

Integrating Undergraduate Research into the Freshman Biology Laboratory

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Introduction

At Roger Williams University, we have a year-long freshman Biology sequence where we are beginning to introduce bring research type experiences into the laboratory. In the first semester, our goal it to enable the students to acquire the skills to write a hypothesis, collect, present, and analyze data, and learn to write a results section. Our second semester is being designed to use research type labs and communicate science in both a written and oral form.

We have designed three modules that will allow students to learn techniques in a more research type environment.

- Survey of Selenium utilizing microorganisms from different environments
- Population fingerprinting of *Portulacaria afra* from different regions
- Plant competition of C₃ and C₄ plants (we use Barley, Corn and Sorghum seeds)

Each module can vary in length depending on what the instructor chooses. The plant competition module can be done in about six weeks. Students work in groups and decide which parameters of competition they want to measure. At the end of the experiment, students harvest the biomass and take their final measurements. This module allows other labs to be performed as measurements can either be done during the lab period.

We have the students write a scientific paper on the results for the first module. Students work on sections of the paper and each section is brought to class for peer review during the lab period. Students then write a draft and a final version to be turned in. Students are introduced to the sections of a scientific paper and the scientific literature. With the plant competition module, we had the groups give an oral presentation to the class during the final period. Was they enter the upper division laboratories with better preparation in both laboratory and communication skills.

Module: Survey of Selenate Utilization

Materials and Methods-20 g of Tryptic Soy Agar was obtained and 1g of lactic acid was added. 500 mL of H₂O was added to the solution. The agar solution was autoclaved. Selenate was added to the TSA. A series of petri dishes containing 1%, 5%, .1%, and .01% of selenium were made using the agar.

A forest culture was inoculated into each of the petri dishes and then incubated at 35 degrees Celsius (we sampled fresh water, salt water and marine sediments).

The colonies turned red when Selenate was oxidized. Further experiments depending on time can be performed including:

Bacteria can be gram stained and identified
Population growth experiments

We have students bring in original research papers to share and discuss. Students are then required to bring in their introduction and material and methods for peer review. Results and discussion sections are brought in later for peer review. Students then finish their paper with literature citations and turn them into the instructor.

Selenate Utilization

0% 1%



Module: DNA Fingerprinting

Plant samples were collected from various sites in and around Grahamstown South Africa. All samples were frozen until assayed.

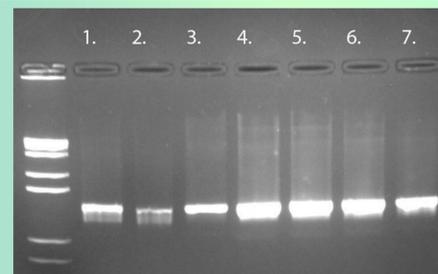
Leaf samples were frozen with liquid nitrogen to grind the samples into a fine powder. The basic protocols of the Qiagen DNeasy® plant mini kit were followed with a few minor changes (starting from step 7 with the fine powder). Extra vortexing and centrifuging was required due to the high viscosity of the *P. afra* samples. After the DNA extraction process, the DNA was examined by running 1% agarose gels containing 1xTBE and Ethidium Bromide. Isolated DNA was frozen in a -20° freezer if the gel was not run on the day of the extraction.

The DNA was visualized under a UV light. Digital photographs of the gel were captured with the Kodak 1D 3.6 software connected to the UV light box. To confirm the presence of the DNA, all samples were tested with Rubisco primers before using the RAPD primers. A set of 40 RAPD primers was purchased from Gene Link™ and primers were selected at random for DNA fingerprinting analysis of *P. afra*.



Rubisco

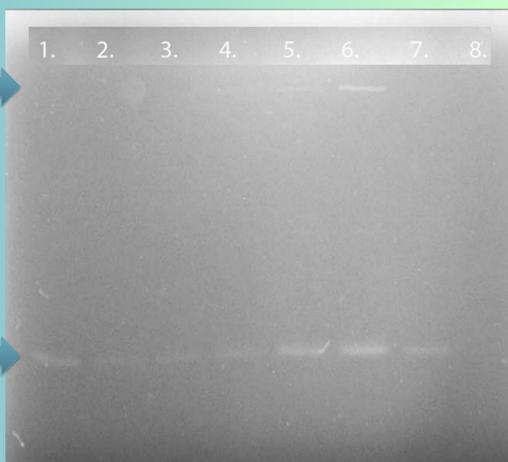
1. Pluto's Vale 4.9
2. Addo 1
3. Route 67 - 3km
4. Graham 1
5. Addo 2
6. Hell's Spoot #2
7. Fish River 10



← Rubisco

Rubisco PCR Primers were used to confirm the presence of DNA in all leaf samples before using RAPD primers. Rubisco is a protein used in the process of photosynthesis by all plants. Once the Rubisco was visualized, RAPD PCR could be carried out.

RAPD Primers 02 & 03



1. Addo 1
2. Addo 2
3. Hapdor Loop
4. Port Alfred 19.4
5. Fish River 10
6. Hell's Spoot #2
7. Pluto 4.9
8. Baviaanskloof 6pm

Figure 3.
The gel displays the RAPD PCR of with primers 02 & 03. Primer 02 looked at the sequence TGCCGAGCTG while primer 03 focused on AGTCAGCCAC. These primers may indicate differences between *P. afra* ecotypes.

Other types of DNA can be used for population analysis using the RAPD primers. We are looking to utilize different fish populations from around Mt. Hope Bay.

Module: Competition

- Students design experiments. We have corn, sorghum, and barley seeds for the students to use. Corn and Sorghum are C₄ plants and Barley is a C₃ grass. Students can do seed density or competition experiments.
- Students decide on which measurements to take and how often. They are required to care for them.
- Plants can be grown in a greenhouse and the experiment can run the whole semester or harvest in 5 weeks.
- Student groups were required to give a powerpoint presentation and they were limited to six slides.
- During this module, traditional lab experiments can be performed.



Outcomes

The traditional labs which run for 3 hours with a know outcome have been used in this lab and students have learned that science is done in three hour blocks. They also expect the results to be in accordance with known results that have already been published.

The new modules are designed to enable:

- Students to learn to read original research papers continue to learn about communicating science to other scientists
- Students learn to write a scientific article and peer review papers from other students.
- The students learn a variety of laboratory techniques and skills for preparation for upper division laboratories
- Students learn to design experiments and decide which parameters to measure
- Students continue to learn to present data and analysis in both written and an oral presentation
- Students learn for some experiments the methods may not work the first time and have to be repeated

We found that most students enjoyed the experience. We will continue to assess and reevaluate the lab to continue improving the experience.

Acknowledgments

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