CourseSource Lesson Manuscript Template and Instructions[1]

Headings highlighted in yellow should be completed before you submit your education module on Thursday.

Headings listed in blue are optional.

Thank you for preparing a submission to *CourseSource*! **Please use this template, which begins on page 3 to prepare your manuscript.**

****When you are ready to submit, please delete the text on Page 1 and 2****

Format of document: Microsoft Word (.docx, all versions after Word 2007)

1. **Title Page**
    a. Title
    b. Authors
    c. Affiliations

Corresponding author address, email, phone number ***CourseSource* Lesson Manuscript Template and Instructions[1]**

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2. **Title Page**
    d. Title
    e. Authors
    f. Affiliations
    g. Corresponding author address, email, phone number
    h. Funding and Conflict of Interest Statement
    i. List of Tables, Figures and Supplementary Materials
    j. Primary Image

3. **Abstract Page**

4. **Article Context Page**

5. **Scientific Teaching Context Page**

6. **Main Text**
    a. Introduction
    b. Scientific Teaching Themes
    c. Lesson Plan
    d. Teaching Discussion

** Subheadings can be added by the authors*

7. **Supporting Materials**

8. **Acknowledgements**

9. **References** (Numbered in order mentioned in text)

10. **Figure and Table Legends**
    a. Table Legends: Numbered in order mentioned in text.
    b. Figure Legends: Numbered in order mentioned in text.

[1] *Lesson template guided by Journal of Microbiology & Biology Education Curriculum Manuscript Submission Guidelines and Science Magazine Article Submission Template*

MANUSCRIPT SUBMISSION CHECKLIST

Please use this checklist after completing your manuscript, (please also delete this page just prior to submission):

- Authors and affiliations listed
- Corresponding author identified and address listed
- Funding and Conflict of Interest Statement included
- List of Figures, Tables and Supplemental Materials included
- Primary Image included
- Abstract included
- Article Context page (Pages 5 – 6)
- Learning Goals composed correctly and clearly relate to Lesson
- Learning Objectives composed correctly and clearly relate to Lesson
- Introduction included
    - Intended Audience addressed
    - Learning Time addressed
    - Pre-requisite Student Knowledge addressed
- Scientific Teaching Context included
    - Active Learning addressed
    - Assessment addressed
    - Inclusive Teaching addressed
- Lesson Plan included
    - Detailed description of how to teach Lesson described
    - Table of timeline of Lesson included (table uploaded separately)
- Teaching Discussion included
    - Observations about the Lesson's effectiveness included
    - Student reactions to the Lesson included
    - Possible improvements or adaptations of Lesson included
- Supplemental Materials included and labeled properly
- Acknowledgements included
- References included
    - Listed in order they appear in text
    - In ASM style
- Table and Figure Legends included
    - Table, Figure and Supplemental Material legends formatted correctly and included
- **Article document has numbered pages and lines**
- Tables, Figures and Supplemental Materials uploaded separately and formatted correctly

Using Genome Analysis of *Methylobacteria* Isolates to Engage Students in Novel Research

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Type of Manuscript: *CourseSource* Lesson Manuscript

Funding & Conflict of Interest Statement: Sources of outside support for the creation of the resource must be named in the contributed manuscript. If funding is related to a potential conflict of interest, include the funding information here. Conflict of interest exists when an author, reviewer or editor has financial, personal, or professional relationships that could inappropriately bias or compromise his or her actions. The presence OR absence of perceived conflicts must be addressed on a Conflict of Interest Notification on the manuscript's title page.

List of Tables, Figures and Supplemental Material: Please list the Figures, Tables and Supplemental materials associated with the Lesson.

Title and Description of Primary Image: We ask that you submit an image with the manuscript that represents the information in the article (e.g. a picture of a dividing cell for a Lesson about mitosis or a picture taken of students doing the activity). This image will be displayed with the title of your article on the *CourseSource* website. If you do not have a primary image, the editorial staff will select one that best fits your article. Please be conscientious of the copyright associated with any image used in your Lesson!

Abstract

In the past two decade, the field of biology has been transformed by enormous amounts of molecular sequence data and the ability to process this vast information with new computational advances. The number of complete genome sequences available to answer biological questions keeps increasing exponentially. Thus, current molecular biology research is being driven more by genome sequencing and functional analysis than by research of individual genes. This module will provide a hands-on, inquiry-based, laboratory experience for students to learn the current approaches used to generate a complete genome sequence of an isolated prokaryote.

Students will isolate *Methylobacteria* from the environment and learn basic microbial methods (bacterial culture, aseptic technique) and molecular biology methods (DNA purification /quantitation, PCR amplification of 16S rRNA, gel electrophoresis, DNA sequencing). Students will also use bioinformatics tools to assemble and analyze their data. Students will explore the diversity of the bacterium, its habitat, some of its unique genes and submit a final report on one isolate.

The abstract should be a single paragraph of 250 words or less. Start with an opening sentence that sets the teaching challenge that you address in this manuscript, provide background information specific to this Lesson, briefly description the Lesson, and end with a concluding sentence.

Article Context: To make the submission process easier, you may want to examine the following form, which you will be asked to fill in 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 in the discussion.
****Not all categories will pertain to your article, in those cases, please select 'NA' when submitting on the website.**

Course
- o Biochemistry
- o Cell Biology
- o Developmental Biology
- o Genetics
- o Microbiology
- o Molecular Biology
- o Introductory Biology
- o Bioinformatics
- o Evolution
- o Ecology
- o Anatomy-Physiology
- o Neurobiology
- o Plant Biology
- o Science Process Skills

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

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

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

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

Assessment Type

- Assessment of individual student performance
- Assessment of student groups/teams
- Assignment
- Exam/quiz, in class
- Exam/quiz, take home
- Homework
- Answer clicker-type question(s)
- Answer essay question(s)
- Answer fill in the blank question(s)
- Answer multiple choice question(s)
- Answer short answer questions(s)
- Answer true/false question(s)
- Create a concept map
- Create a diagram, drawing, figure, etc.
- Create a website
- Create graph, table etc. to present data
- Design an experiment or research study
- Design/present a poster
- Give an oral presentation
- Informal in-class report
- Interpret data
- Order items (e.g. strip sequence)
- Participate in discussion
- Peer evaluation
- Post-test
- Pre-test
- Produce a video or video response
- Respond to metacognition/reflection prompt
- Self evaluation
- Solve problem(s)
- Written assignment: One minute paper
- Written assignment: Brochure
- Written assignment: Essay
- Written assignment: Figure and or figure legend
- Written assignment: Lab report
- Written assignment: Literature review
- Other

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 to 10 key words that are relevant for the Lesson (e.g. mitosis; meiosis; reproduction; egg; etc.)

1. Next Generation Sequencing
2. Genomics
3. Annotation
4. DNA Library
5. Genome Assembly
6. Contigs

Scientific Teaching Context

Learning Goal(s)

- Students will understand how scientists classify life forms utilizing several molecular and phenotypic criteria.
- Student will learn how the scientific method is used to answer a biological question.
- Students will learn the process of using molecular and computer-based analysis to identify new bacterial isolates.
- Students will have an opportunity to engage in novel research.
- The faculty that teach the course will stay current in the field.

Learning Objective(s)

- Students will learn classic microbiological techniques, like how to collect and maintain new bacterial isolates using selective media.
- Students will master aseptic techniques.
- Students will learn to extract and purify genomic DNA from the new isolates.
- Students will learn to amplify the 16S rRNA by PCR.
- Students will be able to prepare a genomic library required for NGS.
- Students will learn the different platforms currently available for genome sequencing.
- Students will learn to assemble and annotate the genome of a prokaryotic isolate .
- Students will learn to compare the genome from an isolate to other known genomes and determine if it is a new species.

Introduction

Project background:

Armillaria gallica is a saprophytic fungus capable of degrading wood and causing white rot on the infested tree by producing specialized enzymes that can chemically break down the two major components in wood: lignin and hemicellulose. Our lab recently isolated a species of *Methylobacterium* from *A. gallica* hyphae isolated in Mansfield, MA. Bacteria within in this genus are characterized by their ability to utilize single carbon compounds such as methanol and formate as the sole carbon source and has been isolated from a variety of sources including soil, dust, freshwater, lake sediments, leaf surfaces and nodules, strawberry plants, rice grains, mosses, herbs, stem tissue, the human mouth and feet, and hospital environments. In addition, *Methylobacteria* have been found in association with over 70 plant species making them potential agents that can affect plant growth and/or suppress disease. Although there has been extensive research into the associations between *Methylobacteria* and plants, to-date there is no literature describing any association of *Methylobacteria* with fungi.

Preliminary studies indicate that one or more species of *Methylobacteria* grow in close association with *Armillaria* individuals from various neighboring towns in southeastern MA (Mansfield, Easton, Bridgewater, Raynham). We are interested in collecting and identifying *Methylobacteria* species growing in close association with *Armillaria*. We would like to compare the genomes of the species associated with the lignolytic fungus to the genomes of the species associated with leaf surfaces.

Pedagogical background:

Inquiry-based/research-based approaches engage students in the process of science by allowing them to answer scientific questions using real data and tools demonstrating how research is performed outside of the typical classroom. Students engaged in the process of science are usually more invested in the outcome and are more likely to retain the material to build upon in future course-work and research experiences.

Student Benefits of inquiry-based and/or research-based approaches:

Studies show that course-based approaches to research and inquiry allow educators to reach larger numbers of students providing them with the skills and motivation to participate in other research opportunities ultimately preparing them as future scientists. Students who participate in undergraduate research are more engaged and are more likely to persist in Science, Technology, Engineering and Mathematics (STEM) fields. Currently at Stonehill, there are more students who want to participate in summer research than there are spots or faculty mentors available. Incorporating faculty research into the science curriculum will provide more relevant research-based experiences for the growing number of Stonehill STEM majors providing better overall student preparation for careers in science.

Faculty Benefits:

The growing number of students in the STEM majors presents a challenge for science faculty because they are expected to teach upwards of 150 students in one semester. This high-teaching load makes it difficult to make significant progress in their research during the academic year. Incorporation of research into the course laboratory component allows faculty to maintain an active research program while engaging many more students than would be possible in the traditional lab setting. In addition, allowing 18+ students the opportunity to examine a newly sequenced genome may lead to novel discoveries potentially resulting in faculty-student co-authored publications.

Intended Audience

Intended for upper level biology, biochemistry and neuroscience majors.

Required Learning Time

This learning module will take approximately 9 weeks: mostly in the lab portion of the course but some of the lecture portion will be dedicated to this module.

Pre-requisite student knowledge

Student must have taken cell biology and genetics. They should have experience with lab techniques like DNA purification and gel electrophoresis.

Scientific Teaching Themes

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

Active Learning

Each student will be actively involved in all the field and laboratory procedures related to the collection and selection of a *Methylobacteria* isolate, the isolation of genomic DNA and the preparation of the DNA library needed for NGS. Once the genome sequencing is done by an external facility, each student will perform the genome assembly and annotation of the isolate's genome.

Assessment

The students' lab notebooks will be graded to evaluate the accuracy and thoroughness of their observations and record keeping, especially during the laboratory portion of the module. Their knowledge of the current technologies available for genome sequencing will be evaluated by written tests. Each student will prepare a written report of his/her isolate.

Inclusive Teaching

- The combination of lab skills and computational analysis involved in this teaching module is relevant to a wide range of fields: environmental, medical/health, evolutionary, biotechnology.
- Summer research opportunities allow students to engage students in novel research with a faculty member. Exposing students to research early in their college careers has been shown to increase retention, build self-confidence, and prepare them for a their profession of choice. However, there are many students who are unable to participate in summer research due to financial reasons or other obligations. By bringing genomics into the classroom, we are reaching a wider group of students including those who otherwise may not have been exposed to this type of research.

Lesson Plan

Provide a detailed description of the Lesson that is sufficiently complete and detailed to enable another teacher to replicate it. You may think of it as if you were explaining to a colleague how to teach your class for you next week, or preparing a detailed methods protocol for a lab technique. For clarity, you may need/want to include subsections such as: pre-class preparation and in-class script. Add subheadings as needed, following the embedded styles in Microsoft word:

Heading 2

Heading 3

Heading 4

A Table (created in Microsoft word) containing a recommended timeline for the Lesson should be included.

Week	Activity	Materials	Assessment
Week 1 and 2	**Search for new isolates of *Methylobacteria* associated with *Armillaria gallica* or leaf surfaces using selective media**	**--Selective media recipes and imprinting protocols will be provided as supplementary material**	**--pre-assessment**
Week 3	**DNA isolation, PCR of 16S rRNA gene, and preparing DNA for sequencing**	**--Protocols for DNA isolation and PCR of 16S rRNA will be provided as supplementary material**	
Week 4	**Analysis of 16S rRNA to determine the genus and species. Are any of the isolates potential novel species?**	**--Provide links to EZtaxon website for 16s rRNA comparison tools --Reference articles that describe the thresholds for species delineation using 16S rRNA sequences**	
Week 5	**DNA Library Preparation of potential novel *Methylobacteria* species**		
Week 6	**Discussion of different types of NGS technologies and how and why they are used.**	**--Questions and answers used for assessment will be provided as supplementary material**	**--students will be given examples of different research objectives and will determine the best sequencing platform to be performed.**

Week 7 (may happen in week 8 or 9 depending on when genome sequencing is complete)	**--Assembly of genome with NextGene --Cleaning up of assembly? --Upload to RAST for Automatted Annotation**		
Week 8	**--Analysis of Genome in RAST including comparative sequence analysis to other known species of *Methylobacteria* to determine novel genes --Analysis of genome using ANI, AAI, GGDC, OS, ROSA calculators to determine if it is a novel species.**	**--Links to online ANI, AAI,GGDC, OS, ROSA calculators and instructions for using them**	**--Data and interpretation will be included in a final report**
Week 9	**--Discussion of possible questions to be asked using the newly acquired genome data**		**--Submission of 2 research questions that could be potentially used as independent research projects --post-assessment**

As needed, expand upon aspects of scientific teaching that are particularly highlighted in the Lesson. As appropriate, provide examples of formative and/or summative assessments and related rubrics. List materials that are necessary or useful for teaching the Lesson, whether they are provided as supplementary materials or as links to other websites.

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, following the embedded styles in Microsoft word:

Heading 2

Heading 3

Heading 4

Acknowledgments

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

References

* Cite references in the parenthesis in text, in the order in which they appear.

1. Begin the reference list on a new page. The reference list is comprehensive and spans the text, figure captions, and materials.
2. Number references in the order in which they appear in the text. Follow ASM style and abbreviate names of journals according to the journals list in NCBI. List all authors of the reference.

Examples of reference style:

1. **Knight JK, Wood WB.** 2005. Teaching more by lecturing less. Cell Biol Educ. **4**:298-310.
2. **Samford University.** How to get the most out of studying: A video series. www.samford.edu/how-to-study/. Accessed August 20, 2013.
3. **Handelsman J, Miller S, Pfund C.** 2006. *Scientific Teaching*. New York, NY:W.H. Freeman.

3. Please add text notes to the end of the reference list; do not mix in references with explanatory notes.

Figure and Table Legends

Begin legends on a new page.

* **A separate file for each figure, table, and supplemental material item should be uploaded. Do not embed them 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**).

Supplemental Materials Files

** Wherever possible, ensure that the article title and authors are visible when a reader opens the file, either in a header, on the first page/first slide, or as a "Notes" sheet in a workbook of spreadsheets.

Title supplemental materials as follows:

1. "Supplemental File S1."
2. Short version of your article title (so that readers can easily tell which article a supplemental material is from). For example, shorten "Why Meiosis Matters: The case of the fatherless snake," to "Why Meiosis Matters".

Examples:

Supplemental File S1: Why Meiosis Matters,-Lecture Presentation Slides

Supplemental File S2: Bad Cell Reception-Assignment Worksheet

Supplemental File S3: Teaching PCR-Demonstration video showing how to use multi-colored yarn to create models of supercoiled DNA

k.
l. Funding and Conflict of Interest Statement
m. List of Tables, Figures and Supplementary Materials
n. Primary Image