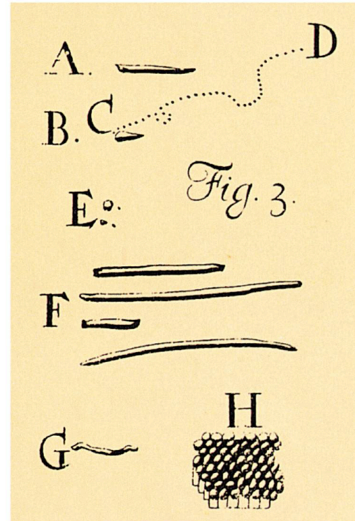
Prokaryotic Diversity BIOL4125, Spring 2018



Antonie van Leeuwenhoek's drawings of bacteria, 1684.

When: 1200-1320, T TH
Where: 112 Tureaud
Instructor: J. Cameron Thrash, Ph.D.
Email: thrashc@lsu.edu
Twitter handle: @jcamthrash
My office: A112 Life Sciences Annex
Office hours: By appointment.
Prerequisite: General Microbiology BIOL2051
Course text: Brock Biology of Microorganisms 14th edn. (older editions will usually work too)
Course twitter handle: @LSUProkDiv, #BIOL4125
Course website(s): Moodle, course page on Wikipedia
eCommunication Policy: The best way to contact me is through email and/or twitter. I will respond to email or twitter messages within 6 hours, except on weekends or between 10pm and 7am. I may respond much quicker, because like you I am glued to my devices, but I do have a life outside of teaching and research (when I'm lucky). If you want an individual physical/Skype appointment, email me with a short description of your issue and the desired time and duration of the meeting. This will be subject to my availability. I accept and encourage twitter follows to both my personal and the course handle, but I do not accept any other social media friend requests (until graduation).

Course description. From the catalog: "Biology of bacteria and archaea; evolution, diversity assessment, systematics, ecology; emphasis on molecular approaches." This course is meant to expand your basic knowledge of microbes established in General Microbiology to help you appreciate the myriad forms, capabilities, and lifestyles of organisms in the Domains Bacteria and Archaea. We will explore their evolutionary relationships on the tree of life, their lifestyle, metabolic, and genomic variations, and introduce methods for measuring microbial diversity.

Course learning outcomes. By the end of this course, you should be able to:
- Describe what is meant by phylogenetic, genomic, metabolic, and lifestyle diversity, and the way these measures are related to/dependent upon each other.
- Understand the scope of microbial diversity across the tree of life.
- Interpret similarity matrices and phylogenetic trees.
- Describe variations in taxa both between and within phyla from the Domains Bacteria and Archaea.
- Understand the role of the 16S rRNA gene as a proxy for microorganisms and how this is used in research.
- Perform basic microbial diversity calculations.
- Describe multiple microbial metabolisms (fermentative and respiratory) and lifestyles (mesophilic, extremophilic, symbiotic).
- Estimate the relative energetic gain between different metabolisms and perform basic redox calculations.
- Interpret primary literature on microbial metabolism, community analysis, taxonomic classification and comparative genomics.
- Hypothesize about the role of microorganisms in a natural sample based on phylogenetic placement and/or genome content.
- Create a Wikipedia entry describing a bacterial or archaeal taxon of your choosing.

How we're going to get there (Course Format)
Classroom mechanics. The class is broken down into several units. Each will take a few weeks to move through. There will be some assigned readings/lecture slides you will be responsible for at each class period, listed below. I may also introduce some assignments each week by email. There will usually also be an online Moodle quiz on the material that closes two hours before class. Each class will usually begin with a short

period for questions and follow with Around the Tree. Then, remaining class time will be comprised of active learning exercises such as discussions, short writing/evaluation assignments, peer instruction, presentations, or perhaps a lecture by me.

Online elements. There is a course Moodle page, and you will need a device with internet capability in each class. We will also make use of Twitter, as the microbiology community has a considerable presence on this medium. The class handle is @ProkDiv4125, and we use the hashtag #BIOL4125. You will also post Around the Tree research links and as part of your in-class exercises, each you will live tweet presentations with this hashtag. We will have a course Wikipedia Dashboard associated with the Wikipedia Page assignment.

Major Assignments. In addition to classroom exercises and quizzes/homework, you will have two Around the Tree presentations, one writing assignment, in the form of a proposal, and a Wikipedia page creation project. The latter two will be peer reviewed in a draft-feedback-revision cycle to help you learn to think critically about our work and incorporate suggestions from reviewers. This is a ubiquitous process in research science, so the more practice we have the better! Your peer-reviewing will also be graded. Details, instructions, and grading rubrics for these major assignments are available in a separate document.

Extra credit. Life is never as orderly as our classroom schedules, and for various reasons, you may have to miss class. Therefore, 20 points are available as extra credit to help you overcome any unexpected issues that come up during the semester and which don't count as excused absences. Extra credit points will come from watching and summarizing MicroSeminar lectures of your choice. Since quizzes are online and you have extra credit opportunities, no makeups will be allowed for quizzes after the free add/drop period.

You will be graded on the following:

Around the Tree	5% (2 x 25 pts)
Peer review	10% (4 x 25 pts)
Wikipedia proposal	15%
Quizzes/homework	20%
Wikipedia page	25%
In-class exercises	25%

Total of 1000 points, graded accordingly:

A- 900-929; **A** 930-969; **A+** > 969
B- 800-829; **B** 830-869; **B+** 870-899
C- 700-729; **C** 730-769; **C+** 770-799
D- 600-629; **D** 630-669; **D+** 670-699
F < 600

Late assignments. Assignments will sacrifice 25% of their points per day they are late except for Around the Tree. Failure to present on your assigned Around the Tree day will result in half of points lost if the written portion is still emailed to me on that day, with 25% additional loss of points for every day after that it is not turned in.

Why aren't we just going to sit through a bunch of your lectures? What about exams? Why is the course set up in this manner?

Extensive research on education and the neuroscience of learning has shown there are much more effective ways for us to learn than by sitting and listening to a person stand in the front of the room and talk. You don't have to come to class to learn that way anyway, for there are endless lectures available online, many from the most eminent scientists in their fields. Some of these may be part of your pre-class assignments. I endeavor to make each class period a session where we come to engage the material together and where I can provide assistance with evaluating information and grasping concepts, rather than simply giving you that information. A big component of this course is reading primary literature, writing, and discussing ideas with your colleagues. In the real world of science research, these activities are major components of day-to-day work. It is essential to learn to read and evaluate material critically, engage other scientists in conversation and debate, and express your ideas to the world with clear, purposeful writing and talking. Spending all night memorizing facts to quickly forget them a month later is not an effective means of doing real science. This class is my attempt to bring to you, in a non-lab setting, an exploration of the fascinating world of Prokaryotes in a manner that will allow us to evaluate some of the amazing diversity around us every day and pass that on by contributing what we learn to the world at large. I'm aiming for class sessions that build community, foster teamwork and investment into the material, and encourage your creativity.

Other important information

C-I Statement. This is a certified Communication-Intensive (C-I) course which meets all of the requirements set forth by LSU's Communication across the Curriculum program, including

- Instruction and assignments emphasizing informal and formal Writing and Technology communication;
- Teaching of discipline-specific communication techniques;
- Use of draft-feedback-revision process for learning;
- Practice of ethical and professional work standards;
- 40% of the course grade rooted in communication-based work; and
- A student/faculty ratio no greater than 35:1.

Students interested in pursuing the LSU Distinguished Communicators certification may use this C-I course for credit. For more information about this student recognition program, visit http://www.cxc.lsu.edu.

Absences/Code of Student Conduct. You are expected to have read, understand, and adhere to the LSU Absence Policy (http://saa.lsu.edu/important-lsu-policies) and the Code of Student Conduct (http://saa.lsu.edu/code-student-conduct). Our goal should be to learn, not simply to get grades. In science, as in life, your integrity is one of, if not the, most valuable asset you have. Preserve it, protect it, cultivate it. Excused absences will receive extra time to complete missed in-class assignments.

Students with Disabilities. If anyone has a disability that may require accommodation, you should immediately contact the office of Services for Students with Disabilities to officially document the needed accommodation. The instructor must be presented with this documentation by the end of the *second week* of class.

Time requirements. It is expected that you will have read or viewed the assigned material prior to class for the background necessary to properly participate in the activities and think critically about the concepts addressed. As a general policy, for each hour you are in class, you (the student) should plan to spend at least two hours preparing for the next class. Since this course is for three credit hours, you should expect to spend around six hours outside of class each week reading or writing assignments for the class.

Class schedule

The schedule is preliminary and subject to change depending on how quickly we are moving through the material. Details on readings, etc., are supplied below.

Class	Week	Date	Unit	Section	Readings, homework	Major Due Dates
1	1	Jan 11th (Th)	Phyl	Intro, reading trees	1-4	
2	2	Jan 16th (T)	Phyl	Tree of Life I- Origins (Lec)	5,6	
3	2	Jan 18th (Th)	Phyl	Tree of Life II- Modern	51,7	Wiki groups
4	3	Jan 23rd (T)	Hist	Prokaryote (No Class)	9-13	
5	3	Jan 25th (Th)	Meas	Diversity and the rare biosphere (Lec)	14,18,19	
6	4	Jan 30th (T)	Meas	Quantifying diversity I	15,16	
7	4	Feb 1st (Th)	Meas	Quantifying diversity II	17	
8	5	Feb 6th (T)	Lifst	Habitats I- Environmental (Henson)	20, 22	
9	5	Feb 8th (Th)	Lifst	Habitats II- Symbionts (Henson)	21	
	6	Feb 13th (T)		Mardi Gras Holiday		
	6	Feb 15th (Th)		No Class		
10	7	Feb 20th (T)	Phys	Redox I- Metabolism terms & Intro (Lec)	23-26	Proposal draft
11	7	Feb 22nd (Th)	Phys	Redox II- Calculations	27,28	
12	8	Feb 27th (T)	Phys	Redox III- More calculations	29	
13	8	Mar 1st (Th)	Phys	Redox IV- In the environment	30-32	
14	9	Mar 6th (T)	Phys	Redox V- Physiology	33	Prop. reviews
15	9	Mar 8th (Th)	Phys	Respirations	34-36	
16	10	Mar 13th (T)	Phys	Fermentations	37,38	
17	10	Mar 15th (Th)	Phys	The lower energetic limits for life (Lec)	39	Final Proposal
18	11	Mar 20th (T)	Phys	Membranes	40,41	

19	11	Mar 22nd (Th)	Hist	Early microbiologists*		
	12	Mar 27th (T)		Spring Break		
	12	Mar 29th (Th)		Spring Break		
20	13	Apr 3rd (T)		Building Wikipedia pages - Carmichael**	8	
21	13	Apr 5th (Th)	Genm	Intro to microbial genomics (Lec)	42,43	
22	14	Apr 10th (T)	Genm	Visualizing pathways	44	Wiki draft
23	14	Apr 12th (Th)	Genm	Reduction vs. streamlining	45,46	
24	15	Apr 17th (T)	Genm	Oligotrophy	46,50	Wiki reviews
25	15	Apr 19th (Th)	Genm	Genomes w/o the bug- metagenomics and single-cell genomics (Lec)	47,48	
26	16	Apr 24th (T)	Genm	Microbial Dark Matter, the ToL, controversy over the ToL	49,51-53	Final Wiki
27	16	Apr 26th (Th)		Wikipedia page presentations		

Phyl- Phylogenetic diversity; Lifst- Lifestyle diversity; Hist- Historical microbiology; Meas- Measuring diversity; Phys- Physiological diversity; Genm- Genomic diversity. *Class held in the Hill Memorial Library. **Class held in CxC Studio 151: 151 Coates Hall.

Readings, etc.

1. Read Syllabus
2. Dodd, M. S., Papineau, D., Grenne, T., Slack, J. F., Rittner, M., Piranjo, F., O'Neil, J., Little, C. T. S. (2017). Evidence for early life in Earth's oldest hydrothermal vent precipitates. Nature. 543: 60-64.
3. Review Jonathan Eisen's slides, posted on Moodle
4. How to read a scientific paper: https://violentmetaphors.com/2013/08/25/how-to-read-and-understand-a-scientific-paper-2/
5. Woese, C. R., & Fox, G. E. (1977). Phylogenetic structure of the prokaryotic domain: the primary kingdoms. *Proceedings of the National Academy of Sciences, 74*(11), 5088–5090.
6. Optional:
    a. Fox, G. E., Magrum, L. J., Balch, W. E., Wolfe, R. S., & Woese, C. R. (1977). Classification of methanogenic bacteria by 16S ribosomal RNA characterization. *Proceedings of the National Academy of Sciences*, 74(10), 4537–4541.
    b. Woese, C. R., Kandler, O., & Wheelis, M. L. (1990). Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya. *Proceedings of the National Academy of Sciences*, 87(12), 4576–4579.
7. Optional: Rinke, C., Schwientek, P., Sczyrba, A., Ivanova, N. N., Anderson, I. J., Cheng, J.-F., et al. (2013). Insights into the phylogeny and coding potential of microbial dark matter. *Nature*, 499(7459), 431–437.
8. Wikipedia Homework, posted on Moodle
9. Pace, N. R. (2009). Problems with "Procaryote." *Journal of Bacteriology*, *191*(7), 2008–2010.
10. Pace, N. R. (2009). Rebuttal: the Modern Concept of the Procaryote. *Journal of Bacteriology*, *191*(7), 2006–2007.
11. Whitman, W. B. (2009). The Modern Concept of the Procaryote. *Journal of Bacteriology*, *191*(7), 2000–2005.
12. Whitman, W. B. (2009). Rebuttal: Problems with "Procaryote." *Journal of Bacteriology*, *191*(7), 2011.
13. Compose a half-page reflection on 9-12. Who made the better argument and why?
14. Staley, J. T., & Konopka, A. (1985). Measurement of in Situ Activities of Nonphotosynthetic Microorganisms in Aquatic and Terrestrial Habitats. *Annual Review of Microbiology*, 39(1). pp. 324-7.
15. Schloss, P. D., & Handelsman, J. (2004). Status of the Microbial Census. *Microbiology and Molecular Biology Reviews*, 68(4), 686–691.
16. Optional: Schloss, P.D., Girard, R. A., Martin, T., Edwards, J., and Thrash, J. C. (2016). Status of the Microbial Census: an Update. *mBio* 7(3):e00201-16.
17. Hill, T. C. J., Walsh, K. A., Harris, J. A., & Moffett, B. F. (2003). Using ecological diversity measures with bacterial communities. *FEMS Microbiology Ecology*, 43(1), 1–11.
18. Fuhrman, J. A. (2009). Microbial community structure and its functional implications. *Nature*, 459(7244), 193–199.
19. Optional: Pedrós-Alió, C. (2012). The Rare Bacterial Biosphere. *Annual Review of Marine Science*, 4(1), 449–466.

20. Groups of 3-4 (from the signup sheet) research and summarize a particular **non-host-associated** ecosystem (i.e., environmental). Presentations: 5 min max. In your presentation on this paper, you will need to summarize the paper and teach the class about **at least two of the figures** from it in that time. In your summary, summarize the paper quickly, then move explicitly to the figures and what they tell us. Do not try to give us a run down of all the data/experiments etc. Only a broad overview of the whole paper is needed. Include what they wanted to achieve and what approach they took. You should aim to have your summary take ~1 min, and 2 min of explanation per figure. All members of the group must present some part of the summary for full credit.
21. Groups of 3-4 (from the signup sheet) research and summarize a particular **host-associated** ecosystem. Presentations: 5 min max. In your presentation on this paper, you will need to summarize the paper and teach the class about **at least two of the figures** from it in that time. In your summary, summarize the paper quickly, then move explicitly to the figures and what they tell us. Do not try to give us a run down of all the data/experiments etc. Only a broad overview of the whole paper is needed. Include what they wanted to achieve and what approach they took. You should aim to have your summary take ~1 min, and 2 min of explanation per figure. All members of the group must present some part of the summary for full credit.
22. Vocabulary homework
    a. Define the following terms:
        i. Commensule
        ii. Symbiont
        iii. Parasite
        iv. Pathogen
        v. Psychrophile
        vi. Thermophile
        vii. Hyperthermophile
        viii. Acidophile
        ix. Halophile
        x. Alkaliphile
        xi. Piezophile/barophile
        xii. Mesophile
    b. Find an example prokaryotic taxon for each
    c. Define the difference between "tolerant" and "-philic."
    d. Provide a primary reference for all of your answers (textbooks count in this case)
23. http://www.jlindquist.net/generalmicro/102catabolism.html
24. Brock Chapter 3, e- donors & acceptors, pg 82-84
25. Redox handout (see Moodle)
26. Optional: http://www.jlindquist.net/generalmicro/102bactnut.html (parts I and II)
27. Brock Appendix 1, energy calculations in microbial bioenergetics, pg A-1-4
28. Grade, strikeout incorrect answers, and provide corrections for your metabolism/redox pre-test. Turn in by beginning of class.
29. Review Brock Appendix 1 again, focusing on calculations from G_f^0
30. http://www.jlindquist.net/generalmicro/102cycles.html
31. Wright, J. J., Konwar, K. M., & Hallam, S. J. (2012). Microbial ecology of expanding oxygen minimum zones. *Nature Reviews Microbiology*, 10(6), 381–394.
32. (Optional) Lovley, D. R., Chapelle, F. H., & Woodward, J. C. (1994). Use of dissolved h2 concentrations to determine distribution of microbially catalyzed redox reactions in anoxic groundwater. *Environmental Science & Technology*, 28(7), 1205–1210.
33. Brock Chapter 3, respiration & e- carriers/proton motive force, pg 89-93
34. Brock Chapter 13, Anaerobic Respiration, pg 410-423
35. Richardson, D. J. (2000). Bacterial respiration: a flexible process for a changing environment. *Microbiology*, 146(3), 551–571.
36. Groups of 3-4 (from the signup sheet) research and summarize an e- transport chain. Presentations: 5 min max- needs to have a drawn mock-up of the e- transport chain, including proteins, reactions, e- flow, etc. One slide or image- walk us through it all. All team members must present.
37. Brock Chapter 13, Fermentations, pg 401-410

38. Groups of 3-4 (from the signup sheet) research and summarize a fermentation. Presentations: 5 min max- needs to have a drawn mock-up of the pathway, including important intermediates and enzymes, etc. One slide or image- walk us through it all. All team members must present.
39. Hoehler, T. M., & Jørgensen, B. B. (2013). Microbial life under extreme energy limitation. *Nature Reviews Microbiology*, 11(2), 83–94.
40. Brock Chapter 2, Cytoplasmic Membrane and Transport, pg 35-49
41. Albers S.-J. and Meyers, B.H. (2011). The archaeal cell envelope. *Nature Reviews Microbiology*, 9, 414-426.
42. Brock, Chapter 6, Investigating Genomes/Microbial Genomes pg. 184-198
43. Tettelin, H., Masignani, V., Cieslewicz, M. J., Donati, C., Medini, D., Ward, N. L., et al. (2005). Genome analysis of multiple pathogenic isolates of Streptococcus agalactiae: implications for the microbial "pan-genome". *Proceedings of the National Academy of Sciences*, 102(39), 13950–13955.
44. Familiarize yourself with KEGG: http://www.genome.jp/kegg/
45. McCutcheon, J. P., & Moran, N. A. (2012). Extreme genome reduction in symbiotic bacteria. *Nature Reviews Microbiology*, 10(1), 13–26.
46. Giovannoni, S. J., Thrash, J. C., & Temperton, B. (2014). Implications of streamlining theory for microbial ecology. *The ISME Journal*, 8(8), 1553–1565.
47. Temperton, B. & Giovannoni, S. J. (2012). Metagenomics: microbial diversity through a scratched lens. *Current Opinion in Microbiology*, 15(5), 605-612.
48. Stepanauskas, R. (2012). Single cell genomics: an individual look at microbes. *Current Opinion in Microbiology*, 15(5), 613–620.
49. (Optional) Wrighton, K. C., Thomas, B. C., Sharon, I., Miller, C. S., Castelle, C. J., Verberkmoes, N. C., et al. (2012). Fermentation, Hydrogen, and Sulfur Metabolism in Multiple Uncultivated Bacterial Phyla. *Science*, 337, 1661–1665.
50. Button, D. K. (1991). Biochemical basis for whole-cell uptake kinetics: specific affinity, oligotrophic capacity, and the meaning of the michaelis constant. *Applied and Environmental Microbiology*, *57*(7), 2033–2038.
51. Hug, L. A.; B. J. Baker; K. Anantharaman; C. T. Brown; A. J. Probst, et al. (2016) A new view of the tree of life. Nature Microbiology, 16048
52. Spang, A, J. H. Saw, S. L. Jørgensen, K. Zaremba-Niedzwiedzka, J. Martijn, A. E. Lind, R. van Eijk, C. Schleper, L. Guy, T. J. G. Ettema. (2015). Complex archaea that bridge the gap between prokaryotes and eukaryotes. *Nature*.
53. (Optional) Zaremba-Niedzwiedzka, K., E. F. Caceres, J. H. Saw, D. Bäckström, L. Juzokaite, E. Vancaester, K. W. Seitz, K. Anantharaman, P. Starnawski, K. U. Kjeldsen, M. B. Stott; T. Nunoura, J. F. Banfield, A. Schramm, B. J. Baker, A. Spang, T. J. G. Ettema. (2017) Asgard archaea illuminate the origin of eukaryotic cellular complexity. *Nature*, 541: 353-358.