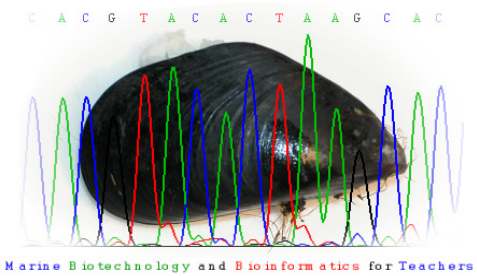

MARINE BIOTECHNOLOGY & BIOINFORMATICS FOR TEACHERS
MOSS LANDING MARINE LABS NSF ITEST GRANT
TEACHER LESSON PLAN FOR CLASSROOM USE

TREE OF LIFE

Title of Lesson: Tree of Life

Designed by:

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Background:

The purpose of this lesson is to bridge the concepts of genetics and evolution for Middle or High School level students and provide a hands on experience with phylogenetic trees. Given a group of organisms students will estimate their relatedness and make a branching phylogenetic tree by hand. In the computer lab, students will be provided with genetic sequences of the same organisms and use the multi-sequence online program ClustalW (http://clustalw.genome.jp/) to create a genetically based phylogenetic tree. This activity will introduce students to the field of bioinformatics by utilizing the ClustalW database for a practical application. The sequences will be provided for students in this activity but connections can be made to the biotechnology techniques employed to obtain sequences by purifying DNA.

Description of Audience:

This bioinformatics activity is designed for use by Middle or High School students, grades 7-12.

State Standards:

This bioinformatics activity fulfills the following State of California Science Standards:

- Grade 7
  - o Genetics 2.e
  - o Evolution: 3.d
  - o Investigation & Experimentation: 7.a,b,c
- Grades 9-12
  - o Genetics: 4.d,e, 5.b
  - o Ecology: 6.g
  - o Investigation & Experimentation: 1.a,d,k

National Standards:

This bioinformatics activity fulfills the following National Science Standards:

- Grades 5-8
  - o Content Standard A: Science as Inquiry
  - o Content Standard C: Life Science
  - o Content Standard E: Science and Technology
- Grades 9-12
  - o Content Standard A: Science as Inquiry
  - o Content Standard C: Life Science
  - o Content Standard E: Science and Technology

STEM Connection:

Bioinformatics careers are tied to this activity, such as contributing data to or developing software for biological analysis such as ClustalW. Such jobs could include Biologists, web programmers and database programmers. Biotechnology careers with reference to the source of the DNA sequences used may entail jobs in Paleontology, Comparative Anatomy, Science Teaching, Ecology and any of a number specialty fields such as Entomology or Mycology.

Goals:

The goal of this lesson is to expose students to the tools of bioinformatics and explore phylogenetic relatedness using concepts from genetics and evolution:

- Make predictions
- Use an online database as an introduction to the field of bioinformatics
- Relate differences at the genetic level to differences between organisms

Learning Objectives:

Upon completion of this lesson, students will be able to conduct multiple-sequence analysis using an online database and produce a phylogenetic tree comparing several organisms:

- Properly navigate a computer to utilize an online database
- Conduct a multiple-sequence query using a database to produce a phylogenetic tree Relate the trees to evolutionary trends and hypothesize on the selective forces involved
- Understand the rationale behind modern Linnean classification of organisms

Purpose / Rationale:

This lesson follows the genetics & evolution units late in the school year. The evolution unit follows the genetics unit and this lesson is a culminating activity for both of those units as well as comparative anatomy and organ systems. The evolution unit is based on the Lawrence Hall of Science GEMS unit, “Life Through Time.” That unit has been modified to include several dissections of model organisms interspersed between the GEMS lessons. The rationale for this lesson is to connect the genetics and evolution units and associated concepts with the dissections.

It is hoped that by incorporating comparative anatomy and dissecting model organisms during an evolution unit the lesson will review material covered during the entire year. Aligning DNA sequences to generate a phylogentetic tree will be a culminating activity to tie together prior studies of anatomy/organ systems and cell biology as well as making a direct link between genetics and evolution. CA state science standards addressed in this lesson include topics under the genetics, evolution and investigating/experimentation headings. National standards covered by this lesson include Life Science, Science as Inquiry, and Science and Technology threads.

Materials / Resources:

- Computer Lab or computers adequate for students working in groups
- Internet access
- http://align.genome.jp/
- Student directions
- Optional Power Point template for student presentation

- Electronic version of DNA or protein sequences of organisms for alignment on Clustal web site
    - To paste in, align, and generate tree
- Optional electronic versions of a different DNA or protein sequence from same organisms
    - (to compare resulting tree)

Prior Teacher Preparation:

What did you have to do to get ready for this lesson? (research, purchases, organization)

Use files provided for sequences or to customize:

- Decide on organisms to compare
- Use NCBI to obtain DNA or protein sequences (same gene) for each
    - http://www.ncbi.nlm.nih.gov/
- Enter species name in search box and select gene, then search
-
- Create text file in FASTA format of the sequences
    - (FASTA format sample:
      >Euglena_viridis

      GDAERGKKLFESRAGQCHSSQKGVNSTGPALYGVYGRTSGTVPGYAYSNANKNAAIVWEDE
      SLNKFLENP
      KKYVPGTKMAFAGIKAKKDRLDIIAYMKTLKD

      (“>” symbol required with species and/or gene identification followed with one return and a text string of DNA bases or single letter amino acid code; must be file type .txt)
- Make file available to students
- Practice making the tree yourself and practice navigating the NCBI site to obtain sequences

3-Step Procedure:

#1 Introduction:

- Make connections between prior knowledge and experiences with what is presented.
- Find out what students ideas are on this topic - uncover misconceptions!
- Review what was learned in prior lessons - then introduce content and vocabulary necessary for today's lesson
- Use teaching charts, video clips, books, presentation software, instructional software, articles, tapes, overhead projector, handouts, models, etc. to accent instruction.
- Create and describe the structure for group learning (if applicable), whole class discussion, and individual work (journal, worksheet).

#2 Exploration:

- Describe in detail the activity or investigation students will pursue with clear directions.
- Describe the path of inquiry or process of discovery to be followed - What questions will you ask? - LIST THEM!
- Prepare a lab sheet for students to record data, answer questions. This can be done in science journals.
- Students Predict / Explain. Then Explore and Discuss. Finally they Revise their explanations and theories.
- Conclude, share results, discuss, ask and answer questions, evaluate lesson, assess student understanding.

#3 Application:

- Students can estimate and then see their position in the phylogenetic tree by including *Homo sapiens* in the sequences to be compared
- Have students brainstorm how this and similar genetic databases might be of use socially, not just in a research field; bring up forensic analysis, genetic disease screening, etc.
- Students can be asked to generate their own list of organism that they want to determine evolutionary relatedness
- Comparing amino acid/protein sequences from the same organisms may show different results due to the redundancy of codons; seemingly closely related organisms can be selected for this follow up; apparently major differences in DNA sequences can actually yield similar if not identical proteins
- Students should select an organism of interest to research in greater depth, describing its place in the Linnean classifcation scheme, from Kingdom to species. For more in depth research students could determine approximately which era or period it evolved, what its closest ancestors are thought to be, and describe the organisms life cycle and general ecological role.
- Career Connection – to modify:

Bioinformatics careers are tied to this activity, such as contributing data to or developing software for biological analysis such as ClustalW. Such jobs could include Biologists, web programmers and database programmers. Biotechnology careers with reference to the source of the DNA sequences used may entail jobs in Paleontology, Comparative Anatomy, Science Teaching, Ecology and any of a number specialty fields such as Entomology or Mycology.

Assessment:

- Observe and question students' initial hand made phylogenetic trees made by students to establish they are incorporating branch difference in length and number to express the desired degree of relatedness
- Observe students use of the online database to produce a tree
- Students will print out or sketch a copy to a notebook showing their final computer generated tree

Teachers' Self Evaluation:

- *Incomplete*