edu/policy/pol-04-25-05 (Equal Opportunity and Non-Discrimination Policy Statement), http://oied.ncsu.edu/oied/policies.php (Office for Institutional Equity and Diversity), http://policies.ncsu.edu/policy/pol-11- 35-01 (Code of Student Conduct), and http://policies.ncsu.edu/regulation/reg-02-50-03 (Grades and Grade Point Average).

- **Classroom capture:** Please be advised that this course is being recorded for current and potential future educational purposes. By your continued participation in this recorded course, you are providing your permission to be recorded. If you do not wish to have your face recorded, please turn off your video in Zoom. The recorded class sessions will be available through Moodle for your viewing and review.

- **Academic integrity.** Students should refer to the University policy on academic integrity found in the Code of Student Conduct (found at http://policies.ncsu.edu/policy/pol-11-35-01). It is the instructor's understanding and expectation that the student's submission of any test or assignment means that the student neither gave nor received unauthorized aid on that test or assignment. Authorized aid on an individual assignment includes discussing the interpretation of the problem statement, sharing ideas or approaches for solving the problem, and explaining concepts involved in the problem. Any other aid would be unauthorized and a violation of the academic integrity policy. Unauthorized aid additionally includes accessing on-line solutions, whether that be posted copies of textbook problem solutions or paying someone to complete your homework. In addition, a*ny computer work submitted must be completed on your own personal computer or from your own eos account to avoid confusion about the origin of the file, and no sharing of files in any way is allowed.*

The documents – both electronic and hard copies of lecture notes, lecture videos, homework assignments and solutions, exams and solutions, or handouts --made available to you for this course are intended only for your personal use. You are not allowed to share any content of the class with any person not signed up for the course this semester; a personal, public, or commercial website; or any other news or advertising media.

All cases of academic misconduct will be submitted to the Office of Student Conduct. Students found guilty of academic misconduct will be subject to, at a minimum, a zero on the assignment in question, up to a zero for that course component (e.g. a zero for the homework portion of the final grade), or a failing grade in the course, depending on the nature of the violation. In addition, if you are found guilty of academic misconduct in the course, you will be on academic integrity probation for the remainder of your years at NCSU, may be required to report your violation on future professional school applications, and could have further implications for ROTC positions and/or employment on campus, including University Housing. It's not worth it!

- **Homework (Projects).** Students will submit projects individually via Moodle. If students create multiple files for their assignments, they must be zipped prior to upload. The assignment schedule will be posted on the course web site.

- **Late projects**. Completed assignments should be submitted to Moodle by the stated deadline. Students may request extensions due to unforeseen circumstances (e.g. medical or family issues) by emailing their instructor. These will be treated on an individual basis. For each week (or part thereof) that an assignment is turned in late without an extension, the homework's score will be multiplied by 0.9. For example, if a homework is turned in 1.5 weeks late, and the raw score for that homework is 88%, the grade for that homework will be 88%*0.9^2 = 71.2%.

- **Homework Forum Policy:** If you have a general question about assignments, **before sending an email to Dr. Crook**, you should post your question on the corresponding homework forum on Moodle. Everyone is encouraged to participate in responding to posted questions on the homework forum.
  - **Bonus:** 3 students with the most engagement on Moodle (based on answering posted questions on forums) will receive Extra Credit (**1% of the final course grade**).
  - **Dos:** You can post a general question about how to approach a specific problem or how to find physical properties of specific molecules. You can also ask questions to better understand what a specific problem is asking for.
  - **Don'ts:** Do not post your final answers to check with others. Do not ask/answer questions about what specific equations to use for a specific problem.

- **Final Proposal**. The last assignment in the course will be a presentation covering an **original** research proposal. This assignment will be due on the last day of class.

- **Project re-grades**. If you believe that an error was made in grading a project, you can submit a re-grade request to your instructor via email. Please be specific in your rationale of why you believe the problem was graded incorrectly (i.e. you can't just say "I think I should have gotten more points here.") Your instructor will review your request and respond to you as soon as possible. **The "statute of limitations" for submitting such claims is one week after the grades are returned.**

- **Attendance.** While lectures will be recorded online, students who find themselves unable to keep up with lectures should work with the instructor to determine a solution.

  - Examples of anticipated situations where a student would qualify for an excused absence are:
    - The student is away from campus representing an official university function, e.g., participating in a professional meeting, as part of a judging team, or athletic team. These students would typically be accompanied by a University faculty or staff member.
    - Required court attendance as certified by the Clerk of Court.
    - Religious observances as verified by Parents & Constituent Services (515-2441). For more information about a variety of religious observances, visit the Diversity Calendar.
    - Required military duty as certified by the student's commanding officer

- **Counting Attendance:** Engagement with course material is a great way to enhance learning. Therefore, engagement will be incentivized through in-class or online participation, which is worth 10% of the final grade. Students must ask or answer one question per week during lectures or via the Moodle forums to receive full participation credit.

- **Absence Policy:** Students are allowed up to 2 unexcused absences without penalty to their grade.

- **Makeup Work Policy:** Students with valid medical issues or other emergencies will be given extensions to projects on an individual basis.

- **Calculation of course grade.** A weighted average grade will be calculated as follows:
  - Projects (4 plus the Review/Proposal) = 90%
    - For the 5 combined projects, the top 4 scores will each be worth 20% of the total grade. The lowest score will be worth 10% of the total grade.
  - Participation (In-class questions or forum posts) = 10%

  Note: We do not curve grades in this course. It is theoretically possible for everyone in the class to get an A (or an F). Your performance depends only on how you do, not on how everyone else in the class does. It is therefore in your best interests to help your classmates, while acting within the bounds of the stated academic integrity policy.

Score	>97	97-93	93-90	90-87	87-83	83-80	80-77	77-73	73-70	70-67	67-63	63-60	< 60
Grade	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F

  - **Requirements for Credit-Only (S/U) Grading:** In order to receive a grade of S, students are required to complete all projects and earn a grade of C- or better. Conversion from letter grading to credit only (S/U) grading is subject to university deadlines. Refer to the Registration and Records calendar for deadlines related to grading. For more details refer to http://policies.ncsu.edu/regulation/reg-02-20-15.

  - **Requirements for Auditors:** Information about and requirements for auditing a course can be found at http://policies.ncsu.edu/regulation/reg-02-20-04.

  - **Policies on Incomplete Grades:** If an extended deadline is not authorized by the instructor or department, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at http://policies.ncsu.edu/regulation/reg-02-50-3.

- **Instructors' commitment**. You can expect your instructors to be courteous, punctual, well organized, and prepared for lecture and other class activities; to answer questions clearly and in a non-negative fashion; to be available during office hours or to notify you beforehand if they are unable to keep them; to provide a suitable guest lecturer when they are traveling; and to grade uniformly and consistently according to the posted guidelines.

- **Consulting with faculty**. We strongly encourage you to discuss academic or personal questions with any of the course instructors during their office hours or by email.

- **ClassEval:** Course and instructor evaluations: Online class evaluations will be available for students to complete during the last two weeks of class. Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any one student responded to any question, and students will never know the ratings for any particular instructors.
  - Evaluation website: https://classeval.ncsu.edu
  - Student help desk: classeval@ncsu.edu
  - More information about ClassEval: http://www2.acs.ncsu.edu/UPA/classeval/index.htm

- Schedule: Online class evaluations will be available for students to complete during the last 2 weeks of the semester and become unavailable before finals begin. A reminder will be posted on the class website.
- **If >90% of students respond, 1% will be added to the grade of everyone. Please fill it out!**

- **Inclusion Statement:** At NCSU, administrators, faculty, and staff are committed to the creation and maintenance of "inclusive learning" spaces, where you shall be treated with respect and dignity and where all individuals are provided equitable opportunity to participate, contribute, and succeed.

  In this course, all students are welcome regardless of race/ethnicity, gender identities, gender expressions, sexual orientation, socio-economic status, age, disabilities, religion, regional background, Veteran status, citizenship status, nationality and other diverse identities that we each bring to class.

  The success of an inclusive classroom relies on the participation, support, and understanding of you and your peers. We encourage you to speak up and share your views, but also understand that you are doing so in a learning environment in which we all are expected to engage respectfully and with regard to the dignity of all others.

- **Religious/Cultural Observance:** Persons who have religious or cultural observances that coincide with this class should let the instructor know in writing (by e-mail for example) by Jan 22, 2022. I strongly encourage you to honor your cultural and religious holidays. However, if I do not hear from you by Jan 22, 2022, I will assume that you do not have any attendance conflicts of this sort.

- **Title IX Statement:** Title IX makes it clear that violence and harassment based on sex or gender is a Civil Rights offense, subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race or national origin. If you or someone you know has been harassed or assaulted, you can find the appropriate resources here: https://diversity.ncsu.edu/title-ix/

- **Non-Discrimination Policy:** NC State provides equal opportunity and affirmative action efforts, and prohibits all forms of unlawful discrimination, harassment, and retaliation ("Prohibited Conduct") that are based upon a person's race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability, gender identity, genetic information, sexual orientation, or veteran status (individually and collectively, "Protected Status"). Additional information as to each Protected Status is included in NCSU REG 04.25.02 (Discrimination, Harassment and Retaliation Complaint Procedure). NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at http://policies.ncsu.edu/policy/pol-04-25-05 or https://oied.ncsu.edu/divweb/. Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity (OEO) at 919-515-3148.

- **Students with disabilities:** Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) (https://policies.ncsu.edu/regulation/reg-02-20-01/). *Students requiring testing accommodations must make arrangements with the DSO to take the exam; note that the DSO web site advises students to make reservations more than 3 days before the test date. We advise that students go ahead and make these reservations at the beginning of the semester since the exam dates are already fixed. The department does not have the facilities to accommodate special testing needs, which the DSO is set up to do.*

- **Supporting Fellow Students in Distress:** As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remains a safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you. When this is the case, I would encourage you to report this behavior to the NC State Cares website: https://ncstatecares.dasa.ncsu.edu/ Although you can report anonymously, it is preferred that you share your contact information so they can follow-up with you personally.

Assignment Schedule (Subject to change)

DATE	SUBJECT	DUE
8/20	Why Engineer Microbial Communities?	
8/22	The Human Gut Microbiota.	
8/27	In-class presentations on research/areas of interest 1	Watch recorded lecture on Plant Microbiomes
8/29	Class Cancelled - Travel	Watch recorded lecture on built environment microbes
9/3	In-class presentations on research/areas of interest 2	Watch recorded lecture on aquatic microbiomes
9/5	Community-level engineering/Challenges.	
9/10	Class Cancelled – NAE Frontiers of Engineering Meeting	**Project #1: Review of undiscussed microbiome.**
9/12	Class Cancelled – NAE Frontiers of Engineering Meeting	
9/17	Class Cancelled – Wellness Day	
9/19	Consortia and strain-level engineering/Challenges	
9/24	Gene-level engineering 1: The transformation barrier, and *in situ* engineering methods.	
9/26	Gene-level engineering 2: Re-inventing the "parts".	
10/1	Metabolism and metabolic engineering	
10/3	Flux balance analysis and metabolic flux analysis	**Project #2: Evaluate transformability and define engineering strategy for an important microbe.**
10/8	Coding in Python and JupyterHub	
10/10	Designing Strains in StrainDesign	
10/15	Class Cancelled – Fall Break	
10/17	Microbial growth and the Lotka Volterra Equations.	**Project #3: FBA and StrainDesign on single microbes**
10/22	Theoretical considerations for Lotka-Volterra.	
10/24	Modeling well-mixed systems in COMETS	
10/29	Modeling spatially-variant systems in COMETS	
10/31	Agent-based models	
11/5	Modeling individual microbes with BacArena	
11/7	Statistical concepts in experimental design.	**Project #4: Modeling microbial communities**
11/12	Class Cancelled – International Conference on Microbiome Engineering	
11/14	Class Cancelled - International Conference on Microbiome Engineering	
11/19	ICME recap	
11/21	Class Cancelled – Seminar at University Women's Club	
11/26	Regulatory, safety, and ethical considerations.	
12/3	Research Proposal Presentations	**Proposals Due**

Required readings for each lecture will be posted to the Moodle Site.