California State University Monterey Bay

ESSP 541 Marine Biotechnology and Bioinformatics for Teachers
Syllabus – Summer 2004

Course Time and Location: July 6-23, 2004 at Moss Landing Marine Laboratories.

Instructors: Dr. Simona Bartl – Moss Landing Marine Labs
Dr. Henrik Kibak – California State University Monterey Bay

Recommended Textbooks:
“Laboratory DNA Science” by Mark V. Bloom, Greg A. Freyer, David A. Micklos
“Introduction to Bioinformatics” by Arthur M. Lesk

Course Description:
This learning experience consists of an intensive 14-day institute with enrollment limited to 15
in-service middle and high school biology teachers. Participants will use biotechnology and
bioinformatics techniques to investigate a scientific question of importance to local marine
fauna. Students will use the experience gained to prepare a lesson plan addressing California
State Life Science Standards for use in their classroom. The goal of this National Science
Foundation supported program is to take teachers through the hands-on process that scientists
use in modern marine scientific research. Participants will use biotechnology techniques to
generate their own DNA data which they will then analyze using bioinformatics software tools
available at the program’s website. Participants will also meet local experts in the areas of
biotechnology and bioinformatics. Each teacher will receive exportable materials and institute
staff support during the following academic year for the incorporation of marine biotechnology
and bioinformatics concepts into their curricula.

Participants will also be expected to participate in the NSF-required formative and program
evaluation. Evaluation activities will include a web-based pre-survey, a post-survey administered
during the last session of the workshop, and a group interview. The external evaluator will also
conduct site visits to selected schools to observe middle and high school biology classes taught
by program participants. Evaluation questions will address program content, organization and
implementation, learning concepts, curriculum materials and prototypes, and professional
development.

Course Outcomes:

Students will be able to isolate DNA from marine invertebrates.

Students will be able to design primers for DNA amplification.

Students will be able to amplify specific DNA sequences using the Polymerase Chain Reaction.
Students will be able to conduct quality control tests on amplified DNA.

Students will able to recombine plasmid DNA and PCR product.

Students will be able to transform competent E. coli with plasmid containing PCR product.

Students will be able to purify cloned plasmid DNA and prepare it for sequencing.

Students will understand dideoxy sequencing and modern variants.

Students will use software tools of bioinformatics to analyze the DNA sequences of their PCR products for open reading frames, similarity to sequences in the international databases.

Students will understand how to prepare phylogenetic trees relating homologous sequences.

Students will become familiar with the use of visualization software for the analysis of protein structures.

Students will visit the UCSC Genome Bioinformatics Institute, a local marine molecular biology labs, and at least one commercial biotechnology company.

In Service High School Teachers: Students will prepare a lesson plan incorporating several of the following California State High School Life Science Standards, preferably the ones in bold.

4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism. As a basis for understanding this concept:

   a. Students know the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA.

   b. Students know how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA.

   c. Students know how mutations in the DNA sequence of a gene may or may not affect the expression of the gene or the sequence of amino acids in an encoded protein.

   d. Students know specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves.

   e. Students know proteins can differ from one another in the number and sequence of amino acids.

   f. Students know why proteins having different amino acid sequences typically have different shapes and chemical properties.

5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells. As a basis for understanding this concept:
a. Students know the general structures and functions of DNA, RNA, and protein.

b. Students know how to apply base-pairing rules to explain precise copying of DNA during semiconservative replication and transcription of information from DNA into mRNA.

c. Students know how genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.

d. Students know how basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules.

e. Students know how exogenous DNA can be inserted into bacterial cells to alter their genetic makeup and support expression of new protein products.

All of the 9th – 12th grade standards on investigation and experimentation apply. For details see http://www.cde.ca.gov/cdepress/standards-pdfs/science.pdf

In Service Middle School Teachers: Students will prepare a lesson plan incorporating several of the following California State Seventh Grade Life Science Standards, preferably the ones in bold.

Cell Biology

1. All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:

a. Students know cells function similarly in all living organisms.

c. Students know the nucleus is the repository for genetic information in plant and animal cells.

Genetics

2. A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences. As a basis for understanding this concept:

d. Students know plant and animal cells contain many thousands of different genes and typically have two copies of every gene. The two copies (or alleles) of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.

e. Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.
Evolution

3. Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:

a. Students know both genetic variation and environmental factors are causes of evolution and diversity of organisms.

d. **Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms.**

e. Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

b. Use a variety of print and electronic resources (including the World Wide Web) to collect information and evidence as part of a research project.

c. **Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.**

d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth’s plates and cell structure).

e. Communicate the steps and results from an investigation in written reports and oral presentations.

**Assessment:**
Assessment for this 5-unit credit/no-credit graduate course is based on evidence of successful completion of the laboratory outcomes (labbook), submission of a passing lesson plan by August 6, 2004, and satisfactory participation in the program evaluation.