Description: This course introduces students to host-associated microbiomes; the genomic collection of bacteria, archaea, fungi, protozoa, and viruses present in a host ecosystem. In each lecture, we will focus on an anatomical location, and discuss the host and environmental pressures which select for the resident microbial community. The material is primarily in animals (mammals, birds, fish, amphibians) but includes some human-specific comparisons. This course will introduce ecological theories (e.g. environmental selection, neutral theory) in the context of microbial communities, the history of host-associated microbiology, and how technology has contributed to or limited our understanding of organisms and their critical role in our health and development. The skill-set objectives include group discussions, reading scientific literature, and scientific writing in a variety of styles and both technical and non-technical formats.

Credit Hours: 3
Prerequisites: BIO 200 or BIO 208 or BMB 155 or BMB 280 or SMS 201; or instructor’s permission
General Education requirements satisfied: Population and Environment
Mode of Instruction: In-person
Time: Synchronous
Digital Services, Hardware, Software: Brightspace

Instructional Material: All reading material will be provided as electronic journal articles via Brightspace and will reflect current literature in host-associated microbial ecology.

Class format: Lecture-based course with regular in-class discussions on relevant topics in science. Lecture Schedule is 15 weeks of 39 total class days: D3 x 1H

Course Goals:
• Introduce concepts, techniques, historical background, terminology, and technology of microbial ecology.
• Familiarize students with online resources, including sequence and other databases, as well as analysis tools.
• Discuss factors which shape host-associated microbiomes and how the microbiome can affect the host.
• Review current literature on host-associated microbial ecology.

Student Learning Outcomes:
As a result of taking this class, students will be able to:
• Describe the dynamics which shape host-associated microbiomes.
• Access online databases of scientific articles and databases.
• Review scientific journal articles and distill their findings while understanding their limitations.
• Communicate science in a variety of formats.
• Discuss topics related to science, such as recognition for achievements and the role of scientists in communicating results to the general public.

In meeting the Population and Environment requirements specifically, students will be able to:
• Describe how host-associated microbial ecosystems are affected by environmental (external to the body) conditions.
• Describe how climate change affects range and diet selection, and how this can impact gut microbial communities and animal survival.
• Describe vertical and horizontal transmission, as well as environmental exposure of microorganisms.
• Describe the effect of pollution and air quality on health and the microbiome.

Attendance policy: Students are expected to attend lectures, but it is understood that life often precludes this. Students may attend class virtually, through Zoom, but at least 1 hour of advanced notice is requested. Students who will miss a significant number of classes, or who require additional accommodations, may contact me to make alternate arrangements.

➢ Pregnancy, lactation, and parenting: I am happy to make accommodations for students based on pregnancy, lactation, and parental needs, as well as work with the Office of Equal Opportunities. Maine state and UMaine policy allows students who are nursing to breastfeed in any space, including in class. If a lactation space is required, please contact E.O. for arrangements.

Class participation: Students are expected to participate in discussions in class. I strive to create inclusive discussions, but if students still find it challenging to participate please notify me and I will alter the discussion format as needed.

Late Assignments: Assignments will be accepted after the deadline, with a 10% reduction in grade per day. Assignments will not be accepted after the final exam slot for this class.

Classroom policy: Supporting inclusion and community in science is an active process that involves both invitation, and support to ensure that the scientific community is and remains an equitable and inclusive place. Students are expected to conduct themselves in a professional and courteous manner, and to abide by University policies.

Campus Policies: “The University of Maine is an EEO/AA employer, and does not discriminate on the grounds of race, color, religion, sex, sexual orientation, transgender status, gender expression, national origin, citizenship status, age, disability, genetic information or veteran’s status in employment, education, and all other programs and activities.” Follow the links for more information.

* Academic Honesty Statement
* Students Accessibility Services Statement
* Course Schedule Disclaimer
* Observance of Religious Holidays/Events
* Sexual Discrimination Reporting (Long)
* Sexual Discrimination Reporting (Short)

** I am a “mandatory reporter”. If you disclose something to me, I am obligated to disclose to the relevant campus Title IX office. This includes information revealed in class assignments.
Grading and Course Expectations:

**Homework:** Homework will be assigned regularly and may be submitted online or in class. These will include written essays/discussion, “posters”, article reviews, drawn concept-network maps, or will involve exploration of microbial ecology online resources such as databases (ex. NCBI, MG-RAST). Some of the homework will be used to create portions of the final project.

- **Article Summaries:** Write a 1-2 paragraph non-technical summary of a scientific journal article on a recent class topic. You may use an article from class or of your own choosing, be sure to include the citation. You must summarize the background/hypothesis, at least one method, and the main results. For extra credit, post your corrected assignment and link to the original article to a social media site and send me a link or screen shot.

- **Concept map:** Create a visual outline (diagram) to use as a study guide around the specified topic. Starting with a main idea or topic in the center, create branches out to secondary ideas, and so on, like a spider web, to create a concept map/diagram of important related topics and information.

**Take Home Exams:** Essay-style exam will test comprehension of the lectures and readings.

**Final Project:**

**Solo version:** Students will create a public outreach presentation in the format of their choice: written essay (2 pg), pamphlet or poster, presentation (5 min + questions), etc. If choosing the pamphlet, poster, or presentation, IN ADDITION, students must submit a long-form description of their topic, approximately 1/2 page (not including citations). The aim is to discuss a particular aspect, ecosystem, problem, or unanswered question in host-associated microbiomes, and to present it in a way that would promote scientific literacy to the general public. Students may use material they generated in assignments or exams, but you may not submit these in the exact same format – you will need to rewrite them in some way. Students will be graded on the quality of information, the creativity of the presentation, and the effectiveness of their communication.

**Group version:** Students may opt to work in groups of up to three, to generate a 1,500-word essay, with the goal of submitting this to Frontiers for Young Minds scientific journal under the Biodiversity designation as a Core Concept: [https://kids.frontiersin.org/specialties/biodiversity](https://kids.frontiersin.org/specialties/biodiversity). Your final project submission should follow journal guidelines: [https://kids.frontiersin.org/participate/authors](https://kids.frontiersin.org/participate/authors). Students will be main authors on this publication, and I will be last author, as I will facilitate editing and submission.

**Grading (out of 100 points):** Discussion in class: 15pts, Homework: 30pts, Take Home Exam: 30pts, Final Project: 25pts

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<th>Grade</th>
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<td>M 8/31</td>
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| M 8/31 | 1 | 1 | “What is a host-associated microbiome?” An introduction to what a host-associated microbiome actually is.  
  - **Reading**: Gilbert_2014_life in a world without microbes |
| W 9/2 | 2 | | “Who’s there? Major players in the microbial world.” An overview on different microorganisms.  
  - **Reading**: Caumette_2015_Historical elements of microbial ecology |
| F 9/4 | 3 | | “A brief history on the discovery of microorganisms.” The discovery of microorganisms, a historical perspective on microbial ecology, the development of microbial theories, and environmental selection.  
  - Discussion: Elitism, recognition, and credit for intellectual property  
  - **Reading**: Prosser_2007_ ecological theory in microbial theory  
  - **Assignment (2pts)**: Learn to use NCBI, due next class. Instructions on Brightspace. |
| M 9/7 | 2 | | Labor day, no class |
| W 9/9 | 4 | | “DNA technology and how it changed our view of the world” A historical perspective and explanation of DNA technology.  
  - **Due**: Learn to use NCBI  
  - **Reading**: Clarridge_2004_16S and clinical microbiology, up to “Basics of sequencing”  
  - **Assignment (3pts)**: Learn to use MG-RAST, due next class. Instructions on Brightspace. |
| F 9/11 | 5 | | “Sequencing technology and how it revolutionized microbial ecology” Explanation of current sequencing technology and technical comparisons thereof, with discussion on how different platforms have different applications. Explanation whole-genome sequencing and gene annotation.  
  - **Due**: Learning to use MG-RAST  
  - **Reading**: Clarridge_2004_16S and clinical microbiology, rest of paper  
  - **Assignment (3pts)**: quizzes on Brightspace; “What is plagiarism” and “Different types of scientific writing”. Due by next class. |
| M 9/14 | 3 | 6 | “An introduction to phylogeny and bioinformatics, the concept of species and how our understanding of diversity is changing” Explanation of phylogenetics, how to calculate and interpret genetic diversity, and the discussion of what constitutes a species.  
  - **Due**: quizzes on Brightspace.  
  - **Reading**: de Queiroz_2005_modern concept of species  
  - **Assignment (2pts)**: make a concept map on microbial ecology and technology following the examples provided. Due next class. Instructions on Brightspace. |
| W 9/16 | 7 | | “Other methods of profiling microbial communities” Information on other microbial profiling techniques, include cell stains, biomarkers, flow cell, FISH and fluoroscopy, SEM/TEM, RAMAN. |
Due: concept map on microbial ecology
Reading: Valm_2012_CLASI-FISH

**Translating sequencing data to journal articles**
How to read graphs, stats, and other data in microbiome articles, and an overview on how this information was gleaned from sequencing data.
Take Home Exam (10pts): directions on Brightspace, due next Friday

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<thead>
<tr>
<th>Date</th>
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<tr>
<td><strong>Digestive Tract Ecosystems</strong></td>
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| M 9/21 | 4 | "The oral microbiome"  
Bacterial communities in the mouth are affected by salival production, which can have health consequences  
Reading: Proctor_2017_nose mouth throat |
| W 9/23 | 10 | "Monogastrics, ceca, and intestines"  
Anatomy of the intestines and the gut microbiome of monogastrics.  
Reading: Moeller_2014_human gut microbiome |
| F 9/25 | 11 | "Coprophagy and microbes"  
More on monogastrics, specifically rodents, rabbits, and zebrafish, the practice of coprophagy, and the benefits and drawbacks of the “cage effect”.  
Due: Take Home Exam, due by midnight  
Reading: Clayton_2016_captivity primate microbiome |
| M 9/28 | 12 | "Gut microbiota of birds"  
The unique digestive tract of birds, what we know about their gut microbiota, and how the gut microbiota of bats is more similar to birds than mammals.  
Discussion: wild, captive, and domestic and the impact on native gut microbes.  
Reading: Price_2015_digestion and aerial lifestyle  
| W 9/30 | 13 | "Ruminants- bacteria"  
The rumen bacterial community, and its importance to the herbivore.  
Reading: Henderson_2015_core rumen microbiome  
Reading: Williams_2019_wilife microbosieme |
| F 10/2 | 14 | "Ruminants- fungi, protozoa, and archaea"  
Bacteria aren’t the only members of the gut community.  
Reading: Ishaq_2015_prot methanogen moose  
Assignment (3pts): Choose a ruminant species discussed in Henderson et al. 2015 and summarize results in a paragraph, due next class |
| M 10/5 | 15 | "Effect of diet on the gut microbiome"  
Due: ruminant summary  
Reading: Singh_2017_influence of diet |
| W 10/7 | 16 | "An in-depth look at the effect of rumen acidosis and microbial therapeutics"  
Reading: Ishaq_2017_SARA |
| F 10/9 | 17 | "The many benefits of fiber"  
How fiber affects the gut microbiota, and the curious case of the panda.  
Reading: Zhao_2018_fiber and diabetes |
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<tr>
<th>Date</th>
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<tr>
<td>M 10/12</td>
<td>Fall break, no class</td>
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<tr>
<td>W 10/14</td>
<td>“I don’t need that kind of toxicity in my life”  How gut microbes detoxify plant-secondary compounds.  - <strong>Due</strong>: concept map  - <strong>Reading</strong>: Kohl 2016 woodrattes and toxins</td>
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<tr>
<td>F 10/16</td>
<td>In-class case-study  In groups, students will discuss a case-study and create a decision tree/workflow about how to go about solving it. Case studies will include medical, ethical, and efficacy dilemmas around probiotics, fecal-microbial transplant, dirt pills, global animal production, etc. At the end of the class, one group member will stand up and give a short summary on the case study problem and how they went about creating a decision tree. Example provided.  - <strong>Group work (5pts of discussion grade)</strong>  - <strong>Take Home Exam (10pts)</strong>: directions on Brightspace, due next Fri</td>
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**Nature vs. Nurture and Development of the Immune System**

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<tr>
<th>Date</th>
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<tr>
<td>M 10/19</td>
<td>“Vaginal microbiome”  The vagina and some surprising studies on smoking.  <strong>Reading</strong>: Brotman 2014 smoking and vaginal microbiome</td>
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<td>F 10/23</td>
<td>“Birth mode and microbial transfer”  A discussion on conflicting studies regarding the effect of birth method on the developing microbiome of infants, and the importance of longitudinal studies for health outcomes.  - Discussion: does birth mode matter, should we have neonatal probiotics?  - <strong>Reading</strong>: Neu 2011 birth mode hygiene hypothesis</td>
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<td>M 10/26</td>
<td>“Microbes and the nature vs. nurture debate”  A look at generational effects of microbes, and whether nature (host) affects microbial communities more than nurture (rearing conditions) in humans, mice, and sheep.  - <strong>Reading</strong>: Wang 2018 rearing conditions in ducks</td>
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<td>W 10/28</td>
<td>“Probiotics, prebiotics, and synbiotics”  A look at what these are, federal regulations, assessment of efficacy, and theory behind why you would choose certain microbes. Do probiotics work?  - <strong>Reading</strong>: Gupta 2016 FMT in perspective  - <strong>Assignment (5pts)</strong>: make a grocery store, cafeteria, or online grocery store run and locate a product labeled as “probiotics”. Write down the product, the microbes used, and any health claims included on the product.</td>
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| M 11/2 | 25  | “Probiotics in animal industries” Improving health, feed efficiency, etc. Do dogs need probiotics?  
- **Reading:** Garcia-Marcorro_2019_saccharomyces_rumen |
| W 11/4 | 26  | “Seasonal effects on the gut microbiome” What happens to wild ruminants and animals when food is scarce, and what happens during hibernation?  
- **Reading:** Carey_2012_ground squirrel hibernation |
| F 11/6 | 27  | “Host-microbe interactions in the gut.” GI tract microbiome and medication efficacy, interactions with epithelia and immune system, and hygiene.  
- **Reading:** Wilkinson_2018_microbiota drug interactions  
- **Assignment (3pts):** make a concept map on microbiota and health. Due next class. Instructions on Brightspace.  
- **Reading:** Sha_2017_microbiota and immune system  
- **Reading:** Scudellari_2017_cleaning up hygiene hypothesis  
- **Take Home Exam (10pts):** directions on Brightspace, due next Fri |
| M 11/9 | 28  | “Intestinal parasites and immune monitoring” An intro to intestinal parasites, and why researchers think they are linked with immune system development and autoimmune/autoinflammatory diseases (i.e. the Hygiene Hypothesis).  
- **Reading:** Kong_2017_skin microbiome |
| W 11/11 |          | Veterans’ Day, no class |
| F 11/13 | 29  | “Factors driving the skin microbiome, and discussion of trouble with primers” The shift to using the 16S rRNA V3-V4 region has come with some problems, including primers that don’t amplify *Propionibacterium*- one of the primary members of skin.  
- **Reading:** Kong_2017_skin microbiome |
| M 11/16 | 30  | “Skin problems and microbes” Atopic problems in dogs and the effect of fur/hair on the skin microbiota.  
- **Reading:** RodriguesHoffman_2014_skin microbiome dogs |
| W 11/18 | 31  | “Skin microbiota of amphibians and health”  
- **Reading:** BritodeAssis_2017_skin microbiota frogs |
|       |      | “Lung microbiome and the difficulty of sampling.” Discussions on the lung microbiome and a cautionary tale of making assumptions about a place you can’t actually get to.  
- **Reading:** Dickson_2015_lung microbiome  
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<th>Date</th>
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<th>Topic</th>
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<tbody>
<tr>
<td>F 11/20</td>
<td>32</td>
<td>“Humans and microbiology of the built environment”</td>
<td>➢ Reading: Meadow 2014 classroom surfaces human contact</td>
</tr>
</tbody>
</table>
| M 11/23 | 13 | “Horizontal transmission” | ➢ Reading: Song 2013 cohabiting with microbes  
➢ Assignment (3pts): Come up with a 3-sentence elevator speech on any subject so far discussed in class, deliver next class |
| W 11/25 | | Thanksgiving, no class | |
| F 11/27 | | Thanksgiving, no class | |
| M 11/30 | 14 | “Horizontal transmission” | ➢ Reading: Song 2013 cohabiting with microbes  
➢ Assignment (3pts): Come up with a 3-sentence elevator speech on any subject so far discussed in class, deliver next class |
| W 12/2 | 35 | “Environmental microbes and health” | ➢ Reading: Griffin 2007 desert dust and human health  
➢ Assignment (5pts of final project): Turn in an outline/description of your final project, about 1 par. of text or outline of slides. Due Fri |
| F 12/4 | 36 | “The problem with pollution” | ➢ Discussion: role of scientists in communicating science  
➢ Assignment (5pts of final project): Turn in an outline/description of your final project, about 1 par. of text or outline of slides. Due Fri  
➢ Assignment (3pts): Article Summary, due by next class |
| M 12/7 | 37 | In-class case-study | ➢ Discussion: role of scientists in communicating science  
➢ Assignment (5pts of discussion grade)  
➢ Group work (5pts of discussion grade) |
| W 12/9 | 38 | “Now what?” | ➢ Reading: Griffin 2007 desert dust and human health  
➢ Assignment (3pts): Article Summary, due by next class  
➢ Group work (5pts of discussion grade) |
| F 12/11 | | Wrap up and evaluations. Will be used for lecture if inclement weather causes class cancelation earlier in the semester. | |
| F 12/18 | | Final Project Due, hand in materials or give presentation (see Final Project Description) | |