

Environmental Microbiology

BIOL 3043-01

Spring, 2024

Lectures: T/Th 9:30-10:45 AM
Spear 116

Instructor

Daniel Jones, Ph.D.

Contact: daniel.s.jones@nmt.edu

Office: 314 MSEC

Office hours: TBA, or by appointment.

Course overview: Most of the diversity of life on Earth is microbial. Bacteria, archaea, and microbial eukaryotes occupy most of the branches of the tree of life, and these microorganisms are everywhere. Not only are bacteria and archaea the numerically dominant organisms in most of Earth's ecosystems, but members of these groups inhabit "extreme" places that are too hot, acidic, or salty for plants and animals to survive. The bacterial and archaeal domains also contain extensive metabolic diversity. Certain bacteria and archaea can take advantage of the energy available from a variety of different chemical reactions, and, in doing so, they transform inorganic compounds, create and destroy rocks and minerals, and act as crucial catalysts in global biogeochemical cycles.

This course is an introduction to the exciting world of environmental microbiology. We will start with the universal tree of life, the major groups of microorganisms, and the structure and function of microbial cells. We will then explore the diversity of microbial lifestyles, including microbial metabolism, energy generation, and the consequences of those lifestyles for global biogeochemical cycling. In the last third of the course, we will apply these foundational topics to microorganisms in natural and engineered systems, including through case studies focused on bioremediation and pollutant transformation, microbial ecology, and astrobiology.

Place in curriculum: This course is an elective for Biology majors; it is a required course for Environmental Engineering and Environmental Science majors. It addresses the New Mexico state Essential Skills (https://hed.state.nm.us/resources-for-schools/public_schools/general-education-of-critical-thinking,-personal-and-social-responsibility,-and-quantitative-reasoning-within-the-science-content-area).

Course learning outcomes: Upon successful completion of this course, students will be able to:

- Describe the major groups of microorganisms and the evolutionary relationships among these groups
- Explain the structures that make up microbial cells and the functions of those structures
- Describe how microorganisms respond to environmental parameters

- Describe the metabolic diversity among microorganisms, and their role in specific biogeochemical cycles
- Describe widely-used methods in environmental microbiology
- Explain the roles of microorganisms in environmental pollution and bioremediation
- Interpret and synthesize material from the primary literature in class discussions and assignments
- Effectively communicate scientific information on environmental microbiology through written and oral work

Program learning outcomes: Learning outcomes for undergraduate degrees in Biology can be found at <https://www.nmt.edu/academics/biology/undergrad.php>

Prerequisites: The prerequisite for this course is BIOL 2110 (Principles of Biology: Cell and Molecular Biology). BIOL 331 (Cell Biology) is required for Biology Majors, and is recommended for all others. However, because environmental microbiology is broadly applicable to the fields of biology, geology, chemistry, and engineering, I will often accept students that have not had these prerequisites. If you have a limited biology background and have arranged with me to take the course, you should expect to work harder than usual to catch up on material that would have been covered in the prerequisites. You may find it useful to develop working collaborations with students who have complementary biology or geology expertise to help you get up to speed.

Mode of instruction: In-person, although we may have some remote presentation to accommodate fieldwork schedules and guest speakers.

Field trips: We will have at least one weekend field trip during the course. Early in the semester, we will travel to Southeastern New Mexico to collect samples from caves in New Mexico's Guadalupe Mountains. These samples will form the basis of laboratory activities for students taking the lab section (BIOL 3043L), but the trip is open to students in the lecture portion provided space is available. The field trip is not required, but I strongly encourage everyone to attend, as it will be a once-in-a-lifetime experience for many students. In addition to caving, the field trip may require up to two miles of hiking. Details will be provided in lecture.

Course website: Canvas course website, <http://learn.nmt.edu>

Readings:

Required text: *Brock Biology of Microorganisms (15th ed.)*, by Madigan et al. Brock Biology is an excellent reference and is the microbiology text of choice for many physical scientists interested in microorganisms. If you don't want to purchase it, a copy is placed on reserve at the Skeen Library and used copies of earlier editions are also available. If you choose to use an earlier edition, you will need to translate the page number for reading assignments. There is also a newer 16th edition available that can be rented from the publisher.

Other required readings: Additional readings will be taken from the scientific literature or other sources. Electronic versions will be made available through the course webpage.

Skeen library reserve: The following references are placed on reserve at the Skeen library

- *Brock Biology of Microorganisms* by Madigan et al. A copy of both the 15th and 12th editions are on reserve.
- *Introduction to Geomicrobiology* by Konhauser (2007). This text is widely-used in geomicrobiology courses, and you might find it useful both for reinforcing specific course concepts as well as when researching for your final paper.
- *Ehrlich's Geomicrobiology* by Ehrlich, Newman, and Kappler (2015) and *Fundamentals of Geobiology* by Knoll (2012). These texts are more advanced geobiology and geomicrobiology references, and may be relevant for students interested in microbe-mineral interactions, global biogeochemistry, and deep time topics.

Grade basis:

Homework	10%
Final paper and presentation	30%
Topic statement, outline, drafts (5%)	
Final paper (20%)	
Final presentation (5%)	
Quizzes and exams (best 5 of 7)	50%
Class participation (including attendance)	10%

Quizzes: We will have seven quizzes over the course of the semester that will cover lecture material, homeworks, and reading material. Your score for this section will be based on your best 5 of 7 quizzes (including the final exam). Each of the five quizzes scored will be worth 10% of the total course grade; however, if you wish, you may choose to increase the weight of the final exam up to 25% and reduce the weight of the other quizzes accordingly.

Homeworks: Homework will take the form of problem sets, short essay questions, or primary literature reviews, and will cover material that will appear on the quizzes. You will have the opportunity to revise any homeworks that do not meet expectations, within one week of receiving feedback.

Presentations: You will give two “lightening talks” during the term: a “microbe of the week” presentation, and a presentation on your final paper. Lightening talks will last five minutes or less, and details will be discussed in class. Breaking down a complex topic into a brief presentation that is appropriate and easily digestible for your target audience is a tall order, but one that is important for your success as a scientist, whether you are talking to a scientific peer, neighbor, state senator, or funding agency representative.

Final projects: The final project for the class will be a research paper on your laboratory project (for students taking BIOL 3043L) or a review paper on a topic of your choice.

Laboratory research paper (BIOL 3043L students only): For your final class project, students in Environmental Microbiology Lab (BIOL 3043L) have the option of preparing a writeup on their laboratory projects. Your paper should be 8-10 pages (12 point Time New Roman font or 11 point Arial font, 1 inch margins, single-spaced), and include figures and tables based on your laboratory research. These can include content, figures, and tables from your laboratory reports, so long as they are professionally formatted. The introduction will include a literature review on

your topic (minimum 10 citations). References are not included in the page limit. You may work together with your laboratory group and are encouraged to share references and figures with your lab partner or group, but the paper itself and all writing **must** be your own work.

Review paper: For the review paper, you will review an environmental microbiological process or group of environmentally-important organisms. The review should be 8-10 pages (12 point Time New Roman font or 11 point Arial font, 1 inch margins, single-spaced), including figures but not references, and you are encouraged to incorporate original figures that you have drafted yourself. You should expect to cite a minimum of 20 articles from the peer-reviewed literature.

Please note the due dates for the project topic, abstract, outline and bibliography, and partial draft on the class schedule. **You are also welcome to turn in a draft to me at any point up until ~2 weeks before the final paper is due.** If you choose to do this (and I highly recommend it!), do not expect to receive immediate feedback from me, but within three days is reasonable. Drafts may be incomplete, but should be well written and not contain egregious spelling errors and typos.

You are encouraged to take advantage of the resources available at the Writing and Communication Lab, which offers qualified tutors for graduate and undergraduate students to improve writing skills (<https://www.nmt.edu/academics/class/center.php>).

Participation and Attendance: Everyone is expected to attend class and participate in lecture, discussions, and other class activities. For full credit on your participation score, you should not have more than two unexcused absences, and more than six unexcused absences will result in 0% for your participation score. We recognize that life happens, and we will make reasonable accommodations for medical absences and for students that contact us in advance about unavoidable absences. This includes absences for COVID-19 and other illnesses; please consult NMT's COVID-19 information page (<https://www.nmt.edu/covid19/>) for up-to-date guidelines.

Tracking participation: You will be asked to track and reflect on your participation through periodic "participation inventories," typically as part of your learning reflections (see below).

Reflections: Assessing your own learning process (metacognition) is a critical skill for lifelong learners. Three times over the course of the semester, you will be asked to reflect on your learning journey in this course. Details will be provided during the semester.

No extra credit is available outside of designated assignments. We will look over any exam or homework questions you think are not graded correctly and adjust your score as appropriate, but we will otherwise not negotiate your final grade. If you are having trouble in class for academic or any other reasons and are concerned about your grade, please see me early on so we can discuss how you can improve your understanding and performance.

NMT Policies and Resources

Academic Honesty: New Mexico Tech's Academic Honesty Policy for undergraduate and graduate students is found in the catalog, which can be found at:

<https://www.nmt.edu/registrar/catalogs.php/>. Further information about academic honesty can be found on the Associate Vice President for Academic Affairs website:

https://www.nmt.edu/academicaffairs/avpaa/academic_honesty.php

You are responsible for knowing, understanding, and following this policy.

Student Resources: Wondering where to go for help? Please see the offices below or visit the “[Where NMT Students Should Go for Help](#)” website.

Student Success: New Mexico Tech offers numerous peer tutoring services for students who are struggling in their courses, or who just wish to receive friendly advice, including the Office of Student Learning (Skeen Library, <https://www.nmt.edu/osl/>), Math Helproom (<https://www.nmt.edu/academics/math/ugrad/mathhelproom.php>), the Writing and Communication Lab (Skeen Library, <https://www.nmt.edu/academics/class/center.php>), and numerous department-run centers. These services are free of charge to students! Students may also consult the Dean for Student Success Initiatives, Elaine Debrine Howell (Fidel, rm. 237; 575-835-5208; elaine.debrinehowell@nmt.edu) or may receive emails from her if they are struggling in class.

Reasonable Accommodations: New Mexico Tech is committed to protecting the rights of individuals with disabilities and providing access and full participation in the educational experience. Students with disabilities who require reasonable accommodations are invited to make their needs known to the Office for Student Access Services (SAS) as soon as possible. Accommodations are not retroactive and may take some time to implement. The process for requesting accommodations can be found at their website https://nmt.edu/ds/for_students.php

You can contact SAS in person at the Fidel Center Room 245, call 575-835-6209, email access@nmt.edu or book through the link on our [website](#).

Counseling Services: The Counseling Center is very excited to announce that Tech has partnered up with the Virtual Care Group (VCG), to offer free supplemental healthcare services to our degree-seeking students. This virtual healthcare includes unlimited Tele-medical and unlimited Tele-therapy/counseling sessions available 24/7, as well as life coaching. Both in-person sessions on campus and this virtual healthcare are available for those degree-seeking students currently enrolled for Fall classes. Download The Virtual Care Group app from your app store. For questions about the platform, please email VCG’s Care Team at care@virtualcaregroup.com. For more information on services at NMT, please call 835-6619, email counseling@nmt.edu or check out our website at <https://www.nmt.edu/cds/>.

Respect Statement: New Mexico Tech supports freedom of expression within the parameters of a respectful learning environment. As stated in the *New Mexico Tech Guide to Conduct and Citizenship* (Student Handbook): “New Mexico Tech’s primary purpose is education, which includes teaching, research, discussion, learning, and service. An atmosphere of free and open inquiry is essential to the pursuit of education. Tech seeks to protect academic freedom and build on individual responsibility to create and maintain an academic atmosphere that is a purposeful, just, open, disciplined, and caring community.”

Title IX Reporting: Sexual misconduct, sexual violence, and other forms of sexual misconduct and gender-based discrimination are contrary to the University’s mission and core values, violate university policies, and may also violate state and federal law (Title IX). Faculty members are considered “Responsible Employees” and are required to report incidents of these prohibited behaviors. Any such reports should be directed to Tech’s Title IX Coordinator (Dr. Peter Phaiiah, 238 Fidel Student Center, 575-835-5953 (O), 575-322-0001 (C), titleixcoordinator@nmt.edu) or reports can be filed online to [Tech’s Title IX & Sexual Misconduct Report](#). Please visit [Tech’s Title IX Website \(www.nmt.edu/titleix\)](#) for additional information and resources.

Land Acknowledgement: We acknowledge that the New Mexico Institute of Mining and Technology campus stands on the unceded ancestral lands of the Pueblo and Apache peoples. These lands were taken by Congress in the Indian land Cession 689 on October 1, 1886, and the people forcibly moved to reservations. These injustices were accomplished under false white-supremacist ideologies such as manifest destiny and the doctrine of discovery. As visitors to these lands we appreciate their millennia of stewardship to the land, water, animals and plants, and the opportunity to live and learn here. Please visit <https://indianpueblo.org/new-mexicos-19-pueblos/> to learn more about these Native nations, their cultures, and sovereignty.

Language on New Mexico Tech policies from <https://www.nmt.edu/academicaffairs/policies.php>, and courtesy of Dr. Steve Simpson.

Language on learning reflections and tracking participation courtesy of Dr. Katherine Mattaini, Tufts University, and Dr. David Clark, Grand Valley State University.

Land acknowledgement text courtesy of Anne Gray, Chris ChoGlueck, Michael Schaefer, and the EES Diversity, Equity, and Inclusion (DEI) committee.

BIOL 3043: Environmental Microbiology

Spring 2024

Course schedule

Brock is the textbook, *Brock Biology of Microorganisms* (15th edition) by Madigan et al.

Please be aware that both lecture materials and readings may be subject to change as the semester progresses

Module 1: Introduction, and the universal tree of life

T	16 Jan	Introduction and course overview	
Th	18 Jan	The universal tree of life <i>Reading: Brock Ch. 1 and Ch. 13</i>	
T	23 Jan	Early evolution and history of life on Earth <i>Reading: Brock Ch. 1 and Ch. 13</i>	
Th	25 Jan	The three domains of life; start microbial structure and function <i>Reading: Brock Ch. 1 and Ch. 13</i>	

Module 2: Microbial structure and function

T	30 Jan	Microbial structure and function <i>Reading: Brock Ch. 2</i>	Quiz 1
Th	1 Feb	Microbial structure and function <i>Reading: TBA, literature discussion</i>	Literature discussion

F-Su Feb 2-4, weekend fieldtrip to Carlsbad Cavern and Guadalupe Mountain Caves

T	6 Feb	Field trip recap; protists <i>Reading: Brock Ch. 18</i>	
Th	8 Feb	Protists; viruses <i>Reading: Brock Ch. 8 & 18</i>	

Module 3: Energy and metabolism

T	13 Feb	Microbial growth <i>Reading: Brock Ch. 5</i>	Quiz 2
Th	15 Feb	Microbial growth continued <i>Reading: Brock Ch. 5</i>	
T	20 Feb	Oxidation-reduction reactions and chemical energy <i>Reading: Brock Ch. 3 p. 78-85 and handouts</i>	Homework 1 due
Th	22 Feb	Chemical energy; microbial energy generation <i>Reading: Brock Ch. 3</i>	
T	27 Feb	Microbial energy generation <i>Reading: Brock Ch. 3</i>	
Th	29 Feb	Fermentation and anaerobic respiration <i>Reading: Brock Ch. 3, relevant sections of Ch. 14</i>	Homework 2 due

Module 4: Metabolic diversity and microbial biogeochemistry

T	5 Mar	Lithotrophy <i>Reading: relevant sections of Brock Ch. 14 and 15</i>	
Th	7 Mar	Phototrophy and photosynthesis <i>Reading: relevant sections of Brock Ch. 14 and 15</i>	Quiz 3
T	12 Mar	Photosynthesis and autotrophy <i>Reading: relevant sections of Brock Ch. 14 and 15</i>	
Th	14 Mar	Finish metabolic diversity and biogeochemical cycling <i>Reading: relevant sections of Brock Ch. 14 and 15</i>	Paper topic due

Spring Break (Stationary Phase)

T	19 Mar	No class (Spring Break)	
Th	21 Mar	No class (Spring Break)	

Module 5: Case studies

T	26 Mar	Bioremediation and contaminant transformations <i>Reading: Brock Ch. 22 Section II & III</i>	Paper outline and abstract due
Th	28 Mar	Bioremediation and contaminant transformations <i>Reading: Brock Ch. 22 Section II & III</i>	Quiz 4
T	2 Apr	Methods in environmental microbiology <i>Reading: Brock Ch. 19</i>	
Th	4 Apr	Microbial ecology topics <i>Reading: TBA</i>	Homework 3
T	9 Apr	TBA (student interest) <i>Reading: TBA</i>	
Th	11 Apr	TBA (student interest) <i>Reading: TBA</i>	Partial paper draft due

Module 6: Astrobiology, class presentations, and course wrap up

T	16 Apr	SRS week; class presentations	Quiz 5
Th	18 Apr	SRS week; class presentations	

T-F, April 16th-19th: Student Research Symposium (class presentations)

S, April 20th: Rocky Mountain Geobiology Symposium

Monday (4/22) is the last day to turn in a full draft of your final paper for instructor feedback

T	23 Apr	Finish class presentations; origin and early evolution of life	
Th	25 Apr	Astrobiology and life elsewhere	Quiz 6
T	30 Apr	Astrobiology continued	

Last day of classes, W May 1st **Final projects due**

Final exam period, day/time TBA **Final exam**