**MICROBIAL ECOLOGY**

**(BIOS 4410A/BIOL 6410A**

**EAS 4803JK/EAS 8803JK)**

**Tentative Syllabus – Spring, 2019**

**Introduction:**

Welcome to microbial ecology. This course is cross-listed for undergraduate and graduate students. The intent of the course is to introduce you to the many facets of microbial life on this planet and to show you that Earth’s ecosystems (including the human microbiome) and microbes are closely intertwined.

Most people think of microorganisms or microbes as harmful, causing disease or just stinking up the refrigerator. However, the reality is that the vast majority of microbes keep humans alive and healthy on Earth. Microbes indeed rule the world! Microbes are responsible directly or indirectly for producing the air we breathe, the food we eat, clean water that we drink, and diseases that make us sick. However, most of the microbial world remains to be discovered and explored. Central ecological questions, that have been largely answered for macrobes, remain understudied in microbes including:

What microbes are present in various ecosystems?

What activities do they perform?

How are these activities interrelated?

In what number does each type of organism occur?

What is the magnitude of its activity *in situ?*

What environmental factors affect this activity?

The availability of next generation genetic sequencing technologies has revolutionized the field of microbial ecology. A census of at least the predominant microbes in nature is now possible. The field is now focused on linking community structure (that is, the composition of a microbial community and the abundance of each member of the community) with the processes occurring within the ecosystem. This course provides an in-depth overview of the role of microbes in the functioning of Earth’s ecosystems. Specific topics will include microbial evolution, phylogeny, physiology, metabolism, community ecology, habitats such as plant and human microbiomes, methods, biogeochemical cycles, biofuels, food microbiology, and bioremediation. The course format will consist of interactive lectures, discussions, and presentations which will draw on information from the latest scientific discoveries in the field.

**Instructor:**

**Joel E. Kostka, Ph.D.,** School of Biological Sciences and Earth & Atmospheric Sciences

Email: joel.kostka@biology.gatech.edu

Phone: 404-385-3325; Office: 225 CE; Office hours: W, 10:00-11:00 am.

**Class Schedule and Location:**

**Lecture: MW 9:05am-9:55am, Room 320 Cherry Emerson**

**Course Learning Outcomes:**

By the end of this course, you will be able to…

* Comprehend the phylogenetic and metabolic diversity of microorganisms as well as their ubiquitous distribution in global ecosystems.
* Describe the origins of microbial life on the planet and how microbes contributed to the chemical evolution of Earth.
* Identify the unique structural and physiological adaptations that allow microbes to be successful in such a large range of environments.
* Describe the latest methods employed for determination of the abundance, distribution, diversity, and activity of microbes in nature.
* Interpret datasets that quantify microbial diversity and function at the ecosystem scale.
* Effectively interpret, synthesize, and present information from primary research papers in the field.

**Required Course Reading Material:**

**Required texts:**

Processes in Microbial Ecology, Second Edition

David L. Kirchman

ISBN-13: 978-0198789413

ISBN-10: 0198789416

Publisher: Oxford University Press

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Life's Engines: How Microbes Made Earth Habitable (Science Essentials)

Paul G. Falkowski

**Required additional supplemental reading:**

* Microbes and Evolution: The World that Darwin Never Saw, Edited by R. Kolter and S. Maloy, 2012.
* Review articles
* Primary literature
* Websites

Additional reading material will be announced and added to the course website on Canvas. You are responsible for checking Canvas daily for updates to the schedule and reading material throughout the semester.

Lecture Powerpoint presentations will be posted on T-square either before or after lecture (at instructor discretion), but always before the respective exam. Additional material may be covered in lectures, and you may be tested over it.

**Prerequisites**: (all require a minimum grade of “D”):

BIOL 3380 - Introductory Microbiology, or CEE 6311 - Microbial Principles or consent of instructor.

**Course Learning Outcomes:**

By the end of this course, you will be able to…

1. Critically read primary literature, analyze experimental results, and reflect on peer presentation of scientific material.
2. Comprehend the phylogenetic and metabolic diversity of microorganisms on Earth.
3. Understand the evolutionary adaptations and environmental controls that determine the success of microorganisms in past and present ecosystems.
4. Be able to explain the key processes and mechanisms by which microbes mediate the functioning of past and present ecosystems.
5. Be aware of the latest approaches used for the characterization of microbial abundance, diversity, community composition, and activity in nature.
6. Design an investigation using cutting-edge methodologies to characterize structure and functioning of microbial communities in nature.

**Grading:**

Undergraduate section:

Research paper discussion questions- 20 %

Two take-home exams- 40 %

QIIME Workshop Assignment- 15 %

Paper presentation- 15 %

Class participation (attendance, reading, discussion)- 10 %

Graduate section:

Research paper discussion questions- 10 %

Two take-home exams- 30 %

QIIME Workshop Assignment- 15 %

Paper presentation - 15 %

Class participation (attendance, reading, discussion)- 10 %

Field lab and report- 20 %

**Description of Course Content**

Class meetings will involve a combination of lectures (1/3), group discussions (1/3), and student presentations (1/3) focused on the primary literature. Course material will be based on weekly readings of recent research articles from the primary literature, review articles, and the Kirchman (2018) text. Primary literature readings and review papers will be made available as pdfs and posted on Canvas.

**Take-home exams**

Exams will each count toward 15-20 % of your final course grade. The two exams are take-home home exams which you will have about 1 week to complete. The exams will include mainly short answer and essay questions. The exams are designed so that the answers will not be ones you can simply find in a textbook, but may very well be based on simulated laboratory or field data that I provide. You are expected to work on each exam alone but you may use the textbook, Powerpoints, your lecture notes, and research papers to aid in the completion of your exams. The first exam, a midterm exam, will cover material up to the exam, and the final exam will cover material from the latter half of the course. However, since the topics discussed after the midterm exam will rely on your knowledge of the earlier material, a comprehensive understanding of the course material will be required for the final exam. Exams will be distributed 1 week prior to the scheduled due date (see schedule below). Exams can only be missed if proper documentation is presented. Make-up exams will be different from the original exams. There is NOT a comprehensive final exam.

**Class Attendance and Participation**

Attendance and active participation are **required**. As outlined in the course requirements section of this syllabus, 10 % of your course grade will be determined by your active participation in class. I will use a “cold-calling” mode of questioning in class. Using index cards you fill out during our first class, I will randomly call on students during each class period to promote discussion. I will grade your response based on the scheme below. Therefore, you are expected to read the required material for each class and come ready to participate and contribute. Participation in the discussions and questioning during student presentations is also expected and will be included in your participation grade. Much of the information needed to succeed on the exams will be provided orally in class, but will not be present in the Powerpoint presentations. **If you do not attend class and rely solely on the textbook and the Powerpoint presentations available on Canvas following each class, you will most likely do very poorly in this course.**

**Index-card class participation grading:**

**0 - no attempt given to answer question, absent**

**1 - a poor attempt is given to answer the question, unclear on many points**

**2 - a good answer with some of the essential features addressed**

**3 - an excellent answer with most or all of the essential features addressed**

**Student Presentations and Research Paper Discussions**

Research articles will be chosen by Dr. Kostka to complement the lectures and to reflect the latest developments in the field. Students will be assigned and responsible for one of the research papers. Groups will be developed in the first few weeks of class depending on enrollment. Students will design and present a graded Powerpoint presentation on the research paper and relevant background information. Their oral presentation will be given during class on the date assigned. Plan the presentation for 30-35 minutes, allowing 15-20 minutes for questions. The format for the presentations is flexible, but should be designed to both summarize the content of the paper and also present ideas for discussion. Dr. Kostka will provide guidelines for what to include in the presentation, and will give an example presentation in week 3.

All students that are not presenting that day will fill out the “presentation assessment form” (see below) at the end of the presentation and turn it in. The presentation grade for each student or group will be derived from the average of the assessment grade from your peers (50%) and from the instructor (50%). The independent critical review by undergraduate students will be graded by the instructor using the critique rubric (see below). The grade from your presentation or critique represents 10% of your course grade.

Students are required to read each research paper carefully (prior to class) and to answer a set of questions relating to the content of each study. These questions are designed to encourage reflection and to prepare students to discuss the goals, methods, and outcomes of the research, and also to become critical reviewers of scientific research articles. Answers (~1-2 pages) to paper questions will be handed in (hard copy) by the end of class on the day the paper is discussed. These answers will be graded. Late assignments will NOT be accepted.

**Extra credit:**

Extra credit **may** be offered for attending specific departmental seminars and symposia, taking good quality notes, and handing in the notes.

**Course expectations and policies:**

**Consideration:** Appropriate classroom behavior is expected at all times. Turn off all cell phones. The only electronic device used can be a laptop if you would like, although this is not required. If you use a laptop, it is for note-taking for this course only, and not for web-surfing, social networking… Students are also expected to be proactive, meeting with their instructor should they encounter difficulties in the class, require assistance or have any unanswered questions. **I encourage you to ask questions!**

**Academic Integrity:**

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic Honor Code, please visit http://www.catalog.gatech.edu/policies/honor-code/ or http://www.catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

**Accommodations for Students with Disabilities:**

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

**Campus Resources for Students:**

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person.

**Academic support**

* Center for Academic Success <http://success.gatech.edu>
  + 1-to-1 tutoring <http://success.gatech.edu/1-1-tutoring>
  + Peer-Led Undergraduate Study (PLUS) <http://success.gatech.edu/tutoring/plus>
  + Academic coaching http://success.gatech.edu/coaching
* Residence Life's Learning Assistance Program

<https://housing.gatech.edu/learning-assistance-program>

* + Drop-in tutoring for many 1000 level courses
* OMED: Educational Services (<http://omed.gatech.edu/programs/academic-support>)
  + Group study sessions and tutoring programs
* Communication Center (<http://www.communicationcenter.gatech.edu>)
  + Individualized help with writing and multimedia projects
* Academic advisors for your major

<http://advising.gatech.edu/>

**Personal Support:**

Georgia Tech Resources

* The Office of the Dean of Students: <http://studentlife.gatech.edu/content/services>; **404-894-6367**; Smithgall Student Services Building 2nd floor
  + You also may request assistance at <https://gatech-advocate.symplicity.com/care_report/index.php/pid383662?>
* Counseling Center: <http://counseling.gatech.edu>; **404-894-2575**; Smithgall Student Services Building 2nd floor
  + Services include short-term individual counseling, group counseling, couples counseling, testing and assessment, referral services, and crisis intervention. Their website also includes links to state and national resources.
  + *Students in crisis may walk in during business hours (8am-5pm, Monday through Friday) or contact the counselor on call after hours at* ***404-894-2204****.*
* Students’ Temporary Assistance and Resources (STAR): <http://studentlife.gatech.edu/content/need-help>
  + Can assist with interview clothing, food, and housing needs.
* Stamps Health Services: <https://health.gatech.edu>; **404-894-1420**
  + Primary care, pharmacy, women’s health, psychiatry, immunization and allergy, health promotion, and nutrition
* OMED: Educational Services: <http://www.omed.gatech.edu>
* **Women’s Resource Center:** [**http://www.womenscenter.gatech.edu**](http://www.womenscenter.gatech.edu)**; 404-385-0230**
* **LGBTQIA Resource Center:** [**http://lgbtqia.gatech.edu/**](http://lgbtqia.gatech.edu/)**; 404-385-2679**
* **Veteran’s Resource Center:** [**http://veterans.gatech.edu/**](http://veterans.gatech.edu/)**; 404-385-2067**
* **Georgia Tech Police:** **404-894-2500**

**Statement of Intent for Inclusivity**

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.

**Syllabus change policy:**

Syllabus changes substantially affecting the grading of the course will not be made. Other syllabus changes may be made and will be announced.

**Course Schedule (TENTATIVE!):**

Please note that topics may be modified/ omitted due to time constraints and exams may be changed.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Day** | **Date** | **Topic** |  | **Reading** |  |
|  |  |  |  |  |  |  |
| Week 1 | M | 7 Jan | Introduction: The significance of microbial life to humans, animals, plants, and the environment |  | Ch. 1, Kirchman  The World That Darwin Never Saw, Kolter and Maloy |  |
|  | W | 9 Jan | Introduction: The significance of microbial life to humans, animals, plants, and the environment |  | Ch. 1, Kirchman  The World That Darwin Never Saw, Kolter and Maloy |  |
|  | F | 11 Jan | Introduction: The diversity of microorganisms, microbiomes, and microbial ecosystems |  |  |  |
| Week 2 | M | 14 Jan | Martin Luther King Jr. National Holiday |  | Ch. 2, Kirchman  Earth's Microbial Engines, Falkowski |  |
|  | W | 16 Jan | Microbial Evolution |  | Early Microbial Life, Konhauser  Deep History of Life, A.H. Knoll |  |
|  | F | 18 Jan | Microbial Evolution |  | Early Microbial Life, Konhauser  Deep History of Life, A.H. Knoll |  |
| Week 3 | M | 21 Jan | Physical-Chemical Environment |  | Ch. 3, Kirchman |  |
|  | W | 23 Jan | Physical-Chemical Environment |  | Ch. 3, Kirchman |  |
|  | F | 25 Jan | Student Presentations Begin |  |  |  |
| Week 4 | M | 28 Jan | Microbial Metabolism |  | Ch. 2 Konhauser; Appendix 1, Brock |  |
|  | W | 30 Jan | Microbial Metabolism |  | Ch. 2 Konhauser; Appendix 1, Brock |  |
|  | F | 1 Feb | Student Presentation |  |  |  |
| Week 5 | M | 4 Feb | Primary Production and Phototrophy |  | Ch. 4 Kirchman; Biller et al. (2015); Chisholm essay |  |
|  | W | 6 Feb | Primary Production and Phototrophy |  | Ch. 4 Kirchman; Biller et al. (2015); Chisholm essay |  |
|  | F | 8 Feb | Student Presentation |  |  |  |
| Week 6 | M | 11 Feb | Organic Matter Decomposition and Heterotrophy |  | Ch.s 5, 11 Kirchman |  |
|  | W | 13 Feb | Organic Matter Decomposition and Heterotrophy |  | Ch.s 5, 11 Kirchman |  |
|  | F | 15 Feb | Student Presentation; Exam 1; Deadline for Grad Students to Choose Proposal Topic; Proposal Abstract Due |  |  |  |
| Week 7 | M | 18 Feb | Cultivation of Environmental Microbes |  |  |  |
|  | W | 20 Feb | Cultivation of Environmental Microbes |  |  |  |
|  | F | 22 Feb | Student Presentation |  |  |  |
| Week 8 | M | 25 Feb | Next Generation Sequencing |  |  |  |
|  | W | 27 Feb | Next Generation Sequencing |  |  |  |
|  | F | 1 March | Student Presentation |  |  |  |
| Week 9 | M | 4 March | Metagenomics |  | Ch. 10, Kirchman |  |
|  | W | 6 March | Metagenomics |  | Ch. 10, Kirchman |  |
|  | F | 8 March | Student Presentation |  |  |  |
| Week 10 | M | 11 March | Microbial Community Structure |  | Ch. 9, Kirchman |  |
|  | M | 13 March | Microbial Community Structure |  | Ch. 9, Kirchman |  |
|  | W | 15 March | Student Presentation |  |  |  |
| Week 11 | M-F | 18-22 March | Spring Break |  |  |  |
| Week 12 | M | 25 March | QIIME Workshop: Pipeline for analysis of SSU rRNA gene amplicon sequences |  |  |  |
|  | W | 27 March | QIIME Workshop: Pipeline for analysis of SSU rRNA gene amplicon sequences |  |  |  |
|  | F | 29 March | QIIME Workshop: Pipeline for analysis of SSU rRNA gene amplicon sequences |  |  |  |
| Week 13 | M | 1 April | Microbial Nitrogen Cycle |  | Ch. 12, Kirchman |  |
|  | W | 3 April | Microbial Nitrogen Cycle |  | Ch. 12, Kirchman |  |
|  | F | 5 April | Student Presentation; QIIME Homework Assignment Due |  |  |  |
| Week 14 | M | 8 April | Microbial Carbon Cycle |  |  |  |
|  | W | 10 April | Microbial Carbon Cycle |  |  |  |
|  | F | 12 April | Student Presentation; Proposals Due |  |  |  |
| Week 15 | M | 15 April | Bioremediation |  |  |  |
|  | W | 17 April | Bioremediation |  |  |  |
|  | F | 19 April | Student Presentation |  |  |  |
| Week 16 | M | 22 April | Student Presentation- Final Exam distributed |  |  |  |
|  | W | 24 April | Wetlands and Plant Microbiomes |  |  |  |
|  | Th-Th | 25 April- 2 May | Final Exam Week |  |  |  |

**Presentation Assessment Form\***

**BIOS 4410/6410; EAS 8803JK**

**Presentation Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Presentation Title: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Names of Presenters: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

5 = excellent; 4 = very good; 3 = good; 2 = fair; 1 = poor

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | Total |
|  | 5 | 4 | 3 | 2 | 1 |  |
| **Mechanics of Communication (3 x 5 = 15 points)** |  |  |  |  |  |  |
| Were the speakers familiar with the A/V equipment? |  |  |  |  |  |  |
| Were the slides easy to read and not overcrowded? |  |  |  |  |  |  |
| Did the speaker show helpful graphics and/or video? |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Presentation (5 x 5 = 25 points)** |  |  |  |  |  |  |
| Was the talk well presented? (e.g. typos, slide order) |  |  |  |  |  |  |
| Did the speakers speak loud enough? |  |  |  |  |  |  |
| Did the speakers avoid trash phrases? |  |  |  |  |  |  |
| Did the speakers strive to keep the audience’s attention? (e.g. eye contact, voice, expression) |  |  |  |  |  |  |
| Were the speakers attentive to the needs of a general audience? (e.g. explain technical terms) |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Content (5 x 10 = 50 points)** |  |  |  |  |  |  |
| Did the talk have distinct introduction, body, and conclusions sections? |  |  |  |  |  |  |
| Was the introduction clear and adequate and did it make the audience curious? |  |  |  |  |  |  |
| Were the results explained clearly, accurately, and simply? |  |  |  |  |  |  |
| Did the conclusion summarize the main points and make clear the “take home message” of the talk? |  |  |  |  |  |  |
| Did the speaker leave sufficient time (10 to 15 min.) for questions? |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| **Questions (2 x 5 = 10 points)** |  |  |  |  |  |  |
| Did the talk stimulate interesting questions and were they answered adequately? |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

**Grand Total Points: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Strengths: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Suggestions for improvement:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Overall Evaluation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Note: this assessment will be provided to presenters after the grade totals are recorded.**