Syllabus for
Microbial Evolution and Diversity
BIOL 5xxx/6xxx

Lecture: 9 – 9:50 Monday/Wednesday/Friday, Science Center room 122
Lab: 1-3pm Tuesday, Life Sciences Building room 13

Instructor: Dr. Mark Liles (lilesma@auburn.edu)

Office: room 316 Life Sciences Building
Lab: room 216 Life Sciences Building (most likely place to find me)

Phone: 844-1656 (office), 844-2200 (lab)

Office Hours: 10:00 am to 12:00pm Wednesday and Friday, by appointment

1) **3 Credit hours:** 3 hours of lecture (MWF), 2 hours of laboratory per week
2) **Textbook:**

Ernst Mayr “What Evolution Is”, selected passages
A packet of selected readings from different authors will be available

Journal articles will be assigned during the course, on a weekly basis (Friday discussion).
Students will be required to submit prior to class a list of 3 questions regarding the article, and ask at least 1 of these questions of the presenting speaker. Each year these articles will be updated to keep the course current.

Some examples of journal articles that may be assigned:
4) Tyson, G.W. et al., Community structure and metabolism through reconstruction of microbial genomes from the environment. Nature. 428:37 (2004)
3) **Course Description:** Introduction to microbial evolutionary history and theory, and survey of microbial diversity. Topics include microbial systematics, molecular mechanisms of evolutionary change, and microbial metabolic diversity. Examples of diverse microorganisms, including human pathogens, symbiotic associations with plants and animals, and environmental microorganisms will be studied from the evolutionary perspective. The laboratory work will integrate with the lecture material, providing laboratory examples of microbial evolution (e.g., antimicrobial resistance) and diverse examples of microbial taxa and metabolism.

4) **Course Objectives:** To understand the diverse evolutionary processes and pressures at work in the microbial world, and the evolutionary history of life on our planet, especially as it relates to microorganisms (i.e., bacteria and archaea). Students will learn the extent of microbial diversity, in terms of phylogenetic, structural, and metabolic characteristics. Many examples of evolutionary change at different time scales in microbial populations will be learned, with lessons from comparative genomics. Graduate students only will be required to lead one scientific paper discussion during the term, and to prepare a term paper on an independent research project. Undergraduate students will also participate in a research project, but will not be required to lead a discussion group or to prepare a term paper.

5) **Course Content:**

**Week 1 (Friday, Aug 17th)**  **Introduction to class**
- A brief history of the physical origin of the Earth and prebiotic conditions

**Week 2 (Aug 20 – 24th)**  **Hypotheses on the origin of life & the Theory of evolution**
- A history of phylogenetic classification
- Natural selection vs Lamarckism
- Hypotheses for origin of life (RNA molecules, Iron-sulfur, Panspermia?)
- Universal common ancestor
- Thermophiles (Thermotoga/Aquifex/Archaea) & Anaerobic metabolism
- Chemolithotrophs
- Uncultured thermophiles in Yellowstone hot springs – who are they?

**Lab 1: Thermophilic microorganisms isolated from mesophilic environments**

**Week 3 (Aug 27 – 31st)**  **Molecular phylogenetic analysis & the Domain Archaea**
- Molecular clocks – Rates of evolutionary change in biological molecules
- 3 Domain organization of life
- Fundamentals of phylogenetic analysis (i.e., from sequence to phylogenetic tree)
- Novel divisions & members of the Aquifex division from Yellowstone hot springs
- Archaeabacteria is now the Domain Archaea
- Euryarchaeota, Crenarchaeota, and Korarchaeota
- Methanogens and methanotrophy

**Lab 2: Methanogens and anaerobic metabolism**

**Week 4 (Sept 5th – 7th)**  **Photosynthetic cyanobacteria and Metabolic classification**
- Oldest fossil evidence of life on Earth
- Cyanobacteria: Aerobic transformation of Earth’s atmosphere
• Metabolic classification based on carbon and energy sources
• Sources of energy and carbon
• Intro to Carbon and Nitrogen cycles

**Lab 3: Cyanobacteria from natural environments**

**Week 5 (Sept 10th – 14th) Mechanisms of genetic variation in prokaryotes**
• Kinds of mutations, phenotypic effects of mutations
• Transduction, transformation, and conjugation
• Homologous recombination and multiple genome copies
• Horizontal gene transfer
• Adaptive mutability
• Antigenic variation
• Radiation resistance in *Deinococcus radiodurans*

**Lab 4: Ultraviolet-radiation and antimicrobial resistance**

**Week 6 (Sept 17th – 21st) “Microbial species” concept & genomic heterogeneity**
• Definition of a species in the Domain Eukaryota
• Phylogenetic resolution of rRNA vs less conserved functional genes
• A phylogenomic species concept, and DNA-DNA hybridization
• Virulence islands among bacterial pathogens

**Lab 5: Computer lab on rRNA sequence-based phylogeny**

**Week 7 (Sept 24th – 28th) Prokaryotic distribution and Mitochondria & Chloroplast origins**
• Cosmopolitan distribution of prokaryotic taxa
• Geographic distribution and phylogenetic resolution
• Endosymbiotic theory for origin of mitochondria and chloroplasts
• Mitochondrial lineage in humans

**Lab 6: Vertical transfer of antimicrobial (or UV) resistance**

**Week 8 (Oct 1st – 5th) Origin of the Eukaryotic cell**
• The “core genome” of Archaea based on comparative genomics (and HGT)
• Similarity of information processing in Archaea and Eukarya
• Evidence for HGT among Archaea and Eubacteria
• Review of class material
• Mid-term

**Week 9 (Oct 8th – 12th) Environmental gradients and co-dependence**
• Winogradsky column, Microbial mats, other vertically stratified environments
• Green non-sulfur bacteria and nonoxygenic photosynthesis
• Sulfur cycle
• Green sulfur bacteria
• Sulfur oxidizers and sulfate reduction

**Lab 7: Winogradsky column**

**Week 10 (Oct 15th – 19th) The division Firmicutes and endospores**
• Division Firmicutes (low G+C% Gram positives)
• Endospores as evolutionary advantage
• *Bacillus cereus* vs *Bacillus thuringiensis* vs *Bacillus anthrasis*

**Lab 8: Selective enrichment for endospore-forming Firmicutes**

**Week 11 (Oct 22nd – 26th) The Division Actinomycetes and antibiosis**
• Division Actinomycetes (high G+C% Gram positives)
• Antimicrobial diversity
• Evolution of symbiotic associations (e.g., ant, fungal, actinomycete interactions)

**Lab 9: Antibiosis and Actinobacteria**

**Week 12 (Oct 29th – Nov 2nd) Divisions CFB and Planctomycetes**
• Division Cytophaga-Flavobacterium-Bacteroides
• Division Planctomycetes

**Lab 10: Gliding motility**

**Week 13 (Nov 5th – 9th) Division Proteobacteria, part I**
• Division Proteobacteria, Part I
• Phototrophs
• Alpha-Proteobacteria
• Beta-Proteobacteria

**Lab 11: Anaerobic phototrophy in Winogradsky columns**

**Week 14 (Nov 12th – 16th) Division Proteobacteria, Part II**
• Division Proteobacteria, Part II
• Co-evolution of microorganisms and Eukarya
• Gamma-Proteobacteria (symbioses, metabolism)
• Delta-Proteobacteria

**Lab 12: Bioluminescence in Vibrio species**

Thanksgiving Break

**Week 15 (Nov 26th – 30th) Eukaryotic microorganisms**
• Fungi and Protozoa
Lab13: Protozoans in Winogradksy columns

Week 16 (Dec 3rd – 5th) The world of viruses
  • Viruses, including bacteriophage diversity and evolution

Lab final (turn in lab notebook)

6) Course Requirements/Evaluation:

Grading is to be conducted according to the following formula:

Mid-term exam 100 points
Final Exam: 200 points (cumulative, with emphasis on section III)
Class Participation 100 points (from a combination of student attendance (taken at random during the semester), student participation (as assessed by quizzes and homework) and from the Friday discussion sessions, in which students receive credit for turning in 3 discussion questions for each peer-reviewed journal article)
Lab notebook 130 points (10 points per lab)
Lab Final 70 points
Paper Discussion 100 points (grad students only)
Term paper: 200 points (grad students only)

A total of 900 points is possible for graduate students, or 600 points for undergraduate students.

Grading will be on a scale of 90-100% = A, 80-89 = B, 70-79% = C, 60-69% = D, <60% = F

7) Course Policy Statements:

ATTENDANCE POLICY / CLASSROOM STRATEGY

Lecture: There is a high correlation between lecture attendance and student grades. If you miss a lecture, get the notes from a classmate. Lectures will be posted on Blackboard, but much of the context and content of the lectures can only be acquired from attending class. Be aggressive in your note-taking: do not simply copy what’s on the blackboard/overhead, but also what the instructor verbalizes about material. Incomplete notes can only translate into incomplete knowledge of required material and substandard performance on exams!

MAKE-UP POLICY: An exam can be made up in the following instances: 1) a serious, incapacitating illness; this requires a letter from the attending physician; 2) official University excuse (see Tiger Cub for policy); 3) death in the immediate family; this requires an obituary notice and/or letter. A student who has missed an exam for one of these validated reasons must notify the instructor within 24 hours of the exam. If a valid excuse is submitted, the student will be allowed to take a make-up exam which may be in an all-essay format.
8) **Justification for Graduate Credit (for Graduate Course Only)**

Graduate students taking this course will further develop their ability to critically evaluate peer-reviewed journal articles and present this work to the class in a journal discussion format. Graduate students will also be required to write a term paper on a relevant topic. The additional work required of graduate students will enhance their learning in the critical areas of scientific reading, scientific presentations, and scientific writing.

**Graduate students taking this course will be required to:**

1) Have already taken BIOL 3200, General Microbiology, and BIOL 3000, Genetics, or the equivalent course in another institution (undergraduate students also)

2) Present and lead a discussion of a scientific paper during one Friday of the course. The paper may be chosen by the professor, or by the student (subject to instructor approval), depending upon which week the paper is presented. Students will be graded upon comprehension of the material and a scientific critique of the material. Students will also be graded in terms of their participation in the discussion of the paper.

3) Compose a term paper on a topic of interest (to both graduate student and instructor) in the field of microbial evolution and diversity. The format will be in the form of a journal review article, and graduate students will be expected to submit a draft for review prior to the submission of the final term paper. The grading for the term paper will include completeness of the introduction, methods, results, and discussion, with cited literature sections. In addition, additional points may be earned for oral presentations of the research project, time permitting.