**Incorporating Genomics in Undergraduate Biology: an Avenue for Inquiry-based Research**

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**Abstract**

The science of Genomics and Bioinformatics have revolutionized the field of biological research in the 21st century. The availability of bioinformatics online resources and genomic databases makes it possible for teachers to incorporate coursework and activities that allow students to conduct research problems in genomics using bioinformatics tools. I recently developed a project-based-learning course on genomics that combined lectures on the science and ethical, legal and social implications (ELSI) of genomics with hands-on lab activities on bioinformatics and DNA analysis. Using bioinformatics tools available at the Microbial Genome Annotation Network (http://www.geni-act.org), the students gained foundational bioinformatics skills and experience first had the concepts of gene and genome structure by annotating genes from the bacterium *Glaciecola psychrophila*, a novel psychrophilic bacteria isolated from an arctic glacier. The students carried out a DNA Barcoding project to catalog and identify native trees growing on campus. Lastly, the students isolated their genomic DNA, submitted it for sequencing and analyzed the sequence to determine their maternal genetic ancestry. Future plans for the course are to incorporate analysis of the personal genome of students interested in having in their genome analyzes and to provide a follow-up independent research course for students to do functional genomics.

**1. Gene Annotation using Geni-Act**

Students learned to use bioinformatics tools to annotate genes from the bacterium *Glaciecola psychrophila* strain 170fs, a gram negative, aerobic, psychrophilic, pigmented, motile bacterium that thrives in seawater from the coastal region of Antarctica (Zhang et al., 2006). Online bioinformatics tools in geni-act (geni-act.com) uses a modular approach to allow students to perform the DNA and protein analyses shown below. Each student was assigned to manually annotate two genes, including a gene annotated as hypothetical.

**2. Mitochondrial DNA & Ancestry**

Mitochondrial DNA (mtDNA) is passed down almost unchanged from a mother to her children. Thus sequencing of mtDNA, particularly in the hypervariable control region, provides genetic information revealing maternal genetic ancestry. Students isolated their genomic DNA from buccal mouthwash, used PCR to amplify the D-loop region and submitted the DNA for sequencing. The DNA sequences were analyzed and compared to a human mitochondrial database.

**Assessment:** 2 exams, worksheets on bioinformatics exercises; geni-act notebook and poster presentation of gene annotation data; Website created presenting the class project on DNA barcoding

**References**


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**3. DNA Barcoding**

**DNA Barcoding**

DNA Barcoding works by comparing short sequences of the genome that are highly variable among different species. To identify plant species, a region of the rbcL gene found in the chloroplast is amplified and sequenced.

The class chose to work on a project to use DNA barcoding to identify the species of native trees growing around the Alfred State campus. Leaf samples from 14 different trees on campus were collected. Genomic DNA from these leaves was isolated, amplified and sequenced. The sequences were matched to the GenBank database using BLAST.

**Map of Alfred State College and the location of trees sampled**