CEE6720/BIO6720: *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, 13th Edition by Michael T. Madigan et al.
   ii) Understanding our Microbial Planet: The New Science of Metagenomics. The National Academies Press.

8. **Teaching in the COVID-19 era**: These are not the ideal conditions but have no doubt that we will make it happen. Our goal is to work together and learn the course material. My plan is to be in the classroom for most, if not all, weeks of the semester, for both lectures of the week. I will also have a synchronous Bluejeans session for those that wish to attend virtually, and make the recorded video available for asynchronous viewing for those that need to review course material in preparation for course exam and homework. We will closely follow Georgia Tech's guidelines on COVID-19. For instance, those that are not vaccinated as strongly encouraged to wear masks when on campus. Please regularly check Georgia Tech's websites on the topic for updates (e.g., https://helpingstories.gatech.edu). The expectations for completing your course assignments (e.g., homework, exams) will be the same for all students, whether attending in person or remotely. The assignments are detailed in the course syllabus.

9. **Syllabus: Class meets Mon-Wed, 9:30-10:45am for Spring 2022 in ES&T L1125 and online (hybrid mode)**

Week	Date	Description
1	Jan 10	Introduction: importance, abundance, and diversity of microbes on the planet.
	Jan 12	Microorganism identification and classification. What is a species?
2	Jan 17	No class, Martin Luther King, Jr. Day
	Jan 19	The important units of microbial diversity. Do units/species actually exist? New insights from metagenomic surveys of natural populations.
3	Jan 24	Methods for studying microbial genomes and communities *in-situ*. Emphasis on metagenomics and metatranscriptomics. Applications and limitations.
	Jan 26	Microbial communities, their complexity and function. Abundant and rare members. Biogeography of microbes. Micro-niches and micro-environments. Biofilms.
4	Jan 31	Mutualism, symbiosis, parasitism. Bacteria-bacteriophage interactions and their importance in natural and engineered systems. Co-evolution of host and pathogen genomes. The human microbiome.

	Feb 2	Organization of microbial genomes and comparisons to other forms of life. Gene organization, regulation, and variation among genomes. Hypothetical genes.
5	Feb 7	How do microbes adapt and evolve? Horizontal gene transfer, recombination, and mutation; their rates.
	Feb 9	Principles of molecular evolution I: Selection pressures, mutation rates, and population sizes. "Nothing in biology makes sense except in the light of evolution".
6	Feb 14	Molecular evolution II (continued): Phylogenetic analysis to study evolution. Applications and limitations.
	Feb 16	**1st Exam (in class)**
7	Feb 21	Microbial DNA sequencing: history, current status, and future. Next generation sequencing. Bioinformatics I: How to decipher the function of genes and sequences of interest (a.k.a. gene annotation).
	Feb 23	Bioinformatics Exercises: Introduction in the command line of Unix/Linux. Install Blast. Command line Blast and ANI calculation.
8	Feb 28	Bioinformatics (Gene annotation continued): Available resources on the internet and their usefulness. Biostatistics. Comparative genomics and annotation.
	Mar 2	Bioinformatics Exercises: Annotating sequence fragments from environmental samples.
9	Mar 7	Bioinformatics Exercises: Detecting horizontal gene transfer (HGT) in phylogenetic trees.
	Mar 9	Bioinformatics Exercises: Detecting horizontal gene transfer (HGT) in phylogenetic trees. *Cont*.
10	Mar14	Bioinformatics Exercises: Identifying microbes based on 16S rRNA genes and handling 16S rRNA amplicon and fragments recovered in shotgun metagenomes.
	Mar16	Bioinformatics Exercises: Identifying microbes based on 16S rRNA genes and handling 16S rRNA amplicon and fragments recovered in shotgun metagenomes. *Cont*.
11	Mar21	NO CLASS. SPRING BREAK.
	Mar23	NO CLASS. SPRING BREAK.
12	Mar28	Bioinformatics Exercises: Metagenomics data handling, assembly, detecting differentially abundant genes. Analyzing metagenomics datasets using online tools and databases.
	Mar30	Bioinformatics Exercises: Testing microbial biogeography based on metagenomics.
13	Apr 4	Bioinformatics Exercises: Recover metagenome-assembled genomes (MAGs) and estimate their *in-situ*/metagenomic abundance.
	Apr 6	Bioinformatics Exercises: Recover metagenome-assembled genomes (MAGs) and estimate their *in-situ*/metagenomic abundance. *Cont*. Taxonomic identification of MAGs with the MiGA webserver
14	Apr 11	Bioinformatics Exercises: Analysis of metatranscriptomics data. Data handling and detection of differentially expressed genes. Internal standards and normalization.
	Apr 13	Bioinformatics Exercises: Analysis of metatranscriptomics data. Data handling and detection of differentially expressed genes. Internal standards and normalization. *Cont*.
	Apr 18	Catch up on Bioinformatics Exercises. Review for take home exam.
	Apr 20	**2nd Exam (take-home) is due.**
15	Apr 25 (last day)	Catch up on Bioinformatics exercises. Synthesis and Review for final exam. How to review a scientific manuscript and write a review.
	May 4	FINAL EXAM. 8:00-10:50AM.