Tentative title: Metagenomics Module for a Biological Process Course

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List of Tables, Figures and Supplemental Material:

To be updated

Abstract Page

This newly adapted module will introduce students to cutting edge molecular tools used to investigate microbial population dynamics in engineered environments.

Students will conduct a group project with available sequencing data and present their findings with process design or optimization suggestions (e.g. wastewater process biofilm problems presented by Juniata students) to their fictional client.

Article Context Page: To make the submission process easier, you may want to fill out the following form, (you will be asked to select answers during the submission process). Choose all applicable options that effectively describe the conditions **IN WHICH THE LESSON WAS TAUGHT**. Modifications to expand the usability of the Lesson will be addressed later in the text.
**Please delete this page prior to submission.
Not all categories will pertain to your article, in those cases, please select 'N/A' when submitting on the website.

- Course
    - Biochemistry
    - Cell Biology
    - Developmental Biology
    - Genetics
    - X Microbiology
    - X Molecular Biology
    - Introductory Biology

- Course Level
    - Introductory
    - X Upper Level
    - Graduate
    - High School
    - Other

- Class Type
    - Lecture
    - Lab
    - Seminar
    - Discussion Section
    - On-line
    - Other

- Audience
    - Life Sciences Major
    - Non-Life Science Major
    - Non-Traditional Student
    - 2-year College
    - 4-year College
    - University
    - Other

- Class Size
    - 1 – 50
    - 51 – 100
    - 101+

- Lesson Length
    - Portion of one class period
    - One class period
    - Multiple class periods
    - One term (semester or quarter)
    - One year
    - Other

- Key Scientific Process Skills
    - Reading research papers
    - Reviewing prior research
    - Asking a question
    - Formulating hypotheses
    - Designing/conducting experiments
    - Predicting outcomes
    - Gathering data/making observations
    - Analyzing data
    - Interpreting results/data
    - Displaying/modeling results/data
    - Communicating results

- Pedagogical Approaches
    - Think-Pair-Share
    - Brainstorming
    - Case Study
    - Clicker Question
    - Collaborative Work
    - One Minute Paper
    - Reflective Writing
    - Concept Maps
    - Strip Sequence
    - Computer Model
    - Physical Model
    - Interactive Lecture
    - Pre/Post Questions
    - Other

- Bloom's Cognitive Level (based on learning objectives & assessments)
    - Foundational: factual knowledge & comprehension
    - Application & Analysis
    - Synthesis/Evaluation/Creation

- Principles of how people learn
  - Motivates student to learn material
  - Focuses student on the material to be learned
  - Develops supportive community of learners
  - Leverages differences among learners
  - Reveals prior knowledge
  - Requires student to do the bulk of the work

- Vision and Change Core Concepts
  - Evolution
  - Structure and Function
  - Information flow, exchange and storage
  - Pathways and transformations of energy and matter
  - Systems

- Vision and Change Core Competencies
  - Ability to apply the process of science
  - Ability to use quantitative reasoning
  - Ability to use modeling and simulation
  - Ability to tap into the interdisciplinary nature of science
  - Ability to communicate and collaborate with other disciplines
  - Ability to understand the relationship between science and society

- Key Words: List 3 – 10 key words that are relevant for the Lesson (e.g. mitosis; meiosis; reproduction; egg; etc.)
  - 16S rRNA
  - Microbial community structure
  - Engineered systems
  - Metagenomics

Scientific Teaching Context Page

Learning Goal(s): Provide clearly stated learning goals, which are broad statements of what the students will know once they have completed the Lesson. Learning goals are typically rather abstract and use words like "know," "understand", "appreciate," or "demonstrate".

For example:

- *Students will understand the interdisciplinary nature of environmental problems in natural and engineered systems.*
- *Students will understand the importance of microbial diversity in engineered systems.*
- *Students will understand microbial community structure analyses using metagenomics (benefit and limitation).*

Learning Objective(s): Define what students who have successfully accomplished the learning goal can actually do. Learning objectives describe student behaviors that are observable, measurable, and testable. Learning objectives should test students' mastery of the material and use words like "define", "predict", "design" and "evaluate."

For example:

- *Describe how and why 16S rDNA sequences are used to analyze microbial community structures*
- *Be able to process and analyze large sequencing data using bioinformatics tools*
- *Be able to analyze microbial community structure dynamics*
- *Provide solutions for engineering problems associated with biological processes*

Main Text

Begin the Lesson text on a new page. Include the following sections:

1. Introduction:
CHEE 4960 Biological Processes will examine the influence of microorganisms on engineered systems. A newly adapted lab module for metagenomics (only data analyses) will introduce students to the cutting edge molecular tools used to investigate microbial population in engineered systems. Students will have opportunities to work on bioinformatics/biostatistical workflows and present their findings with engineering solutions as groups.

Topics Covered:
1. Bacterial Cell Structure and Function
2. Microbial Growth and Kinetics
3. Nutrition and Metabolism
4. Microbial Molecular Biology
5. Metagenomics **(new module)**
6. Stoichiometry and Bacterial Energetics
7. Activated Sludge Processes & Design
8. Anaerobic Processes & Design
9. Biofilm Processes & Design
10. Bioenergy Production Processes (e.g. microbial fuel cells)

- *Intended Audience:* Senior level undergraduate students and master students from civil, chemical and environmental engineering departments.

- *Learning time:* Four weeks (?) for metagenomics module

- *Pre-requisite student knowledge:* Biology I, II and (?)

2. Scientific Teaching Themes: Explain how the Lesson relates to the Scientific Teaching Themes of:

- *Active Learning:* Students will conduct a group project with available sequencing data and present their findings with process design/optimization suggestions to their fictional client (e.g. biofilm problems in a wastewater treatment plant presented by Juniata students).

- *Assessment:* Pre and post tests, completion of project assignment using available sequencing data

- *Inclusive Teaching:* The added metagenomics module will introduces the interdisciplinary nature of engineering problem to participating students.

3. Lesson Plan:
Timeline

Topics Covered:	**Weeks**
1. Bacterial Cell Structure and Function	
2. Microbial Growth and Kinetics	
3. Nutrition and Metabolism	
4. Microbial Molecular Biology	
5. **Metagenomics (new module)**	
6. Stoichiometry and Bacterial Energetics	
7. Activated Sludge Processes & Design	
8. Anaerobic Processes & Design	
9. Biofilm Processes & Design	
10. Bioenergy Production Processes (e.g. microbial fuel cells)	
11. Joint presentation	

4. Teaching Discussion: Share your observations about the Lesson's effectiveness in achieving the stated learning goals and objectives, student reactions to the Lesson, and your suggestions for possible improvements or adaptations to different courses or student populations.

❖ *Subheadings:* can be included within the sections above to increase readability and clarity.

❖ Acknowledgments

Begin the Acknowledgements on a new page. The acknowledgements can be multiple paragraphs.

References

Begin the References on a new page.

* Cite references in the text using superscript Arabic numbers. Use commas to separate multiple citation numbers. Superscript numbers are placed outside periods and commas and inside colons and semicolons.

Figure and Table Legends

Begin legends on a new page.

*** The actual figures, tables, and supplemental materials are uploaded as separate documents and should not be included in this text file.**

Tables:

Table 1. Table legends should contain a short description of the table.

Figures:

Figure 1. The figure legend should begin with a sentence that describes the overall "take home message" of the figure. Figure parts are indicated with capital letters (**A**).

Supplementary Materials: (Follow descriptions for Tables and Figures, listed above.)

- Tables S1-S#
- Figures S1-S#
- Presentations S1-S#
- Text Documents S1-S#
- Movies S1-S#
- Audio Files S1-S#
- External Databases S1-S#