Bioinformatics Bridge to Ecology

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Type of Manuscript: *CourseSource* Lesson Manuscript

Article Context:

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

Course Level
- Introductory
- 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+

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. Metagenomics, Dwarf Mistletoe, Ponderosa Pine, Qiime, Next-gen Sequencing

Scientific Teaching Context

Learning Goal(s)

- *Students will understand the dynamic relationship between mycorrhizal soil communities.*
- *Students will learn metagenomic approaches for evaluating soil microbial communities.*
- *Students will learn how to manipulate raw next-generation sequence data for data analysis.*
- *Students will understand the interrelatedness between above-ground plant and below ground communities.*
- *Students will learn the importance of scientific collaboration.*
- *Students will understand how to communicate scientific results in a poster session setting.*

Learning Objective(s)

- *Students will be able to extract total genomic DNA from soil.*
- *Students will be able to perform Illumina tag PCR.*
- *Students will be able to manipulate raw sequence data using qiime via linux.*
- *Students will be able to computationally merge and filter paired-end reads and filter chimeric sequences.*
- *Students will be able to computationally add metadata to sequence files.*
- *Students will be able to pick operational taxonomic units and create a phylogenetic tree using manipulated metagenomic sequence data.*
- *Students will be able to analyze metagenomic microbial populations using alpha and beta diversity plots and multivariable statistics.*
- *Students will be able to generate visual representations of data.*
- *Students will construct a research poster and present the poster orally during a formal poster session.*

Overall introduction

We are interested in determining the effects of an areal parasite, dwarf mistletoe, on the soil microbial community in a ponderosa pine forest. Soil samples will be collected at the beginning of the Plant Ecology semester and saved for use by the Molecular Biology II course in the next semester. The Plant Ecology class will use merged, formatted, and filtered data sets generated by the previous semester's Molecular Ecology II class to generate alpha and beta diversity indices.

Biology 477: Molecular Biology II

Students in Molecular Biology II focus on the subdisciplines of genomics and bioinformatics. This four week module will engage students in the isolation of total genomic DNA from soil in addition to the metagenomic analysis of sequenced 16S loci in an effort to answer questions regarding ecological community dynamics. This module will culminate in students designing a research poster and communicating the research done to a second class of students enrolled in Plant Ecology the following academic semester. During this module, lecture sessions will introduce the fundamentals of DNA sequencing with a progression to understanding next-generation sequencing chemistries. In the laboratory, students will isolate total genomic DNA from soil samples, quantitate, and amplify a target region within the 16S locus, and send the samples to an off-site sequencing facility. After receiving the raw sequence data, students will manipulate the raw data by merging paired-end reads and filtering the sequence reads based on quality. Additionally, students will format metadata, identify and filter chimeric sequences, and perform OTU picking. Student will communicate their research findings by designing a scientific poster to be critiqued by peer-review. Students will present the final version of their poster during a formal poster session with the primary audience being students enrolled in Plant Ecology. During the poster session, Molecular Biology II students will explain DNA isolation and sequencing chemistry in addition to the metagenomic bioinformatics pipeline used to manipulate the raw sequence data.

Biology 430: Plant Ecology

Students in Plant Ecology will learn the intimate relationships within plant communities and how one community may affect another in a manner that is not immediately obvious. For example, in a forest community above-ground plant parasitism may have an effect on the below-ground microbial community structure and function. A four-week module will be developed in which students will take an already merged, formatted, and filtered metadata set and analyze the effects of ponderosa pine infection by dwarf mistletoe on soil community structure. This four-week module will begin with a poster session given by the previous semester's Molecular Biology II class introducing the plant ecology students to the molecular methods and metadata manipulation. The Plant Ecology class will be required to give a poster session presenting their results the to previous semester's bioinformatics class.

Intended Audience - Students will be juniors and seniors majoring in biology

Required Learning Time - Four three-hour laboratory sessions for each class with supplemental background material provided during lecture sessions of the respective classes.

Pre-requisite student knowledge - Biology I, Biology II, Genetics, Cell Biology, Ecology

Scientific Teaching Themes

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

Active Learning

Traditional lecture will be supplemented with think-pair-share to help students interact with concepts introduced during class. Additionally, students will participate in group discussions to disseminate relevant information found in the primary literature. During laboratory sessions, students will collect specimens from the field, actively carry out wet-bench experiments to isolate total gDNA, master a metagenomics bioinformatic pipeline, and/or analyze statistical bioinformatic output.

Assessment

Knowledge will be assessed using lecture quizzes and lab practicals. Students will be required to create and present research posters to faculty and students in different biology degree tracks.

Inclusive Teaching

The module promotes collaboration with students in different subdisciplines within biology. Part of the collaborative effort is to communicate data obtained so that other students may further analyze the data for publication. This course design encourages students to interact with a larger student population that makes up the diverse student body on campus. Additionally, this module will help students gain an appreciation for the interdisciplinary aspect of science.

Lesson Plan

<u>Molecular Biology II</u>:

1. Lecture Topics
    a. Sequencing chemistry
    b. Metagenomics
2. Lab Session Topics
    a. Session 1 = Isolation of total gDNA from soil, Illumina tag PCR, gel electrophoretic analysis of PCR amplicons.
    b. Session 2 = Gel purification, sending samples in for sequencing, and introduction to Linux
    c. Session 3 = Introduction to Qiime and student practice using the metagenomic bioinformatic pipeline
    d. Session 4 = Merge raw sequence reads, quality filter, add Qiime labels, chimera check, and assign metadata.
    e. Session 5 = Create a scientific research poster
    f. Session 6 = Poster-session (following semester)

Plant Ecology:

Lab Session 1: Introduction to the community; ecological questions; experimental design

Lab Session 2: Field collection

Lab Sessions 3-7: analyzing field data

Lab Sessions 8-11: Metagenomics

Lab session 8: Introduction to bioinformatics and computational tools

Lab session 9: Creating an OTU table and calculating alpha and beta diversities

Lab session 10: Statistical analyses and figure building

Lab session 11: Creating a poster