CEE8813/BIO8803/BIO4803: *Environmental Microbial Genomics*

1. **Course description and objectives:** To expose students to advanced concepts and principles of contemporary microbiological research and associated bioinformatics techniques through representative examples from recent literature. Topics covered include, but are not limited to: the diversity of microbial genes and genomes; the value of this diversity for the life-sustaining biogeochemical cycles, disease control, and biotechnology; the complexity of microbial communities; the interactions among microbes and their environment; and the influence of the environment in shaping and driving the evolution of microbial genomes and microbial communities. Advancing microbiological research has always been linked tightly to technological innovations. Thus, the course will also offer an extensive discussion of the cutting-edge technologies and methodologies that enable contemporary research. Emphasis will be given on "How-To" tackle recurrent research problems through bioinformatics exercises, which will make up about 1/3 of the course. The course should be of interest to graduate students working with microbial systems of environmental or clinical relevance, in engineered or natural settings and to bioinformatics students who wish to get exposed to microbial research and "real-life" data.

2. **Course structure:** The course consists primarily of lectures and bioinformatics exercises, which are based on recent research and review articles, and technological innovations. Students are also required to work, in small teams, on assigned papers and present thorough critiques of the papers to the class.

3. **Instructor:** Dr. Kostas Konstantinidis
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4. **Prerequisites:** "CEE 6311: Microbial Principles" or "BIOL 3380: Intro Microbiology" or equivalent or consent of instructor. Knowledge of basic microbiological and molecular biology principles is required. No previous knowledge of bioinformatics is required (but some knowledge will be helpful).

5. **Evaluation:**

Exams (mid-term, take-home, and final):	90%
Participation in the class and project presentation:	10%

There will be three examinations (30% each), one of which will be completed at home. See lecture schedule for further information. Graduate students (but not undergraduates) will critically evaluate recent literature on a specific research topic and present their evaluation in class as part of their project.

Grading Scale:

Total Percentage Points	Grade	Total Percentage Points	Grade
100-85%	A	50-55%	D
70-85%	B	<50%	F
55-70%	C		

6. **Georgia Tech Honor Code**: Students in this class are expected to abide by the Georgia Tech Honor Code (http://www.honor.gatech.edu/) and to avoid any instances of academic misconduct, including but not limited to:
   1 Use of cell phones during class. Place cell phones in your bag and turn them off.
   2 Possessing, using, or exchanging improperly acquired written or oral information in the preparation of homework, class project, and exams.
   3 Use of material that is wholly or substantially identical to that created or written by another individual or group.
   4 False claims of performance or work that have been submitted by a student.

7. **Textbook:** There is currently no single textbook that adequately covers the material in this course. Hence, there is no required textbook. However, there are assigned readings for which the students will be held responsible. These will be listed on the handout for each lecture session, and will be provided in electronic format (online or through email). The following books are excellent (and rather complementary) resources for this course:
   i) Brock Biology of Microorganisms, 12th Edition by Michael T. Madigan et al.
   ii) Understanding our Microbial Planet: The New Science of Metagenomics. The National Academies Press.

8. **Syllabus: (class meets M-W, 3:05-4:35pm for Spring 2013)**

Week	Date	Description
1	Jan7	Introduction: importance, abundance, and diversity of microbes on the planet.
	Jan9	Microorganism identification and classification. What is a species? The important units of microbial diversity. Do units/species actually exist?
2	Jan14	Organization of microbial genomes and comparisons to other forms of life. Gene organization, regulation, and variation among genomes. Hypothetical genes.
	Jan16	How do microbes adapt and evolve? Horizontal gene transfer, recombination, and mutation; their rates.
3	Jan21	School Holiday
	Jan23	Methods for studying microbial communities. Emphasis on metagenomics and metatranscriptomics. Applications and limitations. The case of proteorhodopsins.
4	Jan28	Microbial communities, their complexity and function. Abundant and rare members. Biogeography of microbes. Micro-niches and micro-environments. Biofilms.
	Jan30	Mutualism, symbiosis, parasitism. Bacteria-bacteriophage interactions and their importance in natural and engineered systems. Co-evolution of host and pathogen genomes. Obligate vs. opportunistic pathogens.
5	Feb4	The microbial communities of the ocean. Complexity, adaptations to the deep-sea, nutrient cycling, and importance for the global warming. Soil microbial communities. Species composition, nutrient cycling, micro-environments, and a pool of important enzymes and antibiotics for biotechnological applications.
	Feb6	How to review a scientific manuscript and write a review. Discussion of papers.
6	Feb11	**1st Exam (in class)**
	Feb13	Principles of molecular evolution I: Selection pressures, mutation rates, and population sizes. "Nothing in biology makes sense except in the light of evolution".
7	Feb18	Molecular evolution II (continued): Phylogenetic analysis to study evolution. Applications and limitations.
	Feb20	Bioinformatics Exercises: Identifying microbes based on 16S rRNA genes and handling 16S rRNA amplicon pyrosequencing data.

8	Feb25	Microbial DNA sequencing: history, current status, and future. Next generation sequencing.
	Feb27	Bioinformatics Exercises: Detecting horizontal gene transfer in phylogenetic trees.
9	Mar4	Bioinformatics I: How to decipher the function of genes and sequences of interest.
	Mar6	Bioinformatics Exercises: Annotating sequence fragments from environmental samples.
10	Mar11	Bioinformatics (continued): Available resources on the internet and their usefulness. Biostatistics. Comparative genomics and annotation.
	Mar13	Discussion of papers.
		Spring Break
11	Mar25	Methods for tracking individual microorganisms in the environment: non-molecular, function-based approaches.
	Mar27	Molecular methods for tracking individual microorganisms in the environment: FISH, q-PCR, stable isotope labeling and recent developments.
12	Apr1	Handling and interpreting metagenomic data. Comparing environments based on metagenomics. Single-cell approaches and their potential.
	Apr3	Bioinformatics Exercises: NCBI Blast and performing Blast on the command line.
13	Apr8	Bioinformatics Exercises: Analyzing metagenomics datasets using online tools and databases. Assembly of metagenomics datasets. **2nd Exam (take-home) is due.**
	Apr10	Bioinformatics Exercises: Testing microbial biogeography based on metagenomics.
14	Apr15	Meta-transcriptomics/Meta-proteomics. Data handling and analysis. Limitations.
	Apr17	Bioinformatics Exercises: Mapping and annotating metatranscriptomics data.
15	Apr22	Metabolic reconstruction. Theory and tools available.
	Apr24	Discussion of papers. Synthesis and Review.
16		**Final Exam**